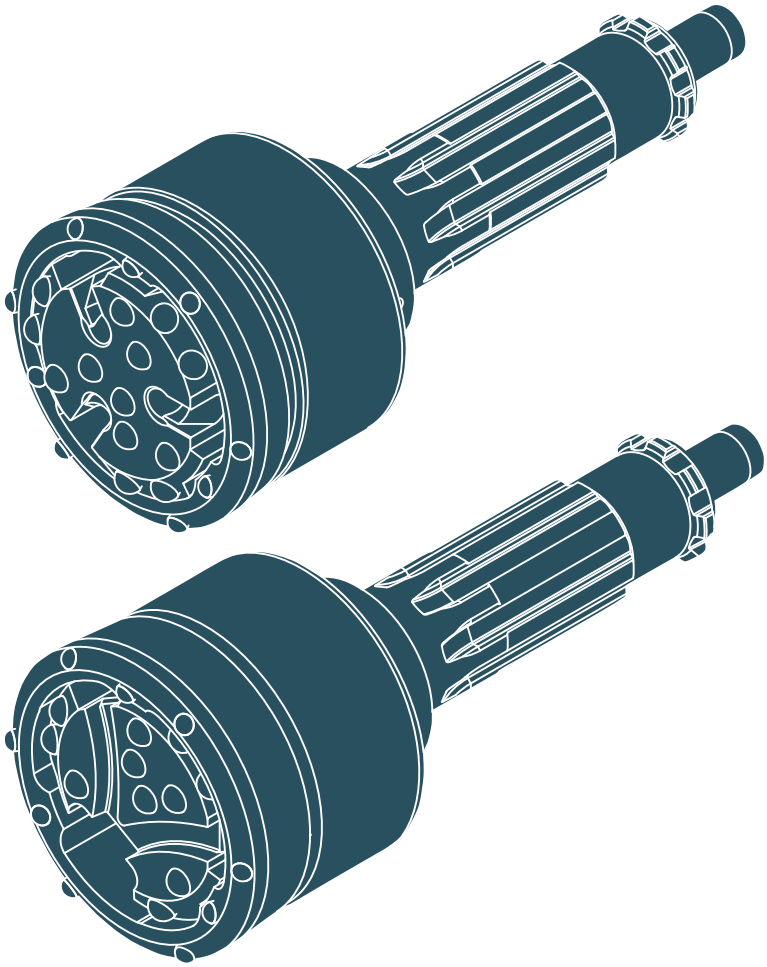
Symmetrix and Elemex casing advancement systems

Operator's instructions



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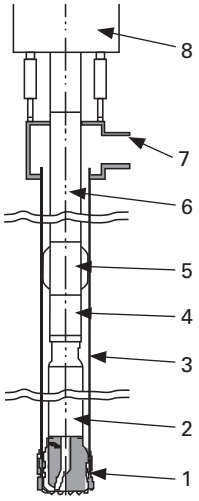
Introduction

Casing drilling parts

1. The casing advancement system principle is to drill a hole larger than the casing OD to advance casing simultaneously while drilling. These systems are comprised of pilot bit and ring bit set or pilot bit, ring bit and casing shoe. Pilot bit drills the center hole, and the ring bit reams the hole big enough for the casing. In normal drilling only the pilot bit is pulled out from the hole when the hole has been drilled. The impact from pilot bit is transferred to the casing shoe which then pulls the casing in to the hole. The feed force is submitted to the casing shoe straight from the pilot bit or through the ring bit.
2. The DTH hammer gives the percussive energy for the drill bit to crush the ground and rock.
3. The casing is needed to either keep the hole open, or in some piles, as a supporting structure.
4. The shock absorber prevents the impact of hammer from conducting through the drill rods to the rotary head; this is needed in systems which nominal sizes are above 12".
5. The centralizer keeps the drill rods in the center of the pipe i.e. keeps the hole from deviating.
6. Drill rods conduct the air to the hammer. They also transfer the feed force and rotation from the rotary head to the Pilot bit.
7. The diverter head is needed to channel the cuttings in a certain direction. It also supports the casing upper end. The support is necessary to prevent the hole from deviating.
8. The rotary head feeds and rotates the drill bit through the drill rods.



1. Casing advancement system – pilot bit + ring bit set or pilot bit + ring bit + casing shoe
2. DTH hammer
3. Casing pipe
4. Shock absorber
5. Centralizer
6. Drill rods (drill pipes)
7. Diverter head
8. Rotary head

* When drilling casing with Top hammer, the concept and the parts are same except there is no DTH hammer in the bottom of the hole, and the part number 2 and 8 are the Top hammer unit. There can also be some changes in the diverter head (part number 7) set-up. If you need more detailed advice either drilling with DTH or Top hammer, please contact your TerraRoc dealer.

Safety

General safety regulations

Read this manual completely before handling or operating your TerraRoc casing sdvancement systems: Symmetrix or Elemex.

The casing advancement system should be run, serviced and repaired by personnel properly trained for their task. These personnel must have sound knowledge about hazards in their respective profession.

General safety regulations must be observed. Personnel should be aware of dangers resulting from abuse of drugs and alcohols as well as effects of medicines legally prescribed, or mixture of any of them. The manufacturer is not liable for any damage caused by unauthorized alterations made to the unit.

Organizational measures

The casing advancement system shall be operated only by personnel who have undergone theoretical and practical training; particular emphasis shall be laid on safety precautions and maintenance.

- Keep this instruction book available on the rig at all times.
- Always use personal protective equipment, as required by circumstances or demanded by regulations.
- If, during operation of the unit, any abnormal action in the safety or operational systems is observed; the unit should be stopped and the problem be investigated and rectified.
- Damaged components should be replaced immediately.
- After repair make sure that the casing advancement system has been inspected and approved by the proper authorities before being brought back to normal operation.
- Never make alterations or modifications to components of the unit, particularly to the safety systems, which might result in hazardous consequences. Modifications done to the unit must be approved and accepted by TerraRoc in writing, in which, a revised operating procedure will be provided if applicable.
- Never make alterations or modifications to components of the unit, particularly to the safety systems, which might result in hazardous consequences. Modifications done to the unit must be approved and accepted by TerraRoc in writing, in which, a revised operating procedure will be provided if applicable.

This manual has been created to give information to the users to ensure the proper and safe use of these products. The aim is to also prevent misuse and accidents which may cause uneconomical use of the equipment or serious injury. However these instructions give only the basic information, and do not replace proper training of the operator who uses the system. There are also always special cases, which might need a closer look. In cases you don't find suitable answer from this manual please contact your local TerraRoc sales company or TerraRoc dealer representative.

TerraRoc reserves the right to make changes in products in order to improve their design or efficiency without notice. This document gives accurate information only in the time it is published. TerraRoc will update the document according the product changes and detected deficiencies. The owner of the equipment has right to copy this document only for internal use.

Operation & maintenance

In addition to this manual you should also have a good knowledge of generally recognized safety and accident prevention regulations. If you follow the regulations you stand a better chance of accomplishing your task without harm to either man or equipment.

- Prior to using any Overburden system for the first time, familiarize yourself with the tools features, its controls and their functions.
- Operators and helpers should wear helmets, (with ear protectors when called for), safety glasses, safety shoes, gloves and suitable clothing. Loose fitting clothing and jewellery can become caught in the moving parts of the machinery, causing serious injury or even death.
- Check the surroundings. During drilling and tramming no unauthorized person should be allowed near the rig.
- Use only authorized parts (TerraRoc parts). Any damage or malfunction caused by the use of unauthorized parts is not covered by warranty nor will TerraRoc be held responsible for any damage or injury.

