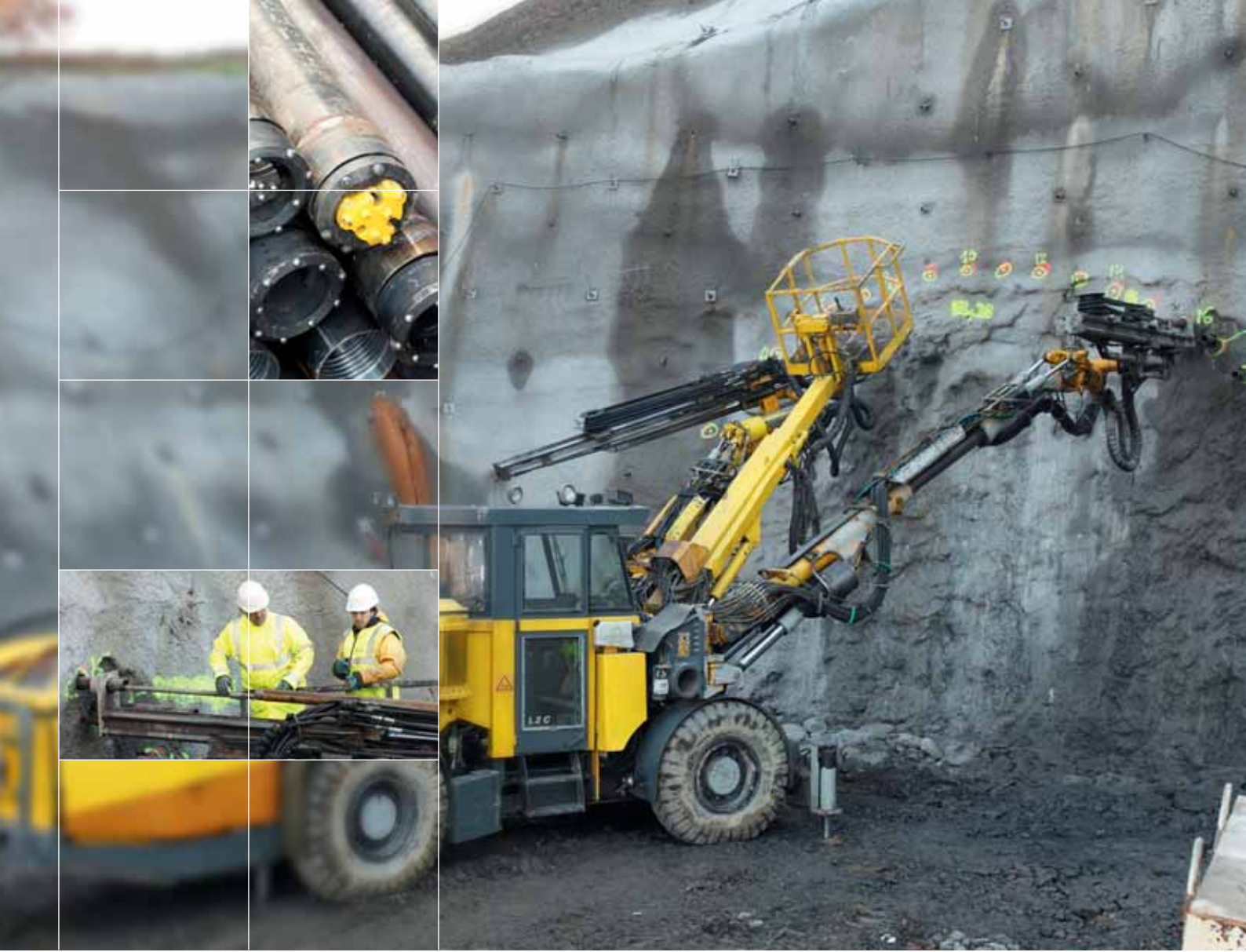


Atlas Copco Geotechnical Engineering Products

Pipe roofing solutions



Sustainable Productivity



Pipe roofing solutions

– pre-support in tunnel constructions

Cities and urban areas around the world are continuously being modernized and infrastructures developed to match an increasing traffic flow. As a result, tunneling projects are moving into more challenging conditions such as soil, weak rock and shallow overburden in already developed areas. No matter what challenges a tunneling project is facing, compromises can never be made on safety and economical efficiency. This calls for innovative and reliable methods of ground support.

