



HERRENKNECHT CUTTER TOOLS.



MANUFACTURED BY HERRENKNECHT.

Reliability, long lifetime and service. In mechanized tunnelling, choosing the right Cutter Tools is a question of trust. Lifetime, efficiency and reliability of Cutters, also called Cutter Disks or Disks, can considerably affect the profitability of mechanized tunnelling works.

Cutters are exposed to more different and sometimes extreme conditions during tunnelling than any other Cutter Tool. Ground temperatures of up to 50 degrees centigrade, rock strengths up to 350MPa, high water pressures, dust or sand put the Cutter Disks and their components to the test. Naturally, the disks need to perform reliably even under these extreme conditions.

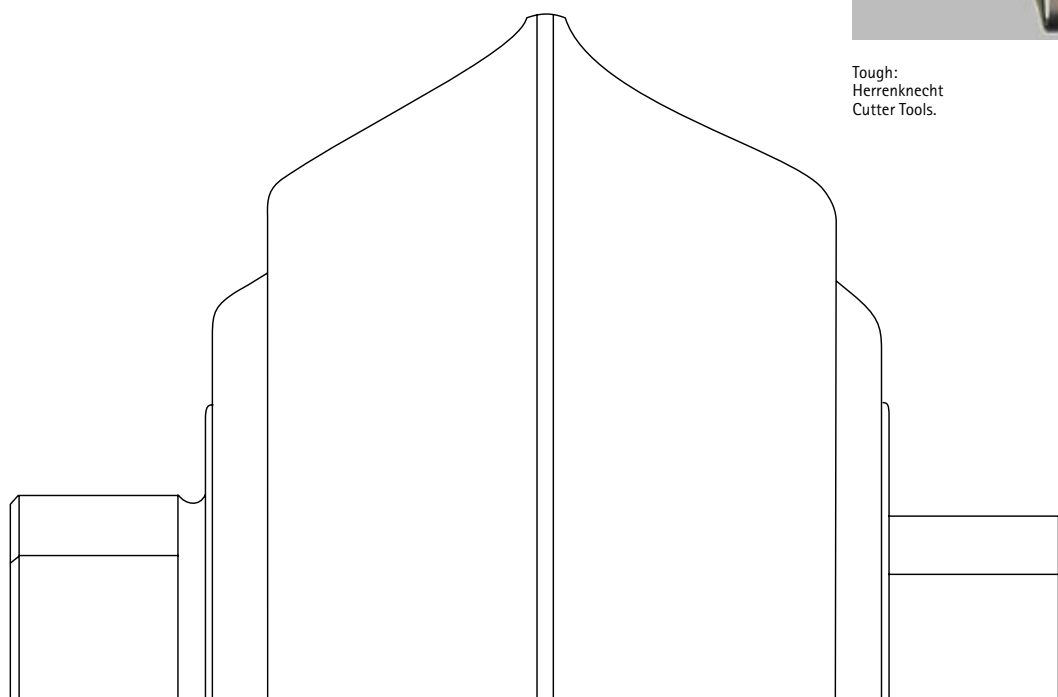
Herrenknecht is one of the leading companies in the production of Cutter Disks, manufacturing and supplying premium high strength Cutter Disks. Our technological leadership in tunnelling along with our great experience in manufacturing Cutter Tools for small and large tunnel diameters guarantees a long lifetime and top performance during tunnelling.

At Herrenknecht, innovations in TBM technology and Cutter Tools go hand in hand. In contrast to other manufacturers who only produce Cutters, we see the Cutter Tools in the context of Cutterhead design and changing procedures of the Cutters. If the Cutterhead and the Cutter Tools are effectively aligned, this not only simplifies the necessary maintenance work, but also positively influences profitability.



Tough:
Herrenknecht
Cutter Tools.

A strong device:
Cutterhead and the
deployed Cutter Tools
have to be aligned
optimal on each other.



RELIABILITY IS EVERYTHING.

Herrenknecht supplies hardware plus service. In addition to the Cutters, Herrenknecht also provides the associated Cutter Service. The service program includes local Cutter Shops that are set up on the construction site. The Cutter Shops guarantee that frequently required spare parts are close at hand and worn Cutters can be quickly refurbished. The Cutter Database is a service frequently used by customers. It helps the site management finding optimum maintenance intervals for the Cutter Tools and thus reduce costs (see pages 12|13).

Herrenknecht Cutter Service includes

- the production of premium high strength Cutter Tools
- a fast, worldwide delivery of all current Cutter Sizes for soft and hard ground
- setting up and managing on-site Cutter Shops
- a database-supported and efficient Cutter Management.



An intelligent Cutter Management is the pre-condition for a successful breakthrough.

Ready for hard rock at the Lötschberg Base Tunnel in Switzerland. Herrenknecht Gripper TBM S-174 at the Launch Shaft.



A question of economic efficiency: Proper strategies in exchange and refurbishment of Cutter Tools.