Any warranty for work performed only covers TerraRoc products, TerraRoc components and work performed by authorized personnel.

Use only genuine TerraRoc parts.

Safety signs

In this manual you will come across the following warning signs.

DANGER

Indicates immediate hazards which WILL result in serious of fatal injury if the warning is not observed.

WARNING

Indicates hazards or hazardous procedures which COULD result in serious or fatal injury if the warning is not observed.

CAUTION

Indicates hazards or hazardous procedures which could result in injury or damage to equipment if the warning is not observed.

Product range

		Symmetrix	Elemex	Model
Permanent casing	Ring bit set	✓	✓	V
		✓	✓	W
		✓		T
	Separate Ring bit	✓	✓	SE
Permanent & retrievable casing	Ring bit set	✓	✓	C
Retrievable casing	Ring bit set	✓	✓	N

Preparation

Scope and limitations

The welding procedure described in this manual is based on a welding procedure qualification carried out according to SFS-EN ISO 15613. The welding procedure qualification is applicable for all the weld joint types used with casing pipe outer diameters of 70 millimeters and above. The parent material thickness and weld material thickness are both limited between 3 mm and 20 mm.

Materials

Filler rod material is selected according to the material of the casing since the casing generally has the higher strength of the two components. The rods available for welding the casing shoes to the casing pipe are ESAB OK 48.00 and ESAB OK 48.08. The rod thickness is 2,5 mm. The correct rod must be selected according to the following table.

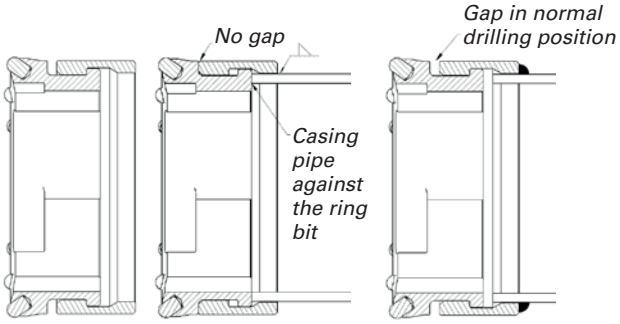
Casing material	Filler rod
S235	ESAB OK 48.00
S275	ESAB OK 48.00
S355	ESAB OK 48.00
S420	ESAB OK 48.00
S450	ESAB OK 48.08
S470	ESAB OK 48.08
S520	ESAB OK 48.08
S550	ESAB OK 48.08

If the casing material used is not shown in the table, the filler material must be selected as follows:

- If the upper limit of the casing material yield strength, when accounted for material thickness and tolerances doesn't exceed the value of 450 MPa ESAB OK 48.00 filler rod is to be used.
- If the upper limit of the casing material yield strength when accounted for material thickness and tolerances exceeds the value of 450 MPa but not the value of 550 MPa ESAB OK 48.08 filler rod is to be used.

Casing shoes welded over the casing

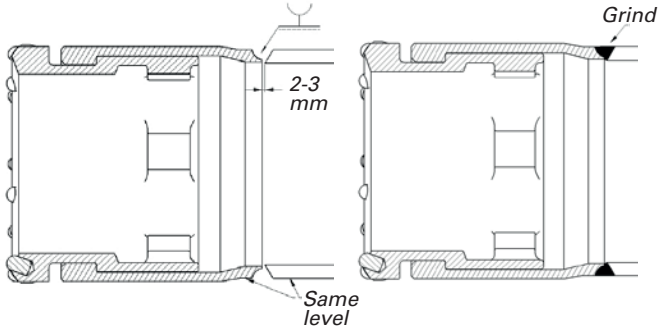
The instructions in this chapter apply for the casing shoes welded over the casing, which include models V, W, T and the permanent C-model. The welding method is shielded metal arc welding (111) and the filler rods must be selected according to the table in Section Materials. The joint type for these products is a multi-run fillet weld carried out in fixed welding position (PB). Prior to welding all the materials must be at the temperature of 15 °C or higher. The seams must be cleaned between passes and the seam ends must be grinded to avoid crack propagation.



1. Before starting, the latest WPS document must be carefully reviewed for correct welding current, travel speed and heat input. The variant of the WPS depends on the casing material.
2. All the welded surfaces are grinded clean prior to welding to ensure good adhesion.
3. The casing shoe is pushed towards the ring bit so that there is no gap between the shoe and the ring bit.
4. The ring bit set is placed over the casing pipe so that the casing pipe end sits firmly against the ring bit while the gap between the ring bit and casing shoe remains closed.
5. The casing shoe is welded on the casing with a full fillet weld going around the perimeter of the casing.

Casing shoes welded end-to-end with the casing

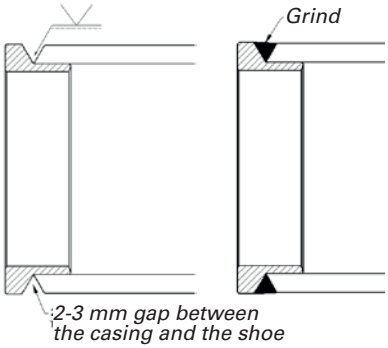
The instructions in this sectin apply for the casing shoes welded end-to-end the casing, which include models N and the retrievable C-model. The welding method is shielded metal arc welding (111) and the filler rods must be selected according to the table in Section Materials. The joint type for these products is a multi-run butt weld with no backing carried out by rotating the pipe (PA). Prior to welding all the materials must be at the temperature of 15 °C or higher. The seams must be cleaned between passes and the seam ends must be grinded to avoid crack propagation.



1. Before starting, the latest WPS document must be carefully reviewed for correct welding current, travel speed and heat input. The variant of the WPS depends on the casing material.
2. All the welded surfaces are grinded clean prior to welding to ensure good adhesion.
3. The casing shoe is tacked on to the casing pipe and a gap of 2-3 mm is left between the pipe and the shoe. Such gap can be achieved, for example, by placing the 2 mm rod core between the two components.
4. The casing shoe is welded on to the casing with a butt weld going around the perimeter of the casing. The whole gap between the shoe and the casing is filled unless stated otherwise.
5. The weld bead is grinded flush with the casing.

Casing shoes welded inside the casing

The instructions in this chapter apply for the casing shoes welded inside the casing, which include the shoes of SE-models and ODEX-models. The welding method is shielded metal arc welding (111) and the filler rods must be selected according to the table in Section Material. The joint type for these products is a multi-run butt weld carried out by rotating the pipe (PA). Prior to welding all the materials must be at the temperature of 15 °C or higher. The seams must be cleaned between passes and the seam ends must be grinded to avoid crack propagation.



1. Before starting, the latest WPS document must be carefully reviewed for correct welding current, travel speed and heat input. The variant of the WPS depends on the casing material.
2. All the welded surfaces are grinded clean prior to welding to ensure good adhesion.
3. The casing pipe is chamfered. Recommended chamfering angle is 30°
4. The casing shoe placed inside the casing and a 2-3 mm gap is left between the welding shoulder and the casing pipe end face.
5. The casing shoe is welded on to the casing with a butt weld going around the perimeter of the casing. The whole gap between the shoe and the casing is filled unless stated otherwise.
6. The weld bead is grinded flush with the casing.

