Atlas Copco Raise Boring Equipment

The Robbins Range

The Raise Boring Concept

Particular Terminology

The raise boring concept involves terminology that is a little different from normal mining language. Raise boring, also called raise drilling, is the process of mechanically boring, drilling, or reaming a vertical or inclined shaft or raise between two or more levels. All levels may be underground, or one level may be at the surface.

During the early development of mechanical raise excavation, different approaches were pursued and, in several cases, systems were developed. The most successful method became known as raise boring.

Today, raise boring is accepted as the world standard for mechanical raise excavation, and the name of Atlas Copco Robbins is synonymous with the technique.

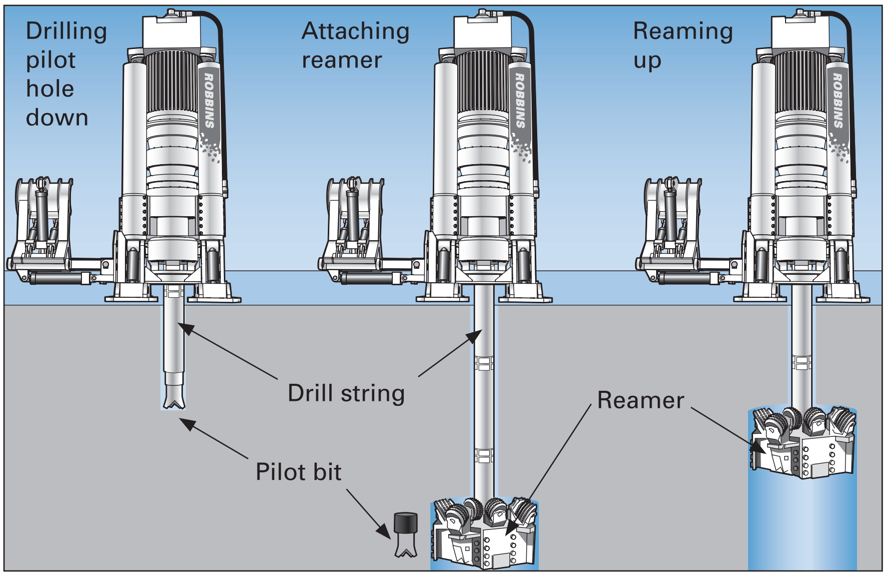


Figure 1: Raise boring process.

Raise Boring Process

In raise boring, the machine is set up at the surface or upper level of the two levels to be connected as shown in Figure 1. A small pilot hole is then drilled down to the lower level using a drill bit attached to a series of cylindrical drill pipe pieces, which form the drill string. Upon completion of the pilot hole, a reamer with a diameter larger than the pilot hole is attached to the drill string at the lower level. Using the reamer, the small pilot hole is reamed back to the machine on the upper level. The cuttings excavated by the reamer fall to the lower level and are removed by any convenient method.

Applications

Raise boring machines have been used in both mining and civil projects for holes in the range 0.6-6.0 m-diameter and up to 1,000 m-long. Some specific applications of bored raises are:

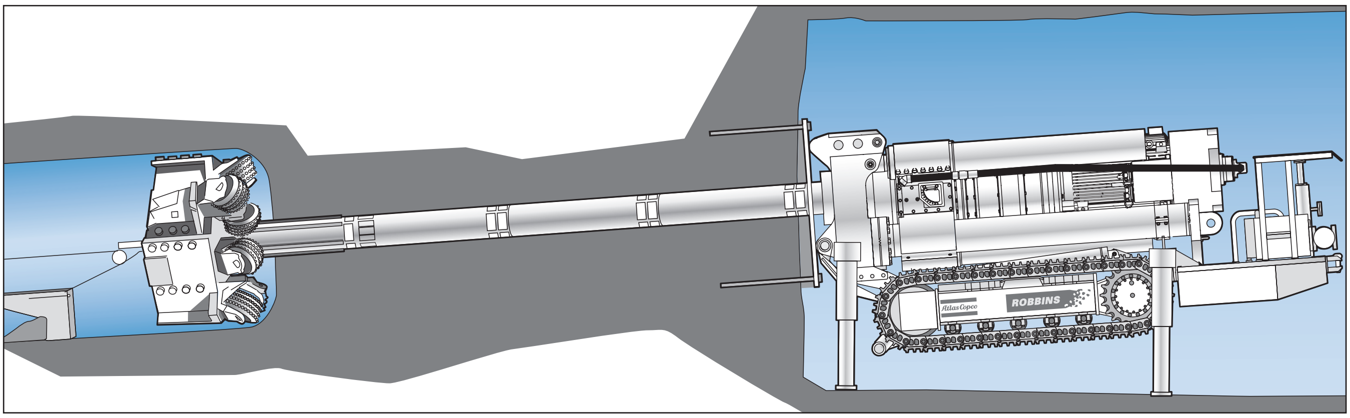
Mining: materials transport; ventilation; manriding; mineral production.

Civil: hydro penstocks and surge chambers; redirection and retrieval of hydro water; petroleum, pressurized gas, and nuclear waste storage; road and rail tunnel ventilation; stormwater storage and drainage; access for pipes, hoses, and cables; water inlets and outlets for fish farms.

Horizontal and Low-Angled Raise Boring

Standard raise boring machines are capable of boring raises at angles from vertical to 45 degrees from horizontal. Raises from 45 degrees to horizontal

Figure 2: Low-angled raise boring.



have been completed with the addition of only a few accessories and minor adjustment of the standard machine as shown in Figure 2.

Other Methods of Vertical Boring

Other methods of mechanical raise and shaft excavation have been developed in addition to raise boring. These methods are described in the sections below and are as follows: boxhole boring; blind shaft boring; down reaming; pilot down - ream down; hole opening; BorPak.

Boxhole Boring

Boxhole boring is used to excavate raises where there is limited or no access to the upper level. Here, the machine is set up at the lower level and a full diameter raise is bored upward.

While boring upward, stabilizers are periodically added to the drill string to reduce oscillation and bending stresses. The cuttings are carried by gravity down the hole, and are deflected from the machine and removed at the lower level. Boxhole boring can be completed with or without a pre-drilled pilot hole, as shown in Figure 3.

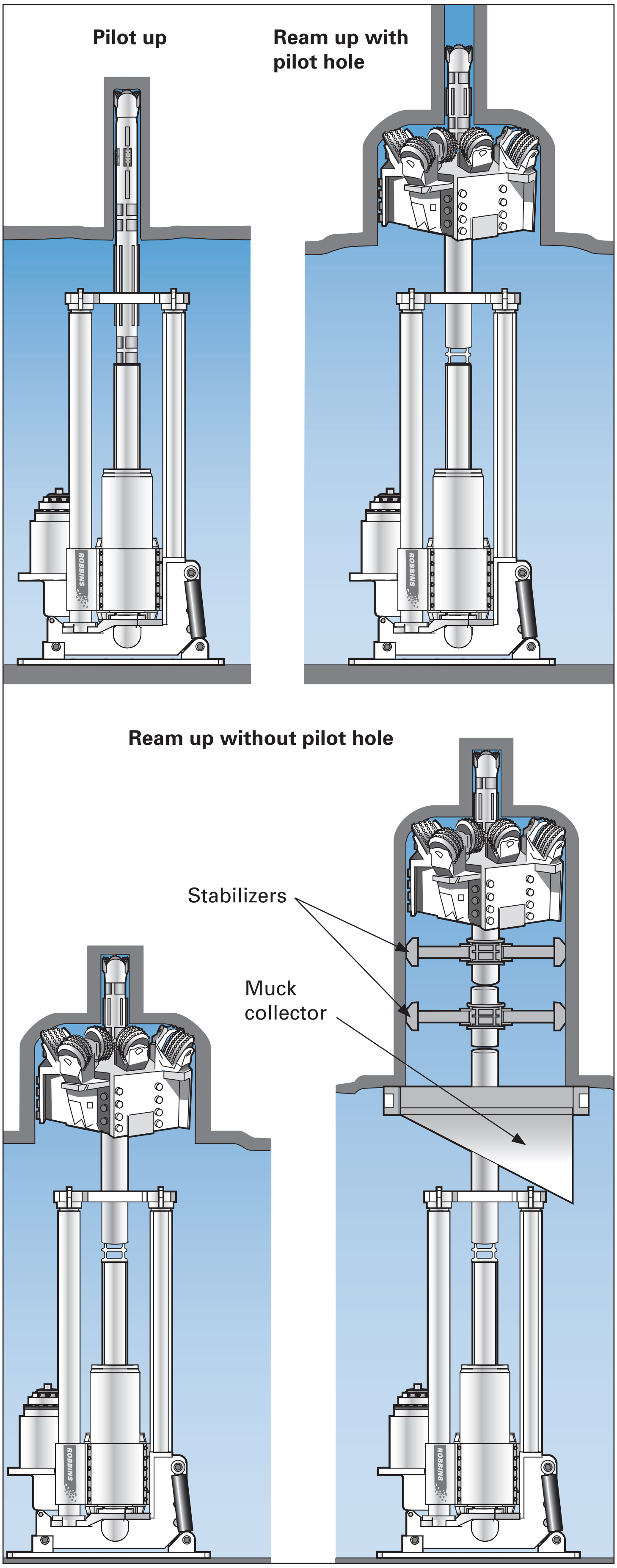


Figure 3: Boxhole boring.

Blind Shaft Boring

Blind shaft boring is used where there is access to the upper level of the proposed raise, but limited or no access to the lower level. With this method, the raise is excavated from the upper level downward using a down reaming system connected by a drill string to the machine above. Weights are added to the reamer mandrel as shown in Figure 4.

Stabilizers are located above and below the weight stack to ensure vertical boring. A reverse circulation system, or a vacuum system, is typically used to remove the cuttings out of the shaft.