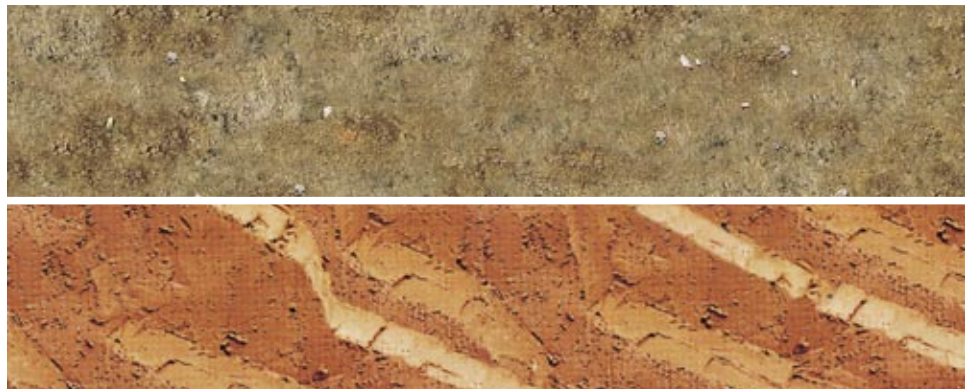


FOR EVERY MISSION THE SUITABLE TOOL.

Through thick and thin. Ground conditions determine the selection and composition of the Cutters as well as their arrangement on the Cutterhead. Every geological condition challenges different areas of the Cutters and their 20 individual components in terms of lifetime. In soft and mixed ground conditions, the entire hub area is often exposed to considerable wear due to the conditions encountered. Sometimes, it is even necessary to apply special hard-facing.

Herrenknecht Cutter crack any geological challenge.

Soft Ground



Mixed Ground



Hard Rock





When everything fits
in hard rock tunnelling,
the tunnel face is
excavated perfectly.

During excavation under high water pressures, the bearing seals are put to the test. Moreover, the correct preload of the Cutter bearing is important for tunnelling in complex ground conditions. The preload must be carried out sensitively and with the necessary experience, especially in soft ground in order to ensure that the Cutters rotate freely and to prevent them from becoming blocked. Here, Herrenknecht has gained a comprehensive know-how due to its worldwide experience.

The ultimate test. During hard rock tunnelling, such as in gneiss and granite, Cutters are exposed to really violent impacts. Here the material characteristics of the Cutter Rings are critical. The high-alloy tool steel used for this purpose needs to have the right balance of hardness and strength. Extremely hard steels are required to penetrate the ground effectively during tunnel excavation. During tunnelling at the Gotthard Base Tunnel in Switzerland, each of the 60 Cutter Disks on the Cutterhead is pushed into the mountain with a force of up to 27 tons. To ensure a long lifetime of these Cutter Rings, the steel alloys used need to have the appropriate toughness in addition to the hardness.

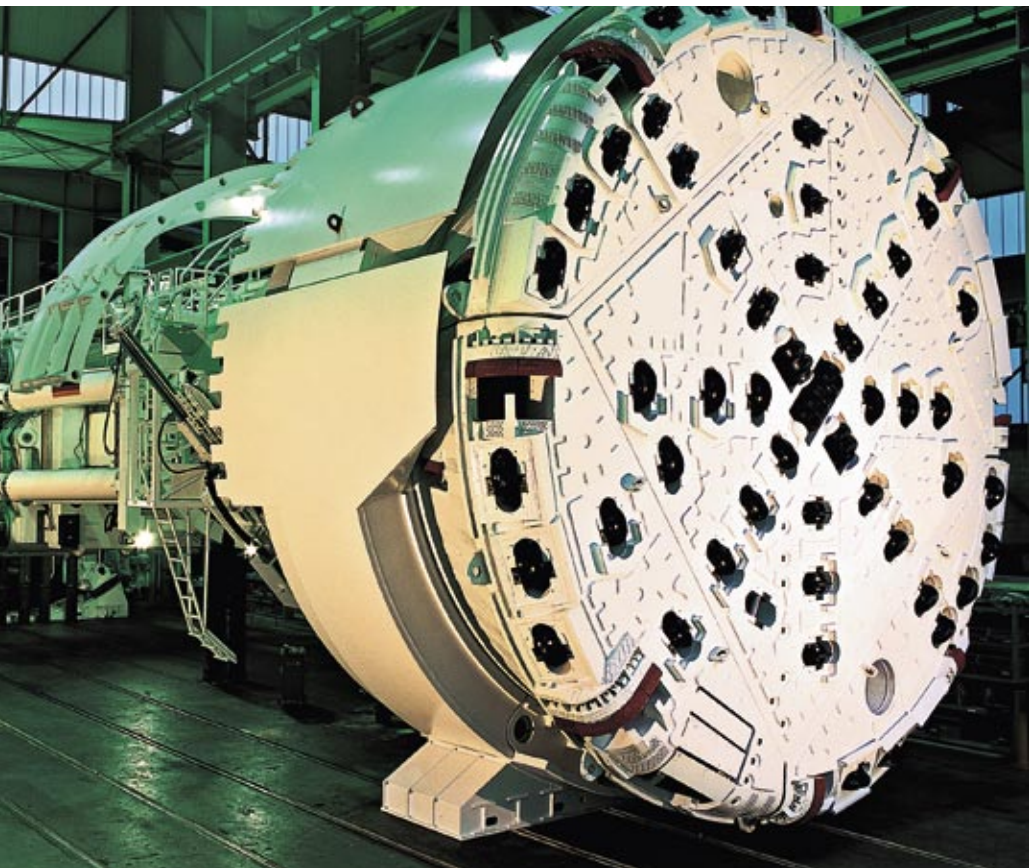
Always playing it safe. The material toughness is an important aspect affecting the life of the tools during hard rock tunnelling. A steel that is too brittle would considerably increase the impact sensitivity of the Cutter Rings as well as wear. Thus, the right combination is essential during the material selection process and the production of the Cutter Rings. It is an art and science in itself and a well kept secret of Herrenknecht.

