Mühlhäuser
Tunneling Systems
With the acquisition of the engineering, manufacturing and project management resources of NFM Technologies, the renowned French manufacturer of tunnel boring machines (TBMs), Mühlhäuser was able to complete its product portfolio, enabling it to offer a full solution from boring to logistics.

Mühlhäuser offers five different types of tunnel boring machines which can each be optimized to fit customer and special project requirements.

**EPB (Earth Pressure Balance) TBM’s** are best suited for cohesive soil with clay and fines but can also tunnel in granular soil containing medium sand.

**Slurry TBM’s** are best suited for granular soil with gravel and sand contents but can also operate in more cohesive soil containing fines. They permit extremely accurate control of confinement pressure, reducing risks of subsidence at the surface in urban areas.

**Open single shield TBM’s** are suitable for unstable and convergent rock.

**Open double-shield TBM’s** achieve the most rapid rate of advance in rock as their design permits simultaneous excavation, advance and segment installation.

**Multimode TBM’s** make it possible to work in varying ground conditions by combining technologies.

The combination of these machine types makes tunneling in any given ground possible.
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The EPB (Earth Pressure Balance) is the most widely used type of tunnel boring machine (TBM) and provides the best compromise between technical specifications and cost. It is best suited for cohesive soil with clay and fines but can also tunnel in granular soil containing medium sand.
EPB shield TBM’s operate in two distinct phases:

1 - **Excavation and advance** is performed by the simultaneous action of the cutting tools on the cutter head and the pushing force of the thrust cylinders in the shield against the segmental tunnel wall. Support of the ground along the cavity is achieved both by the cutter head and shield structures and by injecting air in the cutting chamber in order to pressurize the excavated material.

The injection of additives in front of the cutter head and into the cutting chamber converts the muck into a homogeneous paste forming a watertight plug which is then extracted by a screw conveyor onto a belt conveyor, thus passing from the confinement pressure to the ambient pressure zone. The muck is discharged from the tunnel by a tunnel conveyor or by rail-mounted muck cars.

Behind the shield, the back-up houses all necessary circuits, components and control facilities. It runs on segments and is continuously hauled during excavation.

2 - **Segment installation**: The segments are brought from the surface either by rail bound equipment or by MÜHLHÄUSER service vehicles (MSVs), unloaded onto the back-up, conveyed to the rear of the shield and installed by the erector.

The segments are bedded in the cavity by injecting grout through pipes in the rear of the shield during excavation.

Workers can access the cutting chamber through a manlock at the top of the shield.

Bentonite is provided as an additive and is used to create a sealing cake at the front securing works in a hyperbaric atmosphere.

In some geologies, it is possible to use the machine in open mode without injecting air into the cutting chamber, by using the screw to remove the muck without the pressure balance function.
Technical Data

Ground conditions ................................ soil (clay to medium sand)
........................................................................................................ containing water and rock

Pressure .............................................................. up to 6 bar

Diameter .............................................. from 4.5 m to 15.1 m

Number of references ....................................................... 67
Slurry tunnel boring machines (TBMs) are best suited for granular soil with gravel and sand contents but can also operate in more cohesive soil containing fines. They permit extremely accurate control of confinement pressure, reducing risks of subsidence at the surface in urban areas.
1 - **Excavation and advance** is performed by the simultaneous action of the cutting tools on the cutter head and the pushing force of the thrust cylinders in the shield against the segmental tunnel wall. Support of the ground along the cavity is achieved both by the cutter head and shield structures and by injecting bentonite mixed with water through injection pipes into the cutting chamber. The slurry (bentonite) is, pressurized with air, injected into the front shield area (bubble chamber). Due to the pressurization bentonite is entering the soil and creates a tight sealing layer the so-called filter cake.

Larger solid materials which are mixed with the slurry during excavation, are passing a crusher and are being downsized to allow a slurry transport without blockages. The slurry and crushed material is then extracted through extraction pipes up to a slurry separation plant located on the surface.

Attached to the shield is the back-up which houses all vital components that are needed to operate the TBM such as electrical installations, hydraulic motors, pumps and other equipment in order to provide the machine with power and consumables. The back-up is also used as storage area and an area in which ducts, pipes and cables are extended – the umbilical cord of the machine. The control room / operator cabin is also on the back-up, where all valid data and information is collected and visualized. Based on the data provided the operator can control and steer the machine and is able to react immediately if need be.

The back-up runs on tubbing’s or on rails which are placed onto the segments. As it is attached to the TBM shield, it is continuously hauled during the entire excavation.

2 - **Segment installation**: The segments are transported to the TBM from the surface either by rail bound equipment or by MÜHLHÄUSER service vehicles (MSVs). Inside the back-up the segments are unloaded by a segment crane which carries each segment to the segment feeder located right behind the tail-shield of the machine. From here the segments are picked-up by a segment erector, which places each segment inside the shield until a full ring is formed.

The segments are bedded in the cavity by injecting grout through pipes in the rear of the shield during excavation.

Workers can access the cutting chamber in front of the TBM through a manlock which is connected to a bulk head in the front shield.

