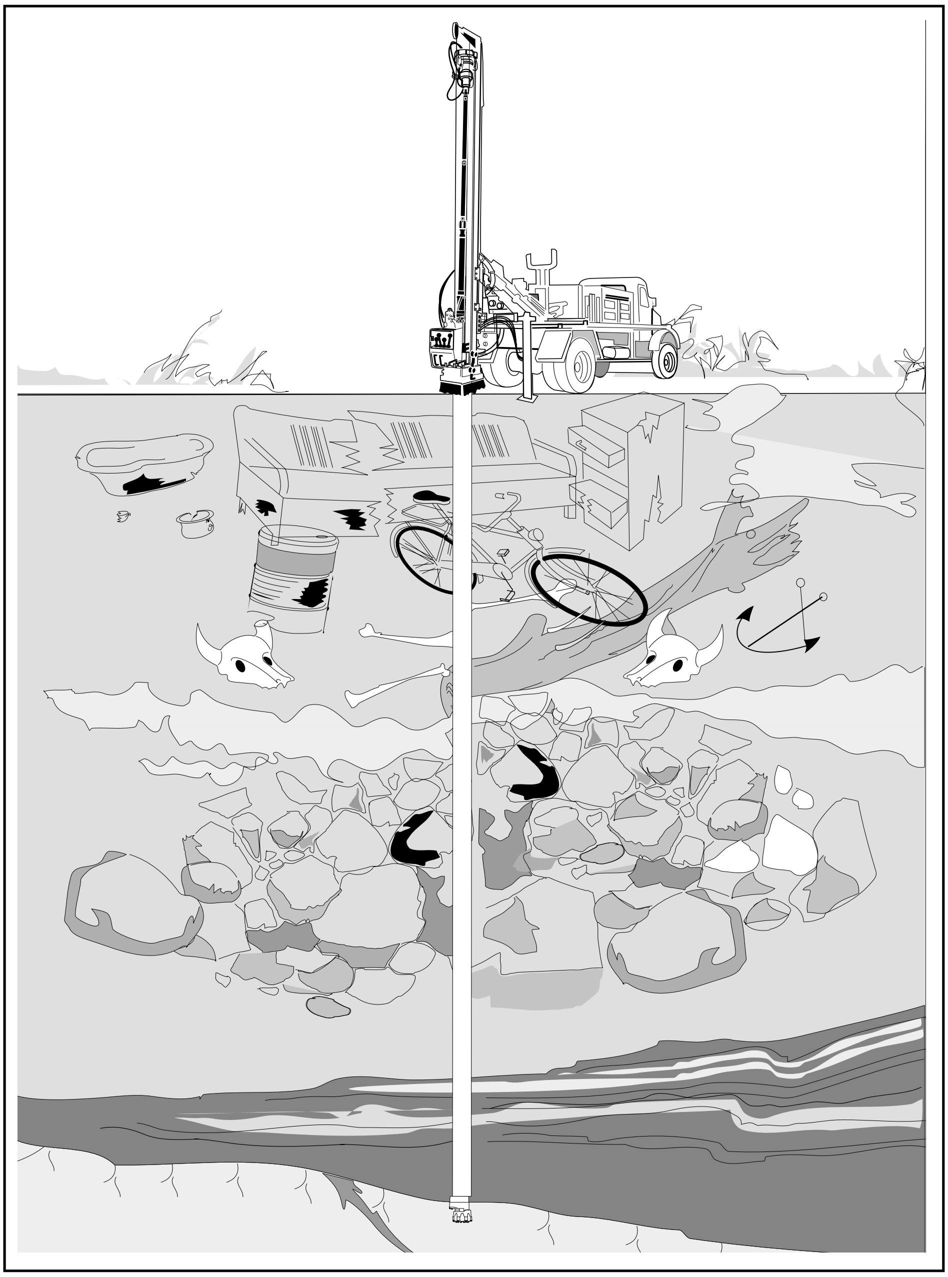
DTH DRILLING TOOLS

TUBEX XL



Mission overburden rock drilling tools

USER´S HANDBOOK

MISSION

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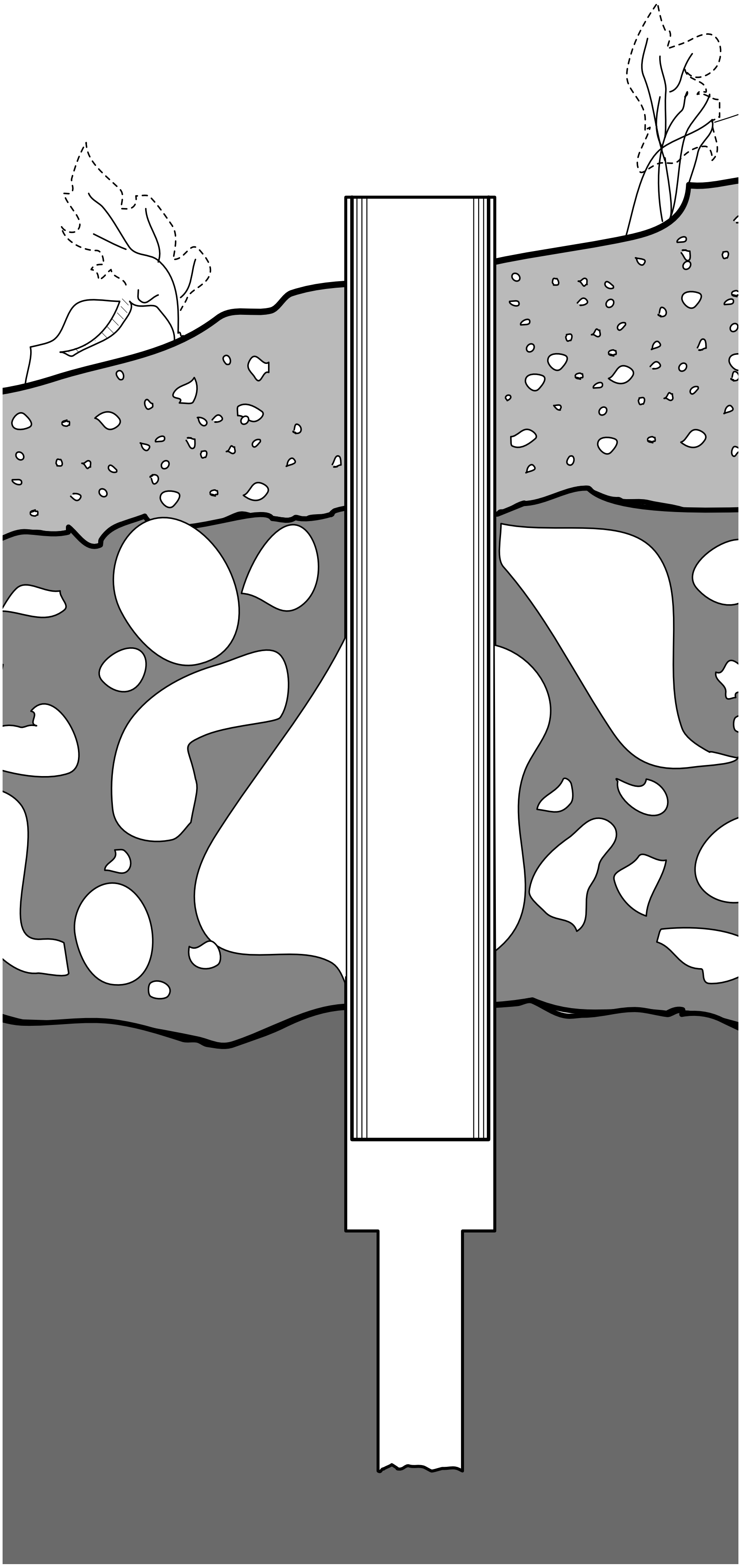


DESCRIPTION OF THE TUBEX XL METHOD

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.

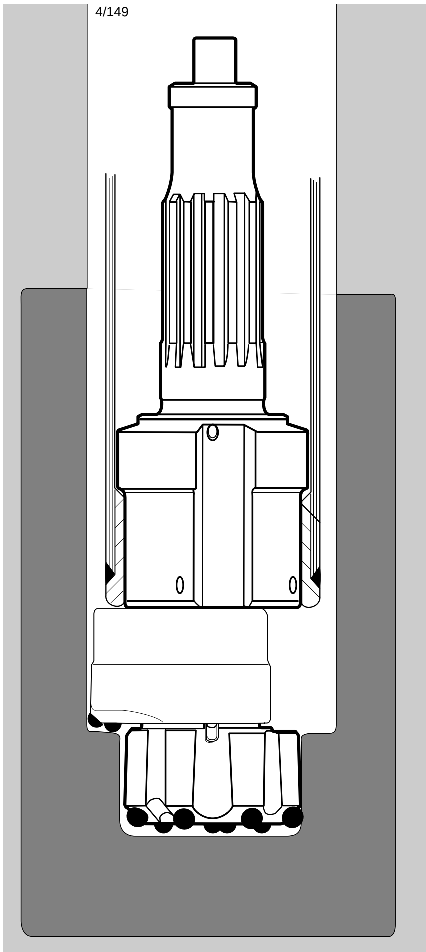
It is impossible to drill through loose overburden using conventional drilling methods. This is because the hole walls collapse continuously, which renders the drill hole useless. The TUBEX XL method was developed by Sandvik to solve this problem. TUBEX XL enables a unique form of simultaneous drilling 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.

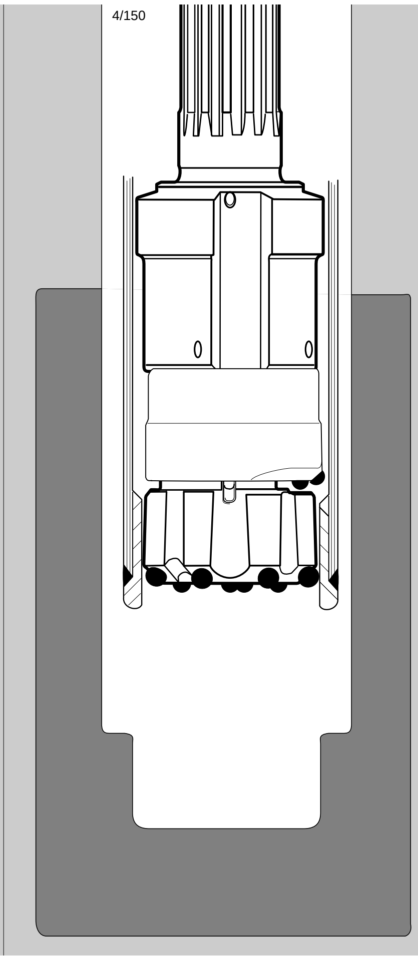
With the TUBEX XL method, the casing tubes do not need to be rotated during drilling. Instead, they are tapped down behind the TUBEX XL equipment, with the aid of a little percussion energy from the rock drill.

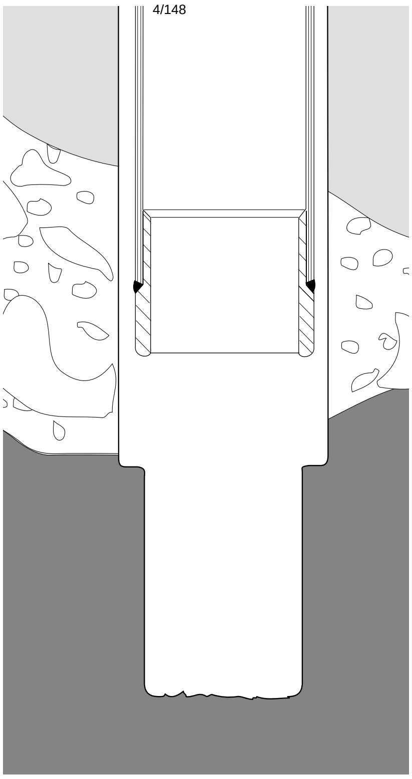
PRINCIPLE OF OPERATION

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.