Beside the Cutter Rings, the bearings are also subject to extreme conditions in hard rock formations. Cutters and bearings can, for example, reach a temperature of 180 degrees centigrade during tunnelling. Therefore, only the best cone bearings are used in Herrenknecht Cutter Disks for hard rock tunnelling.

















TRAFFIC TUNNELLING.

Always the right tool. As market leader, Herrenknecht supplies tunnel boring machines, adapted to the specific projects, with diameters up to 16m in the field of Traffic Tunnelling. We provide machines for all ground conditions: soft, hard, dry or water-bearing ground. Herrenknecht also produces the entire established range of Cutters: 14", 17" and 19" Cutters with ring widths from 13 up to 24mm. Cutters are available as "Single Disks", "Twin" or "Double Disks" in addition to "Monoblock Versions" (14" and 17"), depending on the position in the center, face or gauge area of the Cutterhead.

17" and 19" disks are generally available as both standard and radius ring profile. Beside the lifetime and efficiency of the Cutters, easy Cutter changing and refurbishment



Equipped with 61 Cutters.
Herrenknecht TBM S-211.

| TRAFFIC TUNNELLING | | | |
|---|---|-------------|-----------------------|
| CUTTER TOOLS | | CUTTER SIZE | CUTTER TYPE |
|  |  | 19" | Single Disk |
|  |  | 17" | Single Disk |
|  |  | 17" | Twin Disk |
|  |  | 17" | Monoblock Double Disk |
|  |  | 17" | Twin Disk |
|  |  | 17" | Single Disk |
|  |  | 17" | Monoblock Single Disk |
|  |  | 14" | Monoblock Single Disk |



must also be considered. This applies particularly to the gauge Cutters that are exposed to greater wear due to higher stresses and thus need to be exchanged and refurbished more often.

In this case, Herrenknecht can provide its contractors with integrated solutions by combining know-how in the field of mechanical tunnelling technology with our experience in tool wear and replacement. During the design of the Cutterhead and the rear machine area we take into account that wear-intensive tool positions must be easily accessible. Besides saving time, safety is essential. Backloading systems tailor-made to the contractor's specific requirements allow the maintenance personnel to work protected by the Cutterhead and the shield.

| PROJECT EMPLOYMENT | | WEIGHT | BEARING | SUITABLE GEOLOGY | POSITION OF THE CUTTERHEAD | RING WIDTH (mm) | | | | RING PROFILE | | MPa | MATERIAL |
|-----------------------|----------------|--------|-------------------------------|--------------------------|-------------------------------|-----------------|----|----|----|--------------|--------|-----------|-----------------------------|
| | | | | | | 13 | 16 | 19 | 24 | Standard | Radius | | |
| Atlanta | Georgia, USA | 191kg | high-quality bearing 19" type | Hard Rock | face area gauge area | | | ● | ● | ● | ● | up to 350 | high-alloy tool steel |
| Lötschberg | Porto Portugal | 125kg | high-quality bearing 17" type | Mixed Ground Hard Rock | face area gauge area | | ● | ● | ● | ● | ● | up to 350 | high-alloy tool steel |
| Guadarrama | Dublin Ireland | | | | | | | | | | | | |
| Lötschberg | Dublin Ireland | 277kg | high-quality bearing 17" type | Hard Rock | center area | ● | ● | ● | | ● | ● | up to 350 | high-alloy tool steel |
| Guadarrama | Spain | | | | | | | | | | | | |
| Almaty | Kazakhstan | 161kg | standard bearing 17" type | Soft Ground Mixed Ground | face area gauge area | | | ● | | ● | | up to 100 | high-alloy tool steel |
| Katzenberg | Singapore | 308kg | high-quality bearing 17" type | Soft Ground Mixed Ground | center area | | ● | ● | ● | ● | ● | up to 200 | high-alloy tool steel |
| Gijón | Spain | | | | | | | | | | | | |
| Guangzhou | China | 125kg | standard bearing 17" type | Soft Ground Mixed Ground | face area gauge area | ● | ● | ● | ● | ● | ● | up to 100 | hardened and tempered steel |
| Moscow | Russia | 140kg | high-quality bearing 17" type | Soft Ground Mixed Ground | face area gauge area | | | ● | ● | ● | ● | up to 350 | high-alloy tool steel |
| Portland | Oregon, USA | 78kg | standard bearing 14" type | Soft Ground | face area gauge area | | | ● | ● | ● | | up to 200 | high-alloy tool steel |

UTILITY TUNNELLING.



Hard Rock





















A lack of space leads to diversity. Utility Tunnelling machines – regardless of the geology – have one thing in common: There is not a lot of space on their Cutterhead. Consequently, this restriction leads to diversity. Like for large-diameter machines, the object is to achieve a possibly uniform penetration of the tunnel face.