Installing the pilot bit

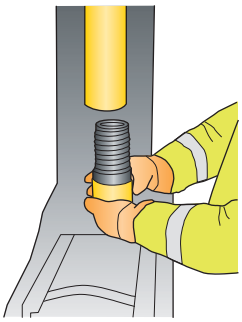
Before installing the pilot bit to the DTH hammer or Top hammer drill rods, the bit must be inspected for any defects. If the inspection of an already-used pilot bit is neglected, it might break in the hole, which may result in the loss of the hole. Inspection instructions can be found on page 12. When installing the pilot bit to the DTH hammer, the splines have to be lubricated by using a copper or zinc based compound (thread grease). See also instructions given in the hammer manufacturer's safety and operating instructions. When installing the pilot bit to the Top hammer drill rods, the principal is practically the same as when installing a rock bit.

⚠ CAUTION

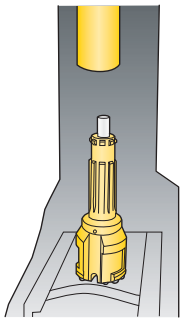
- In this document only the basic principals of how to install the Pilot bit are given. Always read the hammer manufacturers safety and operating instructions, and use them in detail. Use only tools and accessories intended for the purpose of assembling and disassembling the bit and hammer.

Basic bits

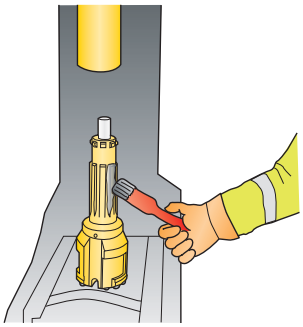
This section explains the basic sequence of how to install a normal pilot bit into the DTH hammer; when removing the bit from the hammer, the sequence is the opposite. Normal pilot bits are bits which do not require drive pins etc. when installing it to the hammer. Most of the bits are like this excluding a few of the biggest sizes (for example QL200). In the following figures, the installation sequence is shown.



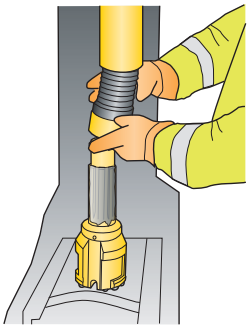
1. Remove the chuck from the hammer.



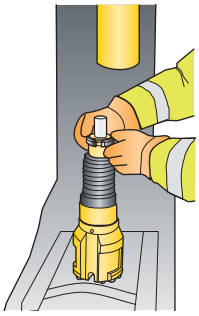
2. Align pilot bit under hammer. This step can also be done after the chuck and retainer rings have been installed into the bit. This may be beneficial especially in larger sizes.



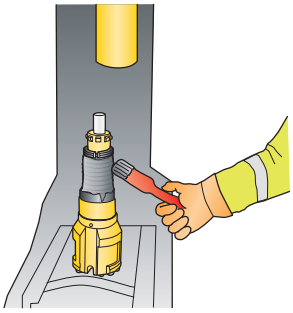
3. Grease the entire pilot bit shank including splines, retainer ring groove and foot valve. Lack of grease in the shank area may cause rapid wear and brake of the pilot bit.



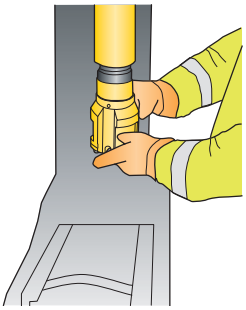
4. Install the chuck into the Pilot bit shank.



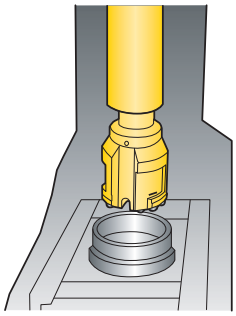
5. Install the retainer ring into the pilot bit shank. Make sure the retainer ring is properly in its place, and the rubber ring is intact.



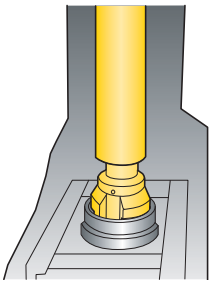
6. Grease the chuck. If the thread of the chuck is not greased properly, the chuck may not open without excessive force, which may break the hammer.



7. Screw the chuck, pilot bit and retainer ring into the hammer. Make sure the foot valve is not damaged during this step.



8. Set the bit basket into its place under the pilot bit.

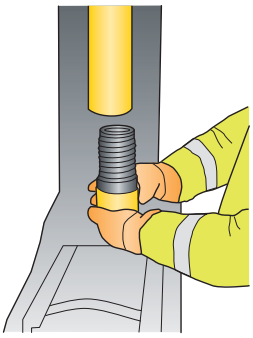


9. Lay the pilot bit into the bit basket. Make sure to use a suitable bit basket, and that the pilot bit is properly in its place.

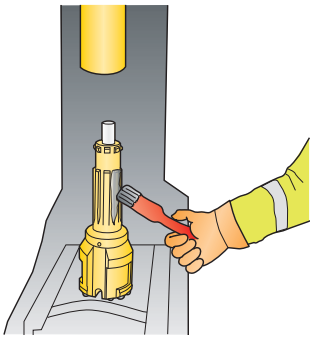
10. Tighten the chuck into the hammer. Consult the hammer manufacturer's safety and operating instructions, to find out the proper tightening torque. If there is not a bit basket, use some other method to make sure the chuck is properly tightened.

Pilot bits with drive pins

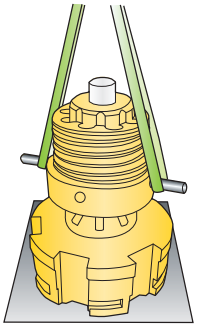
In this section, the installation of how to install a pilot bit with drive pins into the DTH hammer is explained; when removing the bit from the hammer, the sequence is the opposite. In the following figures, the installation sequence is shown.



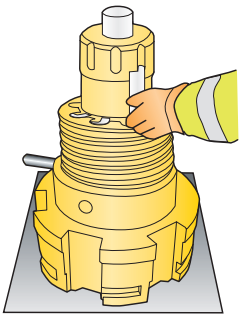
1. Remove the chuck from the hammer.



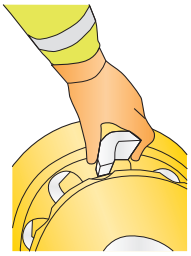
2. Ensure the pilot bit splines are greased. Lack of grease in splines and shank, may cause the chuck and the pilot bit to break.



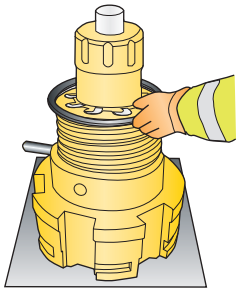
3. Install the chuck into the pilot bit shank. Always use lifting accessories.



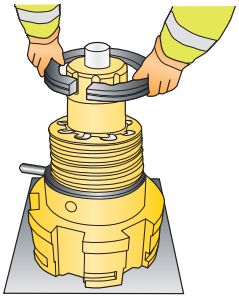
4. Install the drive pins; be sure that the drive pins are installed correctly. They should be at the side which takes the force from the rotation.



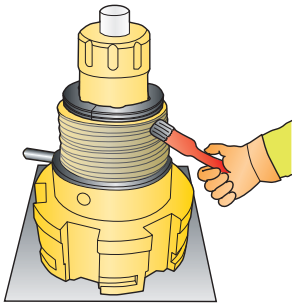
NOTE: Normally you can find small text "TOP" milled in to the upper side of the pin. If the pins are installed incorrectly, the pilot bit and the shank will wear rapidly and may break.