Down-reaming

Down-reaming begins by drilling a conventional pilot hole, and then enlarging it to the final raise diameter by reaming from the upper level to the lower level as shown in Figure 5. Larger

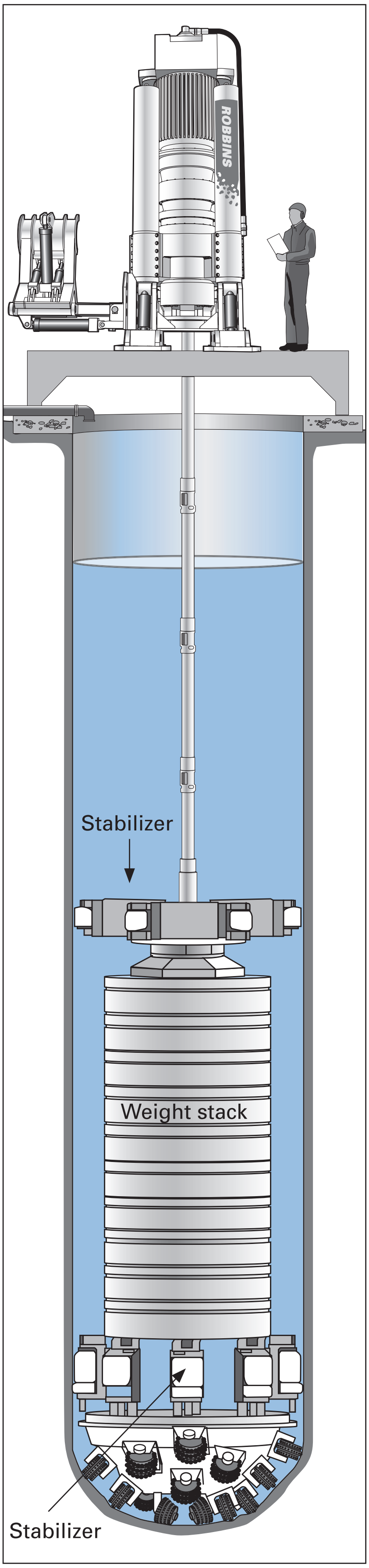


Figure 4: Blind shaft boring.

diameters can be achieved by conventionally reaming a pilot raise, and then enlarging it by down-reaming.

During reaming, the cuttings gravitate down the pilot hole, or reamed hole, and are removed at the lower level. To ensure sufficient down-reaming thrust and torque, the down-reamer is fitted with a non-rotating gripper and thrust system, and a torque-multiplying gearbox driven by the drill string. Upper and lower stabilizers ensure proper kerf cutting, and reduce drill string oscillations.

Pilot Down - Ream Down

This method, also known as hole opening, is used to enlarge an existing pilot hole with a small-diameter reamer. The operation is similar to pilot hole drilling, the only difference being that a small reamer is used instead of a pilot bit. The small reamer is designed to use the existing pilot hole to guide the drilling. Stabilizers are used in the drill string behind the reamer to prevent it from bending.

Pilot down - ream down hole opening is only used when a standard reaming system is either impractical or impossible, as shown in Figure 6.

BorPak

The BorPak system is used for blind hole boring. It comprises a guided boring machine, a power unit, a launch tube/transporter assembly, a conveyor, and an operator's console. The BorPak operates like a microtunnelling machine, climbing up the raise as it bores. Cuttings pass through the centre of the machine, falling down the raise and launch tube onto a conveyor. This revolutionary machine has the potential to bore from 3.9 to 6.6 ft (1.2 - 2.0 m) diameter holes at angles as low as 30 degrees. Like a raise boring machine, the BorPak offers high speed drilling, but eliminates the need for a drill string. It also provides the steering flexibility of a raise climber.

BorPak is especially attractive when flexibility and mobility are at a premium, or when the job requires drilling a series of short raises. ■

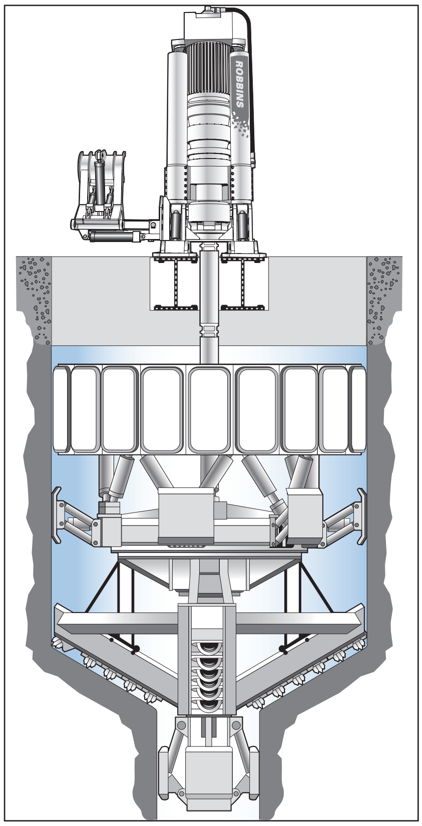
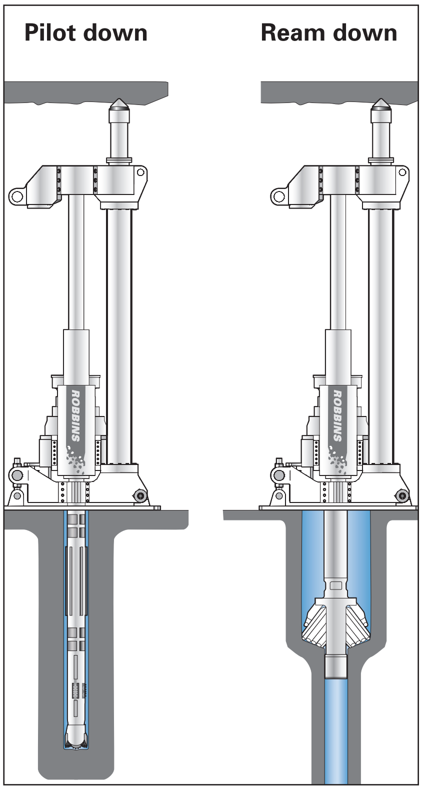


Figure 5: Down reaming.

Figure 6: Pilot down, ream down.



The Raise Boring Machine

Thrust and Rotation

The raise boring machine (RBM) provides the thrust and rotational forces necessary for raise boring as well as the equipment and instruments used to control and monitor the raise boring process.

The RBM is composed of five major assemblies described in the sections below.

These are: derrick assembly comprising mainframe and base plates; hydraulic system; lubrication system; electrical system; and control console.

Figure 1: Derrick assembly layout .

Derrick Assembly

The derrick assembly supplies the rotational and thrust forces necessary to turn the pilot bit and reamer as well as to raise and lower the drill string. This assembly consists of several major components. These are: base plates; mainframe; columns; headframe; hydraulic cylinders; and drive train assembly.

Base Plates

The base plates, left-hand and right-hand, provide the structure for supporting the weight of the derrick assembly as well as for positively transferring the forces required for raise boring into the derrick mounting system.

The base plates are normally set on a level concrete foundation pad and anchored by rock bolts passing through the pad into the rock formation below. In some instances, the base plates are mounted to a steel beam system, which in turn is secured to concrete foundation pads and the rock formation.

Mainframe

The mainframe is the major load bearing structure of the derrick assembly. It is mounted and secured on the base plates with removable turnbuckles and expansion pins. Each turnbuckle consists of two threaded eyes screwed into a turnbuckle body. The turnbuckles establish and maintain the required boring dip angle. After the boring angle is confirmed, the expansion pins are tightened to provide linkage between the mainframe and turnbuckles, and the base plates and turnbuckles, for the positive transfer of boring forces.

Removable pivot brackets mounted at the rear of the mainframe allow the hydraulic cylinders of the transporter system to be attached to the mainframe for derrick erection and takedown.

These brackets also serve as rests for the derrick assembly when loaded on the transporter. The mainframe is equipped with a worktable. This is designed with a hollow centre to allow passage of drill string components from the drive train assembly into the pilot hole. The plane of the worktable top surface remains perpendicular to the axis of the drill string at all dip angles.

All worktables are equipped with, or are used in conjunction with, a worktable wrenching system. This reacts the machine torque into the mainframe for threaded connection makeup and breakout. The wrenching system is also used to hold the drill string and the cutting components securely in the hole when adding or removing parts.

The worktable also provides mounting for various accessories necessary for raise boring machine setup and

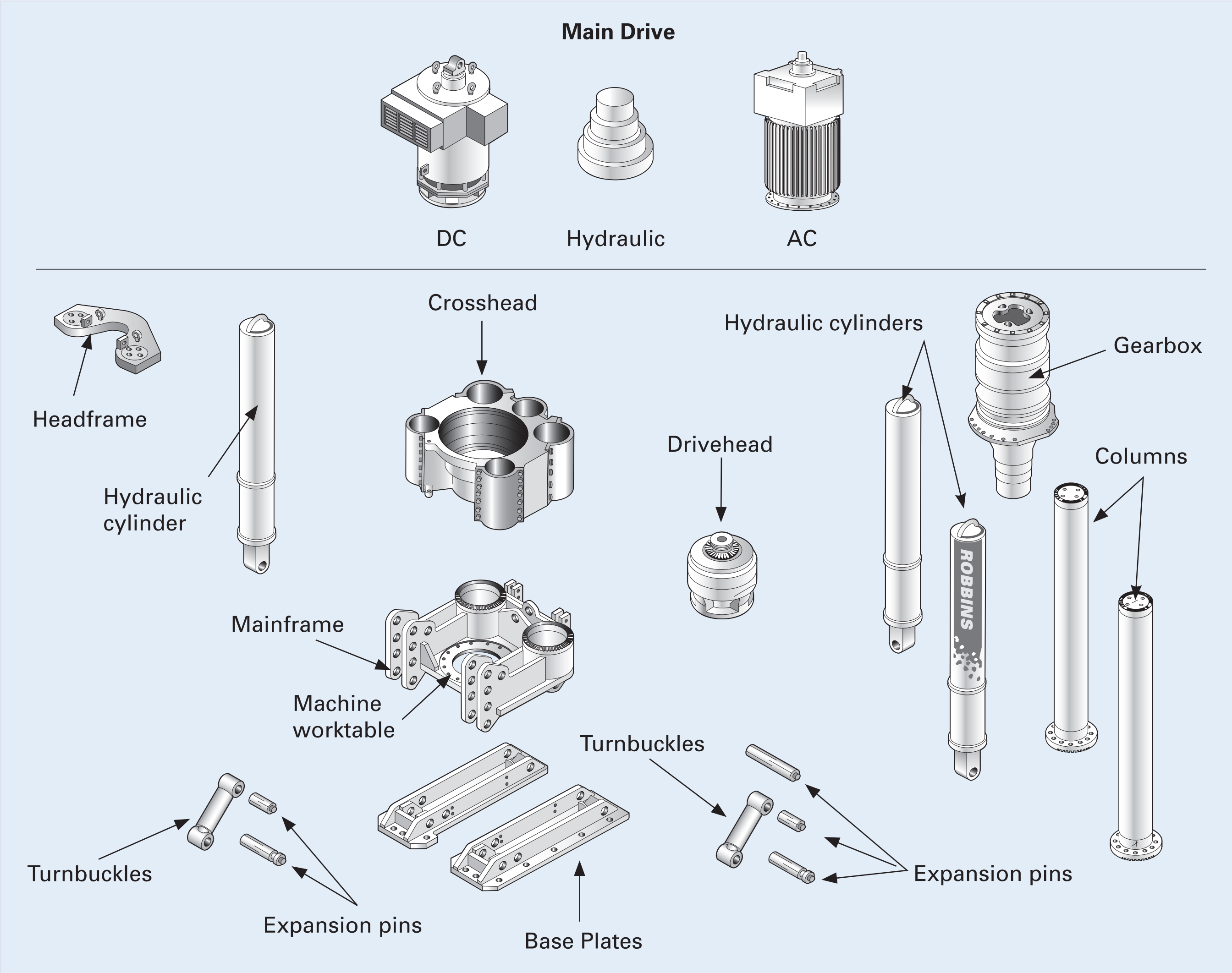


Figure 2: Exploded view of derrick assembly.

operation, such as the pilot hole starter bushing, the outlet housing of the bloöie system, the drivehead installation and removal tools, and the ram assembly, if fitted.