Settlements from excavation

Tunnel excavation causes stresses to the ground that may result in settlements. The effect of settlements is hazardous not only to nearby buildings and structures but also to the people working inside the tunnel. The answer to these challenges is pre-support, a method of pre-reinforcing the formation ahead of the tunnel face to ensure that the excavation can proceed safely until heavier and permanent support structures have been installed.

Pre-support increases stability

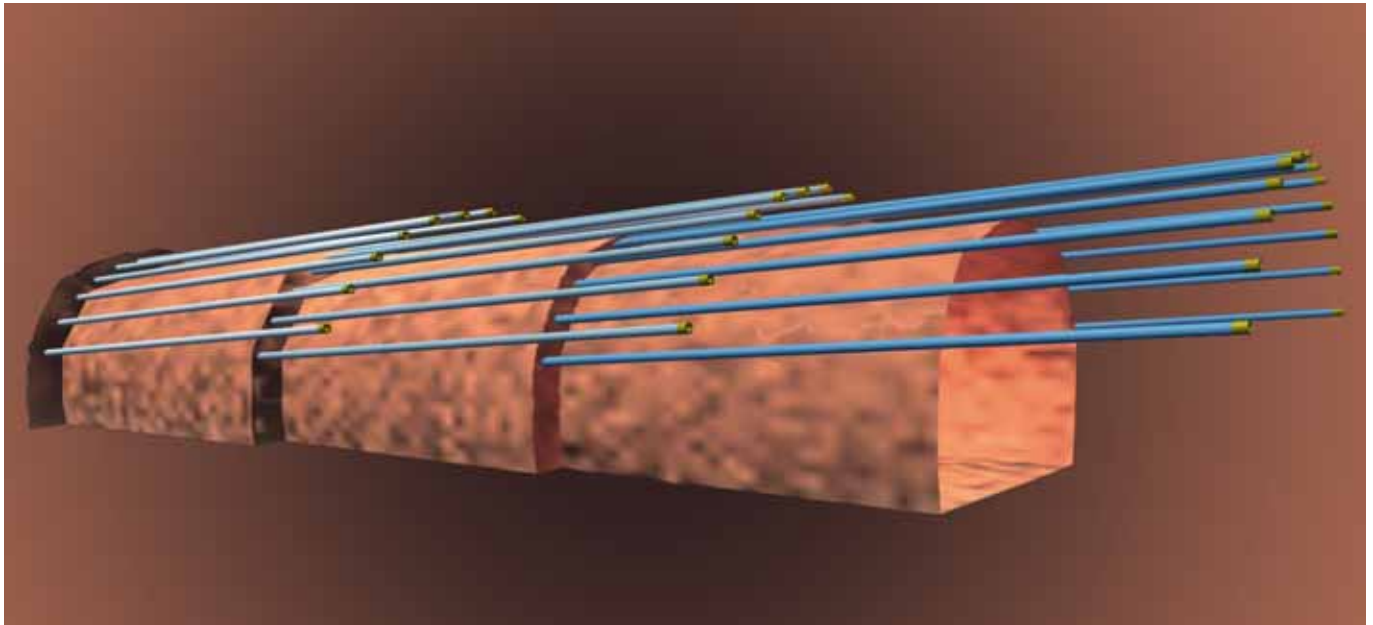
Over the last decades, technical developments have led to an increased use

of different pre-support technologies preventing unwanted accidents and protecting surrounding structures from damages. Some of these methods, such as freezing and jet grouting, are known as both cost and time consuming while the method known as pipe roofing is becoming increasingly popular and has many economical advantages. The experience gained from several tunnel projects, indicates that the pipe roof support method not only increases the stability of the tunnel itself as well as the working face, but it also significantly decreases the subsidence induced by the excavation. The popularity of this pre-support method has led to many

different names. You might recognize it as Umbrella, Tube Umbrella, Pipe Canopy or Fore Poling.

The principles of pipe roofing

In implementing the method, steel pipes are installed ahead of the tunnel face arranged like an umbrella or canopy around the excavation line. The umbrella stabilizes and protects the ceiling and face of the tunnel by increasing the load bearing capacity of the ground. Thanks to the rigidity of the steel pipes, distribution of loads will be improved and the critical spot will be moved further ahead of the working face.