For Utility Tunnelling Cutterheads Herrenknecht therefore offers a wide range of Cutter Tools. The range for hard rock formations starts with the 8" Cutter Disk. Herrenknecht has specialized in Cutters with a diameter from 8" upwards in the field of premium Utility Cutter Tools. During the development and the design of the Cutter Tools much of the experience of the large-diameter machines could be used. The Herrenknecht product range in Utility Tunnelling, includes Cutter Tools from 8" up to the 17" Cutter Disks that are also used in the field of Traffic Tunnelling.

Like their larger counterparts, the Cutter Tools for small diameters are also made of high-alloy tool steel. In general, the object of Utility Tunnelling is to use the largest Cutter Disk possible. The reason behind this is the higher maximum load capacity of the larger bearings. The diameter of the Cutter Tools determines the size of the bearings and consequently the maximum loads. The larger the bearings the higher is the maximum load capacity of the Cutter Tools.

Cutter Disks smaller than 12" are supplied as monoblock due to the limited space available. Herrenknecht provides Cutter Disks from 12" upwards with an exchangeable Cutter Ring.

UTILITY TUNNELLING

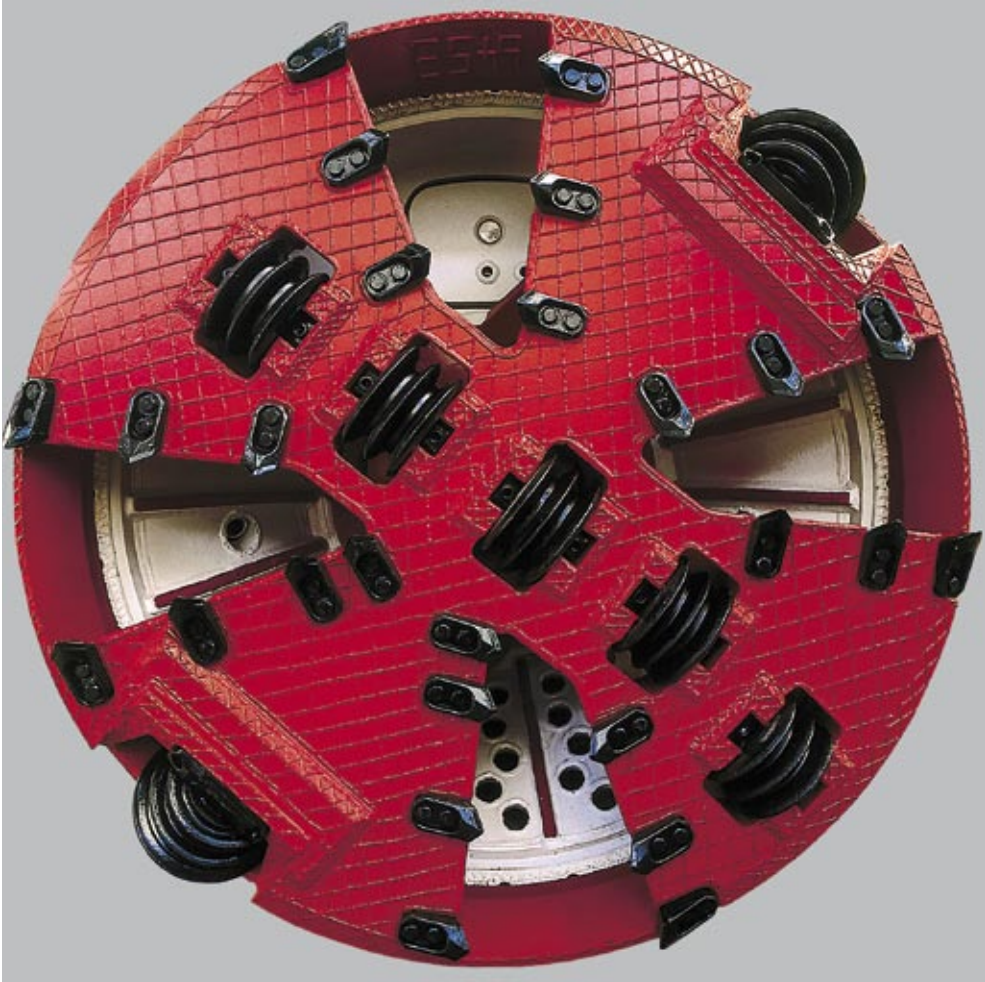
| CUTTER TOOLS | CUTTER SIZE | CUTTER TYPE | PROJECT EMPLOYMENT | | | WEIGHT | BEARING | SUITABLE GEOLOGY | POSITION OF THE CUTTERHEAD |
|---|-------------|---|--|---|----------------------------------|--------|----------------------------------|---------------------------|----------------------------|
|   | 17" | Single Disk | M-944M M-949M Valencia Spain | | | 125kg | high-quality bearing 17" type | Mixed Ground Hard Rock | face area gauge area |
|   | 17" | Twin Disk | M-944M M-949M Valencia Spain | | | 277kg | high-quality bearing 17" type | Mixed Ground Hard Rock | center area |
|   | 14" | Double Disk Single Disk | M-971M Shenzhen China | M-678M Seoul Korea | | 95kg | high-quality bearing 14" type | Mixed Ground Hard Rock | center area |
|   | 14" | Single Disk | M-971M Shenzhen China | M-678M Seoul Korea | | 85kg | high-quality bearing 14" type | Mixed Ground Hard Rock | face area gauge area |
|   | 12" | Monoblock Double Disk Monoblock Single Disk | M-813M Singapore | M-583M Parma Italy | | 70kg | high-quality bearing 12" type | Mixed Ground | face area gauge area |
|   | 12" | Double Disk | M-813M Singapore | M-729M Hong Kong China | M-799M Saragossa Spain | 69kg | high-quality bearing 12" type | Mixed Ground | face area gauge area |
|   | 12" | Single Disk | M-813M Singapore | M-729M Hong Kong China | M-799M Saragossa Spain | 58kg | high-quality bearing 12" type | Mixed Ground | face area gauge area |
|   | 11" | Monoblock Double Disk Monoblock Single Disk | M-899M Wrightsville Pennsylvania, USA | M-804M Bilbao-Udondo Erandio Spain | M-708M Jeddah Saudi-Arabia | 48kg | high-quality bearing 11" type | Mixed Ground | face area gauge area |
|   | 10" | Mb. Double Disk Mb. Single Disk Mb. Triple Disk | M-693M Qatar | | | 30kg | high-quality bearing 10" type | Hard Rock | face area gauge area |
|   | 8" | Monoblock Double Disk | M-1005M Baltimore Maryland, USA | M-1007M Baltimore Maryland, USA | | 18kg | high-quality bearing 8" type | Mixed Ground Hard Rock | face area gauge area |