Columns

Chrome plated cylindrical columns provide torque transfer from the drive train assembly into the mainframe. These columns are connected at their bottom to the mainframe, and at their top to the headframe. They pass through machined bushings in the crosshead, and guide the crosshead as it travels up and down.

Headframe

The headframe is mounted atop the derrick assembly columns, linking them together. This dampens column vibration, and shares the boring torque between columns. The headframe is most commonly secured to the columns by use of a bolted crown gear coupling system.

Hydraulic Cylinders

The hydraulic cylinders supply the thrust required for raising and lowering the drill string in relation to the raise boring machine. These same cylinders also supply the thrust necessary for both pilot hole drilling and raise reaming. Extra thrust capacity is often provided in the design of these cylinders to deal with special circumstances.

Drive Train Assembly

The drive train assembly supplies to the drill string and cutting components the rotational power necessary for raise boring. General descriptions of the three major components making up the drive train assembly are given below. These are: crosshead; main drive motor; and gearbox.

Crosshead

The crosshead is a moving platform to which the main drive motor system and gearbox are mounted. Driven by the hydraulic cylinders and guided by the columns, the crosshead raises and lowers the drill string and transfers torsional forces into the columns.

Most Atlas Copco Robbins raise boring systems utilize the crosshead as a reservoir for the gearbox lubrication oil. Other lubrication system components, such as the lubrication motor and pump, can also be housed in the crosshead.

Main Drive Motor System

The main drive motor system of the derrick assembly supplies the rotational power necessary for raise boring. Four types of main drive motor systems can be used with Atlas Copco raise boring machines. These systems are: AC, DC, hydraulic and VF.

The AC system has the simplest design, lowest cost, and highest reliability of all raise drill drive motor systems. It features fixed speed and fixed torque, and is best suited to competent ground, where minimum motor stalling will be encountered.

DC drive is variable speed and variable torque, and is best suited for larger raise diameters in mixed ground conditions.

Hydraulic drive, employing variable speed and good torque limiting control, is suited for use in all ground conditions and has high reliability.

The VF drive system, developed in-house by Atlas Copco, combines the simplicity of the AC drive motor system with exact motor speed, torque, and positioning control.

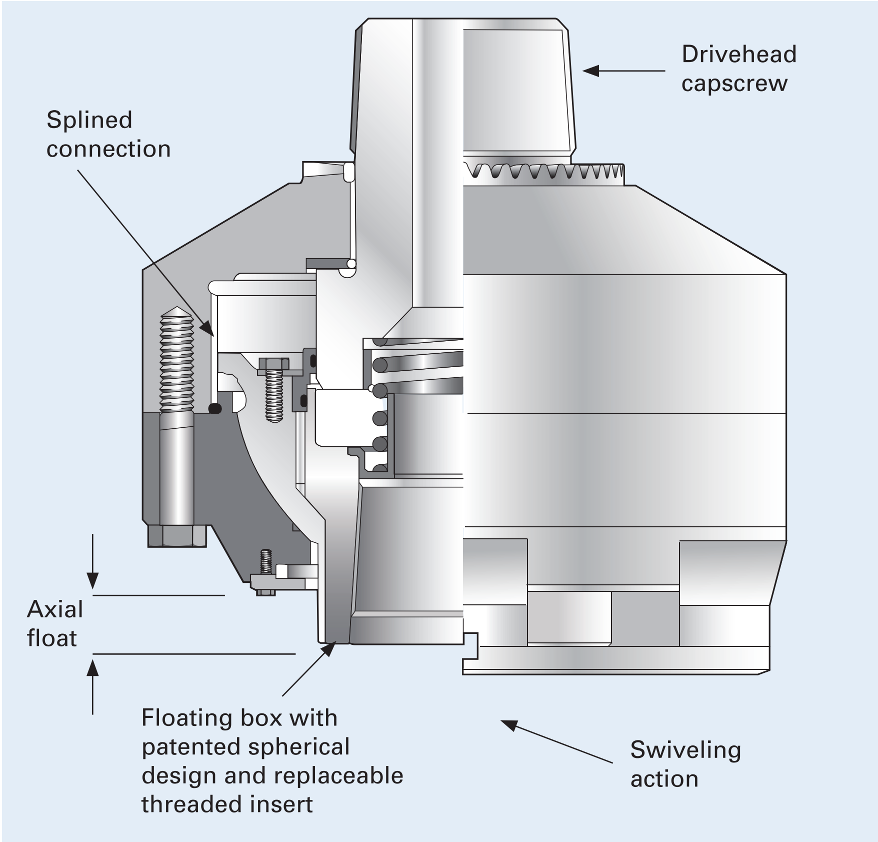
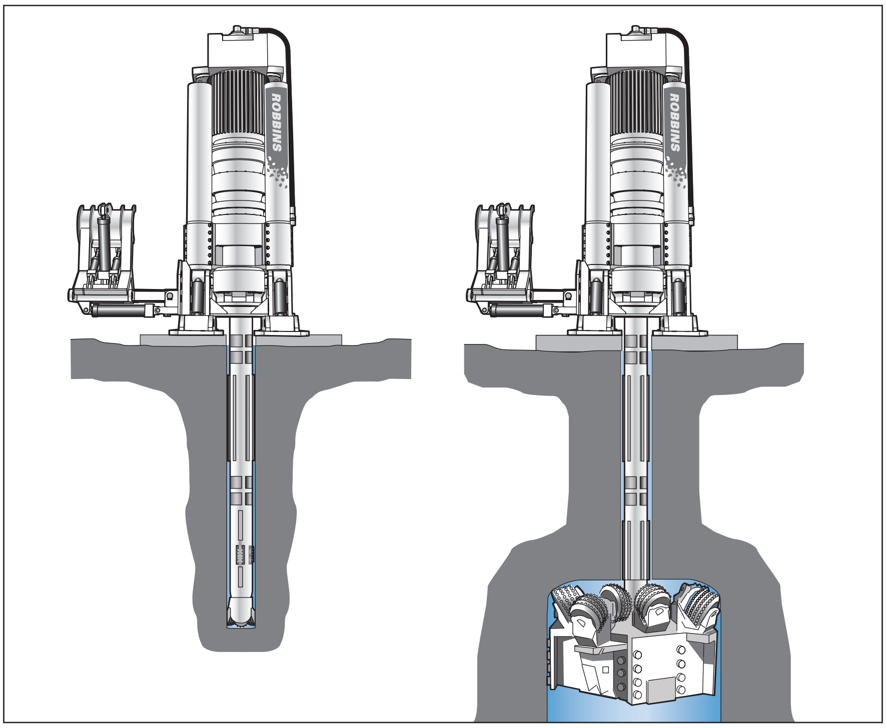


Figure 3: Cross-sectional view of the drivehead.

The VF system circuitry controls the speed, torque, and position of its AC motor by first converting the incoming AC mine power to DC, and then converting it back to an AC signal. The frequency and voltage of the AC signal outgoing to the AC motor can be adjusted, enabling precise speed, torque, and positioning control.

Figure 4: Pilot drilling and reaming.



Gearbox

The gearbox mounts directly to the main drive motors at its input end, and reduces motor input speed to a speed compatible with raise boring and increase tork.

Most gearboxes use a planetary reduction system. This shares the load among three planetary gears, reducing the diameters of the individual gears required, and allowing a more compact drive train assembly.

Gearbox reductions must include ratios capable of providing high torque and low speed for raise reaming, and high speed and low torque for pilot hole drilling. It is not uncommon to have a multi-speed gearbox with a variable speed motor.

Figure 5: Hydraulic power unit.

The output end of the gearbox is attached by a splined connection to the floating box, which connects it to the drill string. The splined connection, while enabling the rotational power of the drive train assembly to be transmitted into the drill string, also allows the floating box to drift axially when threading or unthreading drill string components.

Axial free float permits the threading of the floating box to follow the threading of the stationary drill string component, greatly reducing the chances of thread damage during connection make-up or breakout. Periodic height adjustment of the drive train assembly in relation to the drill string component is necessary, which can be carried out by the operator.

Splined connection floating boxes supplied with newer raise boring machines are equipped with a spherical design patented by Atlas Copco Robbins. This provides a swivelling action in addition to free float. This prevents bending stresses from damaging the gearbox, and accommodates slight drill string misalignment.

The floating box can be housed internally within the gearbox, or mounted to the output end of the gearbox as a separate component. When mounted separately from the gearbox, the assembly housing the floating box is referred to as the drivehead as shown in fig 3.

The drivehead is connected to the output end of the gearbox by spindle bolts or a single threaded capscrew. If a single capscrew is employed for this connection, drivehead installation and removal tools are required when installing or removing the drivehead from the gearbox.

Figure 6: Electrical power unit.

Hydraulic System Assembly

The hydraulic system supplies hydraulic power for raise boring.

This assembly comprises the hydraulic power unit and all interconnecting hose assemblies.

The hydraulic power unit is on a skid-mounted structure containing a hydraulic reservoir. These are used as mounting platforms for the majority of the components making up the hydraulic system. Included in these components are the motors and pumps used to power the hydraulic system along with various valves, filters, and manifolds.