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:

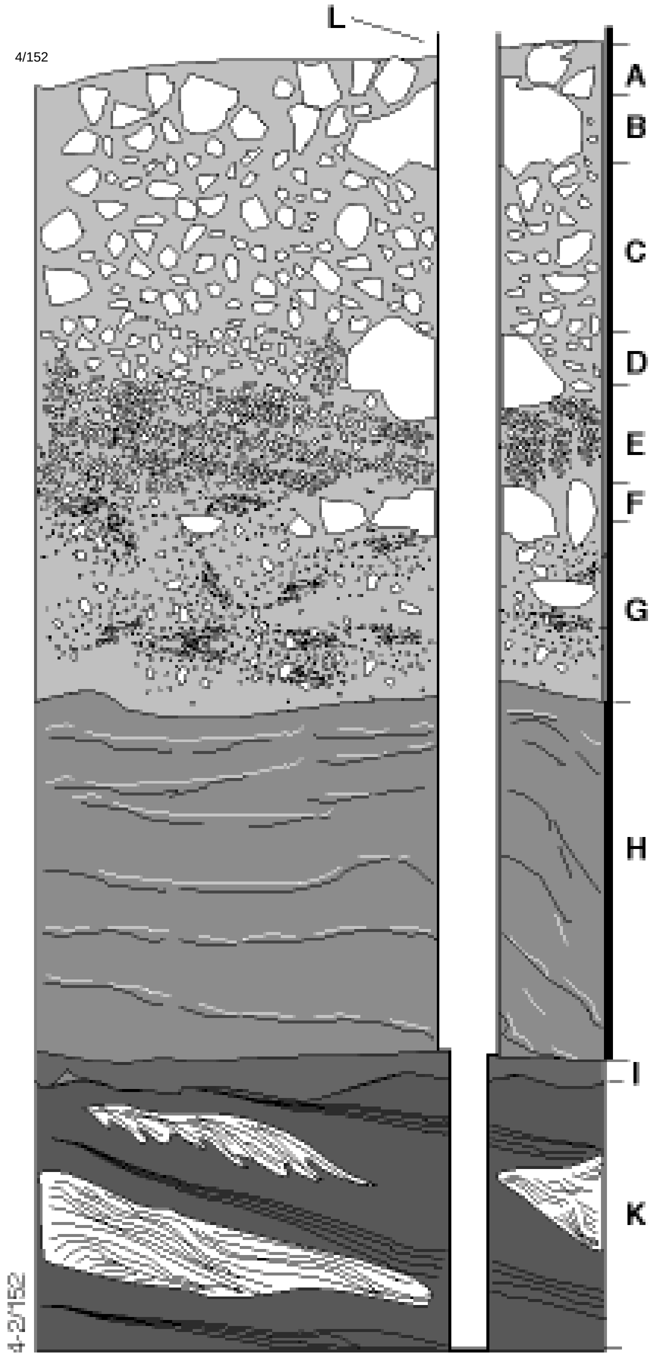
- inexpensive casing tubes can be left in the drill hole;
- drilling can be continued with conventional equipment after the casing tubes have reached the bedrock;
- it is possible to take continuous soil samples.

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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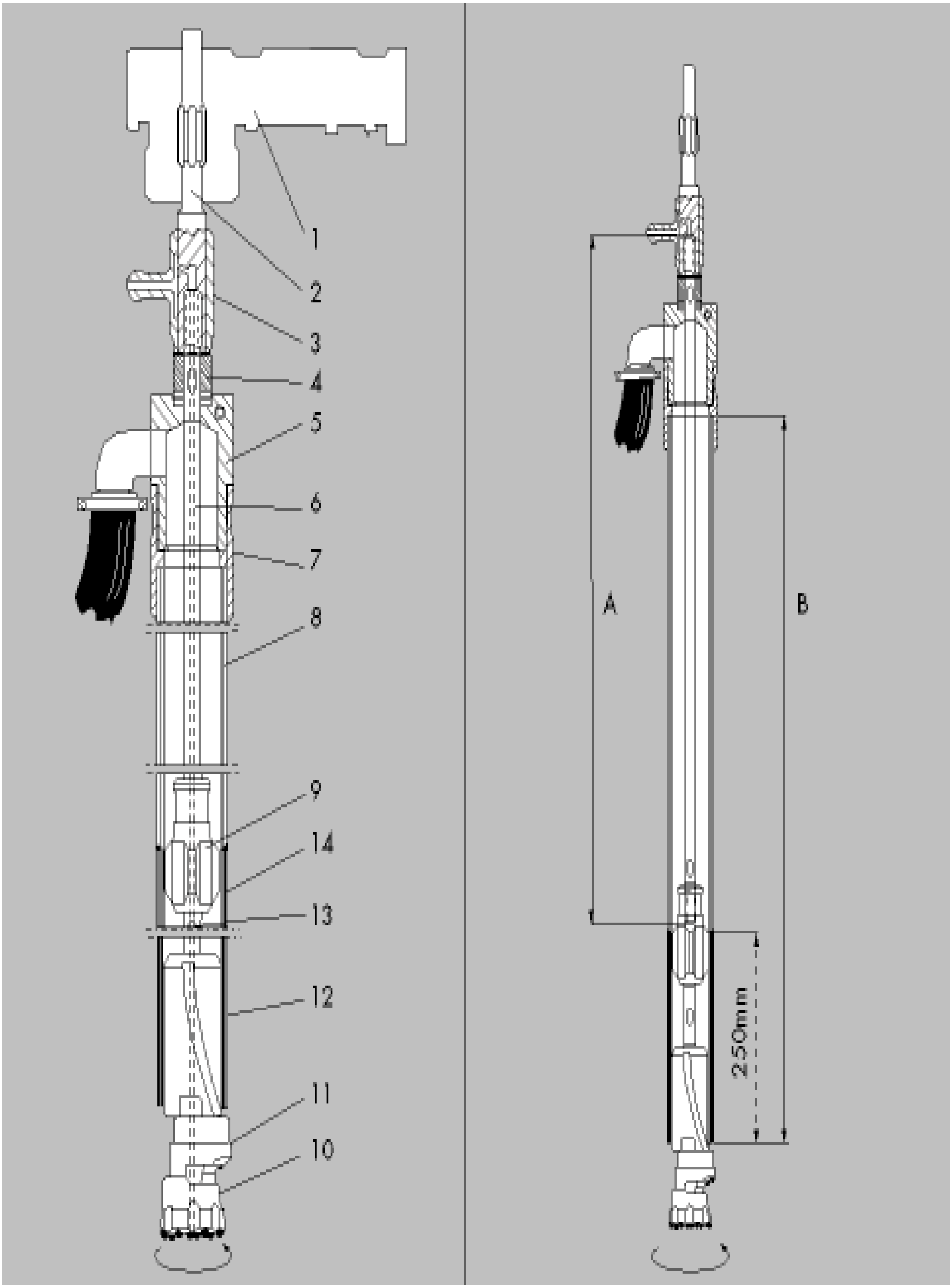


EQUIPMENT & FUNCTION

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.

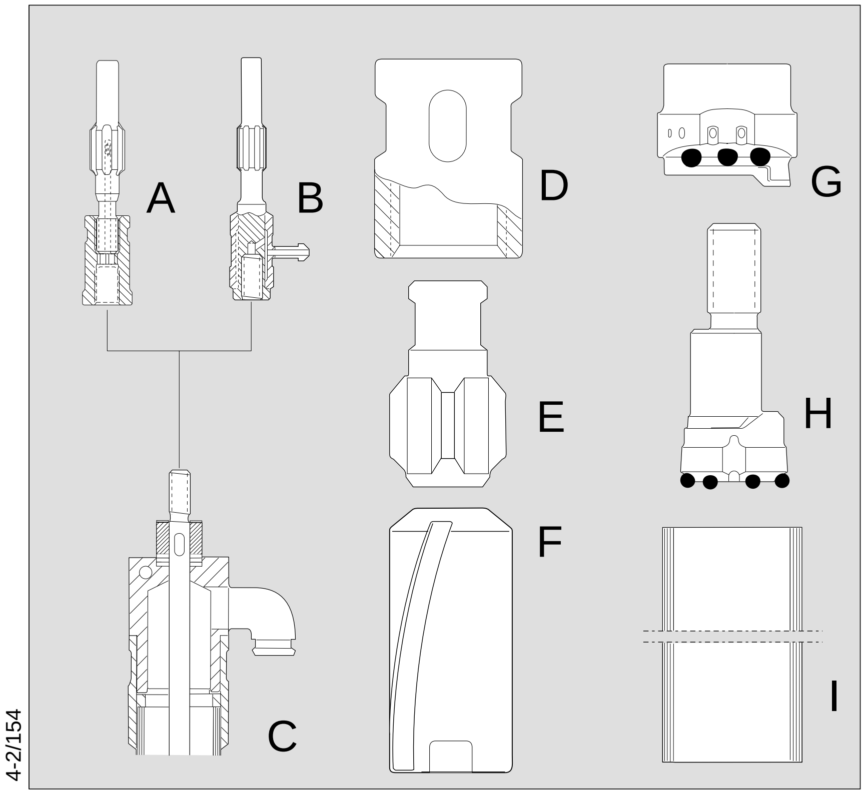
Note also that the hole depth is limited because of energy losses in the joints of the drill string and the friction between the casing tubes and the hole wall.

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

TUBEX XL FOR TOPHAMMER DRILLING



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Shank adapter A and B
- transmits percussion energy to the drill string (R 38) and driving cap
- transmits rotation to the drill string

Shank adapter A
- R38, T38, or T45 shank adapter with built-in separate flushing can be used
- the shank adapter can be joined to the R38 extension rod by means of a driving sleeve

Shank adapter B
- R38 shank adapter with female thread, intended for separate flushing

Driving cap C
- transmits percussion energy from the shank adapter to the casing tubes
- collects the drill cuttings, which can be ducted away via a hose

Adapter sleeve D
- transmits percussion energy from the driving cap to the casing tubes
- protects the rear edges of the casing tubes from deformation and wear

Wing coupling E
- centralizes the drill string inside the casing tubes
- fitted between the first and second extension rods, and at every third or fourth joint thereafter

Guide device F
- has internal thread at both ends
- centralizes the pilot bit and reamer inside the bit tube
- has grooves for the passage of drill cuttings

Reamer G
- fitted with cemented carbide buttons
- swings out around the eccentric shaft of the pilot bit
- has a diameter marginally smaller than the inside diameter of the bit tube
- when swung out into the reaming position, the reamer reams a hole somewhat larger than the outside diameter of the bit tube

Pilot bit H
- fitted with cemented carbide buttons
- has eccentric shaft to accommodate the reamer
- stop lugs limit the turning movement of the reamer to 180°
- has threaded shaft for attachment to the guide device

Bit tube I
- internal diameter dimensioned to give minimal radial play between guide device and bit tube
- protects the front edge of the casing tube from deformation and wear

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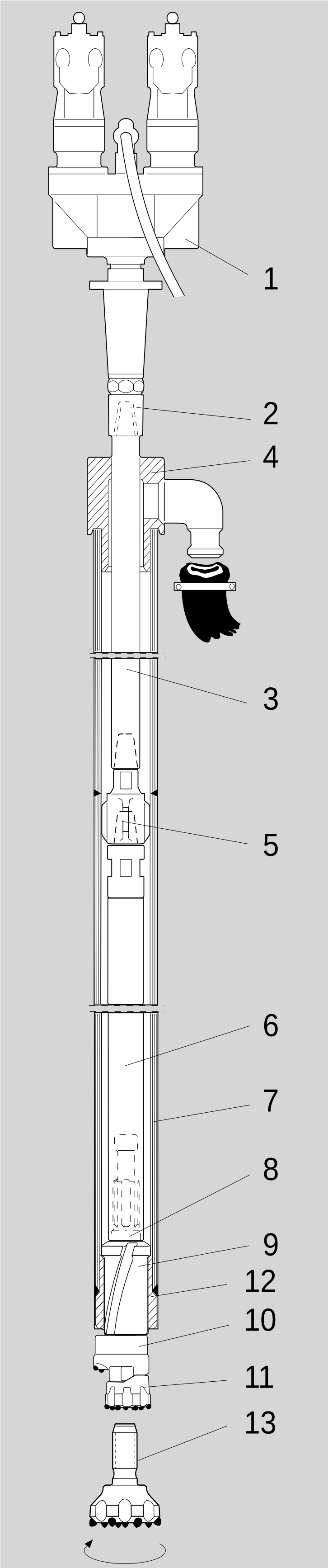


TUBEX XL FOR DTH DRILLING

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.