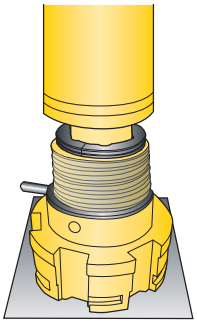
5. Install the washer. Remember to use the right size washer. Check the size from the hammer manufacturers operating instructions.



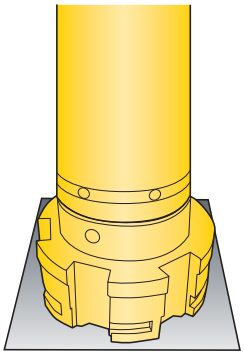
6. Install the retainer ring into the pilot bit shank. Make sure the retainer ring is properly in its place, and the rubber ring is intact.



7. Grease the chuck thoroughly. If the thread of the chuck is not greased properly, the chuck may not open without excessive force, which may break the hammer.



8. Align the DTH hammer above the pilot bit.



9. Screw the hammer into the chuck with the pilot bit and retainer.

10. Tighten the chuck in to the hammer.

DANGER

Risk of serious injury, keep all cloths and body parts away from the moving machine parts.

WARNING

- Do not lay fingers under the chuck.

CAUTION

- Consult the hammer manufacturer's safety and operating instructions, to find out the proper tightening torque. A special breakout bench can also be used to do these steps.

Connecting pilot bit to ring bit or ring bit set

Symmetrix and Elemex systems use a bayonet-type locking. This locking type locks and unlocks by rotating the pilot bit in relation to the ring bit. Rotate the pilot bit in the normal drilling direction to lock the pilot bit into the ring bit. With DTH this is clockwise, and with the Top hammer this is counter clockwise. Rotating in the opposite direction will unlock the pilot which can then be pulled out from the hole.

WARNING

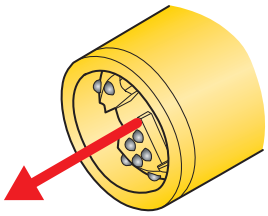
- If you touch the ring bit or ring bit set by hand, do not use machine power to rotate the pilot bit. Risk of serious injury.

With the separate ring bit, the locking can be checked from between the ring bit and casing shoe. From there, the ring bit bayonet can be seen in the pilot bits bayonet groove. The casing must be supported against the casing shoe pulling shoulder to keep the gap open.

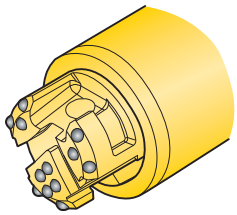
When locking the pilot bit to the ring bit, do so in a position so that the face of the ring bit set is visible; use the following sequence:

1. Lower the pilot bit near the ring bit locking shoulders (impact shoulders).
2. When the pilot bit reaches the ring bit, rotate it slowly until the pilot bits flushing grooves are in line with the ring bits locking shoulders.
3. Lower the pilot bit into its proper position in the ring bit (ring bits locking shoulders align with pilot bits flushing grooves). Be sure it is in correct place.
4. Rotate the pilot bit in the drilling direction to lock it in its place in the ring bit. It can be seen from the pilot bits flushing grooves: they have to be completely open. The locking can be tested by pulling the pilot bit upwards (backwards), if it moves without the ring bit (and the casing), the locking has failed. Keep the casing supported by, for example, a wire to prevent it from falling during the ring bit installation.

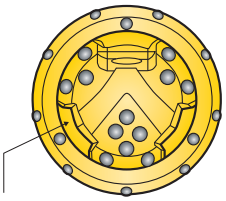
Use the following sequence to secure the pilot bit to the ring bit (model SE)



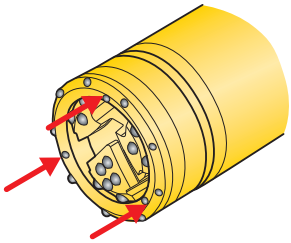
Lower the pilot bit to the casing pipe, against the casing shoe (pre welded to the opposite end of the casing).



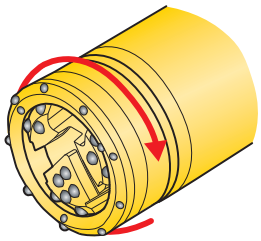
Align the separate ring bits locking shoulders (impact shoulders) to the same line as the pilot bits flushing grooves.

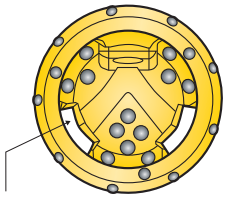


Locking is open, ring bits locking bayonet is in the pilot bits plushing groove.



Push the ring bit into its place in the pilot bit. Also swap the picture position. So change the left picture to right and vice versa.





Locking is on, Ring bits locking bayonet is in the Pilot bits bayonet groove, and the flushing groove is completely open.

Rotate the ring bit in relation to the pilot against the drilling direction so that it lock into its place in the pilot bit. Make sure they have locked properly.

WARNING

- Do not use machine power to rotate the pilot bit when connecting the ring bit by hand.
- Keep the casing supported by, for example, a wire to prevent it from falling during the Ring bit installation and locking check.

WARNING

- Do not touch moving parts! Risk of serious injury. In smaller sizes it is also possible to rotate the Ring bit by hand. Do not use machine power in this case.

Use the following sequence to secure the pilot bit to the ring bit set (model V, W, T, N & C)

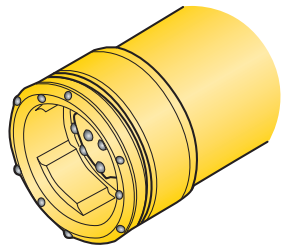
1. Lower the pilot bit against the ring bit. This must be done smoothly. Especially the last few cm, the pilot bit should be moved very slowly and carefully.
2. When the pilot bit reaches the ring bit, start to rotate it slowly in the drilling direction.

WARNING

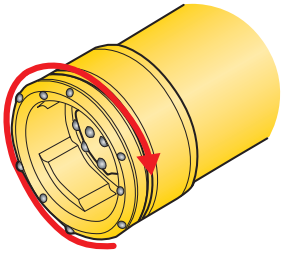
- Do not use high feeding force or torque. If the pilot bit won't turn, do not try to turn it by using excessive force. This may break the outer gauge buttons, and destroy the pilot. If the pilot won't turn, pull it slightly upwards, turn it a few degrees in the drilling direction and then start from the beginning.

3. When the pilot bits flushing grooves are in line with the ring bits locking shoulders (impact shoulders), the pilot bit will start to go forward again. Let the pilot bit go smoothly as far it will go (excluding Drill Thru-models), and continue rotating the pilot bit to the drilling direction. If the rotation of the pilot bit stops or when it has turned 120 degrees, try to pull it up. If the pilot bit starts to come up without the casing, the locking has failed. Start the sequence from the beginning.

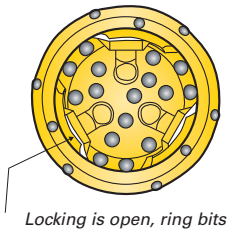
   If the pilot bit won't come up without the casing, it has locked in to its place. Keep the casing supported by, for example, a wire to prevent it from falling during the ring bit installation. After installing the ring bit (and casing) in to the pilot bit (and in to the drill rig), keep the casing supported firmly (with for example with wire etc.) to prevent it from falling! This support is removed only when the drilling starts. Also check the locking between pilot bit and the ping bit before drilling! The locking might get loose if the drill rig is moved after the casing has been installed.