Lifting eyes are provided on the hydraulic power unit for hoisting and positioning.

Design of individual hydraulic system assemblies varies according to the type and size of machine. The service manual should be consulted for specific hydraulic system setup, operation, and maintenance procedures.

Lubrication System

The lubrication system assembly ensures proper delivery of lubricating oil to the high-speed bearings and other selected components of the drive train assembly gearbox. This assembly is commonly made up of the lubricating oil reservoir, with level gauge, thermometer, and breather; pump drive motor; and lubricating oil pump, filter, heat exchanger, and flow meter.

Most Atlas Copco Robbins raise boring machines employ the crosshead of

Figure 7: Robbins 73RH C with RCS control panel.

the drive train assembly as the lubrication reservoir, and as the housing for the lubrication pump drive motor and pump.

Some machines are designed with the lubrication system reservoir and components located separately from the derrick assembly, usually to permit the derrick to be tilted to bore raises at low dip angles without affecting the level of the lubrication oil reservoir and the functionality of the lubrication system.

Electrical System

The electrical system assembly comprises the electrical power unit and all electrical power and control cables.
The electrical power unit consists of an enclosed cabinet containing the power and control distribution hardware and circuitry for the entire raise boring system. Lifting eyes are provided on this cabinet for hoisting and positioning.

Power and control cables are included in the electrical system assembly. Most of these cables are of the quick-coupler type, with all plugs and receptacles identified for ease in making proper connections during system setup.

Because of varying site power supplies, and differences in main drive motor systems and machine options, the design of electrical system assemblies can be quite diverse from machine to machine. The service manual supplied with each raise boring machine should be referenced for specific electrical system setup, operation, and maintenance procedures.

Control Console

The modern rig control system from Atlas Copco features a Control Area Network (CAN) for digital communication between all modules connected to the bus wire. The entire system features various I/O (In/Out) modules for communication with all machine sensors and meters, a master module for computing and processing of operational data, and a display module for presentation of calculated data.

The I/O modules are positioned in the thrust pack and the drive pack, as well as on the derrick assembly. The computing module is usually placed in the drive pack, which is located in a safe, dry place for power supply and convenience to major components.

The display module is part of the control panel, itself a robust assembly enclosed in a waterproof envelope, specially designed for outdoor and underground use.

Manufactured and delivered to over 400 units since 1998, this proven, standardized control system is modular, with all major parts interchangeable with other similarly-controlled Atlas Copco products. ■

Computers Improve Rock Excavation Productivity

Rig Control System Applied to Raise Boring

Atlas Copco Robbins is applying its well-established RCS drill rig computer technology to raise borers. This represents a quantum leap forward with respect to drilling accuracy, equipment reliability, logging capabilities, reduction of manpower, and serviceability. CAN-bus technology, well proven in the automobile industry, is an integrated part in the computerization. The new systems are an option on new raise borers, and have already been retrofitted to a number of older machines.

Figure 1: RCS is a common platform for all Atlas Copco mining and construction products.

Introduction

In mines and tunnels, an accurate excavation profile contributes to better rock stability and overall economy. These qualities accelerated the acceptance of computerized rigs underground, giving Atlas Copco the confidence to apply the technology to other products, including raise borers.

The latest generation of raise borers requires less operators to supervise them, while offering improved working environment and high production with reliability.

Atlas Copco has a great interest in what raise boring can do to improve the rock excavation process as a whole, and continually monitors the performance of machines working for customers around the world.

The PLC system, installed on drill rigs for many years, uses a large radial network to connect the central computer with the various sensors and processors. It handles analog high-speed signals, while hosting many processors for advanced digital communication and man-machine communication. This means that all sensors are hooked into one central computer, which processes the instructions sequentially.

When automating a raise borer that is hosting only a few steps, PLC is probably still a good solution. However, as control systems become larger and more complicated, the mix of high-precision and high-speed signals becomes more difficult to optimize in PLC systems, and the radial networks involved require intense cabling.

CAN-bus Raise Borers

With the introduction of the CAN-bus system on the new generation of Atlas Copco Robbins raise borers, completely new thinking in the derrick control and rod changing systems has been enabled. Two levels of customer access to the parameters are possible. At the first level, the operator can change a few parameters. At the next level of parameter access, the foreman is provided with a password. At this level he can change all of the relevant parameters.

Another important feature with the CAN-bus rigs is that these have a built-in diagnostic procedure for the electronic system, making it easy to find and repair faults. The electronic components on the CAN-bus rigs are common and interchangeable, thus requiring fewer spares at site.

CAN-bus can be adapted to the type of application, whether surface or

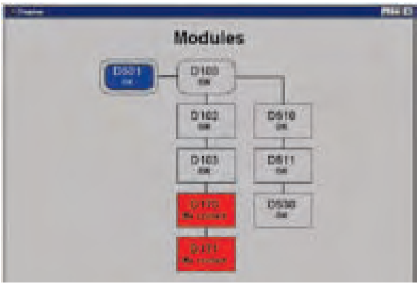


Figure 2: Monitoring module condition.

underground, the pilot and reamer sizes, the level of automation, and the introduction of new functions, without the need to install a heavy and expensive computer in the small and less complex rigs.

Quality Drilling

The new raise borers offer numerous improvements in the drilling and quality of the drilling result, which eventually will lead to lower overall cost. Some of the advantages are listed.

Higher availability of the raise borer is expected

The running costs are expected to be lower, as the proper follow-up of the machine performance and direct fault finding will improve the availability of the rig.

Because fault tracing is carried out by the software, the service organization does not require a deep knowledge of digital or computer technology.

Monitoring of the rock characteristics is possible

Using the MWD (Measuring While Drilling) function, rock parameters can be logged during pilot drilling and reaming, without extra input. This is valuable in interpreting the results of parameter monitoring.

Easier Rod change

Using radio remote control, the operator is able to undertake rod changing without assistance, removing the need for a second person.

Rig Control Systems

RCS promotes quieter and more spacious surroundings for the operator, since there are no longer any hydraulics or gauges in the cabin. Instead of dials and switches, the operator has a screen and joysticks, backed up by a full diagnostic and fault finding facility. Once he has programmed the hole, the computer takes over, optimizing the pilot drilling or reaming process, and leaving him free to carry out other duties.

Stress on the operator is reduced, while his productivity is increased. The result is quality holes and happier workers.

RCS also provides a gradual ramp-up of power at the start of pilot drilling and reaming. Smoother control during the boring operation then takes the stress off the drill string, and improves the penetration rate.

When jamming starts to occur, it is detected by an increase in rotation pressure, which immediately causes boring to stop, avoiding unnecessary-torsional stresses in the machine and drill string.

Future Trends

Automation products are already available to connect a raise borer to a customer's communication network.

Once the raise borer is connected to the network, the project control and management systems will receive vital information on drilling data and the rig's internal condition. The raise borer will also be able to load new working orders and information.

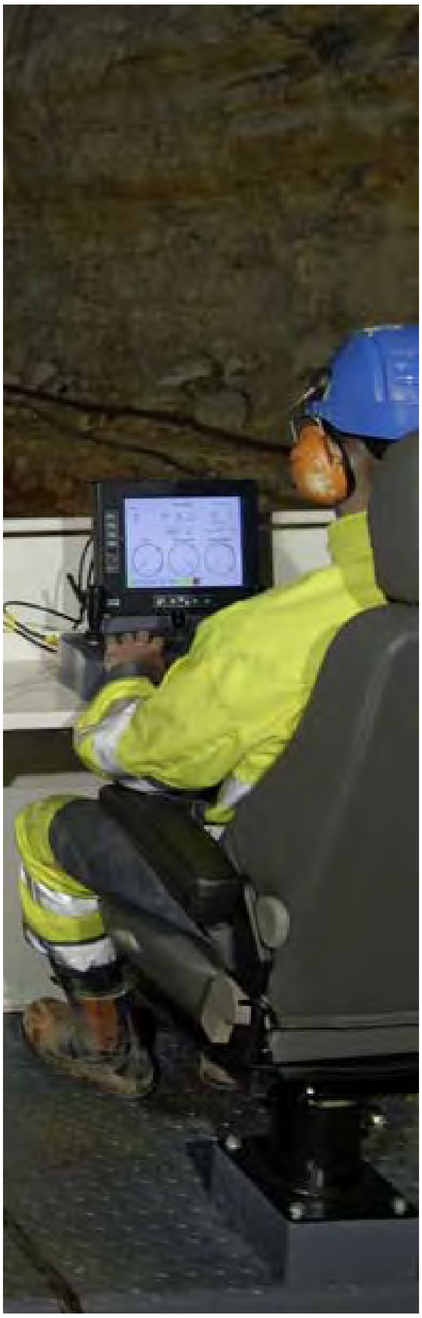
The new series raise borers are automation-ready and intelligent, with options such as tele-remote operation, navigation and autonomous operation. They also have a customer application interface to standardize the exchange of data between machine and jobsite.

The connectivity network offers customers better service support, with engineers based at the home factory carrying out remote troubleshooting. Rigs can report failures, and request servicing, using either direct modem connection, or via the Internet.

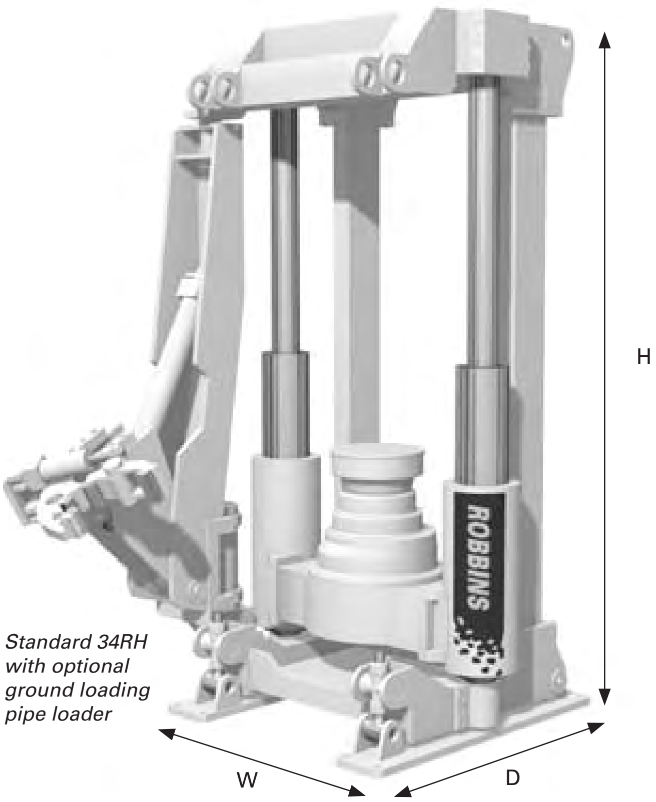
With the RCS system, and its PC-based technology, upgrading raise borers of all types and manufacture has never been easier.