High flexibility

The pipe roof support method is a pre-support concept widely used in conventional tunneling, but has also gained interest as a support system for TBM tunnels. This method of supporting potentially unstable ground ahead of the excavation face provides a high degree of flexibility and is easily adapted to the encountered conditions.

Cost-efficient and easy to adapt

Requiring only standard equipment and little training of your operator crew, your investment in employing special machinery or contractors is notably reduced.

Maximized safety

By reinforcing the ground ahead of the excavation, the ground is never without support. This means that the installation of regular tunnel support can be carried out more effectively and with increased safety for the operators.

Extended possibilities

Using the same principals, installation method and equipment, perforated PVC and steel pipes can be installed for drainage purposes, bringing added value in controlling the ground water, especially in extreme conditions.

A complete package

Atlas Copco has a long history and extensive experience in delivering products for ground support and rock reinforcement. By introducing a system solution with optimized products dedicated for pipe roofing, customers can now take full advantage of Atlas Copco's vast experience. The Pipe Roof System offers high quality products perfectly matched together for maximized safety. In combination with Atlas Copco's wide range of capital equipment for drilling and grouting, we are delivering a unique turnkey solution for improved productivity..

Designing a pipe roof

Engineers consider various measures for design including ground properties, overhead height, tunnel geometry, load analysis, and last but not least the surrounding structures, especially above the tunnel with regards to settlement analysis.

The most critical specifications of the pipe roof, from a design point of view are:

- (outer) diameter of the pipes
- wall thickness
- length of pipes and overlap
- spacing of the pipes

Generally, pipes with outer diameter of 76-140 mm and wall thickness of 6-10 mm are installed using standard tunneling equipment. In some specific cases, larger diameter pipes might be installed using special rigs and Down-The-Hole drilling method.

The pipe roof length is commonly 9-18 metres and due to the overlap the excavated length underneath is around 3-6 metres shorter.

A complete package from Atlas Copco

Atlas Copco offers a complete package for pipe roofing, including everything from consumables to drilling and grouting equipment.



Symmetrix - at the heart of the system

The centerpiece of the package is the well-known and well-proved Symmetrix casing advancement system. The Symmetrix system is a solution for concentric drilling and simultaneously advancing of pipes and offers several benefits in pipe roofing.



The Symmetrix system components

- a **pilot bit** which drills the center part of the hole and transfers the impact energy to the ring bit
- a **ring bit set**, which is an integrated ring bit and casing shoe, welded to the front of first pipe, known as the starter pipe. The ring bit, which is connected to the pilot bit through locking mechanism, drills the void needed to advance the pipe into the ground simultaneous to drilling.

Straightness

In pipe roofing applications, straightness is vital in both design as well as economical aspects. Symmetrix systems have proved to drill very straight holes thanks to their centric design and smooth drilling.

Internal flushing

Atlas Copco Symmetrix system, is designed so that the flushing media (mainly water in this application) transports the drill cuttings from the bit face, back inside the pipes. Considering the fact that the system is used when ground is poor or unconsolidated, internal flushing allows for drilling the pipes with no disturbance to the ground.

Efficiency and productivity

Symmetrix systems can drill at high speed in virtually any ground. Customers can rest assured that the pipes will be installed successfully and efficiently independent of the encountered ground formation. The easiness to unlock and lock the pilot bit from the ring bit set also adds to the high productivity offered by the Symmetrix system.

Less torque

The Symmetrix systems advances the pipes by impact energy simultaneously to drilling a hole slightly larger than the outer diameter of the pipes. This means, the pipe is not rotated while drilling, requiring less torque than alternative solutions. Customers can thereby utilize relatively small drilling rigs.

Drill string

The Speed Rod with wrench flat from Atlas Rock Drilling tools (Secoroc) is suitable for this application and commonly used. Due to practical principles, Speed Rods (male-female) with wrench flats are widely used. Since the flushing media used in pipe roofing is water, all rods provided are fully carburized to increase life expectancy and durability.



Steel pipes

The pipes included in the Pipe Roof System offer are:

Starter pipe. The first pipe section welded to the ring bit set on one end and female threaded on the other end.