Pilot bit near the ping bit set.

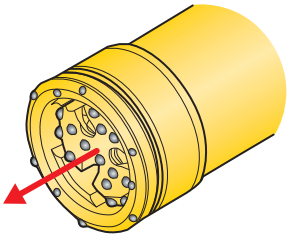


Rotate the ping bit set (or pilot).

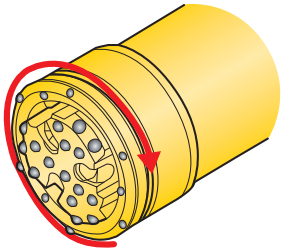


Locking is open, ring bits locking. Bayonet is in the pilot bits flushing groove.

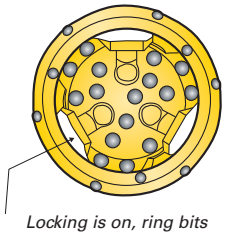
Pilot bit in right position.



Lower the pilot bit.



Rotate the ring bit set (or pilot).



Locking is on, ring bits locking. Bayonet is in the pilot bits bayonet groove, and the flushing groove is completely open.

Pilot bit in right position.

DANGER

- Risk of serious injury, keep all cloths and body parts away from the moving machine parts.

Operation

When operating the bit, always use the needed safety equipment. Minimum personal safety equipment, which is needed when using these systems are: safety helmet, hearing protection, safety shoes, protective breathing mask (when not using water to bind the dust), eye protectors and safety gloves. Also, abide by all the national and worksite safety regulations.

Drilling parameters

Feed force

Feed force varies according to the situation. Feed force depends for example from the drill bit type, ground condition, the drilling phase, depth of the hole. However, there is a general rule of the thumb which can be used to approximate the needed feed force.

The rule of thumb is: **Feed force (kg) = 10kg per Ring bit OD (mm)**

This feed force is used when drilling in basic conditions in normal situation. If you need the feed force in Newton's, multiply the value by 10. From this value, the adjustment can be started when trying to find the best feed force in the current conditions.

Exceptions

- The feed force has to be reduced when the drilling is started. After approximately 0.5 m has been drilled, the max feed force can be applied (if all other conditions allow it).
- The feed force has to be reduced in the collaring phase. In collaring the feed force is reduced to prevent the hole from deviating, and to prevent the bit from getting stuck. The force must be reduced from approximately 2/3 to 1/3; depending on the situation.
- The feed force has to be reduced when passing through a boulder or rock. When passing through, the bit may be badly stuck, if the driller is not reducing air and feed (in this order) immediately. There also might be loose ground or even an air pocket below the boulder. If the air and feed is not reduced in this situation, the hammer will blank fire. This might cause the bit and even the hammer to break down. For this reason the driller has to be alert the entire extent of the drilling cycle; especially when the ground includes lots of boulders.
- The feed force must be reduced in deep holes. In very deep holes, the weight of the drill rods increase to a level which will need to be considered; this weight must be reduced from the feed force. Calculate the weight of the drill rods, and when their weight goes over 1/5 of the feed force, the reduction has to

be started. When the weight of the rods exceeds the needed feed force, the drill has to be turned to “Hold back mode” to reduce the feed force on the drill bit.

Rotation

Rotation speed depends on the bit size and hammer impact frequency. The aim is that the outer gauge buttons (carbides) break “fresh” ground formation for every impact of the hammer piston. When the rotation is too slow, the buttons crush previously, already broken ground formation. This will cause low penetration rate and excessive wear of buttons and drill bit body. When the rotation is too fast, outer gauge buttons will wear fast or breaks. There is a general rule of the thumb which can be used to approximate the needed rotation speed.

The rule of thumb is:

$$\textbf{Rotation speed (rpm)} = \frac{7600}{\textbf{bit size (mm)}}$$

From this value, the adjustment can be started. This can be done by monitoring the size of the cuttings coming out from the diverter head and from the penetration rate. Between holes, it can also be monitored from the wear of the drill bit buttons.

Adjustment rules and exceptions

- The harder the rock is, the slower the rotation speed can be.
- If the buttons wear more from the leading edge, the rotation speed is too fast. The wear flat should always be at the top of the button.
- The rotation should be off when the drilling of a new hole is started on the grounds surface. This will confirm that the hole will begin in a straight formation. The rotation can slowly begin after a few cm to 0.5m, depending how loose the ground is.

Air volume

The flushing is characterized with a term called “up hole velocity” or “bailing velocity”.

These terms means the theoretical upward velocity of the air in the casing pipe. This velocity should always be over 15m/s, but it is recommended that it would not exceed 35m/s. The bigger the annulus between drill rods and the casing inner wall, the slower the up hole velocity is. The calculation can be started by checking how much air the hammer needs. After this, the up hole velocity is calculated. If it is not sufficient enough, bigger drill rods should be used.

In some hammers, there is bypass valves which enables to get more flushing air in to the casing without feeding more air in to the hammer. These can also be used to increase the up hole velocity. If the hole is deep (over 25 m) and especially in larger sizes, the up hole velocity should be over 19 m/s. To get proper impact, but not too high for the overburden drilling, the air pressure should be between 14-15 bar! In shallow holes higher pressure might cause the drill bit breakage. In deep holes a slightly higher pressure has to be used to compensate the back pressure which builds up in the airline, hoses, drill rods and in the casing.

The higher pressure is needed when the cuttings won’t come easily up to the surface. Normally this is not needed before depth of 50 to 100m.

Up hole velocity can be calculated from the formula below:

$$V = \frac{Q}{A} = \frac{Q / 60}{\pi (iD/2)2 - \pi d / 22}$$

where:

V = up hole velocity m/s
Q = cubic meters per minute
A = square meters
iD = casing inner diameter (m)
d = drill rod outer diameter (m)

Exceptions

- The air should be reduced when the drilling is started to avoid hole deviation. High pressure live air in the surface of the ground also causes a severe risk of flying particles and rocks which may cause serious injury!
- The air should be reduced when collaring to avoid hole deviation. Depending on the situation, it can be reduced to approximately 2/3 or even less.
- The air should be reduced when passing through a boulder or rock to prevent blank fire of the hammer. Blank fire could cause the bit and the hammer to brake up.

Summary of the drilling parameters

Feeding force
Rotation speed
Air Volume

Starting drilling

Normal (10 kg per ring bit outer diameter in mm)
Rotation 0
Air 60%

Drilling in overburden

Normal
Normal
70–90%

When encountering boulders

70%
Normal
60%

When drilling in rock

Normal
Normal
Normal

Drilling work

The drilling depends strongly from the ground conditions. The driller should always be alert, and adjust the drilling parameters according to the current situation and conditions. Below are a few basic rules for the drilling work.

- DTH drills in clockwise and Top hammer drills counter clockwise.
- Before starting the drilling, it must be checked that the casing is in to the correct direction and in correct place. For this, use bubble tube (builders level) or other high precision device to level the casing to exact direction. When starting the drilling of hole in to the ground, it should be done without rotation or with a minimum of rotation and with reduced amount of air. The air and rotation can be increased after few cm to 0,5m depending

the bit size and ground conditions. This is for to prevent the hole to start deviating.