Atlas Copco Robbins is now able to provide a full range of automation options to its computerized raise borers, such as:

- Automatic collaring
- Automatic rod handling
- Automatic drill control
- Breakthrough automatic stop
- Detection of worn out reamer and pilot drill bits
- Lubrication surveillance system
- Smart oil leakage shut down
- Digital drill plan handling
- Maintenance logging
- Drill quality logging
- Measure While Drilling logging
- Mine radio text message system
- Rig Remote Access



34RH



Standard 34RH with optional ground loading pipe loader

The Robbins 34RH is a low profile and small diameter raise drill, ideal for slot raises, back filling and narrow vein mining applications. The multipurpose and light weight raise drill can be used for conventional raise boring, downreaming as well as upward boxhole boring depending on the configuration of the various options available. This makes the Robbins 34RH the most versatile raise drill on the market.

Features & Benefits

- The single power pack hydraulic drive features variable speed and good torque limiting control.
- Rigid columns provide efficient torque reaction, extending the service life of the thrust cylinders.
- Telescopic thrust cylinders provide high thrust in low profile.
- The entire drive train features a hollow centre, enabling efficient transmission of any flushing media to clear the pilot hole.
- A choice of different types of worktables is available. The slide open worktable facilitates downreaming or boxhole applications while the horseshoe fork worktable wrench, as well as the worktable wrench, are available for conventional raise boring only.
- The optional ground loading pipeloader offers maximum flexibility in terms of pipe handling. It is capable of installing all the drillstring components as well as the reamer*** (*** Max. diameter 1060mm).
- The optional high rpm version offers almost twice the production for downreaming applications.

Main specifications

Frame	Low	Standard	Wide
Raise diameter			
Nominal	1.2 (4 ft)	1.2 m (4 ft)	1.2 m (4 ft)
Range*	0.6-1.5 m (2-5 ft)	0.6-1.5 m (2-5 ft)	0.6-1.5 m (2-5 ft)
Raise Length			
Nominal	340 m (1115 ft)	340 m (1115 ft)	340 m (1115 ft)
Maximum*	610 m (2000 ft)	610 m (2000 ft)	610 m (2000 ft)
Drill Pipe			
Diameter	203 mm (8 in)	203 mm (8 in)	254 mm (10 in)
Optional diam.	254 mm (10 in)	254 mm (10 in)	203 mm (8 in)
Length, s/s**	750 mm (2.5 ft)	1219 mm (4 ft)	1219 mm (4 ft)
Pilot Hole			
Diameter	229 mm (9 in)	229 mm (9 in)	279 mm (11 in)
Optional diam.	279 mm (11 in)	279 mm (11 in)	229 mm (9 in)
Torque and Force			
Reaming Torque	64 kNm (47 500 ft-lbs)	64 kNm (47 500 ft-lbs)	64 kNm (47 500 ft-lbs)
Reaming Thrust	1285 kN (289 000 lbs)	1285 kN (289 000 lbs)	1285 kN (289 000 lbs)
Installed Power	110-160 kW (150-215 hp)	110-160 kW (150-215 hp)	110-160 kW (150-215hp)
Main drive	Hydraulic	Hydraulic	Hydraulic
Dimensions			
Height extended	2900 mm (115 in)	3250 mm (128 in)	3350 mm (132 in)
Height retracted	2900 mm (115 in)	3250 mm (128 in)	3350 mm (132 in)
Width	1700 mm (67 in)	1700 mm (67 in)	2200 mm (87 in)
Depth	1650 mm (65 in)	1800 mm (71 in)	2250 mm (89 in)
Weight			
Derrick	7 200 kg (15870 lb)	7 600 kg (16755 lb)	11 100 kg (24470 lb)
Dip adjustment			
from horizontal	90° - 60° (45°)	90° - 60° (45°)	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

44RH

Building on the proven design of our low profile and light weight raise drills, the Robbins 44RH adds higher torque and thrust to a small diameter raise drill. The 44RH is a versatile and high production raise drill, for raise requirements in the smaller diameter range.

Features & Benefits

- The single power pack hydraulic drive features variable speed and good torque limiting control. The well proven RCS system adds reliability and user friendliness.
- Rigid columns provide efficient torque reaction extending the service life of the thrust cylinders.
- Telescopic thrust cylinders provide high thrust in low profile.
- The entire drive train features a hollow centre, enabling efficient transmission of any flushing media to clear the pilot hole.
- The sturdy worktable is available with insert or horse-shoe fork wrench for fast and reliable pipe threading.
- The sideloading pipeloader offers safe and efficient pipe handling.

Main specifications

Raise diameter	
Nominal	1.5 (5 ft.)
Range*	1.0-1.8 m (3.5-6 ft)
Raise Length	
Nominal	340 m (1115 ft)
Maximum*	610 m (2000 ft)
Drill Pipe	
Diameter	203 mm (8 in)
Optional diam.	254 mm (10 in)
Length, s/s**	1219 mm (4 ft)
Pilot Hole	
Diameter	229 mm (9 in)
Optional diam.	254 mm (10 in)
Torque and Force	
Reaming Torque	75 kNm (55 000 ft-lbs)
Reaming Thrust	2000 kN (450 000 lbs)
Installed Power	160 kW (150 hp)
Main drive	Hydraulic
Dimensions	
Height extended	3350 mm (132 in)
Height retracted	3350 mm (132 in)
Width	1750 mm (69 in)
Depth	1600 mm (63 in)
Weight	
Derrick	8 000 kg (17636 lb)
Dip adjustment	
from horizontal	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

53RH

The Robbins 53RH is an unique multi purpose raise drill, able to performe upwards boxhole boring as well as conventional raise boring, without any modifications to the drive assembly. The Robbins 53RH is of low profile design which gives it the most application flexibility in restricted environments.

Features & Benefits

- The hydraulic drive features variable speed and good torque limiting control. The well proven RCS system adds reliability and user friendliness.
- Rigid crosshead guide columns provide efficient torque reaction extending the service life of the thrust cylinders.
- Telescopic thrust cylinders provide high thrust in low profile.
- Unique design with dual drive chucks heads for easy change between boring mode.
- A removable swivel enables efficient flushing in both boxhole boring and raise boring.
- A sliding fork worktable wrench in combination with the optional semi-automatic drive head wrench, eliminates the need to handle heavy wrenches. (Optional).
- The sideloading pipeloader offers safe and efficient pipe handling both in boxhole and raise boring mode.

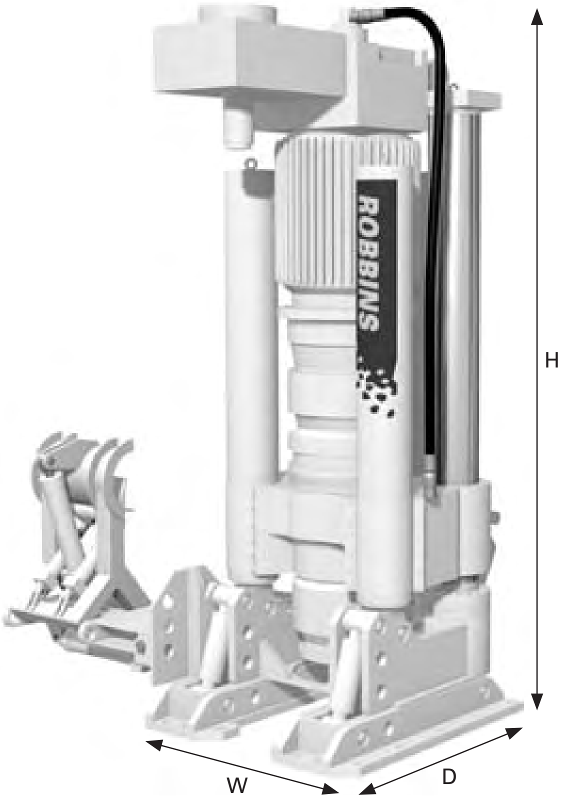
Main specifications

Models	**53RH**	**53RH-EX**
Raise diameter		
Nominal	1.8 m (6 ft)	1.8 m (6 ft)
Range*	1.2-2.4 m (4-8 ft)	1.2-2.4 m (4-8 ft)
Raise Length		
Nominal	490 m (1610 ft)	490 m (1610 ft)
Maximum*	650 m (2130 ft)	650 m (2130 ft)
Drill Pipe		
Diameter	286 mm (11-1/4 in)	286 mm (11-1/4 in)
Length, s/s	750 mm (2.5 ft)	1219 mm (4 ft)
Pilot Hole		
Diameter	311 mm (12-1/4 in)	311 mm (12-1/4 in)
Optional diameter	349 mm (13-3/4 in)	349 mm (13-3/4 in)
Torque and Force		
Reaming Torque	156 kNm (115 000 ft-lbs)	156 kNm (115 000 ft-lbs)
Reaming Thrust	3350 kN (754 000 lbs)	3350 kN (754 000 lbs)
Installed Power	255 kW (340 hp)	255 kW (340 hp)
Main drive	Hydraulic	Hydraulic
Dimensions		
Height extended	2700 mm (106 in)	4000 mm (158 in)
Height retracted	2700 mm (106 in)	3650 mm (144 in))
Width	1900 mm (75 in)	1900 mm (75 in)
Depth	2150 mm (85 in)	2150 mm (85 in)
Weight		
Derrick	14 000 kg (30865 lb)	14 000 kg (30865 lb)
Dip adjustment		
from horizontal	90° - 60° (45°)	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

73R



With more units sold worldwide than any other raise drill model in production, the Robbins 73R has become the reliable workhorse for virtually any raise boring application. The 73R is a medium size raise drill, ranging from 1.5 to 3.1m (5-10ft.) in diameter.