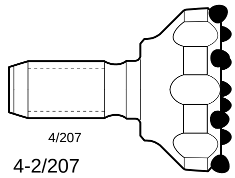
The basic TUBEX XL ”package” consists of four components: the pilot bit (11), reamer (10), guide device (9) and guide sleeve (5). The shape and function of the pilot bit and reamer are basically the same as for tophammer TUBEX XL, but the pilot bit has a right-hand thread.

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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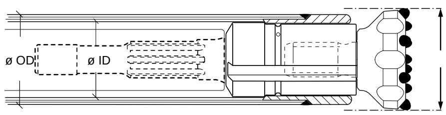

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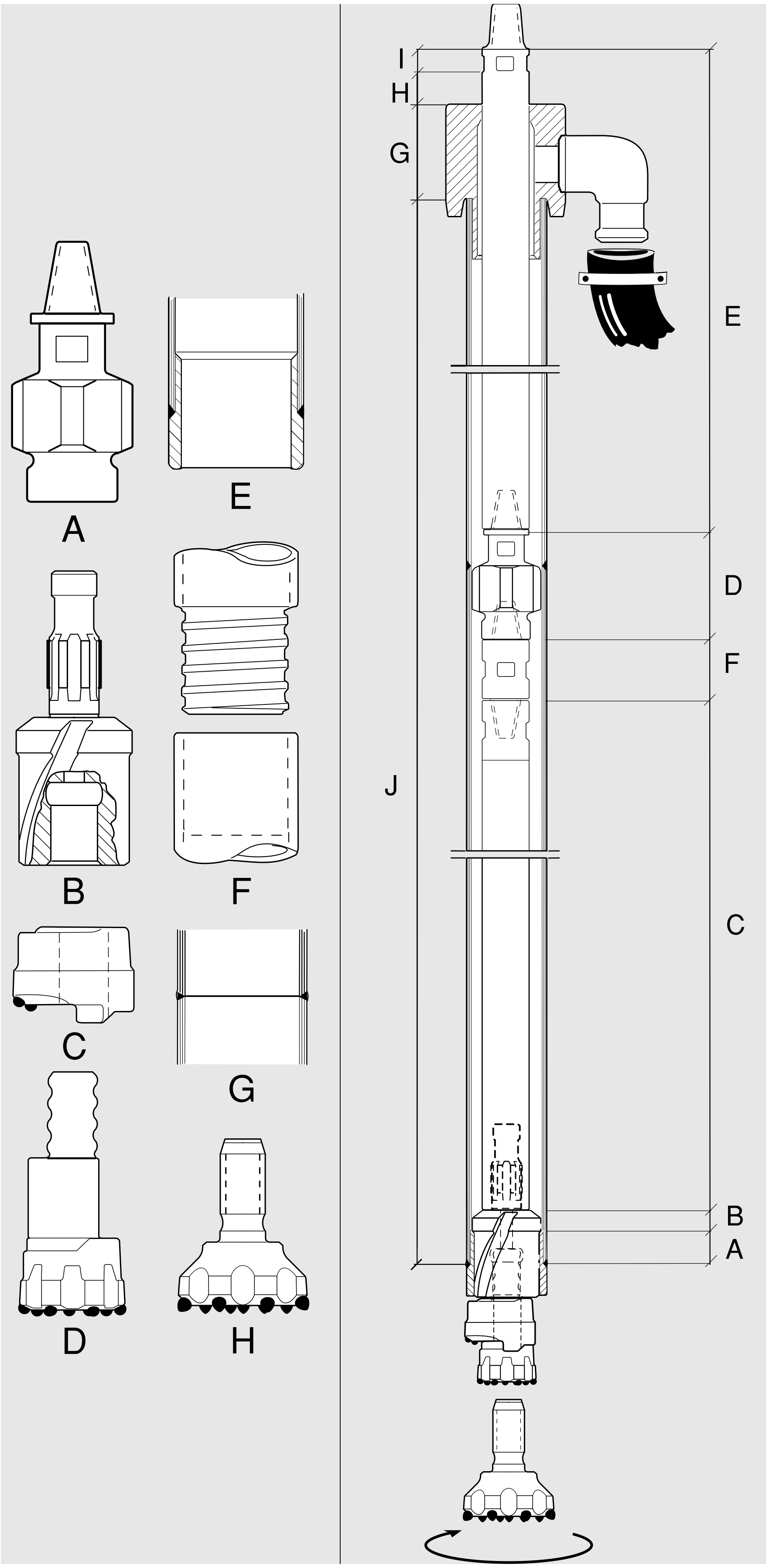


TUBEX XL FOR DRILLING WITH DTH HAMMERS

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 withdrawn. 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:

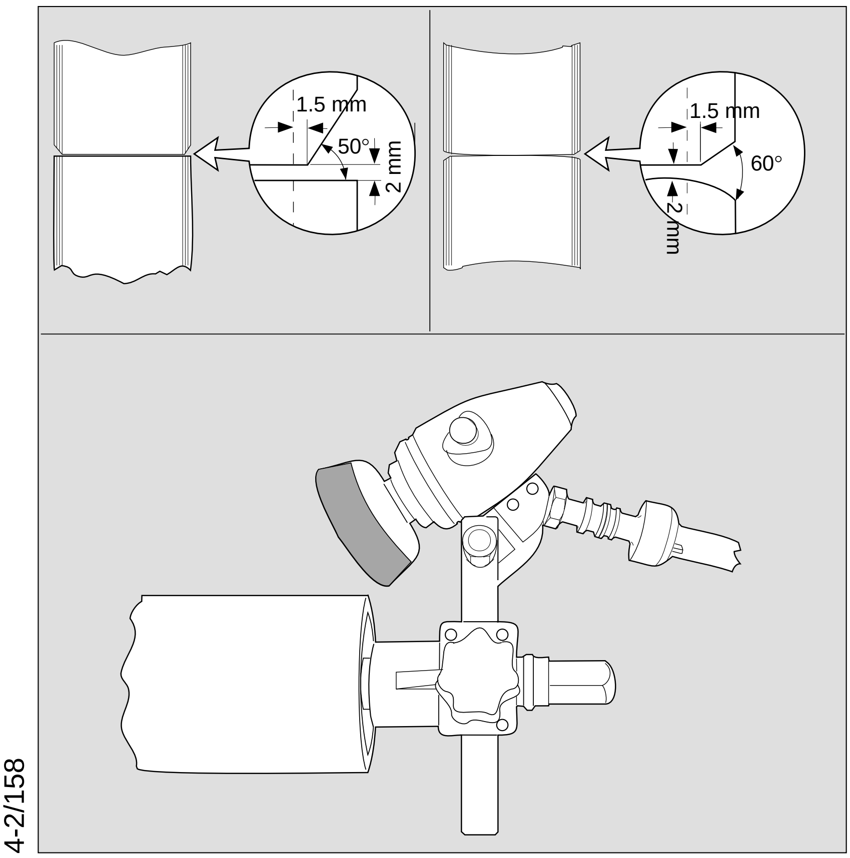
Outside diameter of casing tube: ± 1%

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

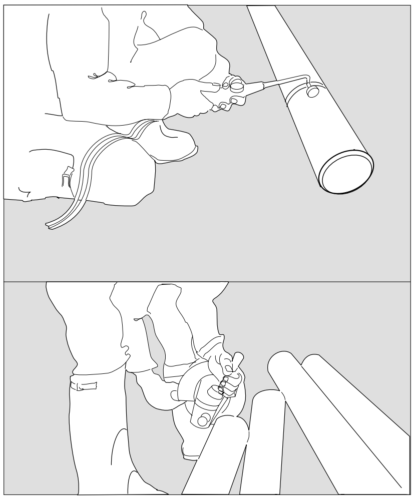


Bevelling/chamfering

In order to produce a weld of good strength, the lower end of the casing tube should be bevelled, as shown in the figure on the left. Alternatively, the ends of both casing tubes can be bevelled, 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.

Cutting

Casing tubes can be cut at the worksite by means of any of the following:



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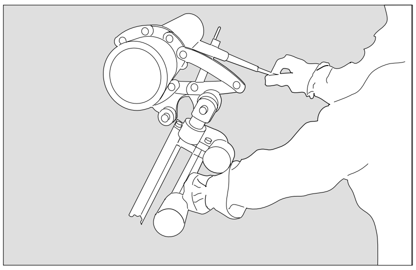
- gas torch
- a hand held pneumatic grinder
- a chain knife (tube cutter).

Comments on the above alternatives are as follows:
It is difficult to get a clean, right-angled cut when using a gas torch.



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The hand-held pneumatic grinder is not precise. The chain knife (tube cutter) is the best choice, because it gives a perfect, right-angled cut.

If the casing tubes were ordered from the supplier in specified lengths, they will have been cut by machine with great precision. Cutting at the worksite will be necessary only if a welded string of casing tubes is to be taken up and re-used.

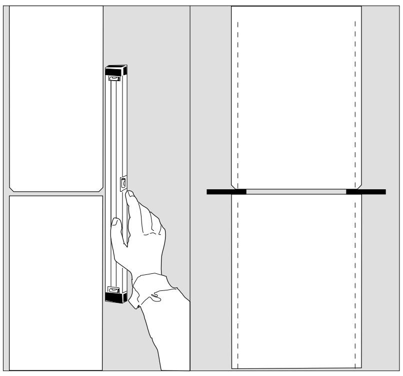
It is very important for the cut to be made at perfect right angles to the centre line of the casing tube.

Joining casing tubes
Do not drill the casing tube too far into the ground when joining is to take place. It is much easier to make the joint above the drill-steel support, at a convenient height. This lets you lift up the next tube easily, and weld in a comfortable position.

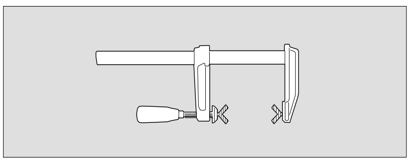
A drill tube must be inserted into the new casing tube before it is lifted up. The two components are then lifted up together, and the drill tube is threaded into position. Now the ends of the casing tubes can be positioned for welding. Make sure you line up the casing tubes perfectly before starting to weld. Place spacers between the two casing tubes, so that you get a suitable gap (approx. 2 mm) for welding.

Fix the casing tubes into position with the aid of a welding fixture, or clamp. Tack weld in four

4-2/161 A



places around the joint, at 90° intervals. Then weld carefully to



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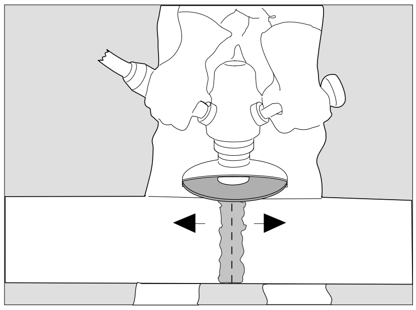
produce a bead with good penetration, and without pores. Grind the outside of the weld so that it is flush with the casing tubes. Weld the casing tubes according to the instructions that follow.