Extension pipe. A male-female threaded pipe section used to extend the pipe to desire length.

End pipe. The end pipe can be either an extension pipe or a pipe section with no thread at the rear (mouth) depending on the used practice for grouting.



Threads

All pipes have trapezoidal thread with double start and 10mm entrance and thread ran out to assure easy make up of the joints.

Welding

The Symmetrix ring bit set is welded to the front of the starter pipe using an automated robot to enhance the quality of welding and quality consistency.

Optional injection valves

Pipes can be delivered with 12mm or 16mm injection valves for respectively 3-5bar or +10bar injection.

Accessories

To complete the offer, a range of different tools and accessories including suitable wrenches, centralizers and injection caps can be provided when necessary.

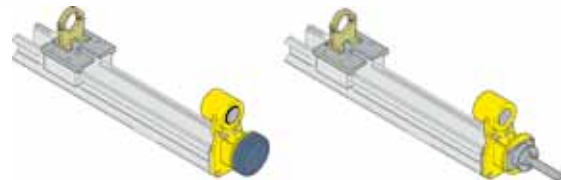
Capital equipment for pipe roofing

Tunneling face drilling rigs

Atlas Copco Boomer tunneling rigs are used world wide for pipe roofing applications. These high-capacity drill rigs can meet all your demands from 6 to 206 m² coverage area. The unique Atlas Copco boom system offers outstanding flexibility and precision to ensure straight-hole drilling performance in high-quality tunnelling.

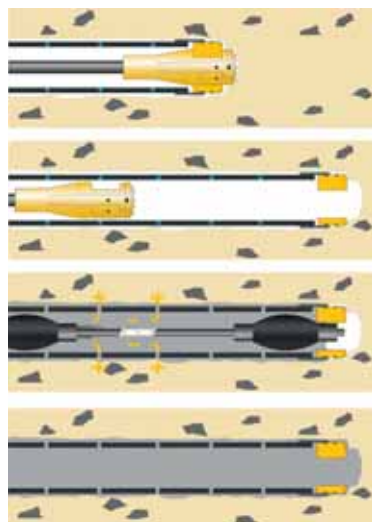


The front and middle guides are replaced to an application specific design for easy handling of the pipes.



Grouting equipment

Atlas Copco offers compact platform mounted grouting equipment very well suited for pipe roofing. The Atlas Copco Unigrout range is designed to fulfill customers requirements for high quality grouting to seal, strengthen or consolidate formations and structures. Unigrouts for pipe roofing as well as tunneling applications are mainly electric driven.



Cement grout is commonly used for filling the gap between the pipes and ground. A grout cap at the pipe mouth is used and backfill grouting applied. However, sometimes customers use pipes with one way injection valves for injecting grout with higher pressure providing improved grouting quality and further consolidated ground. In these cases, double packers might be utilized.

Specifications



Pipe Roof System - range

Atlas Copco offers systems with pipe diameters ranging from 76.1 to 139.7 mm and wall thickness ranging from 6.3 to 10.0 mm.

Pipe quality and steel grade

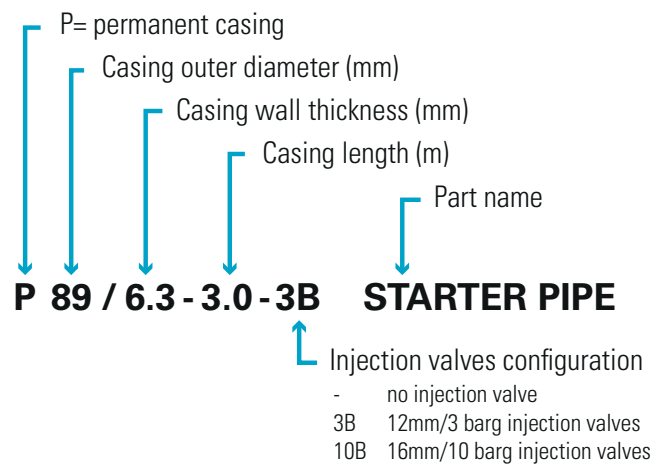
Pipes or casings in the Atlas Copco Pipe Roof standard assortment are made out of high-quality, first hand steel pipes longitudinally welded with removed welding seam. This ensures a completely round shape and good straightness along the pipe. Steel grade and other characteristics are shown in below table.

