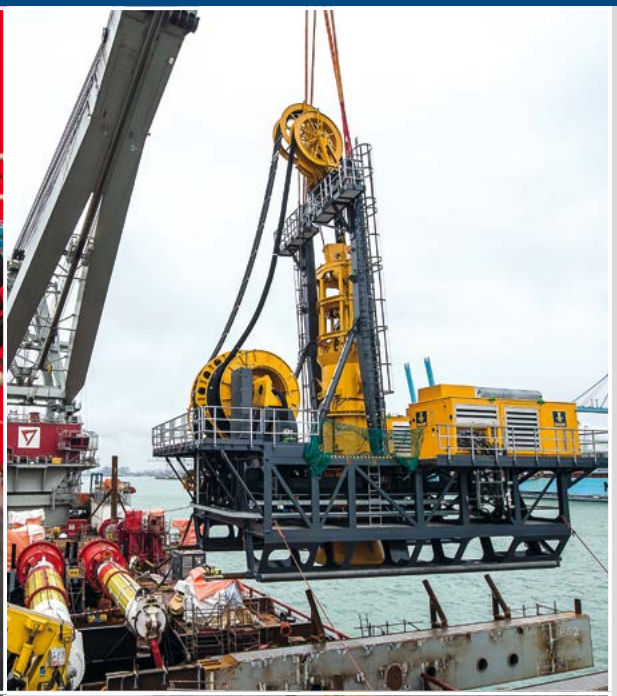
BAUER

Maritime Technologies



Experience for you!

"Technology market leader and pioneer for innovations, at the same time down-to-earth with responsibility towards society and environment - that's our goal." Prof. Dr. Sebastian Bauer

We could start by telling you about Sebastian Bauer, who founded a copper forge in the German town of Schrobenhausen some 200 years ago. We could then move on to how his workshop prospered and developed to a leading construction company for specialist foundation engineering. The story would continue to the mid 20th century, when innovation and the drive for perfection prompted Bauer to develop and build their own high-quality and high-performance machinery.

And it still wouldn´t end in the 21st century, Bauer now family-run in the seventh generation and meanwhile a globally operating group with more than 100 branches and subsidiaries operating in the fields of special foundation engineering (Bauer Spezialtiefbau), in manufacturing of foundation equipment (Bauer Maschinen) and focusing on products and services in the fields of water, energy, mineral resources and environmental technology (Bauer Resources).

But we think what really matters about us and to our customers is this:
We are a strong partner with face and values, we are down to earth, and we are dedicated to perfection in everything we touch.

1790
Foundation as a copper forge in Schrobenhausen, Germany

1928
Well drilling in Bavaria, Germany

1958
Invention of the ground anchor by Dr.-Ing. K. H. Bauer

1976
First hydraulic rotary drill rig BAUER BG 7

1984
First diaphragm wall trench cutter BC 30

More than machines: Competent consulting

Quality is not an act,
it is a habit.

Of the thousands of machines Bauer Maschinen has built since production started in the 1970´s with the first rotary drill rig BG 7, many of them are still in operation all over the world – in Siberia as well as in the desert. State of the art technology developed end-to-end by our inhouse engineers and full machine tests prior to delivery are one side of the coin. Bauer Maschinen can serve any customer need with the most comprehensive product portfolio.

The other side is project-specific consulting by highly trained experts, with a focus on your special requirements.

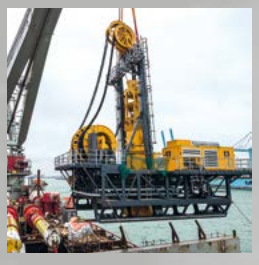
- **Quality and experience in specialist foundation engineering**
- **Global operation – local contacts in over 70 countries**
- **Reliability in technology, service**
- **Customized solutions**
- **On-site support over entire machine service life**

1980´s
Start of international equipment sales

1993
Diamond deposit exploration with a BC cutter in water depth of 160 m (South Africa)

2005
Drilling inside of a monopile with a Bauer Fly Drill (Barrow, UK)

2011/2012
Monopile foundation in rock for tidal turbine with BSD 3000 (Orkneys, UK)



2017
Dive Drill relief drilling for offshore windfarm (North Sea, Scotland)

Advantages of the BAUER Maritime Technologies

For offshore foundations there are many situations where piles cannot be driven to their full penetration. When pile refusal is reached (e.g. boulders or rock layers), when calcareous sand are not suitable for pile driving method or when noise produced by the hammering can damage the marine species, BMT is able to provide technologies for the offshore foundation engineering, based on the onshore drilling know-how. For big monopiles (up to 6 m) or for piled structures (jackets or tripods), BAUER Maschinen GmbH provides the right solutions.