Soft Ground

Mixed Ground

| MPa | MATERIAL | SPECIAL FEATURE |
|--|-----------------------------|-----------------------|
| up to 350 | hardened and tempered steel | |
| up to 350 | high-alloy tool steel | |
| Single: up to 350 Double: up to 200 | high-alloy tool steel | pressure compensation |
| up to 100 | hardened and tempered steel | pressure compensation |
| Single: up to 350 Double: up to 250 | high-alloy tool steel | |
| up to 200 | high-alloy tool steel | |
| up to 350 | high-alloy tool steel | |
| Single: up to 350 Double: up to 200 | high-alloy tool steel | |
| up to 150 | high-alloy tool steel | |
| up to 100 | high-alloy tool steel | |



MAINTENANCE MANAGING EFFICIENTLY.



Effective refurbishment:
In general only the Cutter
Rings have to be changed,
as only these directly
crack the rock.

Navigation

▼ Search

GO

Cutter inventory

▼ Activities

Read only

▼ Database

- Cutterhead Inspection
- Repair Reports
- Cutter inventory
- Cutter Parts List
- Cutter parts

▼ Analysis

- Repairs
- Cutter consumption
- Diagrams

▼ Project

Sample Project



Note: you can find further information on the Cutter Database as well as contact details in the Herrenknecht R & D brochure. Furthermore, please visit www.herrenknecht.com

The Cutter Database gives an overview. In addition to the wide range of Cutter Tools for all imaginable applications, Herrenknecht provides its customers with comprehensive, practical services.

The Cutter Database developed by Herrenknecht is a management tool that has already been frequently used by customers. It is based on the experience of wear and Cutter exchange strategies gained during a number of projects. The Cutter Database allows users to develop economic project strategies in terms of Cutter Disk exchange and refurbishment. At the same time, the database incorruptible records the Cutter Type as well as the time, place and reason for exchange or refurbishment. The Cutter Database thus delivers a complete history of each Cutter Disk, informs about the relevant costs incurred during the last excavation and allows to forecast favourable maintenance intervals and Cutter exchanges. To make the Cutter Database usable to our customers throughout the world the software is available in german, english, spanish and french language.

Repair data of the Cutters can also be easily transmitted to Herrenknecht Cutter Shops.

Exchanging Cutter Tools is laborious. When designing the Cutterhead, Herrenknecht considers that wear-intensive tool positions must be easily accessible. Backloading concepts do not only save time, but also improve safety.



WEAR UNDER CONTROL.