| Steel grade and properties | | | | | | | | | |
|----------------------------|-----------|---------------------------------|---------------------------------------|---------------------|-------|--------|-------|-------|--------|
| EN 10025 | DIN 17100 | Yield min. (N/mm ²) | Tensile strength (N/mm ²) | Elongation min. (%) | C max | Mn max | P max | S max | Si max |
| S355 | St 52-3 | 355 | 490 - 630 | 22 | 0.2 | 1.6 | 0.035 | 0.035 | 0.55 |

Note: Other Steel Grades can be provided upon request

Designation Code

The product designation code to the right is applicable for the pipe products presented in the tables on the following pages. For Symmetrix pilot bit designation and detailed specifications, please refer to product catalogue (PMI 6991 1570 01).



Product listing

All below listed products are suited for installation of pipe roofs using top hammer drilling technique. Other length and wall thickness can be provided upon request. Larger pipe diameters for installation using special rigs and DTH drilling method can be offered upon request

| Atlas Copco Pipe Roof, outer casing diameter 76,2 mm (3") | | | | |
|--|---|-------------------------------|--------------------|----------------|
| Wall thickness (mm) | Part | Designation | Pipe Weight (kg/m) | Product Number |
| max 8.0 | Symmetrix Pilot Bit | P76/8-41-R32 | | 8092402214 |
| 7.1 | Starter Pipe Complete | P76/7.1-2.95-STARTER PIPE | 12.1 | 8092420006 |
| | Extension Pipe | P76/7.1-3.0-EXT PIPE | | 8092420007 |
| | End Pipe | P76/7.1-3.0-END PIPE | | 8092420128 |
| | Starter Pipe Complete with Injection Valves | P76/7.1-2.95-3B-STARTER PIPE | 12.1 | 8092420008 |
| | Extension Pipe with Injection Valves | P76/7.1-3.0-3B-EXT PIPE | | 8092420009 |
| | End Pipe with Injection Valves | P76/7.1-3.0-3B-END PIPE | | 8092420129 |
| | Starter Pipe Complete with Injection Valves | P76/7.1-2.95-10B-STARTER PIPE | 12.1 | 8092420010 |
| | Extension Pipe with Injection Valves | P76/7.1-3.0-10B-EXT PIPE | | 8092420011 |
| | End Pipe with Injection Valves | P76/7.1-3.0-10B-END PIPE | | 8092420130 |
| | Injection Cap with 1" connection | P76/INJECTION CAP | | 8092420131 |

| Atlas Copco Pipe Roof, outer casing diameter 88,9 mm (3 1/2") | | | | |
|--|---|-------------------------------|--------------------|----------------|
| Wall thickness (mm) | Part | Designation | Pipe Weight (kg/m) | Product Number |
| max 8.0 | Symmetrix Pilot Bit | P89/8-54-T38 | | 8092400954 |
| 6.3 | Starter Pipe Complete | P89/6.3-2.95-STARTER PIPE | 12.8 | 8092420014 |
| | Extension Pipe | P89/6.3-3.0-EXT PIPE | | 8092420015 |
| | End Pipe | P89/6.3-3.0-END PIPE | | 8092420162 |
| | Starter Pipe Complete with Injection Valves | P89/6.3-2.95-3B-STARTER PIPE | 12.8 | 8092420018 |
| | Extension Pipe with Injection Valves | P89/6.3-3.0-3B-EXT PIPE | | 8092420019 |
| | End Pipe with Injection Valves | P89/6.3-3.0-3B-END PIPE | | 8092420163 |
| | Starter Pipe Complete with Injection Valves | P89/6.3-2.95-10B-STARTER PIPE | 12.8 | 8092420020 |
| | Extension Pipe with Injection Valves | P89/6.3-3.0-10B-EXT PIPE | | 8092420021 |
| | End Pipe with Injection Valves | P89/6.3-3.0-10B-END PIPE | | 8092420164 |
| 7.1 | Starter Pipe Complete | P89/7.1-2.95-STARTER PIPE | 14.3 | 8092420022 |
| | Extension Pipe | P89/7.1-3.0-EXT PIPE | | 8092420023 |
| | End Pipe | P89/7.1-3.0-END PIPE | | 8092420132 |
| | Starter Pipe Complete with Injection Valves | P89/7.1-2.95-3B-STARTER PIPE | 14.3 | 8092420026 |
| | Extension Pipe with Injection Valves | P89/7.1-3.0-3B-EXT PIPE | | 8092420027 |
| | End Pipe with Injection Valves | P89/7.1-3.0-3B-END PIPE | | 8092420133 |
| | Starter Pipe Complete with Injection Valves | P89/7.1-2.95-10B-STARTER PIPE | 14.3 | 8092420028 |
| | Extension Pipe with Injection Valves | P89/7.1-3.0-10B-EXT PIPE | | 8092420029 |
| | End Pipe with Injection Valves | P89/7.1-3.0-10B-END PIPE | | 8092420134 |