Features & Benefits

- The AC version offers a fixed four speed drive with high durability and maintainability.
- The hydraulic and VF drive features variable speed and good torque limiting control.
- The well proven RCS system adds reliability and user friendliness.
- A patented, two piece swivel float box prevents transfer of bending moments to the gearbox, and a replaceable threaded insert lowers maintenance costs.
- Rigid crosshead guide columns provide efficient torque reaction extending the service life of the thrust cylinders.
- A simple in-line drive system provides balanced thrust loads to improve cutting action.
- A sliding fork worktable wrench in combination with the optional semi-automatic drivehead wrench, eliminates the need to handle heavy wrenches (Optional).
- Small footprint requires a smaller drilling pad and fewer tie down bolts.

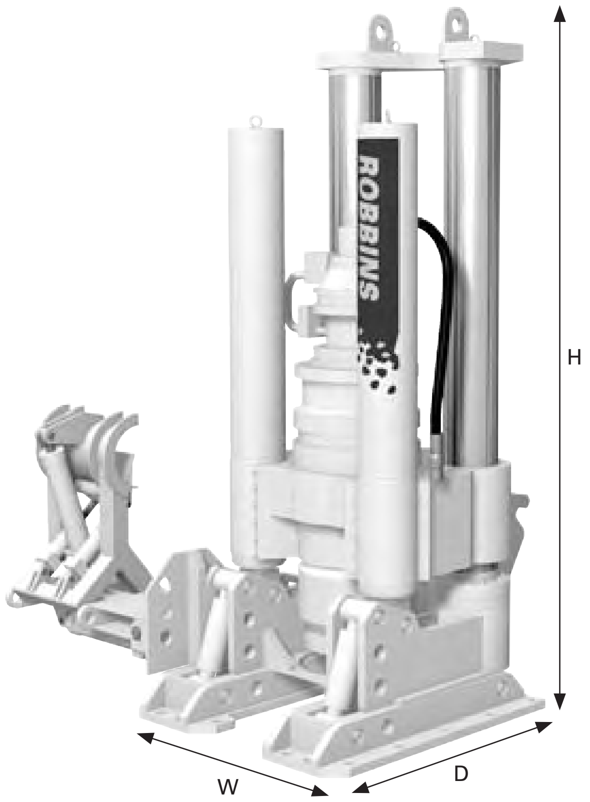
Main specifications

Models	**73RAC**	**73RH**	**73RVF**
Raise diameter			
Nominal	2.1 m (7 ft)	2.1 m (7 ft)	2.1 m (7 ft)
Range*	1.5-2.4 m (5-8 ft)	1.5-3.1 m (5-10 ft)	1.5-3.1 m (5-10 ft)
Raise Length			
Nominal	550 m (1800 ft)	550 m (1800 ft)	550 m (1800 ft)
Maximum*	700 m (2300 ft)	700 m (2300 ft)	700 m (2300 ft)
Drill Pipe			
Diameter	254 mm (10 in)	286 mm (11-1/4 in)	286 mm (11-1/4 in)
Optional diam.	286 mm (11-1/4 in)	254 mm (10 in)	254 mm (10 in)
Length, s/s**	1524 mm (5 ft)	1524 mm (5 ft)	1524 mm (5 ft)
Pilot Hole			
Diameter	279 mm (11 in)	311 mm (12-1/4 in)	311 mm (12-1/4 in)
Optional diam.	311 mm (12-1/4 in)	279 mm (11 in)	349 mm (13-3/4 in)
Torque and Force			
Reaming Torque	173 kNm (128 000 ft-lbs)	225 kNm (166 000 ft-lbs)	225 kNm (166 000 ft-lbs)
Reaming Thrust	4159 kN (935 000 lbs)	4159 kN (935 000 lbs)	4159 kN (935 000 lbs)
Installed Power	215 kW (290 hp)	305 kW (400 hp)	305 kW (400 hp)
Main drive	Electric (AC)	Hydraulic	Electric (VF)
Dimensions			
Height extended	5550 mm (219 in)	5250 mm (207 in)	5900 mm (232 in)
Height retracted	3600 mm (142 in)	3800 mm (150 in)	3850 mm (152 in)
Width	1600 mm (63 in)	1600 mm (63 in)	1600 mm (63 in)
Depth	1900 mm (75 in)	1900 mm (75 in)	1900 mm (75 in)
Weight			
Derrick	12 000 kg (26455 lb)	11 500 kg (25350 lb)	13 000 kg (28660 lb)
Dip adjustment			
from horizontal	90° - 60° (45°)	90° - 60° (45°)	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

83RH



The ruggedly built, large diameter and high torque Robbins 83RH, is one of the toughest raise drills going for the widest applications throughout the mining industry. The 83RH is recommended for reaming shafts and raises from 2.4 up to 4.5 m (8-15 ft.) in diameter.

Features & Benefits

- The hydraulic drive features variable speed and good torque limiting control. The well proven RCS system adds reliability and user friendliness.
- A patented, two piece swivel float box prevents transfer of bending moments to the gearbox, and a replaceable threaded insert lowers maintenance costs.
- Rigid crosshead guide columns provide efficient torque reaction extending the service life of the thrust cylinders.
- A simple in-line drive system provides balanced thrust loads to improve cutting action.
- A sliding fork worktable wrench in combination with the semi-automatic drivehead wrench, eliminates the need to handle heavy wrenches (Optional).
- Small footprint requires a smaller drilling pad and fewer tie down bolts.

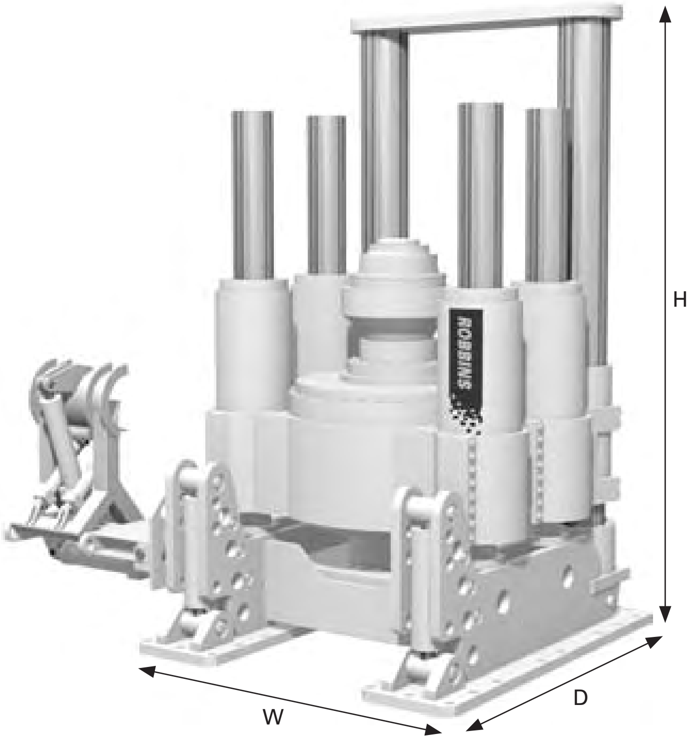
Main specifications

Raise diameter	
Nominal	4.0 m (13 ft)
Range*	2.4-4.5 m (8-15 ft)
Raise Length	
Nominal	500 m (1640 ft)
Maximum*	1000 m (3280 ft)
Drill Pipe	
Diameter	327 mm (12-7/8 in)
Length, s/s**	1524 mm (5 ft)
Pilot Hole	
Diameter	349 mm (13-3/4 in)
Torque and Force	
Reaming Torque	407 kNm (300 000 ft-lbs)
Reaming Thrust	6124 kN (1 376 700 lbs)
Installed Power	455 kW (600 hp)
Main drive	Hydraulic
Dimensions	
Height extended	6000 mm (236 in)
Height retracted	4350 mm (171 in)
Width	1650 mm (65 in)
Depth	2150 mm (85 in)
Weight	
Derrick	20 000 kg (44100 lb)
Dip adjustment	
from horizontal	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

91RH



The Robbins 91RH is the latest addition to the Robbins low profile series that brings the advantage of raise boring to more underground mine locations. Its modular design allows it to be disassembled into relatively small components for easy transport through smaller haulage ways. Yet the powerful hydraulic drive of the 91RH makes it ideal for large raises up to 5,0m (17 ft.).

Features & Benefits

- The hydraulic drive features variable speed and good torque limiting control. The well proven RCS system adds reliability and user friendliness.
- A gearbox incorporated in a barrel allows the drive train to be disassembled into smaller components without loosing the preload of the main bearings. This saves time during maintenance & transportation.
- Rigid crosshead guide columns provide efficient torque reaction extending the service life of the thrust cylinders.
- A simple in-line drive system provides balanced thrust loads to improve cutting action.
- A sliding fork worktable wrench in combination with the semi-automatic drivehead wrench, eliminates the need to handle heavy wrenches.

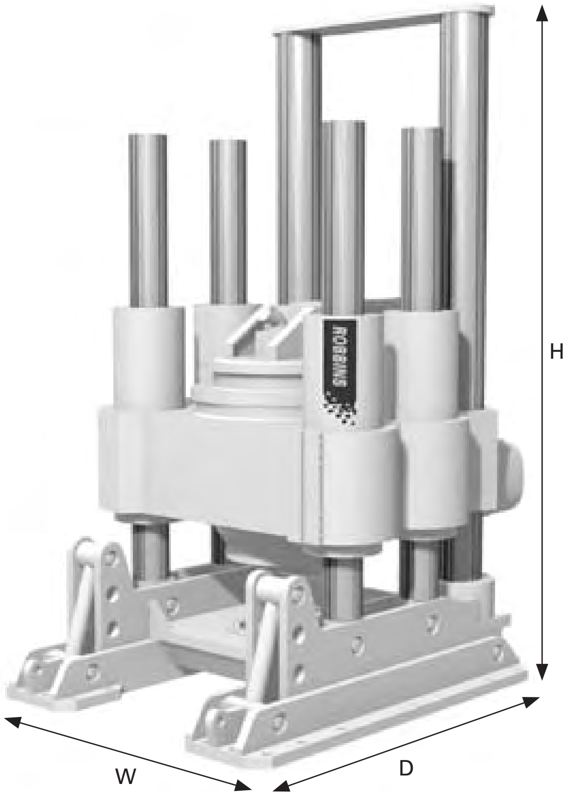
Main specifications

Raise diameter	
Nominal	5.0 m (17 ft)
Range*	2.4-5.0 m (8-17 ft)
Raise Length	
Nominal	600 m (1640 ft)
Maximum*	1000 m (3280 ft)
Drill Pipe	
Diameter	327 mm (12-7/8 in)
Length, s/s**	1524 mm (5 ft)
Pilot Hole	
Diameter	349 mm (13-3/4 in)
Torque and Force	
Reaming Torque	450 kNm (330 000 ft-lbs)
Reaming Thrust	6700 kN (1 510 000 lbs)
Installed Power	500 kW (670 hp)
Main drive	Hydraulic
Dimensions	
Height extended	5100 mm (201 in)
Height retracted	4000 mm (158 in)
Width	2300 mm (91 in)
Depth	2500 mm (99 in)
Weight	
Derrick	24 000 kg (53 000 lb)
Dip adjustment	
from horizontal	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

97RDC



The Robbins 97RDC is a high power and low profile raise drill, specially designed for mines with size and weight restrictions. Despite its low profile, the 97RDC is one of the largest raise drills ever produced. Recommended diameter range is 2.4 up to 5.0 m (8-17 ft.).