- The normal drilling should be done with constant rotation, air and feed force, if there is no reason to make changes. The driller should however be alert, and monitor the rotation, penetration rate and cuttings during the drilling, and make changes to the drilling parameters when needed.
- If the drill bit gets stuck and the rotation stops, pull the bit upwards so, that its starts rotating again. Then start the feeding again with small feed force and reduced air. The feed force and air can be returned to normal when the drill bit has penetrated the difficult area.
- When encountering a boulder lower the air and feed force. The air should be approx from 50% to 80% of the normal air, and the feed force approx from 50% to 70% of the normal feed force.
- When breaking through a boulder, the air and feed force (in this order) should be lowered immediately to prevent blank fire and breakage of the bit and hammer. The air and feed force can be increased when the bit is through, and against solid ground again.
- If the cuttings won't come up easily, add more air, and stop drilling to flush the hole for time needed to remove the cuttings from the hole.
- If the cuttings are sticky and start to build up in to the inner walls of the casing or on the drill rods, try to add some water to the hammer air. If still no result, try drilling additives like foam.
- If there is no particular reason, do not stop the rotation, feed or air.
- If the penetration rate is very poor, or the penetration stops completely, the drilling should be stopped! If drilling is continued in situation like this, the drill bit will wear out fast and eventually brake down.

Drill through model (C)

With Drill Through models driller can continue drilling with the Pilot bit without continuing the casing drilling. These models are especially meant for drilling short rock sockets. By using Drill through models, driller don't have to pull all the drill rods and hammer away from the hole and change them to normal rock drilling equipment to drill a short rock socket. Drill through system is not meant for deep rock holes like wells.

To continue the drilling with only the pilot bit, follow the steps given next. Step 1, turn off the air to the hammer after the casing is drilled in to its destination depth, to stop the hammer from hitting. Step 2, loose the feed force. Step 3, rotate the pilot bit about 0.5 to 1 rounds smoothly to the counter drilling direction, to unlock the Pilot bit from the ring bit. With DTH equipment this is to counter clockwise. Step 4, start to feed the pilot bit smoothly. Step 5, let small amount of air to pass in to the hammer to get it hit smoothly. Do not rotate the bit. When the pilot bit has penetrated in to the rock about 3 mm to 8 mm depending from the size of the bit, start to rotate the pilot bit slowly to the drilling direction. When the drilling has continued about 50 mm to 100 mm, the drilling can be continued with full impact, feed and rotation. If the casing still follows the Pilot bit, do these steps again from the beginning.

Additives

Water

Water can be added either in to the air line or injected in to the diverter head. When water is injected to diverter head, the sole purpose is to reduce the amount of dust. The dust poses a health risk, and especially in urban areas the dust can cause problems. When water is added to the air line, it is to help the cuttings come up more smoothly. Normally water is needed when the drilled ground consists of "sticky" formations, which have the tendency to stick to the inner walls of the casing or to the drill rods. Especially in certain types of clay formations, the added water can prevent the casing from becoming blocked.

When water is used, a separate water pump must be utilized to pump the water. If water is injected into the airline, the output pressure has to be higher than the air pressure in the airline. A displacement pump is reccommended for this purpose.

Water can however cause severe problems if it is not handled properly. For example water can cause heavy corrosion within the drill components including: the drill rods, the hammer and the drill bit. Below are some issues which must be considered when using water.

- If water is used in the airline, the lubrication oil amount has to be increased.
- The water injected in to airline has to be pure and its ph must be neutral. There can't be any impurities or particles. These might cause the hammer or bit to brake.
- If water is added in to air line, and the drill isn't used in few days, all the parts including the hammer have to be disassembled, dried and lubricated.
- Water added to air line reduces the impact force of the hammer.
- Water added to air line may cause cavitations in the impact surfaces of the pilot bit shank and hammer piston. The cavitations may cause the pilot bit or the hammer to brake.
- Water jets coming from between pilot bit shanks impact surface and hammers piston impact surface can cut the shanks foot valve (exhaust tube). If this happens, the hammer piston stops moving and the drilling will stop.
- The water flow should be small as possible and adjusted according how the cuttings are coming out.

Foam / Polymers

Foam additives can be used if the ground formation has a strong tendency to stick in to the inner wall of the casing and on to the drill rods which causes the casing to be blocked. In this type of situation the foam "lubricates" the walls, and "breaks" the formation to smaller and smoother pieces. Heavy foam can also be helpful if the cuttings are unwilling to come up from the hole.

There are a few basic rules when using foam additives, which are listed below. Always use the instructions given from the foam additive manufacture as well.

Use of foam may increase corrosion of parts if not handled properly. This is because the foam additive washes the oil film away from the metal parts. For this reason, attention should be paid to the lubrication; the amount of lubrication has to be increased when using foam. The amount of hammer oil may have to be doubled. Once drilling with foam is finished, all the parts including the hammer must be disassembled, washed with clean water, dried and lubricated.

If foam or polymers are used, they are pumped straight in to the airline. Normally it is easiest to add the foam ingredient to the flushing water which is injected into the airline, but a separate foam pump can also be used; foam always needs water.

Oil

Lubrication is a very important matter when drilling. If lubrication is neglected, the hammer and the bit will break quickly. There should always be adequate amounts of oil present in the air line to lubricate the hammer and the drill bit. Check the recommendations in your hammer manufacturer's operation instructions, and use the correct lubrication accordingly.

Use only high quality, environmentally safe rock drill oil. For "dry drilling" (no water used) it is generally recommended to use 0.16 L of oil/hour/every 2.8 m^2 of air delivered by the compressor. For wet drilling, the amount should be doubled. If the hammer manufacturer recommends a different amount, use as indicated by them. Lubrication oil is injected straight into the airline with separate oiler.

Inspection

In this section, there is inspection instructions for the drill bit and drilling cycle. These aspects should always be in order. Read and use the hammer and drill rig safety and operating instructions as well.

Before installing the bit

Inspect the following before installing the pilot bit into the hammer.

- The foot valve must be intact and mounted into the right place and height. The foot valve must also be properly attached. It is not allowed to swing or move in any way by hand power. Damaged valve must be replaced before drilling.
- Check if there are any signs of wear in the valve. Check that there are no marks caused by water jetting. The foot valve can be cut in to pieces during the drilling. If this happens, the hammer piston stops moving, and the whole drilling will stop.
- Inspect to make sure the pilot bit splines are intact. There should not be any heavy wear, fractures, breakages or burn marks in them. If the splines are worn to an acceptable level, the worn should be even. If the wear in the splines is uneven or they are damaged in any other way, the Pilot bit should be replaced.
- Check if the pilot bit shanks impact surface (the surface which takes the impact from the hammer piston) is clean and intact.

  If there are marks of heavy cavitation, other bad worn marks or any breakages the pilot bit should be replaced.
- Check if the impact and rotation shoulders are in good condition. If they are worn out, the pilot bit should be replaced.
- Check the carbide buttons. If they wear flat and are over 1/3 of the diameter of the button, the buttons has to be sharpened. If they have worn out, the pilot bit has to be replaced.

Before installing ring bit, ring bit set or casing shoe

Inspect always at least these before installing the ring bit, ring bit set or the casing shoe. Parts with any fractures or damages should not be used!

- All the parts have to be intact. Check especially the retrievable models, are there any fractures or any heavy wear marks. Fractured or badly worn ring bits should not be used!
- Used ring bits (concerning retrievable models and horizontal models) can still function properly even though some of the carbide buttons are missing. It depends on the size of the ring bit and the depth of the hole to be drilled how many buttons is allowed to be missing from the ring. In most cases it is enough if ¾ of the buttons are in place. The most important ones are the outergauge buttons.
- Check is the casing shoe round. Deformed casing shoes (like elliptical etc.) should not be used. However if the casing shoes is only little bit off round, and can be installed in to the casing without excessive force, it can be used.
- When using ring bits with integrated casing shoes, confirm that the casing shoe rotates. It is not necessary that the casing shoe rotates completely freely. However, it should not be badly jammed.