Atlas Copco Pipe Roof, outer casing diameter 88,9 mm (3 1/2") - continues from previous page

| Wall thickness (mm) | Part | Designation | Pipe Weight (kg/m) | Product Number |
|---------------------|---|-------------------------------|--------------------|----------------|
| 8.0 | Starter Pipe Complete | P89/8.0-2.95-STARTER PIPE | 15.9 | 8092420030 |
| | Extension Pipe | P89/8.0-3.0-EXT PIPE | | 8092420031 |
| | End Pipe | P89/8.0-3.0-END PIPE | | 8092420135 |
| | Starter Pipe Complete with Injection Valves | P89/8.0-2.95-3B-STARTER PIPE | 15.9 | 8092420034 |
| | Extension Pipe with Injection Valves | P89/8.0-3.0-3B-EXT PIPE | | 8092420035 |
| | End Pipe with Injection Valves | P89/8.0-3.0-3B-END PIPE | | 8092420136 |
| | Starter Pipe Complete with Injection Valves | P89/8.0-2.95-10B-STARTER PIPE | 15.9 | 8092420036 |
| | Extension Pipe with Injection Valves | P89/8.0-3.0-10B-EXT PIPE | | 8092420037 |
| | End Pipe with Injection Valves | P89/8.0-3.0-10B-END PIPE | | 8092420137 |
| | Injection Cap with 1" ball valve | P89/INJECTION CAP BV | | 8092420046 |
| | Injection Cap with 1" connection | P89/INJECTION CAP | | 8092420141 |

Atlas Copco Pipe Roof, outer casing diameter 101,6 mm (4")

| Wall thickness (mm) | Part | Designation | Pipe Weight (kg/m) | Product Number |
|---------------------|---|-------------------------------|--------------------|----------------|
| max 8.0 | Symmetrix Pilot Bit | P102/8-65-T38 | | 8092402721 |
| 7.1 | Starter Pipe Complete | P102/7.1-2.95-STARTER PIPE | 16.5 | 8092420048 |
| | Extension Pipe | P102/7.1-3.0-EXT PIPE | | 8092420049 |
| | End Pipe | P102/7,1-3.0-END PIPE | | 8092420142 |
| | Starter Pipe Complete with Injection Valves | P102/7.1-2.95-3B-STARTER PIPE | 16.5 | 8092420050 |
| | Extension Pipe with Injection Valves | P102/7.1-3.0-3B-EXT PIPE | | 8092420051 |
| | End Pipe with Injection Valves | P102/7.1-3.0-3B-END PIPE | | 8092420143 |
| 8.0 | Starter Pipe Complete | P102/8.0-2.95-STARTER PIPE | 18.5 | 8092420054 |
| | Extension Pipe | P102/8.0-3.0-EXT PIPE | | 8092420055 |
| | End Pipe | P102/8.0-3.0-END PIPE | | 8092420165 |
| | Starter Pipe Complete with Injection Valves | P102/8.0-2.95-3B-STARTER PIPE | 18.5 | 8092420056 |
| | Extension Pipe with Injection Valves | P102/8.0-3.0-3B-EXT PIPE | | 8092420057 |
| | End Pipe with Injection Valves | P102/8.0-3.0-3B-END PIPE | | 8092420166 |
| | Injection Cap with 1" connection | P102/INJECTION CAP | | 8092420060 |