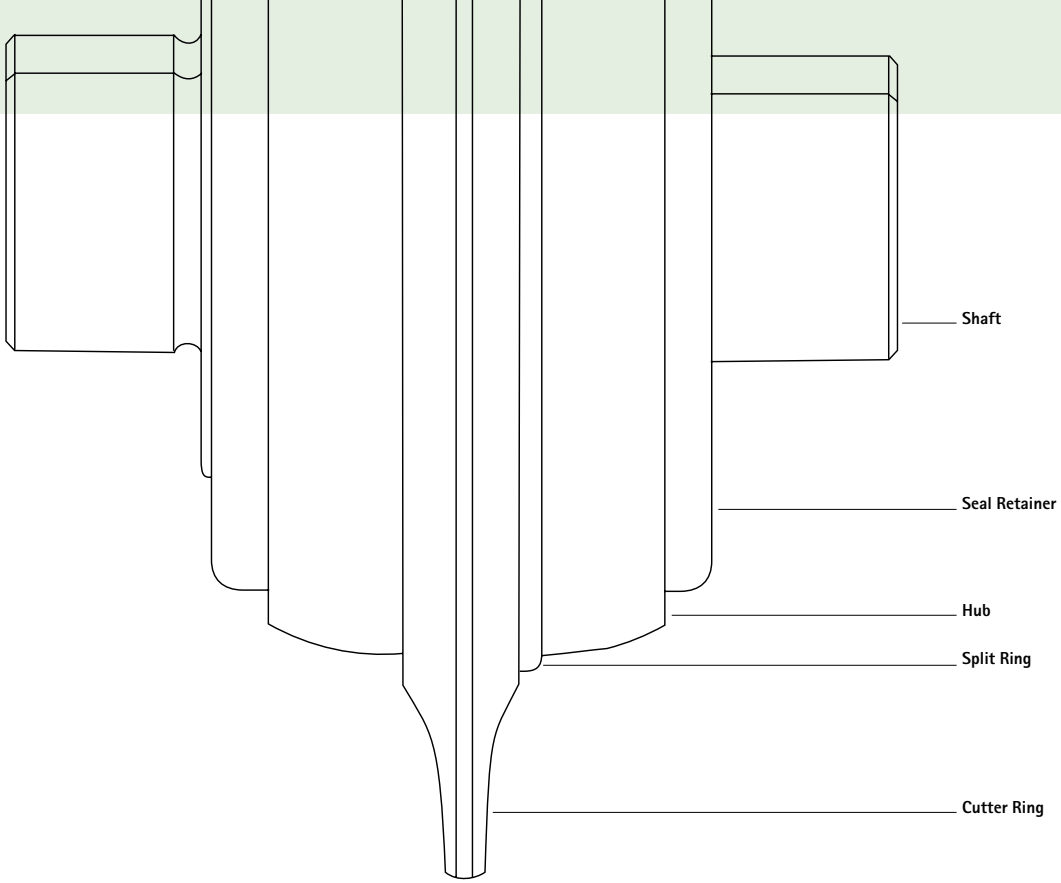
Dismantling of the
Split Ring from the Hub.

Tailor-made refurbishment. A service often used and appreciated by contractors is the setting up of local Cutter Shops on the construction site. Herrenknecht Cutter Shops are equipped with all necessary tools and spare parts to refurbish worn Cutter Disks promptly and professionally. Cutter Shops can be set up on any site worldwide. Of course, worn Cutters can also be refurbished in the Herrenknecht Cutter production plants in the USA, Switzerland and China.

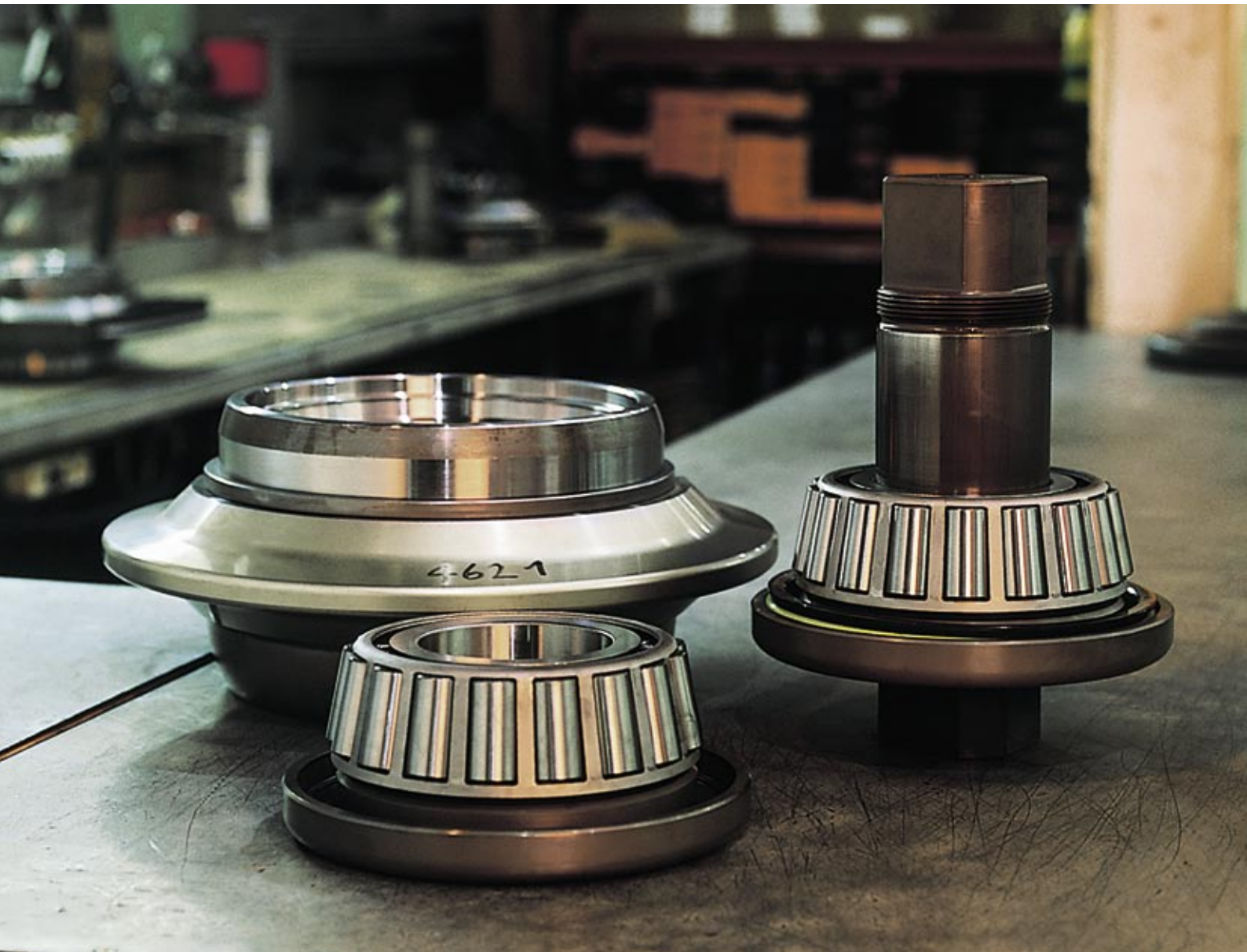
On behalf of the contractors, Herrenknecht also manages the storage of the Cutter Tools or the education of the site personnel. The best way to find solutions is to work together in order to effectively control the wear management and costs.