Before use

Every time check these aspects before starting the drilling.

- Shoulders in the pilot bit and in the ring bit should be intact and without any bad wear marks. Bits with heavy wear marks should be repaired or replaced!
- The bit body in the pilot bit and in the ring bit should be intact and without any bad wear marks. Bits with heavy wear marks should be repaired or replaced!
- The casing shoe should be intact, without any heavy wear marks, and properly welded. If the welding is not properly done, or if there is fractures, the casing shoe might break off during the drilling. This will cause the loss of the hole and in worst cases the loss of the bit, hammer and rods!
- Check the condition of the buttons in pilot bit and used ring bit. Bits with worn out buttons should not be used. All the carbide buttons should be inside wear tolerances!
- Is there all the buttons left in the bits? Used pilot bits and ring bits can still drill if there is not all the buttons left. It depends on the size of the bit and the depth of the hole to be drilled how many buttons is allowed to be missing. In most cases it is enough if ¾ of the ring bit buttons are in place. The most important ones are the outer gauge buttons.
- The pilot bits flushing grooves and air holes are open. There should not be any obstacles in them which might block the flushing during the drilling.
- After the pilot bit has been connected to the ring bit, check that the connection is properly locked.

Handling

Lifting

WARNING

Risk of serious injury!

- Pilot bits should be lifted with the lifting eyes from the threaded holes, or with firm grip from the shank!
- Lifting should always be done by using extra caution!
- Use only lifting accessories heavy enough for the purpose!
- Use only accessories and devices which are mend for lifting!
- Do not use broken lifting accessories like lifting ropes, slings, straps or halyards!
- Be sure that there is nothing or no one under the lifted load (bit)!
- When the load (bit) is lifted, do not put any body parts under it!
- When using crane for lifting, be sure there are nobody in the area where the load (bit) might swing!
- If lifting eye is used, use only lifting eyes which enable lifting from every direction!
- If lifting eye is used, be sure that it has been properly fixed! The screw has to be screwed completely and tightened!
- Always use lifting accessories! Only very light loads can be lifted by hand.
- Use safety helmet, safety boots and safety gloves!
- Pilot bit should never be laid face up!
- Be sure the surface where the bit is lowered is supporting and straight!
- Before lifting, make sure the lifting accessories are holding firmly and they are properly fixed!
- The pilot bits, ring bits or casing shoes should never be lifted and carried unsecured with the forklift.
- When lifting pilot bit when it is in vertical direction, it should always be lifted from all lifting eyes at the same time when they are used.
- Use only same length lifting accessories when several is used.

Unpacking

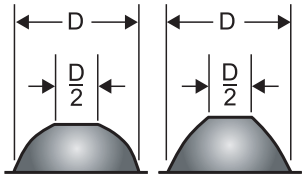
- Always use personal safety equipment! At least safety boots, safety gloves and helmet.
- The packages should always be on supporting and straight ground when unpacking.
- If package is bonded with band steel, beware that it might shoot up when it is cut.
- If package is bonded with band steel, beware of the sharp edges.
- Beware of the Ring bit or Casing shoe stack when unpacking! The stack might collapse.

Maintenance

Grinding the drill bit

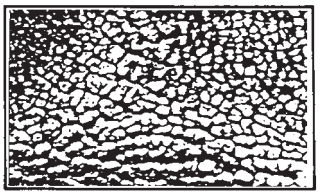
The rate of bit wear depends on the rock formation, and is highest in rocks with a high quartz content. A suitable grinding interval should be determined according to the rate of bit wear. It is more economical to regrind too early rather than to suffer poor penetration rates and risk damaging the drill bit through overdrilling.

When to regrind



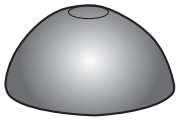
Button bits should be reground when the penetration rate drops, or if any of the cemented carbide buttons are damaged (fractured buttons should be ground flat). It is both practical and economical to redress the buttons when the wear flat reaches about 1/3 of the diameter of the button.

Look out for "snake skin"



If microscopic fatigue cracks – so-called "snake skin" – begin to appear on the cemented carbide buttons, they must be ground away. In any event, bits should be reground after 300 metres of drilling at the most. This should be done even if there are no visible signs of wear and the penetration rate continues to be good. If snakeskin is not removed, the cracks will deepen and ultimately result in button fracture.

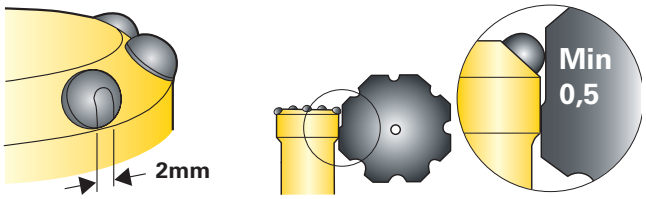
Do not grind away too much cemented carbide



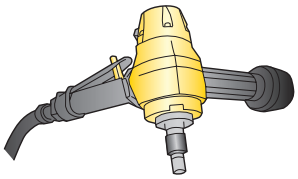
Do not grind too much on the top of the buttons. Let a few millimetres of the wear flat remain on top of the button. Always grind broken buttons flat A drill bit can remain in service as long as the gauge buttons maintain the diameter of the bit. Fractured buttons must always be ground flat to prevent chips of cemented carbide from damaging the other buttons.

Avoid grinding the perimeter

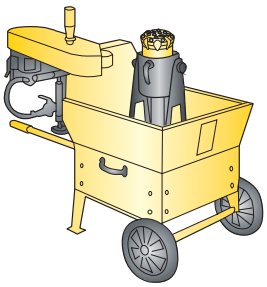
Gauge-button anti-taper has to be removed by grinding, although excessive reduction of the bit diameter should be avoided. Leave about 2mm of the wear flat. If necessary, remove some of the bit body steel below the gauge buttons, so that a clearance (taper) of 0.5mm is maintained. If the flushing holes start to deform, open them up with the aid of a rotary burr or steel file.



Grinding equipment



The Grind Matic HG is a portable, hand-held, air-powered grinding machine for button bits, ideal for use at the worksite. It is used with diamond-impregnated grinding cups, which can be used with or without water flushing.



The Grind Matic Manual B-DTH is a mechanized air-powered grinding machine for button bits. It is mounted in a steel box-barrow, which can be wheeled easily

DANGER

- Take great care when breaking the driver chuck joint using the bit removal tool in combination with reverse rotation. If the shaft of the tool is not locked or touching the edge of the feed beam, the shaft can turn with great force when breaking the driver chuck joint.
- Blows against hammer or bit can cause fragments of metal to fly. Always wear goggles when breaking joints.
- Never disassemble the spring unit if the friction springs may be preloaded.
- Before grinding, always check the flushing holes of the drill bit for traces of explosive. Contact with the grinding wheel can cause the explosive to explode causing serious or fatal injury as well as damage to the equipment.
- To clean the flushing hole, use only a wooden rod, copper wire or flushing water.

WARNING

- Take great care when handling the drill bit. Mind your fingers!
- When removing and fitting exhaust tubes, always wear protective goggles, gloves and appropriate protective clothing. Carelessness can result in injury to the eyes or other body parts.
- Foot valves are brittle. Heavy blows can deform or dislocate the exhaust tube, with the risk that it would then obstruct the movement of the impact piston.