Product listing

| Atlas Copco Pipe Roof, outer casing diameter 114,3 mm (4 1/2") | | | | |
|---|---|--------------------------------|---------------------------|-----------------------|
| Wall thickness (mm) | Part | Designation | Pipe Weight (kg/m) | Product Number |
| max 10.0 | Symmetrix Pilot Bit | P114/10-75-T38 | | 8092401737 |
| 6.3 | Starter Pipe Complete | P114/6.3-2.95-STARTER PIPE | 16.8 | 8092420062 |
| | Extension Pipe | P114/6.3-3.0-EXT PIPE | | 8092420063 |
| | End Pipe | P114/6.3-3.0-END PIPE | | 8092420168 |
| | Starter Pipe Complete with Injection Valves | P114/6.3-2.95-3B-STARTER PIPE | 16.8 | 8092420066 |
| | Extension Pipe with Injection Valves | P114/6.3-3.0-3B-EXT PIPE | | 8092420067 |
| | End Pipe with Injection Valves | P114/6.3-3.0-3B-END PIPE | | 8092420169 |
| | Starter Pipe Complete with Injection Valves | P114/6.3-2.95-10B-STARTER PIPE | 16.8 | 8092420068 |
| | Extension Pipe with Injection Valves | P114/6.3-3.0-10B-EXT PIPE | | 8092420069 |
| | End Pipe with Injection Valves | P114/6.3-3.0-10B-END PIPE | | 8092420170 |
| 7.1 | Starter Pipe Complete | P114/7.1-2.95-STARTER PIPE | 18.8 | 8092420070 |
| | Extension Pipe | P114/7.1-3.0-EXT PIPE | | 8092420071 |
| | End Pipe | P114/7.1-3.0-END PIPE | | 8092420145 |
| | Starter Pipe Complete with Injection Valves | P114/7.1-2.95-3B-STARTER PIPE | 18.8 | 8092420074 |
| | Extension Pipe with Injection Valves | P114/7.1-3.0-3B-EXT PIPE | | 8092420075 |
| | End Pipe with Injection Valves | P114/7.1-3.0-3B-END PIPE | | 8092420146 |
| | Starter Pipe Complete with Injection Valves | P114/7.1-2.95-10B-STARTER PIPE | 18.8 | 8092420076 |
| | Extension Pipe with Injection Valves | P114/7.1-3.0-10B-EXT PIPE | | 8092420077 |
| | End Pipe with Injection Valves | P114/7.1-3.0-10B-END PIPE | | 8092420147 |
| 8.0 | Starter Pipe Complete | P114/8.0-2.95-STARTER PIPE | 21.0 | 8092420078 |
| | Extension Pipe | P114/8.0-3.0-EXT PIPE | | 8092420079 |
| | End Pipe | P114/8.0-3.0-END PIPE | | 8092420148 |
| | Starter Pipe Complete with Injection Valves | P114/8.0-2.95-3B-STARTER PIPE | 21.0 | 8092420082 |
| | Extension Pipe with Injection Valves | P114/8.0-3.0-3B-EXT PIPE | | 8092420083 |
| | End Pipe with Injection Valves | P114/8.0-3.0-3B-END PIPE | | 8092420149 |
| | Starter Pipe Complete with Injection Valves | P114/8.0-2.95-10B-STARTER PIPE | 21.0 | 8092420084 |
| | Extension Pipe with Injection Valves | P114/8.0-3.0-10B-EXT PIPE | | 8092420085 |
| | End Pipe with Injection Valves | P114/8.0-3.0-10B-END PIPE | | 8092420150 |
| | Injection Cap with 1" ball valve | P114/INJECTION CAP BV | | 8092420094 |
| | Injection Cap with 1" connection | P11/INJECTION CAP | | 8092420154 |