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General comments on welding
=A simple welding fixture helps to keep the new casing tube in perfect alignment with the rest of the casing string. This is essential for problem-free drilling.

The weldability of the casing material is usually good. If welding is carried out correctly, then hardening or embrittlement should not occur either in the weld itself or in the zones that are affected by heat. However, there is a risk of hot-crack formation in materials with comparatively high sulphur and phosphorous contents.

Welding must not be carried out when there is snow, frost or damp in close proximity to the joint that is to be welded. Before welding, substances such as oil, paint etc. should be removed from the welding surface and surrounding zone. If this is not done, there is a high risk of porosities in the weld. In order to avoid the risk of embrittlement and subsequent fracture, it is recommended that the temperature of the material to be welded should be above 0° C when welding begins.

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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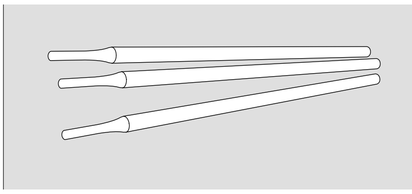


Electrodes

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

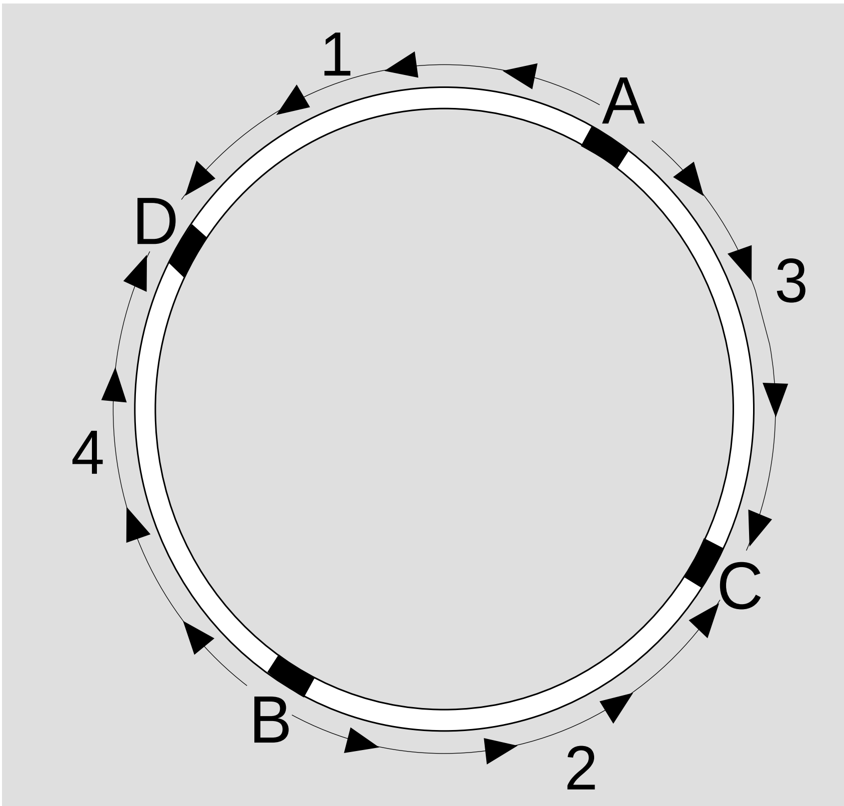
- ESAB OK 48.00
- Philips 35
- Oerlikon Supercord
- Arcos Ductilend 70

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.

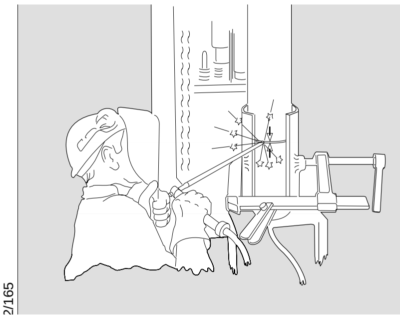
Welding procedure

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



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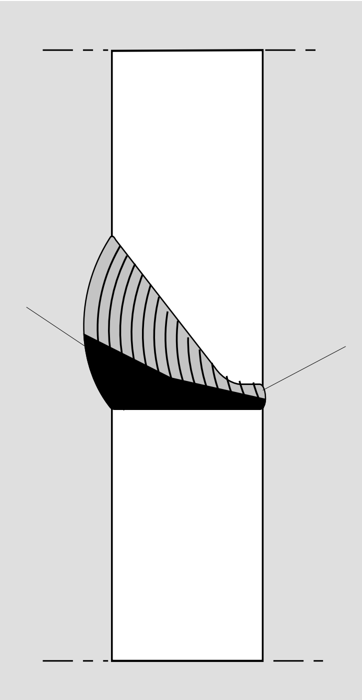
The depth of bead penetration should not exceed 0.5 mm beyond the internal diameter of the casing tube. The height of the weld on the outside of the casing tube should not exceed 2 mm, and should be ground down. Grinding on the casing tubes should be carried out in the longitudinal direction only.

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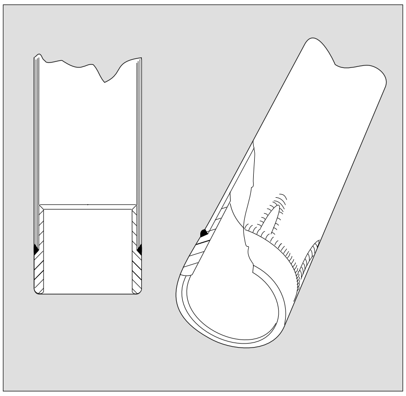
If the height of the weld is not ground down, problems could arise when drilling through boulders.

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.

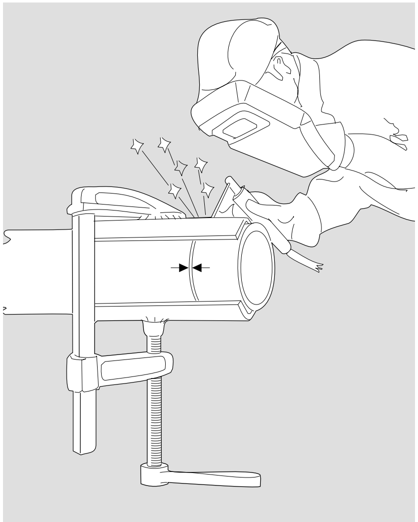
When deep holes are to be drilled with TUBEX XL, it is very important to use genuine Sandvik Coromant casing shoes. Sandvik casing shoes are made of steel with high fatigue strength and are especially hardened for this purpose. Poor quality material in a casing shoe will wear out before required hole 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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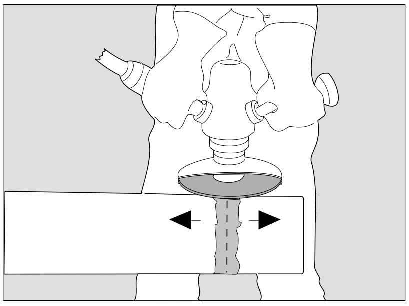
1 Heat up the casing shoe or bit tube to 150-200° C.
2 Fit the welding fixture and line up the two ends that are to be welded.
3 Use OK 78.16 welding electrodes or equivalent electrodes of another make.

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



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.

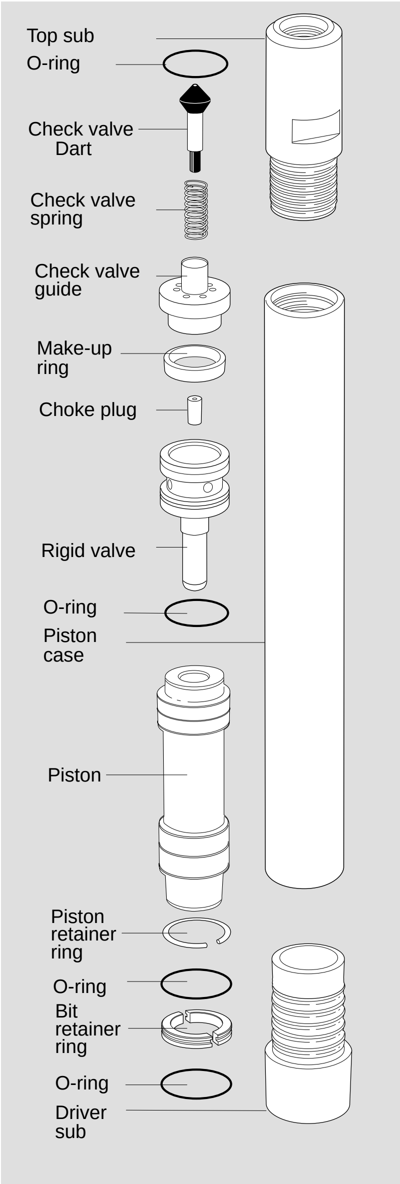
4 Correct welding of the casing tubes is very important, owing to tensile stress in the weld. Follow the instructions given.

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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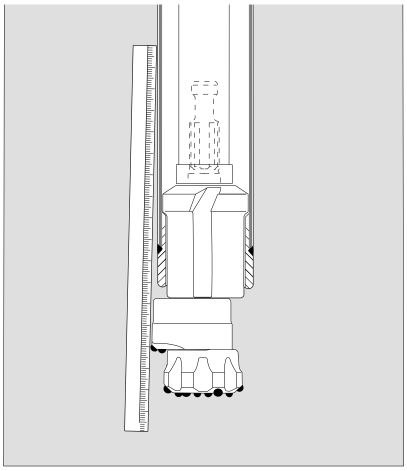

TUBEX XL 140 and larger dimensions are equipped with a through hardened pilot bit pin that is held in place by a self-locking spring pin. The main function of the pilot bit pin is to prevent the pilot bit from unscrewing when drilling in soft

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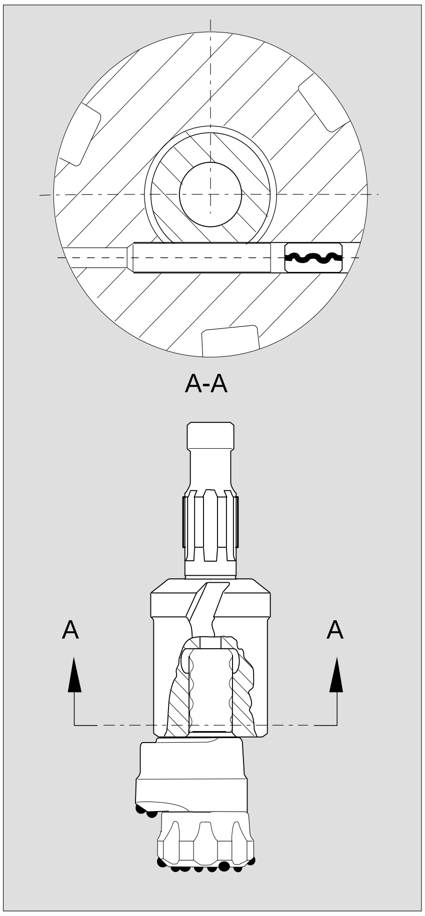
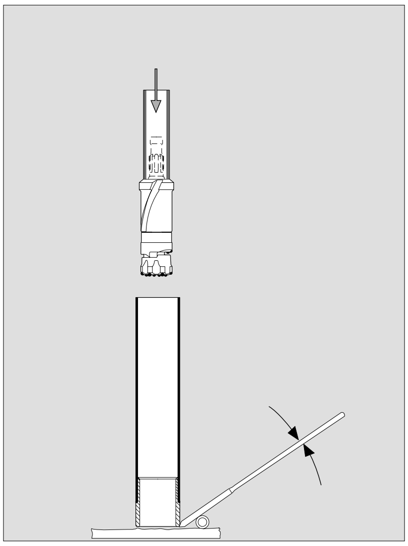


and cavitied formations, i.e. formations that do not give sufficient resistance to the blows from the hammer (idle blows). When closing the reamer, it is very important to reverse rotate only one revolution at a time, in order to avoid fracturing the pilot bit pin. Check that the pilot bit pin is undamaged before starting each new hole.