Features & Benefits

- The digital DC drive incorporates the latest electric technology. The well proven RCS system adds reliability and user friendliness.
- A patented, two-piece swivel float box prevents transfer of bending moments to the gearbox, and a replaceable threaded insert lowers maintenance costs.
- Rigid crosshead guide columns provide efficient torque reaction extending the service life of the thrust cylinders.
- The low profile lay-out employ an offset drive line with under slung motors, planetary gearing and telescopic cylinders.
- A sliding fork worktable wrench in combination with the semi-automatic drivehead wrench, eliminates the need to handle heavy wrenches.

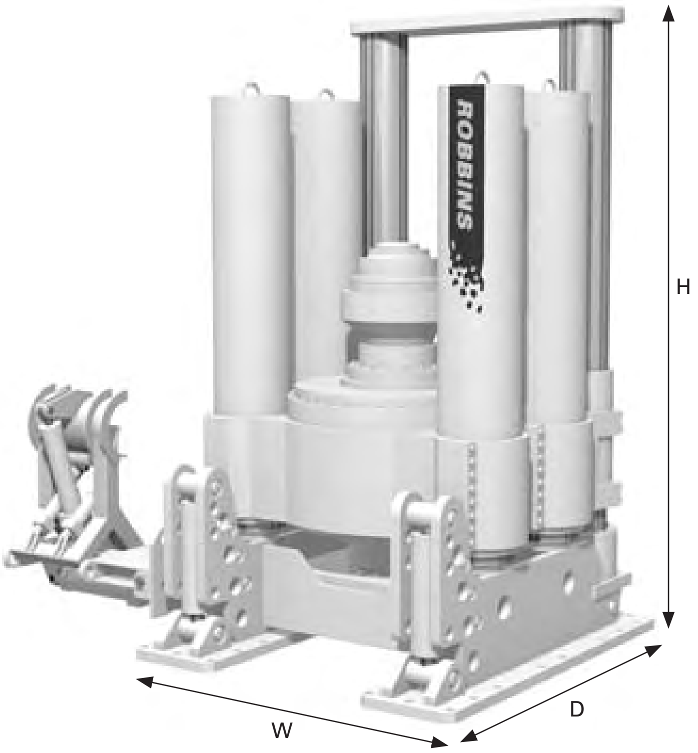
Main specifications

Raise diameter	
Nominal	5.0 m (17 ft)
Range*	2.4-5.0 m (8-17 ft)
Raise Length	
Nominal	600 m (1640 ft)
Maximum*	1000 m (3280 ft)
Drill Pipe	
Diameter	327 mm (12-7/8 in)
Length, s/s**	1524 mm (5 ft)
Pilot Hole	
Diameter	349 mm (13-3/4 in)
Torque and Force	
Reaming Torque	450 kNm (330 000 ft-lbs)
Reaming Thrust	6845 kN (1 538 200 lbs)
Installed Power	375 kW (500 hp)
Main drive	Electric (DC)
Dimensions	
Height extended	4400 mm (173 in)
Height retracted	4400 mm (173 in)
Width	2250 mm (89 in)
Depth	3300 mm (130 in)
Weight	
Derrick	24 000 kg (53 000 lb)
Dip adjustment	
from horizontal	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

123R



Designed for large diameter and long hole raise boring applications, the Robbins 123R is a very powerful raise drill. The 123R is designed for large diameter raises, ranging from 3,1 m up to 6,0 m (10-20 ft.), making it the preferred choice for sinking shafts in mining applications or in civil engineering applications.

Features & Benefits

- The hydraulic or VF drive features variable speed and good torque limiting control. The well proven RCS system adds reliability and user friendliness.
- A gearbox incorporated in a barrel allows the drive train to be disassembled into smaller components without loosing the preload of the main bearings. This saves time during maintenance & transportation.
- Rigid crosshead guide columns provide efficient torque reaction extending the service life of the thrust cylinders.
- A simple in-line drive system provides balanced thrust loads to improve cutting action.
- A sliding fork worktable wrench in combination with the semi-automatic drivehead wrench, eliminates the need to handle heavy wrenches.

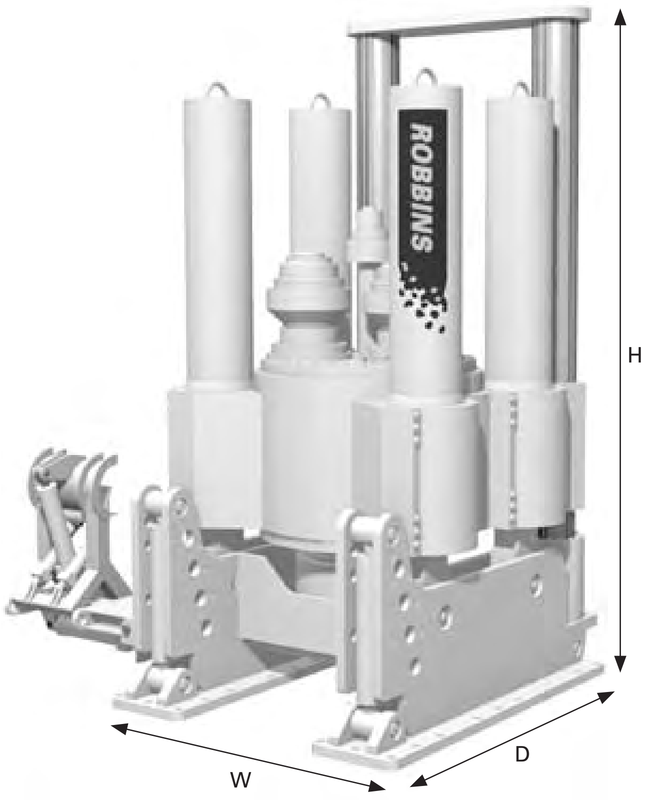
Main specifications

Models	**123RH**	**123RVF**
Raise diameter		
Nominal	4.0 m (13 ft)	5.0 m (17 ft)
Range*	3.1-5.0 m (10-17 ft)	3.1-6.0 m (10-20 ft)
Raise Length		
Nominal	920 m (3020 ft)	920 m (3020 ft)
Maximum*	1100 m (3610 ft)	1100 m (3610 ft)
Drill Pipe		
Diameter	327 mm (12-7/8 in)	352 mm (13-7/8 in)
Optional diameter	352 mm (13-7/8 in)	327 mm (12-7/8 in)
Length, s/s	1524 mm (5 ft)	1524 mm (5 ft)
Pilot Hole		
Diameter	349 mm (13-3/4 in)	381 mm (15 in)
Optional diameter	381 mm (15 in)	349 mm (13-3/4 in)
Torque and Force		
Reaming Torque	450 kNm (330 000 ft-lbs)	540 kNm (398 000 ft-lbs)
Reaming Thrust	8923 kN (2 000 000 lbs)	8923 kN (2 000 000 lbs)
Installed Power	500 kW (670 hp)	525 kW (700 hp)
Main drive	Hydraulic	Electric (VF)
Dimensions		
Height extended	5700 mm (224 in)	5800 mm (228 in)
Height retracted	TBA (TBA)	TBA (TBA)
Width	2300 mm (91 in)	2300 mm (91 in)
Depth	2500 mm (99 in)	2500 mm (99 in)
Weight		
Derrick	25 400 kg (56000 lb)	25 400 kg (56000 lb)
Dip adjustment		
from horizontal	90° - 60° (45°)	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

191RH



Designed for large diameter and long hole raise boring applications, the Robbins 191RH is the most powerful raise drill in the Atlas Copco Raise Boring series. The 191RH is designed to meet the requirements for very long, large raises, ranging from 4,5m to 6,0 m (15-20 ft.) to a depth of 1400m (4500 ft.)

Features & Benefits

- The hydraulic drive features variable speed and good torque limiting control. The well proven RCS system adds reliability and user friendliness.
- A gearbox incorporated in a barrel allows the drive train to be disassembled into smaller components without loosing the preload of the main bearings. This saves time during maintenance & transportation.
- Rigid crosshead guide columns provide efficient torque reaction extending the service life of the thrust cylinders.
- A simple in-line drive system provides balanced thrust loads to improve cutting action.
- A sliding fork worktable wrench in combination with the semi-automatic drivehead wrench, eliminates the need to handle heavy wrenches.

Main specifications

Raise diameter	
Nominal	5.0 m (17 ft)
Range*	4.5-6.0 m (15-20 ft)
Raise Length	
Nominal	1000 m (3280 ft)
Maximum*	1400 m (4590 ft)
Drill Pipe	
Diameter	375 mm (14-3/4 in)
Length, s/s**	1524 mm (5 ft)
Pilot Hole	
Diameter	381 mm (15 in)
Torque and Force	
Reaming Torque	814 kNm (600 375 ft-lbs)
Reaming Thrust	11 600 kN (2 607 800 lbs)
Installed Power	750 kW (1000 hp)
Main drive	Hydraulic
Dimensions	
Height extended	6500 mm (256 in)
Height retracted	4600 mm (181 in)
Width	2300 mm (91 in)
Depth	2700 mm (106 in)
Weight	
Derrick	45 000 kg (99 200 lb)
Dip adjustment	
from horizontal	90° - 60° (45°)

* Depending on machine version and rock conditions
** Shoulder to shoulder

Visit **www.raiseboring.com** for more information

Power Pack

Main Drive pack

On a hydraulic driven machine the hydrostatic drive provides hydraulic power to the hydraulic motor(s). It consists of a fully enclosed, skid equipped mounting frame with an oil pan, a hydraulic reservoir and a 3-phase motor equipped with strip heaters driving one variable displacement pump. Mounted in the pack are return line filters, heat exchanger, breather and manifold assembly. The power pack may also be equipped with a built-in fire suppression system. The electrical cabinet is accessed separately on one side of the unit. It contains most of the electrical control components such as circuit breakers, earth fault relay, under/over voltage relay & control transformer.