| Atlas Copco Pipe Roof, outer casing diameter 139,7 mm (5 1/2") | | | | |
|---|---|--------------------------------|---------------------------|-----------------------|
| Wall thickness (mm) | Part | Designation | Pipe Weight (kg/m) | Product Number |
| max 10.0 | Symmetrix Pilot Bit | P140/10-100-T45 | | 8092402164 |
| 7.1 | Starter Pipe Complete | P140/7.1-1.3-STARTER PIPE | 23.2 | 8092420102 |
| | Extension Pipe | P140/7.1-1.5-EXT PIPE | | 8092420103 |
| | End Pipe | P140/7.1-1.5-END PIPE | | 8092420155 |
| | Starter Pipe Complete with Injection Valves | P140/7.1-1.3-3B-STARTER PIPE | 23.2 | 8092420104 |
| | Extension Pipe with Injection Valves | P140/7.1-1.5-3B-EXT PIPE | | 8092420105 |
| | End Pipe with Injection Valves | P140/7.1-1.5-3B-END PIPE | | 8092420156 |
| | Starter Pipe Complete with Injection Valves | P140/7.1-1.3-10B-STARTER PIPE | 23.2 | 8092420106 |
| | Extension Pipe with Injection Valves | P140/7.1-1.5-10B-EXT PIPE | | 8092420107 |
| | End Pipe with Injection Valves | P140/7.1-1.5-10B-END PIPE | | 8092420157 |
| 8.0 | Starter Pipe Complete | P140/8.0-1.3-STARTER PIPE | 26.0 | 8092420114 |
| | Extension Pipe | P140/8.0-1.5-EXT PIPE | | 8092420115 |
| | End Pipe | P140/8.0-1.5-END PIPE | | 8092420158 |
| | Starter Pipe Complete with Injection Valves | P140/8.0-1.3-3B-STARTER PIPE | 26.0 | 8092420116 |
| | Extension Pipe with Injection Valves | P140/8.0-1.5-3B-EXT PIPE | | 8092420117 |
| | End Pipe with Injection Valves | P140/8.0-1.5-3B-END PIPE | | 8092420159 |
| | Starter Pipe Complete with Injection Valves | P140/8.0-1.3-10B-STARTER PIPE | 26.0 | 8092420118 |
| | Extension Pipe with Injection Valves | P140/8.0-1.5-10B-EXT PIPE | | 8092420119 |
| | End Pipe with Injection Valves | P140/8.0-1.5-10B-END PIPE | | 8092420160 |
| 10.0 | Starter Pipe Complete | P140/10.0-1.3-STARTER PIPE | 32.0 | 8092420120 |
| | Extension Pipe | P140/10.0-1.5-EXT PIPE | | 8092420121 |
| | End Pipe | P140/10.0-1.5-END PIPE | | 8092420171 |
| | Starter Pipe Complete with Injection Valves | P140/10.0-1.3-3B-STARTER PIPE | 32.0 | 8092420122 |
| | Extension Pipe with Injection Valves | P140/10.0-1.5-3B-EXT PIPE | | 8092420123 |
| | End Pipe with Injection Valves | P140/10.0-1.5-3B-END PIPE | | 8092420172 |
| | Starter Pipe Complete with Injection Valves | P140/10.0-1.3-10B-STARTER PIPE | 32.0 | 8092420124 |
| | Extension Pipe with Injection Valves | P140/10.0-1.5-10B-EXT PIPE | | 8092420125 |
| | End Pipe with Injection Valves | P140/10.0-1.5-10B-END PIPE | | 8092420173 |
| | Injection Cap with 1" ball valve | P140/INJECTION CAP BV | | 8092420126 |
| | Injection Cap with 1" connection | P140/INJECTION CAP | | 8092420161 |

Drill rods

Depending on the diameter and thread of the shank adaptor, the determined pipe diameter and length, suitable drilling rods can be selected.

| Suitable SPEEDROD for pipe roofing | | | |
|---|-------------------|---------------------|--------------------|
| Description | Length (m) | Product code | Part number |
| R32 SPEEDROD with Wrench Flat | 3.1 | 203-2531-90-MF-C,02 | 90510130 |
| T38 SPEEDROD with Wrench Flat | 1.8 | 235-2718-MF-C,02 | 90003065 |
| T38 SPEEDROD with Wrench Flat | 3.1 | 235-2731-MF-C,02 | 90500630 |
| T38 SPEEDROD with Wrench Flat | 3.7 | 235-2737-MF-C,02 | 90502628 |
| T45 SPEEDROD with Wrench Flat | 1.5 | 236-2915-MF-C,02 | 90503039 |
| T45 SPEEDROD with Wrench Flat | 3.1 | 236-2931-MF-C,02 | 90502249 |



Atlas Copco Geotechnical Drilling and Exploration
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