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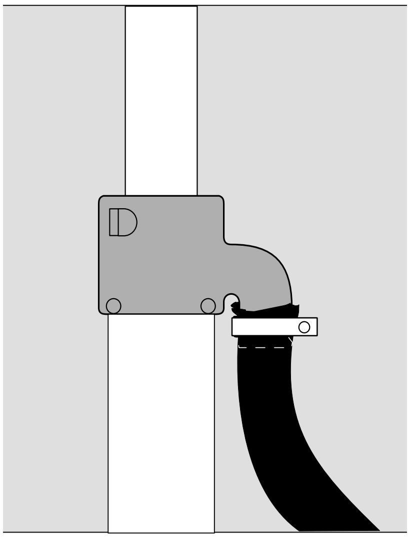
the percussion mechanism of the DTH hammer be used to get the TUBEX XL equipment through the casing shoe! At worst, this could result in the equipment jamming inside the casing shoe, which would then have to be cut open in order to remove the TUBEX XL equipment.

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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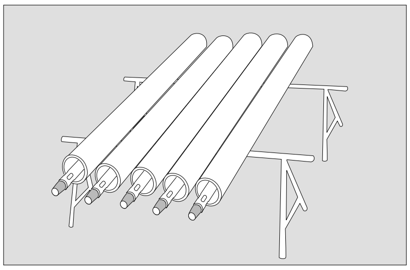
will not have to wash down any buildings etc!

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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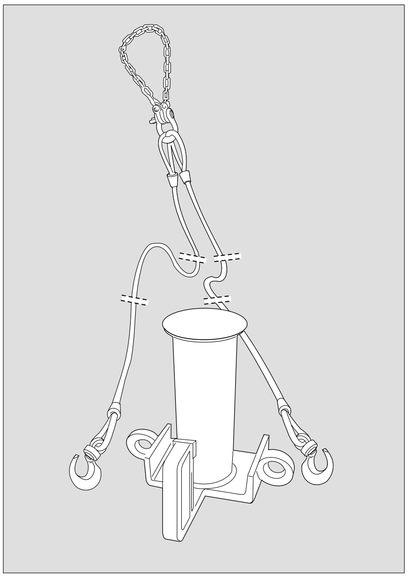
ultimately the internal components of the DTH hammer as well.

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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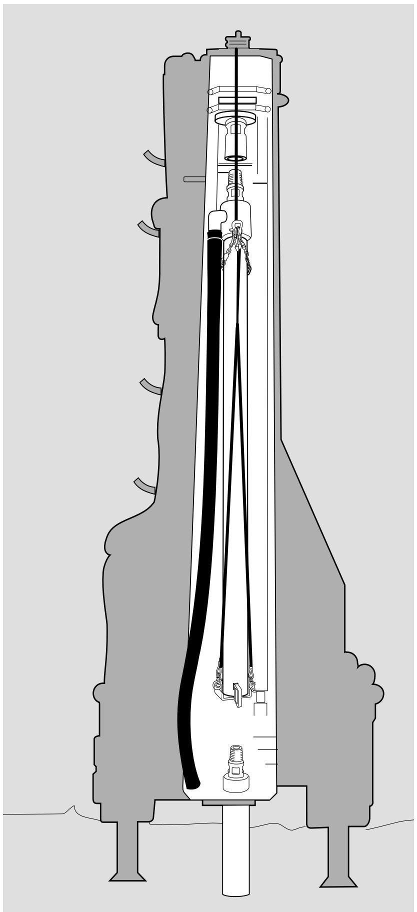
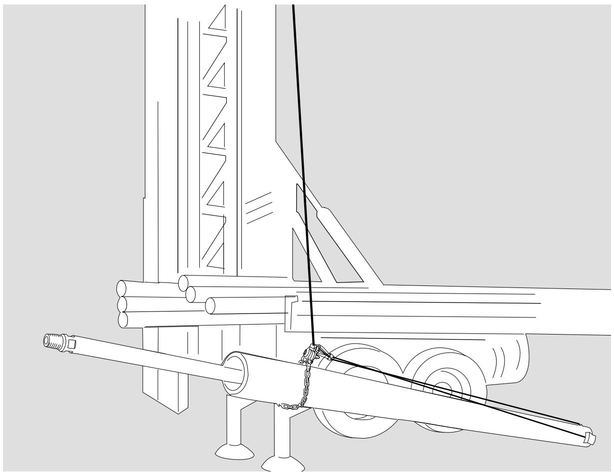


Lower the casing tube so that it rests on the edge of the drill steel support, and remove the lower



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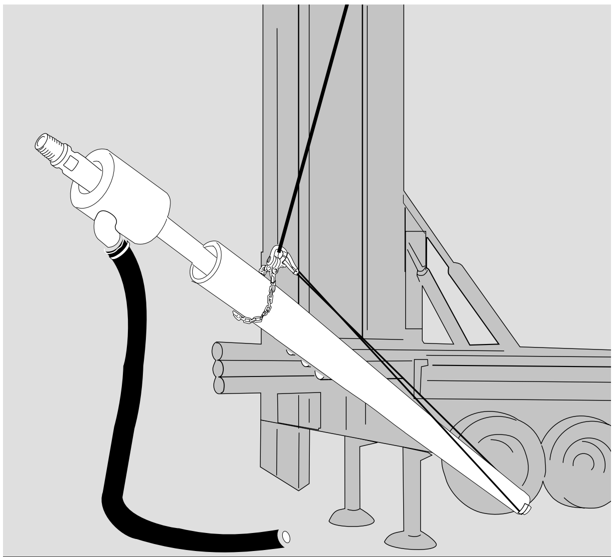
part of the lifting sling.

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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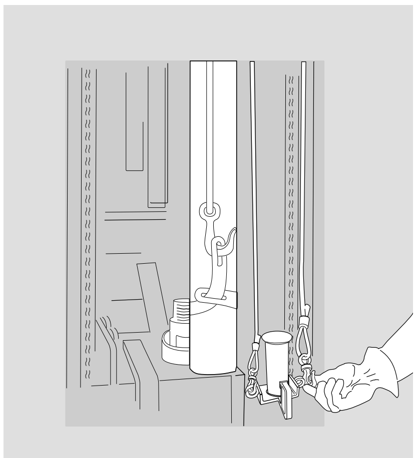

Fix the casing tubes end to end, with the aid of the welding fixture (page 14).

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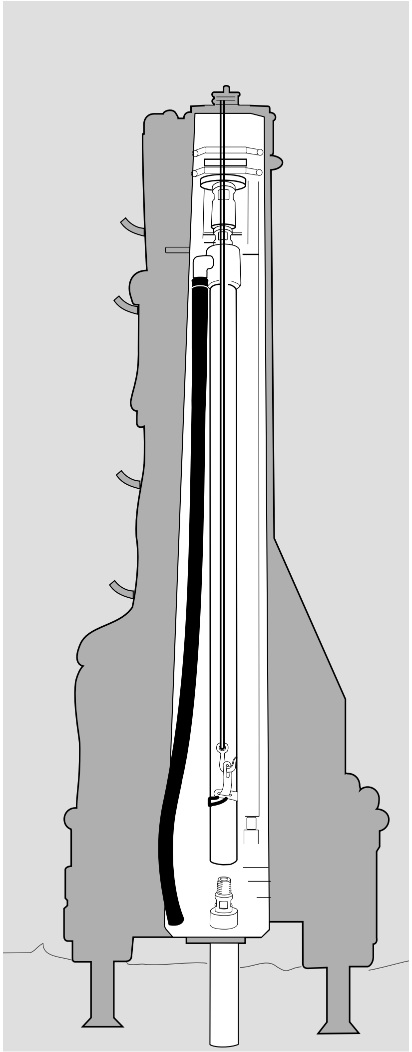

Setting up the drill rig

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.

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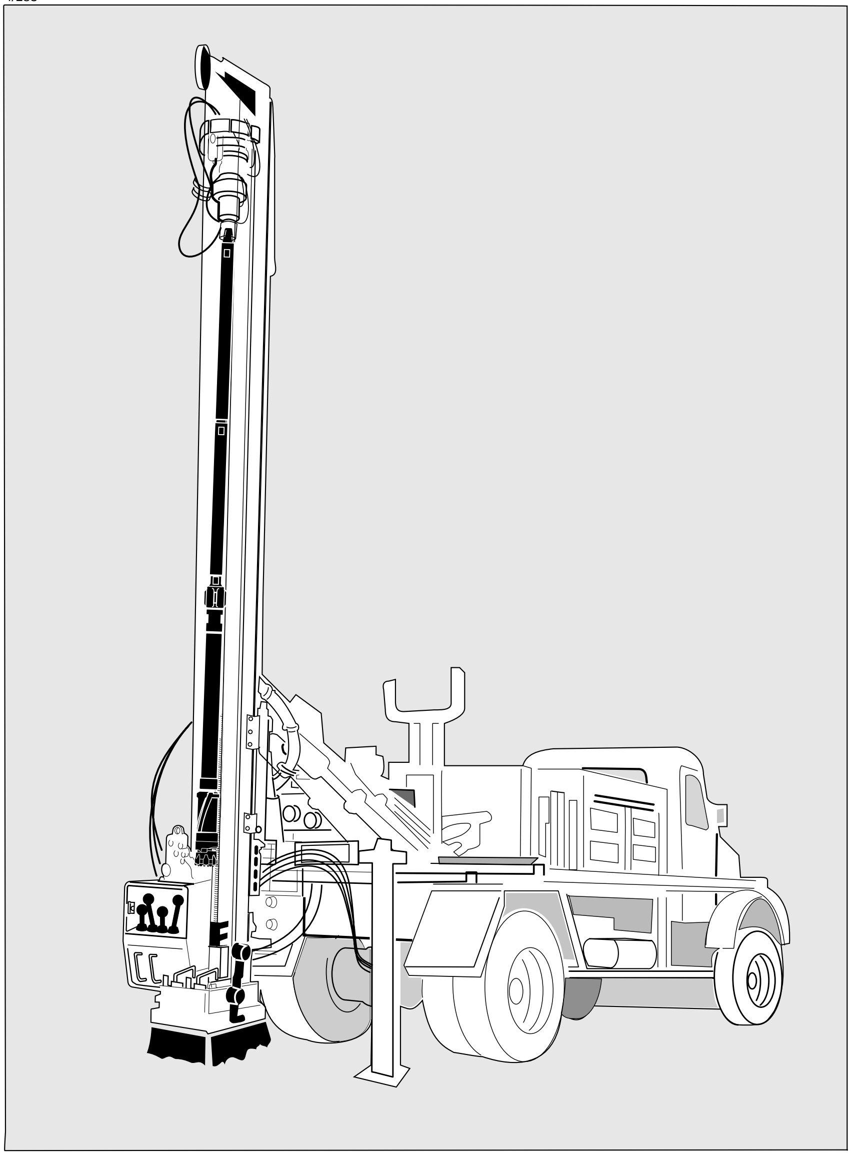

Drilling

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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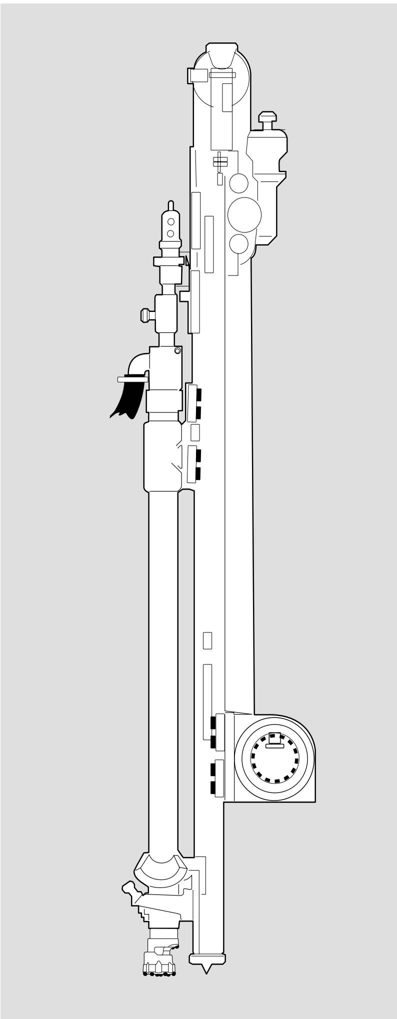

Before drilling is discontinued for any length of time, the hole should be flushed out thoroughly to remove any drill cuttings. If drilling is discontinued without flushing the hole properly, drill cuttings can drop to the bottom of the hole and jam the DTH hammer in the hole.