⚠ CAUTION

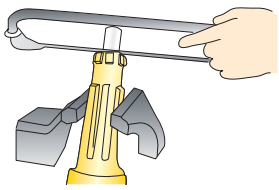
- Always wear ear protectors, protective clothing, gloves and goggles when grinding.
- Use a dust extraction system or an approved dust mask. This is of special importance when dry grinding indoors.

How to replace the exhaust tube

When the exhaust tube becomes worn or damaged, it must be replaced. If this is not done, the performance of the hammer will be seriously affected.

⚠ WARNING

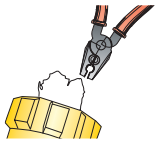
- Never go to the front of the bit or look straight in to the front of the bit! Live air coming from the air holes can cause severe injury!
- Never use full air while starting the drilling! Fast live air can dart rocks from the ground which may cause severe injury!
- Never stand under the exhaust tube of the diverter head! Dropping rocks and dirt may cause severe injury! Be sure there is no one under it while drilling!
- Never turn the bit to unlock direction if the purpose is not to unlock the Pilot bit from the Ring bit!
- Never lay any body parts under the bit or the casing!
- Never start drilling if you are not certain that there are no underground structures like gas lines, water lines, electricity lines, tunnels etc. in the path of the planned hole!
- Always use safety helmet, safety goggles, safety gloves, safety shoes, hearing protection, proper working clothes, protective breathing mask and other necessary safety equipment!
- Beware of the moving parts of the bit and drilling machine! Never touch or go near the moving parts!
- Be cautious when installing a separate Ring bit in to the Pilot bit! Do not put fingers between the Ring bit and the Casing shoe!
- Do not make any changes to the bit, which are not individually instructed in this document!
- Do not stand near the casing when drilling!
- Never use pressurized air to clean yourself or other persons!



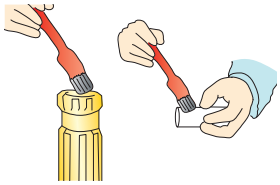
1) Cut off the damaged exhaust tube using a hacksaw blade or knife.

2) Remove the internal parts of the exhaust tube from the bit shank with the aid of a screwdriver.

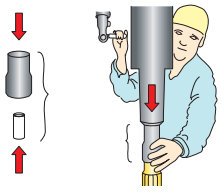
3) Removal can be made easier by preheating the valve to 50-70 °C.



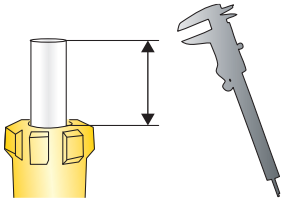
4) Remove any remaining parts of the exhaust tube using a pair of tongs.



5) Coat the part of the exhaust tube that is pressed into the drill bit with rubber glue (or a similar substance). The rubber glue will act as a lubricant during fitting, and as a fixative thereafter. If rubber glue is not available, use silicone grease or some other similar lubricant. Put some glue in the bit shank as well.



6) Press the new exhaust tube into the seat in the flushing hole in the bit shank using a special assembly tool. DO NOT use a hammer to seat the exhaust tube. Heavy blows can damage the exhaust tube or cause it to locate incorrectly so that it is struck by the impact piston during drilling. Use some kind of hydraulic press to press it gently but firmly on to its seat in the bit shank.



7) Check the protrusion from the end of the shank. Too much or too little protrusion will seriously affect the performance of the hammer.

Disposal

Oils and greases might be hazardous to environment. Always collect oil and grease leakages and residues and treat in accordance with local regulations. Use biodegradable fluids and oils when possible.

Chemicals as flushing additives can be hazardous to environment. Dispose all chemicals according to the manufacturer's instructions and local regulations.

Metal parts for example bit body, are usually recyclable. Dispose in accordance with local regulations.

Plastic and rubber are sometimes recyclable. Dispose in accordance with local regulations.

Trouble shooting

In this section there are some suggestions of potential problems which can occur, possible causes and solutions. If the penetration slows down drastically, the drilling should be stopped, and the possible reason identified. The penetration will not suddenly start again by itself. First thing to check is the flushing. If the solution is not found from these instructions, see also the hammer manufacturers troubleshooting instructions.

Fault	Cause	Remedy
Heavy wear on bit bdy, no proper penetration	1) Too weak impact from hammer	1) Add more air to hammer
		1) If compressor is under 13 bar, increase pressure in compressor
	2) Too small feed force	2) Increase feed force
Heavy wear on carbide buttons	1) Too slow rotation speed	1) Increase rotation speed
	2) Too high rotation speed	2) Decrease rotation speed
	3) Too small feed force	3) Increase feed force
	4) Too weak impact from hammer	4) Add more air to hammer
Broken carbide buttons	1) Steep parts in bit face	1) Do not drill in ground known to contain large amounts of steel
	2) Button maintenance has been neglected	2) Grind broken button flat and maintain other buttons
	3) Chips from alternate broken button	3) Grind broken buttons flat
	4) Bit possibly stuck in boulder edge	4) If rotation stops itself, raise bit up and begin again with small feed and minor air
	5) Too fast rotation speed	5) Decrease rotation speed
Carbide button pop out	1) Hammer runing without proper backing against the bit face	1) Never operate the hammer if drill bit is not properly against ground
	2) Too small feed force	2) Increase feed force
Cuttings are fine, drilling creates lots of dust, slow penetration	Too slow rotation speed	Increase rotation speed
Rotation stops during drilling	Bit is stuck	Lift the bit slightly, start again with light feed force and minor air
Broken foot valve (exhaust tube)	1) Worn out piston in hammer	1) Check and replace the piston
	2) Worn out chuck in hammer	2) Check and replace the chuck/ hammer
	3) Worn out shank in Pilot bit	3) Check and replace the Pilot bit
	4) Water jetting	4) Reduce amount of water in air line; use clean water
Cuttings are not coming up	1) Not enough up hole velocity	1) Add more aur to the hammer; use bigger drill rods
	2) Casing plugged	2) Clean the casing and use more water or foam while drilling; flush casing with air every 10 sec. while drilling
Uneven wear in shank spline	Hammer striking sequence is too short, foot valve is too long	Check the hammer, shorten the foot valve
Shank cut off	1) Too low feed force in soft or broken formation	1) Increase feed force
	2) Rubbing damage from Retainer ring	2) Replace worn or damaged Retainer ring
	3) Cavitation in shank / Pilot bit head corner	3) Decrease amount of water in the air line; use only clean water
	4) Blank fire when drilling through a boulder	4) Decrease air and feed immediately when the bit meets the bottom of the boulder
	5) Excessive operating air pressure	5) Lower air pressure
	6) Fillet erosion (notching) from underfeeding in shank / Pilot bit head corner	6) Increase feed
	7) Shank overheating due to insufficient lubrication	7) Increase hammer oil amount
Breakage in the shank impact surface or shank corner	Foreign objects on the impact surface	Ensure there are no objects such as rocks, sand or dirt in the hammer piston or in the shank impact surface when the Pilot bit is connected into the hammer; use only clean water
Slow penetration rate	1) Too small feed force	1) Increase feed force
	2) Flushing problems	2) Check the flushing
	3) Weak hammer impact	3) Use adequate operating pressure; use proper size hammer

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TerraRoc

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Finland

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Grangemouth FK3 8BT,
Scotland,

USA
7500 Shadwell Drive,
Roanoke, Virginia, 24019
USA