The bentonite used to extract material creates a sealing cake at the front securing works in a hyperbaric atmosphere.
Technical Data

Ground conditions ...................... soil (cobble to fine sand) ............................................................... with water and rock
Pressure ............................................................ up to 10 bar
Diameter ............................................. from 4.5 m to 15.1 m
Number of references................................. 20
Open Single Shield TBM

Open single shield tunnel boring machines (TBMs) are suitable for unstable and convergent rock ensuring maximum safety in environments with fragmented rock.
Open single shield TBM’s operate in two distinct phases:

1 - **Excavation and advance** is performed by the simultaneous action of the cutting tools on the cutter head and the pushing force of the thrust cylinders in the shield against the segmental tunnel wall. Support of the ground along the cavity is achieved both by the cutter head and the shield structures. The material, cut into small fragments called "chips", passes through openings in the cutter head to the cutting chamber and is discharged by buckets onto a belt conveyor.

The muck is discharged from the tunnel by a tunnel conveyor or by rail-mounted muck cars.

In order to avoid jamming in convergent ground, the excavation diameter can be enlarged by lifting the cutter head vertically with torque cylinders and adapting the cutting tools dressing.

Behind the shield, the back-up houses all necessary circuits, components and control facilities. It runs on segments and is continuously hauled during excavation.

2 - **Segment installation**: The segments are brought from the surface either by rail bound equipment or by MÜHLHÄUSER service vehicles (MSVs), unloaded onto the back-up, conveyed to the rear of the shield and installed by the erector.

The segments are bedded in the cavity by injecting grout through pipes in the rear of the shield during excavation.

Workers can access the cutting chamber for maintenance from the center of the shield by retracting the belt conveyor.

In some cases, grout is injected only in the lower part of the ring and the rest of the annular void is filled with pea gravel from the back-up.
Open Single Shield TBM

Technical Data

Ground conditions ..................................... soft to hard rock,
.................................................... fractured and convergent,
............................................................... with water inrushes

Diameter .............................................. from 4.5 m to 12.5 m

Number of references......................................................... 8
Open double-shield tunnel boring machines (TBMs) achieve the most rapid rate of advance in rock as their design permits simultaneous excavation, advance and segment installation.
1 - **Excavation and advance** is performed by the simultaneous action of the cutting tools on the cutter head and the pushing force of the main thrust cylinders in the front shield while the gripper shield locks the rest of the machine in position by means of two pads which are thrust against the cavity periphery.

A telescope shield connects the gripper and front shields and provides access to the cavity. Support of the ground is achieved by both the cutter head and the shield structures.

The excavated material, cut into small fragments called “chips”, passes through openings in the cutter head to the cutting chamber and is discharged by buckets onto a belt conveyor.

The excavated material is discharged from the tunnel by a tunnel conveyor or by rail bound muck cars.

2 - **Segment installation:**

The segments are brought from the surface either by rail bound segment cars or by MÜHLHÄUSER service vehicles (MSVs), unloaded onto the back-up, conveyed to the rear of the shield and installed by the erector held by auxiliary thrust cylinders against the tunnel wall.

At the end of excavation, the gripper pads are loosened from the cavity wall and the gripper shield is pulled forward by retracting the main thrust cylinders. At the same time, the segments are bedded in the cavity by injecting grout through pipes in the rear of the shield.

Behind the shield, the back-up houses all necessary circuits, components and control facilities. It remains stationary during excavation and shield recycling and is hauled forward before starting a new tunneling cycle.
If the ground is too weak to withstand the gripper pads, the machine is used as a single shield by using the auxiliary cylinders to move forward.

Workers can access the cutting chamber for maintenance from the center of the shield by retracting the belt conveyor.

In some cases, grout is injected only in the lower part of the ring and the rest of the annular void is filled with pea gravel from the back-up.

**Technical Data**

- Ground conditions: medium to hard fractured rock
- Diameter: from 4.5 m to 12.5 m
- Number of references: 14
The multimode tunnel boring machine (TBM) makes it possible to work in varying ground conditions by combining technologies. Most multimode TBMs consist of EPB shield (earth pressure balance) and open single shield.
Multimode TBMs operate in two distinct phases:

1 - **Excavation and advance** is performed by the simultaneous action of the cutting tools on the cutter head and the pushing force of the thrust cylinders in the shield against the segmental tunnel wall. Support of the ground along the cavity is achieved both by the cutter head and shield structures.

In EPB mode, the excavated material is pressurized by injecting air into the cutting chamber while the injection of additives in front of the cutter head or into the cutting chamber converts the muck into a homogeneous paste forming a watertight plug which is extracted by a screw conveyor onto a belt conveyor, and thus from the confinement pressure to the ambient pressure zone.

In open single shield mode, the screw conveyor is retracted and replaced by a primary belt conveyor and buckets are assembled at the rear of cutter head to discharge the muck.

In both modes, the muck is discharged from the tunnel by a tunnel conveyor or by rail-mounted muck cars.

Behind the shield, the back-up houses all necessary circuits, components and control facilities. It runs on segments and is continuously hauled during excavation.

2 - **Segment installation:** The segments are brought from the surface either by rail bound segment cars or by MÜHLHÄUSER service vehicles, unloaded onto the back-up, conveyed to the rear of the shield and installed by the erector.

The segments are bedded in the cavity by injecting grout during excavation through pipes in the rear of the shield.

It is possible to use the screw conveyor only to remove the muck without pressure balance function if no air is injected into the cutting chamber.

In EPB mode, access for workers for maintenance in the cutting chamber is made through a manlock provided at the top of the shield, while in open mode it is provided from the center of the shield by retracting the belt conveyor.

Bentonite is provided as an additive and is used to create a sealing cake at the front and secure works in a hyperbaric atmosphere.
Technical Data

Ground conditions ........ variable, from soil with water to rock
Pressure ............................................................... up to 6 bar
Diameter .............................................. from 6.0 m to 12.5 m
Number of references....................................................... 11