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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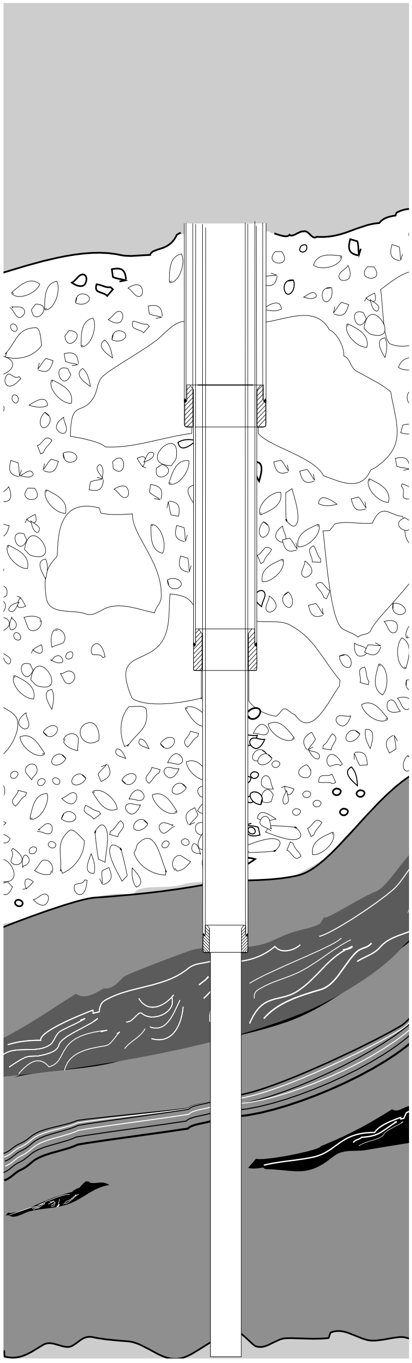
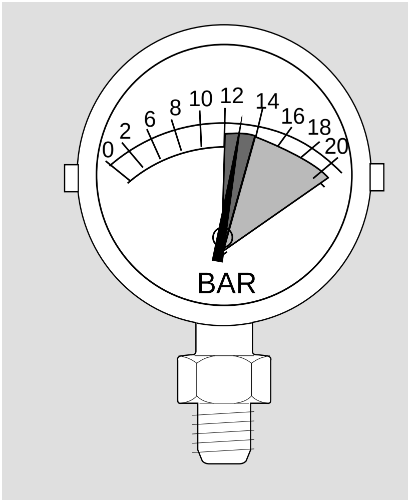


Recommended drilling data

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.

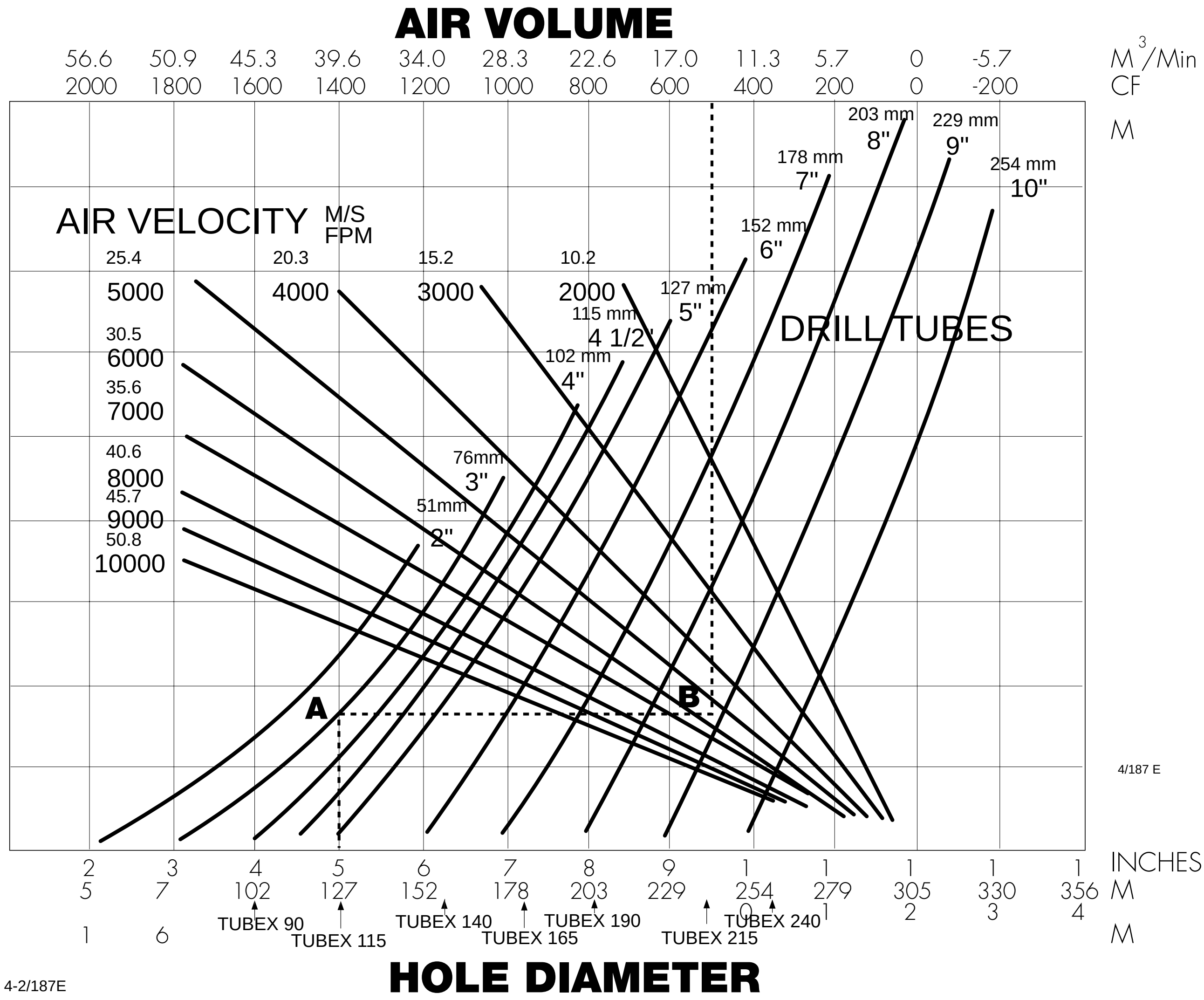
TUBEX XL	76	127	90	115	140	165	190	215	240	280	365
Rotation speed (RPM)	50-70	15-25	20-30	20-25	15-20	15-20	10-15	10-15	10-15	10-15	10-15

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.



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.

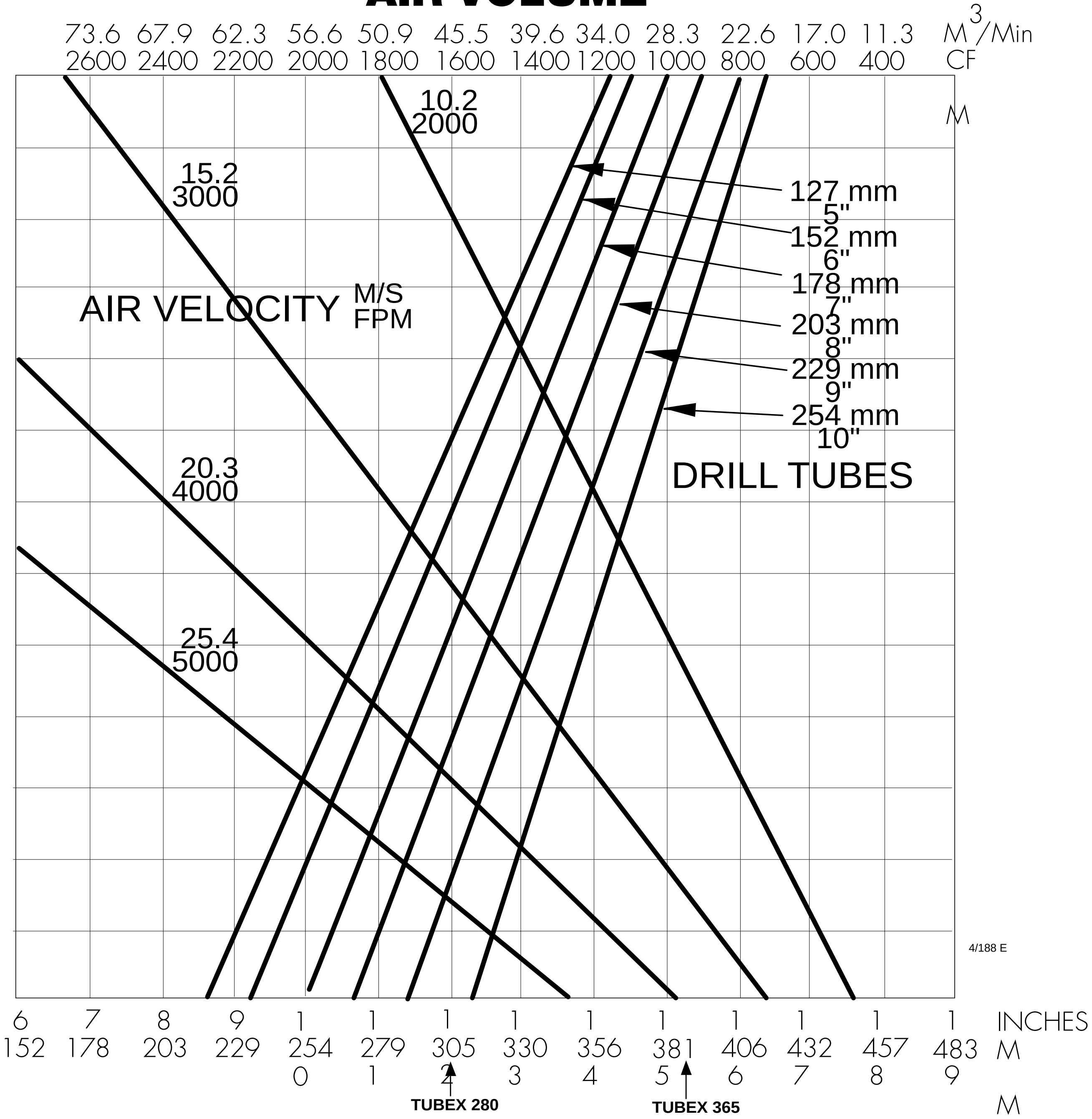
Example:

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



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)