On an electric driven machine (AC, DC or VF) the main drive pack contains the power and control distribution hardware and circuitry for the entire raise boring system. The cabinet is fully enclosed and may incorporate heaters for humidity control. A simple and reliable softstart provides the control for the AC motor.

The latest digital DC drives ensure the best possible performance of the DC motor. State of the art VF drives are available upon request. Included are also components such as circuit breakers, earth fault relay, under/over voltage relay & control transformer.

Thrust pack

The thrust pack provides hydraulic power to the derrick assembly auxiliary components. It consists of a fully enclosed, skid equipped, mounting frame with an oil pan, a hydraulic reservoir and a 3-phase motor equipped with strip heaters driving two variable displacement pumps, one for the fast traverse circuit and one for the high thrust system. It also drives one gear pump for the auxiliary and cooling circuits.

Features & Benefits

- Compact and lightweight enclosure for protection in underground environment.
- Lifting lugs and fork lift provisions for easy lifting and positioning.
- Thanks to the use of integrated technology, the number of components and wiring in the cabinet can be kept to a minimum.
- Modern proportional valves in the hydraulic system allow for safe and smooth operation.
- Service lights inside the units are turned on automatically when doors are opened.
- Can be equipped with optional service receptacles for connecting additional equipment.

Specifications

Depending on machine specification and type of drive, the number of power packs and the dimensions of the power packs may vary. Most Robbins raise drills however use two packs. One for the main drive system (rotation) and one for thrust. Each unit is built to withstand the harsh environment in underground mining and uses standard Atlas Copco components.

Power Pack		Length		Height		Width		Weight	
		metric	imperial	metric	imperial	metric	imperial	metric	imperial
34RH Low	Single pack	3300 mm	130 inch	1450 mm	57 inch	1550 mm	61 inch	5500 kg	12125 lb
34RH Standard	Single pack	3300 mm	130 inch	1450 mm	57 inch	1550 mm	61 inch	5500 kg	12000 lb
34RH Wide	Single pack	3300 mm	130 inch	1450 mm	57 inch	1550 mm	61 inch	5500 kg	12000 lb
44RH	Single pack	3300 mm	130 inch	1450 mm	57 inch	1550 mm	61 inch	5500 kg	12000 lb
53RH	Drive pack	2800 mm	111 inch	1450 mm	57 inch	1500 mm	59 inch	4250 kg	9400 lb
	Thrust pack	2200 mm	87 inch	1450 mm	57 inch	1300 mm		2400 kg	5300 lb
53RH-EX	Drive pack	2800 mm	111 inch	1450 mm	57 inch	1500 mm	59 inch	4250 kg	9400 lb
	Thrust pack	2200 mm	87 inch	1450 mm	57 inch	1300 mm	52 inch	2400 kg	5300 lb
73RH	Drive pack	2800 mm	111 inch	1450 mm	57 inch	1500 mm	59 inch	4250 kg	9400 lb
	Thrust pack	2200 mm	87 inch	1450 mm	57 inch	1300 mm	52 inch	2400 kg	5300 lb
73RAC	Drive pack	1900 mm	75 inch	1300 mm	52 inch	800 mm	32 inch	900 kg	2000 lb
	Thrust pack	2200 mm	87 inch	1450 mm	57 inch	1300 mm	52 inch	2400 kg	5300 lb
73RVF	Drive pack	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
	Thrust pack	2200 mm	87 inch	1450 mm	57 inch	1300 mm	52 inch	2400 kg	5300 lb
83RH	Drive pack	3000 mm	119 inch	1450 mm	57 inch	1600 mm	63 inch	4800 kg	10600 lb
	Thrust pack	2200 mm	87 inch	1450 mm	57 inch	1300 mm	52 inch	2400 kg	5300 lb
91RH	Drive pack	3300 mm	130 inch	1450 mm	57 inch	1600 mm	63 inch	5000 kg	11000 lb
	Thrust pack	2400 mm	95 inch	1450 mm	57 inch	1300 mm	52 inch	3300 kg	7300 lb
97RL	Drive pack	2550 mm	101 inch	1500 mm	59 inch	1300 mm	52 inch	1800 kg	4000 lb
	Thrust pack	2400 mm	95 inch	1450 mm	57 inch	1300 mm	52 inch	3300 kg	7300 lb
123RH	Drive pack	3300 mm	130 inch	1450 mm	57 inch	1600 mm	63 inch	5000 kg	11000 lb
	Thrust pack	2400 mm	95 inch	1450 mm	57 inch	1300 mm	52 inch	3300 kg	7300 lb
123RVF	Drive pack	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
	Thrust pack	2400 mm	95 inch	1450 mm	57 inch	1300 mm	52 inch	3300 kg	7300 lb
191RH	Drive pack	3500 mm	138 inch	1450 mm	57 inch	2000 mm	79 inch	7500 kg	16500 lb
	Thrust pack	2400 mm	95 inch	1450 mm	57 inch	1300 mm	52 inch	3300 kg	7300 lb

Transporters

Transporters are used for transporting the derrick to and from the boring site. Additionally the transporters are equipped with hydraulic cylinders for derrick erection during system setup and derrick take-down after completion of the raise. Atlas Copco offers different types of transporters to suit different needs.

Diesel Crawler

The diesel powered crawler is equipped with integrally suspended twin crawler tracks, separately powered by hydraulic motors. The diesel engine drives two hydraulic pumps, one for the tracks, and one for the fan/erection. The track drives are driven by a variable displacement pump and controlled by two proportional valves, each valve controlling a dual displacement motor, which in turn are mounted to planetary-type final drive units.

These final drive units are mounted inside of the rear track drive sprockets. The diesel engine also provides power to the erection system making the crawler an independent unit. Controls are either radio remote or via an umbilical cord. The high and low speed in combination with proportional controls makes the crawler easy to control and the powerful diesel engine ensures adequate manoeuvrability.

Diesel Crawler

Air Crawler

The air crawler is equipped with twin crawler tracks, integrally suspended and separately powered by a hydraulic motor in each track with dual displacement, mounted to planetary-type final drive units The hydraulic pump is driven by an air motor. In order to operate, the crawler must be supplied with compressed air at max. 6 bar (90 PSI) and minimum 15 m^3/min (500 ft^3/min) air supply. The air motor also drives a hydraulic pump for powering the erection system. There is also an air-driven 24 V generator on the crawler for supply of its electric circuits. The erection system comprises two proportionally controlled hydraulic cylinders. Controls are either radio remote or via an umbilical cord.

Air Crawler

Sled

The sled is the simplest form of transporter. Skids are provided on the sled to enable the derrick to be transported and positioned by use of an independent mine transport source. The hydraulic erection cylinders of the sled must be connected to the hydraulic system of the raise boring machine for derrick erection and derrick take-down. An optional electrical powered power pack can be supplied.

Sled

Conversions factors

This unit → Times → Equals

Length

mm (millimetres)	x 0.001	= m
cm (centimetres)	x 0.01	= m
dm (decimetres)	x 0.1	= m
km (kilometres)	x 1000	= m
in (inches)	x 25.4	= mm
ft (feet)	x 0.305	= m
yd (yard)	x 0.914	= m
miles	x 1609	= m

Power

kW (kilowatts)	x 1000	= W
Horsepower	x 735.5	= W
Horsepower, U.K.	x 745.7	= W
ft.lbf/sec	x 1.36	= W
Btu/h	x 0.29	= W

Volume

1 (litres)	x 0.001	= m^3
ml (millilitres)	x 0.001	= l
dm^3 (cubic decimetres)	x 1.0	= l
cm^3 (cubic decimetres)	x 1.0	= ml
mm^3 (cubic millimetres)	x 0.001	= ml
in^3 (cubic inches)	x 16.39	= ml
ft^3 (cubic feet)	x 28.316	= l
Imperial gallon	x 4.546	= l
U.S. gallon	x 3.785	= l
Ounces (Imp. fluid oz)	x 28.41	= ml
Ounces (U.S. fluid oz)	x 29.57	= ml
Pints (U.S. llq.)	x 0.4732	= l
Quarts (U.S. liq.)	x 0.9463	= l
yd^3 (cubic yards)	x 0.7646	= m^3

Force

kN (kilonewton)	x 1000	= N
kp (kilopond)	x 9.81	= N
kgf (kilogramme force)	x 9.81	= N
lbf (pound force)	x 4.45	= N

Torque

kpm (kilopondmetres)	x 9.81	= Nm
lbf in (poundforce inch)	x 0.11	= Nm
lbf ft (poundforce foot)	x 1.36	= Nm

Equals ← Divided by ← This unit

This unit → Times → Equals

Mass (weight)

g (grammes)	x 0.001	= kg
t (tonnes, metric)	x 1000	= kg
grains	x 0.0648	= g
oz (ounce)	x 28.35	= g
ozt (troy ounce)	x 31.10	= g
lb (pounds)	x 0.4536	= kg
tons (long, US)	x 1016	= kg
tons (U.K)	x 1016	= kg
tons (short)	x 907	= kg

Speed

km/h (kilometres/hour)	x 0.2777	= m/s
m/s	x 3.6	= km/h
mph (miles/hour)	x 0.45	= m/s
mph	x 1.61	= km/h
ft/s (foot/second)	x 0.3048	= m/s
ft/s (foot/second)	x 18.29	= m/min
ft/s (foot/minute)	x 0.3048	= m/min

Frequency

blows/minute	x 0.017	= Hz
kHz (kiloHertz)	x 1000	= Hz
r/min (rev./minute)	x 0.01667	= r/s
degrees/second	x 0.1667	= r/min
radians/second	x 0.1592	= r/s

Pressure

bar	x 100	= kPa
bar	x 100 000	= Pa
kp/cm^2	x 0.98	= bar
atm (atmospheres)	x 1.01	= bar
psi (pounds/in^2)	x 6.895	= kPa
psi	x 0.06895	= bar

Area

mm^2 (square mm)	x 0.000001	= m^2
cm^2 (square cm)	x 0.0001	= m^2
in^2 (square inches)	x 645	= mm^2
ft^2 (square feet)	x 0.929	= m^2
yd^2 (square yards)	x 0.8361	= m^2
Acres	x 4047	= m^2
Square miles	x 2.590	= km^2

Equals ← Divided by ← This unit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