Herrenknecht Quality Cutter
are manufactured in China,
Switzerland and the USA.



Prepared for Hard Rock.
Refurbished Cutter Tools in
the Swiss Cutter Shop.



REFERENCES TRAFFIC TUNNELLING.

Together with our contractors Herrenknecht has been able to win a considerable number of international projects in Traffic Tunnelling (Ø up to 16m) in 28 years of company history. Herrenknecht tunnelling technology masters every geological challenge. Today, tunnels can be built exactly where they are required to extend, shorten or improve existing traffic routes. With this selection of reference projects, we would like our contractors, planners and clients to be able to gain greater insight into our wealth of experience and the efficiency of our Cutter Tools.

| REFERENCES TRAFFIC TUNNELLING | | | |
|--|----------------|-------------------|--------------------|
| | PROJECT NO. | MACHINE TYPE | DIAMETER |
| Gotthard Base Tunnel Switzerland | S-210 | Gripper TBM | 8,830mm |
| | S-211 | | 9,330mm |
| | S-229 S-230 | | 9,580mm |
| Lötschberg Base Tunnel Switzerland | S-167 S-174 | Gripper TBM | 9,430mm |
| Guadarrama Spain | S-201 S-202 | Double Shield TBM | 9,510mm |
| Metro Oporto Portugal | S-160 S-203 | EPB Shield | 8,700mm |
| Dublin Port Tunnel Ireland | S-193 | Single Shield TBM | 11,825mm |
| CSO Tunnel Portland Oregon, USA | S-231 S-232 | Mixshield | 5,050mm 5,140mm |
| West Area CSO Tunnel Atlanta Georgia, USA | S-288 S-289 | Gripper TBM | 8,230mm |

The ultimate test
for every Cutter Disk:
The St. Gotthard Moun-
tain in Switzerland.





Tunnelling at its best.
The result is a clean swept
and precise tunnel.



Note: you will find further information on Traffic
Tunnelling in the relevant Herrenknecht brochure.
Furthermore, please visit: www.herrenknecht.com

| TUNNEL LENGTH | CUTTER TYPE | GEOLOGY | ROCK STRENGTH | LIFETIME | CUTTER MANUFACTURE | SERVICES | PROJECT HIGHLIGHTS |
|--------------------------------------|---|---|---------------|---------------------------------|--------------------|--|--|
| 13,955m 11,581m 2x 11,350m | 17" Single Disk 17" Twin Disk | gneiss granite | up to 250MPa | 80 – 1,000m ³ /SR | Switzerland | lump sum contract stockkeeping local Cutter Shop | extremely high overburden blocky ground changing geology longest traffic tunnel worldwide |
| 8,925m + 10,300m | 17" Single Disk 17" Twin Disk | old crystalline gneiss granite granodiorite | up to 280MPa | 80 – 2,000m ³ /SR | USA | delivery | blocky ground |
| 14,500m 14,500m | 17" Single Disk 17" Twin Disk | granite weathered granite | up to 220MPa | 160 – 350m ³ /SR | USA | delivery local Cutter Shop stockkeeping | extremely changing geology |
| 5,700m + 4,000m | 17" Single Disk 17" Twin Disk | unconsolidated material granite | up to 125MPa | 60 – 200m ³ /SR | USA | lump sum contract | inner-city tunnelling |
| 2,246m + 2,246m | 17" Single Disk 17" Twin Disk | limestone slate | up to 150MPa | 2,300 – 3,000m ³ /SR | USA | lump sum contract | inner-city tunnelling |
| 4,350m 1,350m | 14" Monoblock 14" Single Disk 14" Double Disk | sand alluvium gravel boulders | | 1,800 – 2,000m ³ /SR | USA | delivery | inner-city tunnelling |
| 6,800m 6,600m | 19" Single Disk 19" Twin Disk | gneiss granite | up to 300MPa | 230 – 500m ³ /SR | USA | lump sum contract stockkeeping local Cutter Shop | relatively low overburden inner-city tunnelling |



REFERENCES UTILITY TUNNELLING.

Herrenknecht is one of the world's leading manufacturer of tunnel boring machines in the field of Utility Tunnelling. More than 1,000 Herrenknecht Utility Tunnelling Systems have already made it possible to excavate supply and disposal tunnels in any geological condition and with diameters up to 4,000mm. Tailor-made process and service concepts allow the contractor to achieve effective TBM performances. Herrenknecht also covers the entire range of process technology in Utility Tunnelling.