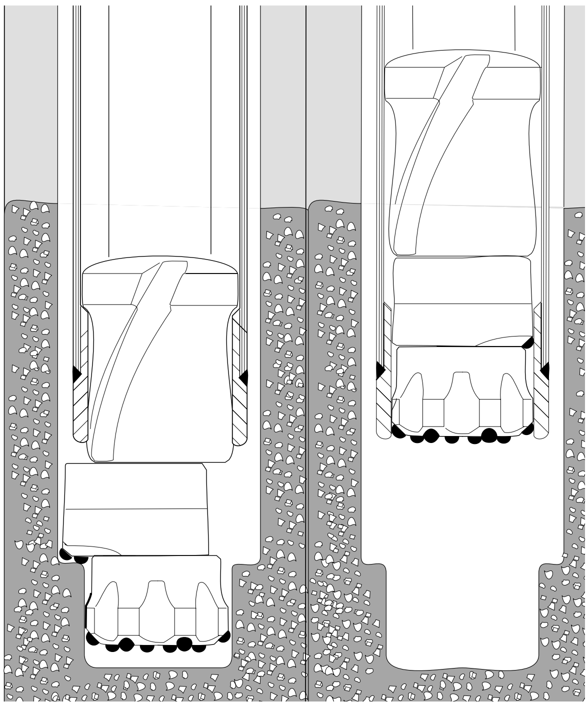
$$\text{Flushing velocity (m/s)} = \frac{F \times 1273}{D_H^2 - D_P^2}$$

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

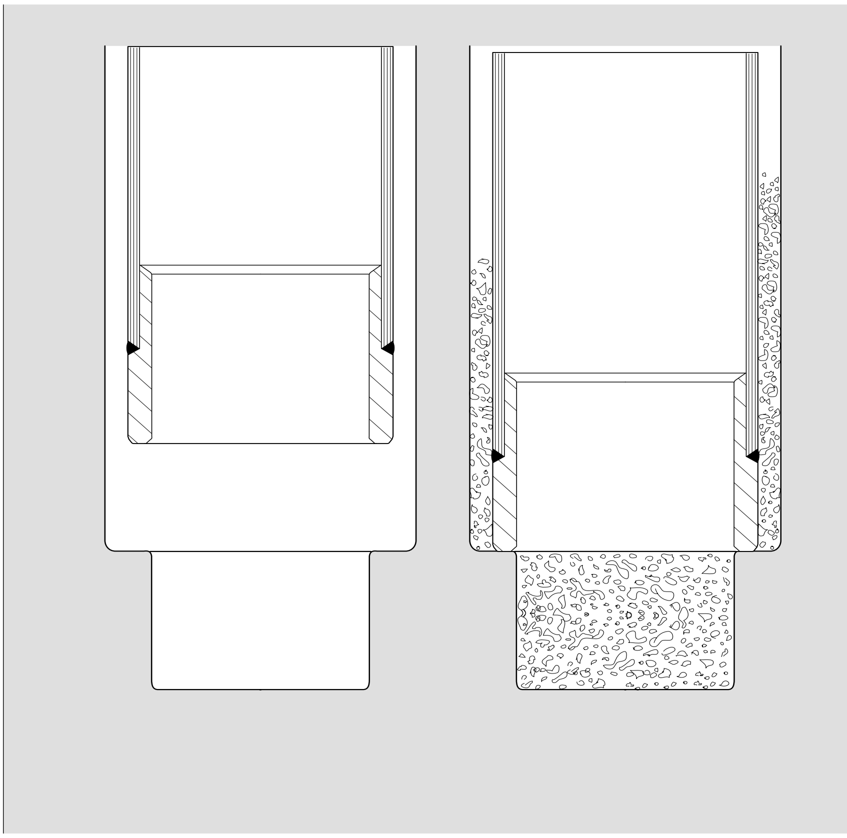
Once the casing tubes have been taken down to the desired depth, TUBEX XL drilling is stopped and the equipment is pulled up through the inside of the casing tubes.

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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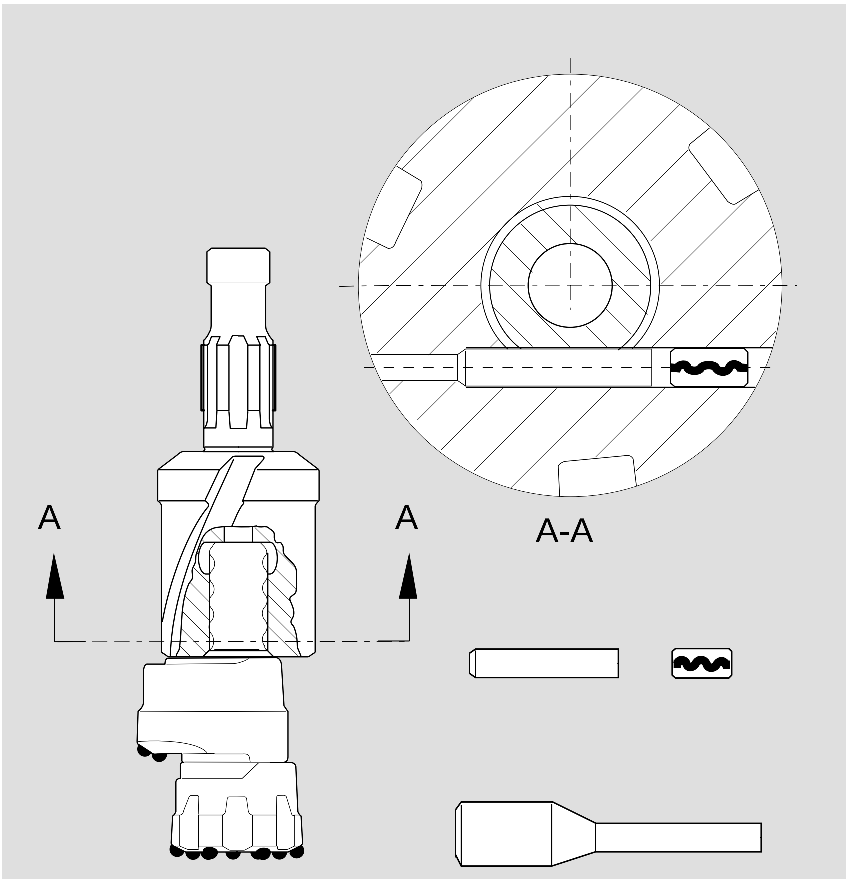

Start by pulling up the casing string by about 10 cm. Then (for TUBEX XL 115) pour about 10 litres of cement grout into the hole. To obtain an effective seal, the cement can be pressed up around the outside of the casing tubes, with the aid of a special tool.

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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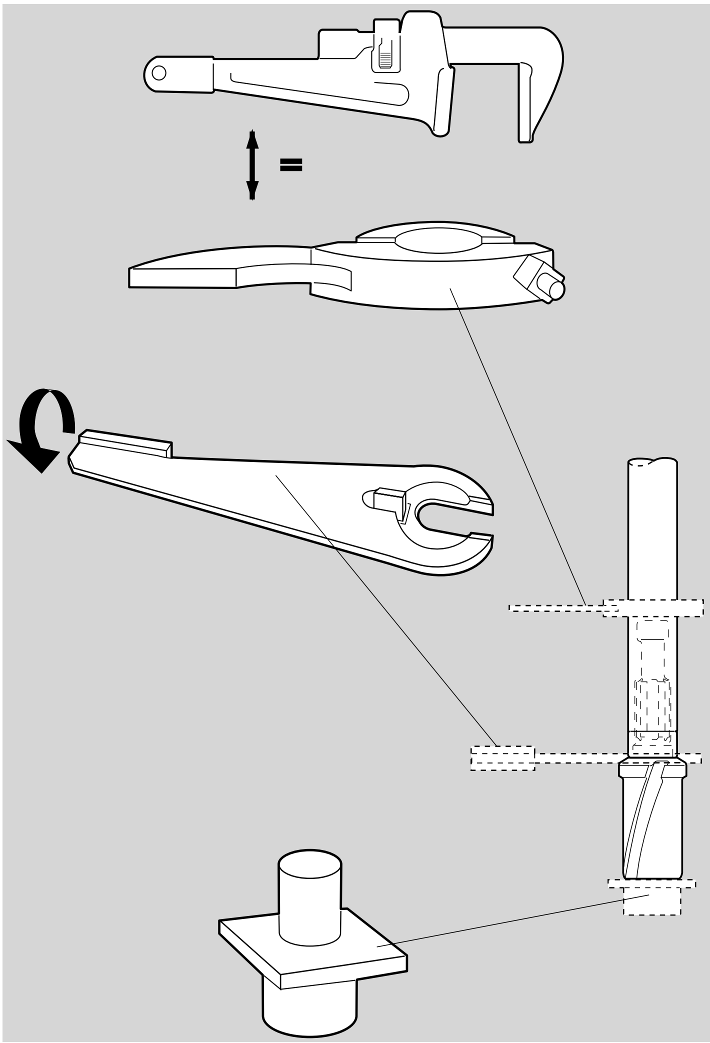

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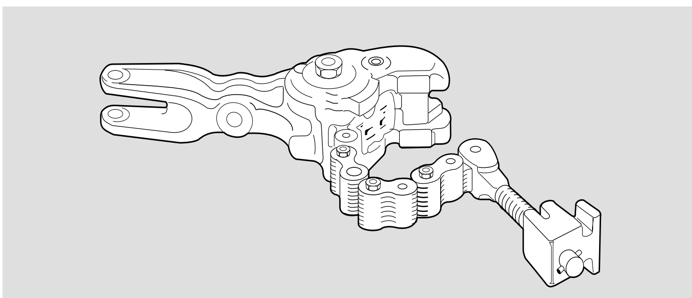


If the drill rig is intended for larger TUBEX XL equipment, it will probably be equipped with a hydraulic breakout table and an adjustable chain tongue. The equipment will make all breakout operations easier.

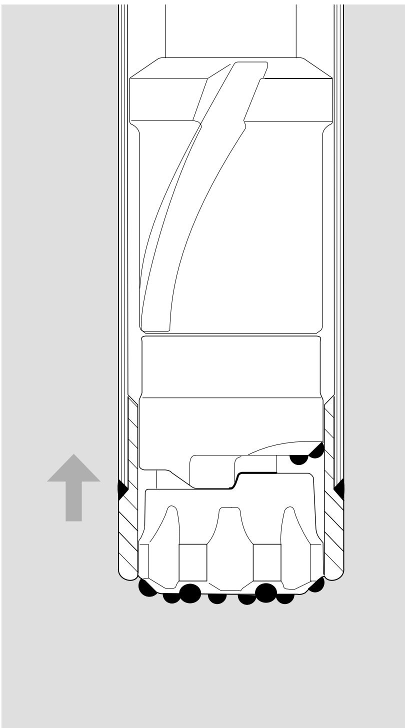
Continued drilling with TUBEX XL

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.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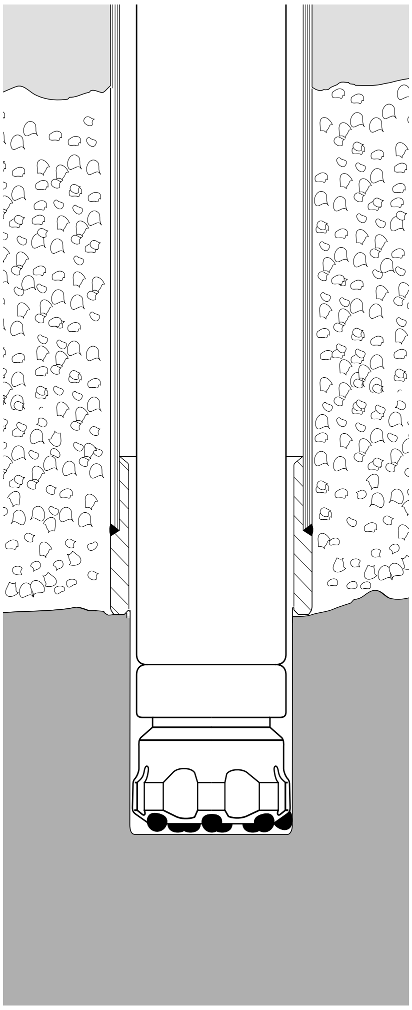

Continued drilling with regular DTH

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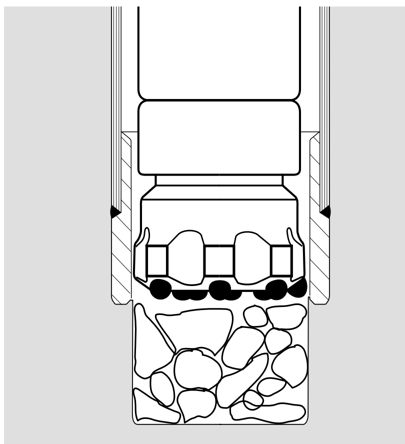

N.B. The guide sleeve used in TUBEX XL drilling must be removed from the top sub of the DTH hammer before normal drilling can continue. This is because its outside diameter is greater than the inside diameter of the casing shoe.

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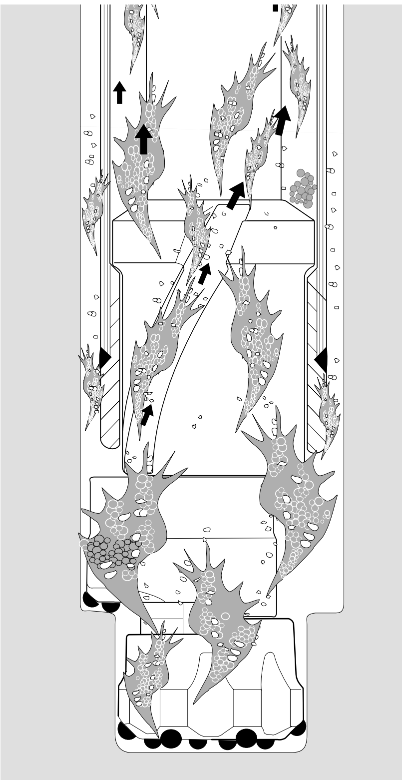


Foam flushing

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.

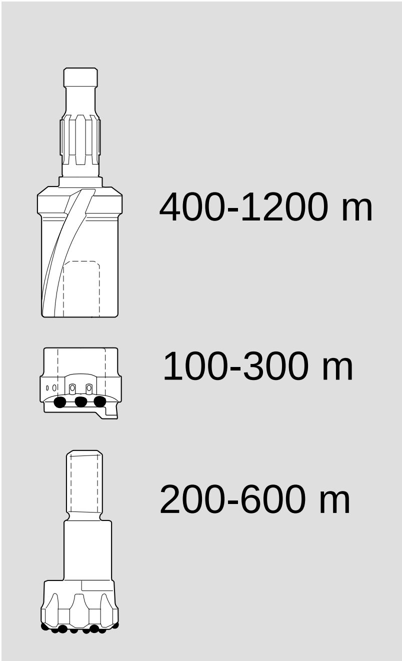
Tophammer drilling exceptions

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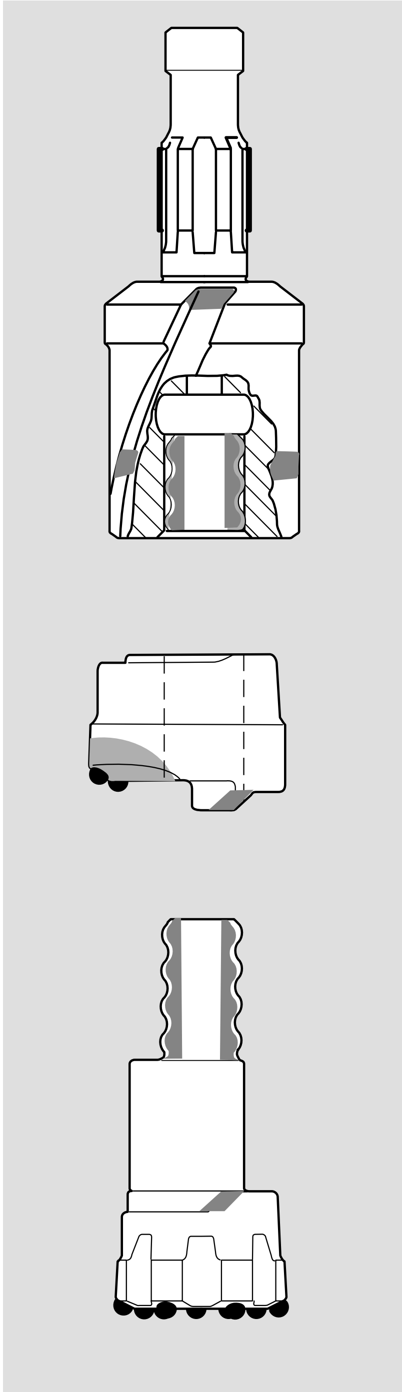
Different components in the TUBEX XL package have different service lives. A rough rule of thumb is that two reamers are used to one pilot bit, and two pilot bits are used to one guide device.

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.

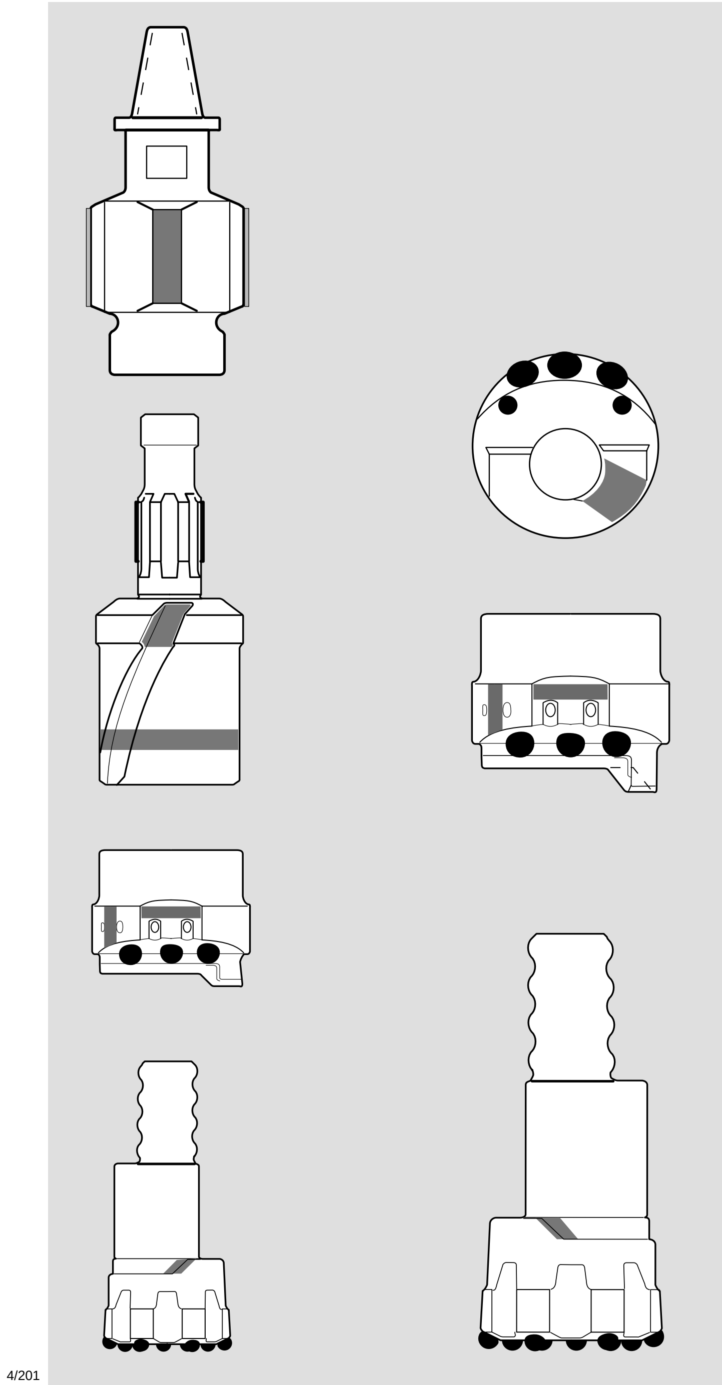
Reamer: Stop-lug, hardface when wear exceeds 3-4 mm.

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

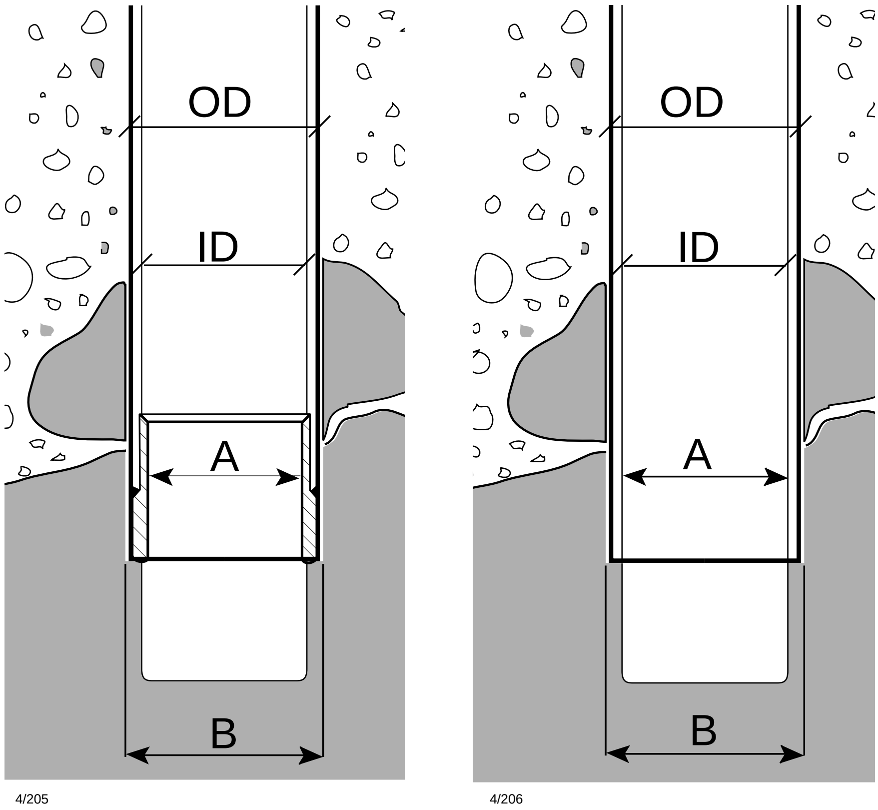
* Threaded casing tube also available
‡ Not standard

TUBEX XL PRODUCT RANGE

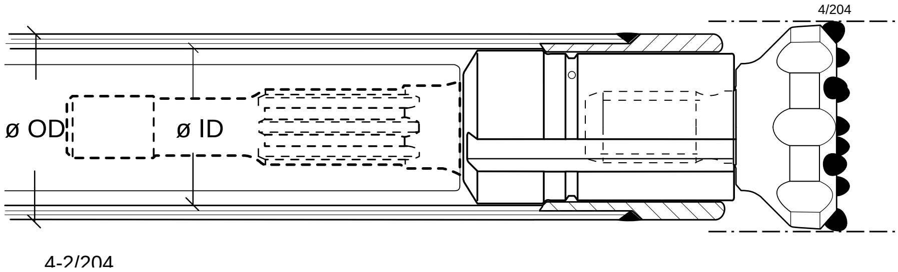
For Tophammers (no casing shoe)

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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