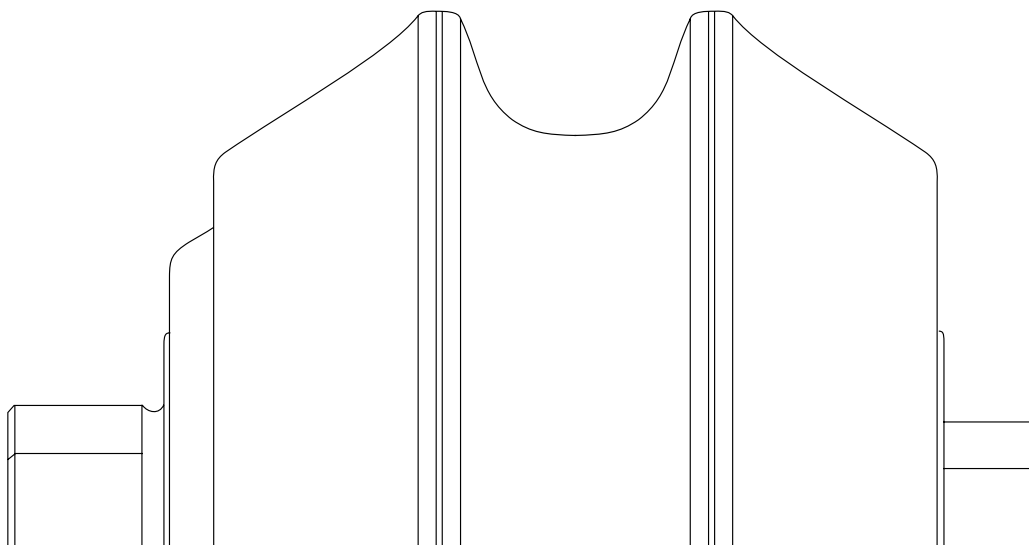
Strength until breakthrough.
Reliability is essential when
choosing Cutterheads for
Utility Tunnelling Projects.





REFERENCES UTILITY TUNNELLING

| | PROJECT NO. | MACHINE TYPE | Ø NOMINAL Ø CUTTING | TUNNEL LENGTH | CUTTER TYPE | GEOLOGY | ROCK STRENGTH | TUNNEL EMPLOYMENT | PROJECT HIGHLIGHTS |
|--------------------------------|-------------|--------------|------------------------|---------------|-------------|-------------------------------------|---------------|-------------------|--|
| Bilbao-Udondo Erandio Spain | M-804M | AVN1200T | 1,200mm 1,505mm | 200m | 11" | quartzite sandstone limestone | up to 270MPa | Sewage | |
| Table Rock South Carolina, USA | M-899M | AVN1200T | 1,200mm 1,505mm | 150m | 11" | granite | up to 250MPa | Fresh water | extremely abrasive (CAI 5.6) |
| Hong Kong China | M-675M | AVN1800T | 1,800mm 2,160mm | 840m | 12" | tuff | up to 411MPa | Cable Tunnel | extremely hard, abrasive (CAI 5.6) consignment stock |
| Shenzhen China | M-971M | AVND3000 | 3,000mm 3,800mm | 2,500m | 14" | lime claystone | up to 120MPa | Pipeline | more than 5bar pressure compensation |
| Chenglingji China | M-819M | AVND2440 | 2,440mm 3,100mm | 2,000m | 12" | lime claystone | up to 100MPa | Pipeline | more than 5bar pressure compensation |





WWW.HERRENKNECHT.COM

Herrenknecht AG is a technology and market leader in mechanized tunnelling. As the only provider of a full range of services worldwide, Herrenknecht delivers high-tech tunnel boring machines for all ground conditions and with all diameters – ranging from 0.10 to more than 16.0 meters.

Herrenknecht's tailor-made machines create pipeline systems for water and sewage, for gas and oil (Utility Tunnelling) as well as tunnelling systems for car, metro and railway traffic (Traffic Tunnelling) around the world. Our tunnel boring machines are forging ahead with the world's longest railway tunnel and the largest metro lines. They help to cross under water with supreme accuracy and to lay pipelines throughout continents.

Herrenknecht sees itself as a partner in team-work tunnelling throughout the entire project. Comprehensive services for all aspects of tunnel boring activities complement our range.

The Herrenknecht Group employs more than 1,800 people and has more than 30 subsidiaries and associated companies working in related fields, e.g. in logistic solutions or deep drilling systems.

Herrenknecht AG
D-77963 Schwanau
Phone +49 7824 302-0
Fax +49 7824 34 03
pr@herrenknecht.com

Herrenknecht
Schweiz AG
CH-6474 Amsteg
Phone +41 41 8848 080
Fax +41 41 8848 089

Herrenknecht
Tunnelling Systems INC.
Auburn 98001
Washington, USA
Phone +1 253 833 7366
Fax +1 253 833 7108

Herrenknecht Guangzhou
Tunnelling Equipment CO., LTD.
Guangzhou 510760
China
Phone +86 20 822 09300
Fax +86 20 822 19020

HERRENKNECHT



Tunnelling Systems