Not only for offshore foundations but also in the field of subsea exploration and mining BAUER technology is used. MeBo, the deep sea coring rig and the Vertical Approach, where seabed samples can be collected with the help of the trench cutter technology are also part of the BMT.

Applications

Offshore foundations

Offshore wind structures

Platforms for the oil & gas industry

Subsea exploration

Bauer Systems for offshore foundations		
Equipment	**Range of Diameter**	**Soil**
BSD (Bauer Sea Bed Drill)	2 - 3 m	Rock
Dive Drill	2 - 3.5 m	Medium dense to cemented sediments, hard cohesive soil
Fly Drill	1.5 - 3.5 m	Medium dense to cemented sediments, hard cohesive soil
BC Cutter	4 - 6 m (in sections)	Cemented soil with boulders and rock

The BSD 3000 is a reverse circulation drill with a full face roller-bit with heavy weights. It is specifically designed for drilling in rock.

A typical application is the construction of boreholes for monopiles or tripod foundations whenever the bedrock is encountered at seabed level.

Drilling procedure
Lower and fix the drill template at seabed level.

Install the conductor casing inside of the template.

Lower the drill unit with rotary drive, drill pipe, heavyweights and full face roller bit into the conductor casing.

The rock is broken into pieces by the full face cutting tool.

The drill spoil is transported to the top by the air-lift technique - the air lifting pipe ends shortly above the drill rig. All the main functions are monitored through cameras and sensors.

The drill rig and the umbilicals withstand all forces caused by currents and waves. The umbilical handling system has to compensate for the unavoidable movements of the vessel.

Main components of the BSD 3000
1. Drill template (with legs including leveling system, weight plates and the centerpiece with casing clamp and oscillator).

2. Conductor pipe (with drilling shoe, internal brackets and plates to support the drill unit).

3. Drill unit (with rotary drive, climbing mechanism, drill pipe, heavyweights and full face roller bit).

Additional components:
4. The umbilicals for the supply of hydraulic oil, air, grout and signals.

5. The umbilical handling system with quick release mechanism and mooring winches.

6. The operator‘s cabin with hydraulic power unit and compressors.

7. The deck storage frame for conductor pipe and drill unit.

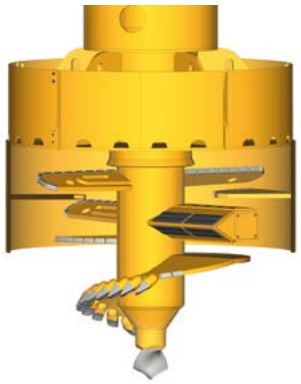
Technical specifications	
Operating weight (approx.)	270 t
Drilling diameter	2 - 3 m
Drilling depth	11 m
Max inclination of seafloor template	7 %
Torque (rotary drive) max.	110 kNm
Torque (oscillator) max.	600 kNm
Crowd force	100 t

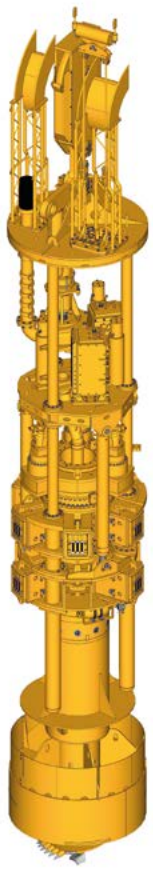
Dive Drill – Relief Drilling Inside of Casing

The Dive Drill is a rotary drilling system intended to operate from the inside of driven steel tubes to support the pile-driving method and possibly as an alternative pile installation method in hard to soft soils for offshore foundation construction, in particular for monopiles or tripod foundations in the diameter up to 3.5 m.

The Dive Drill is used to clean out the soil plug inside of the casing, which is an effective means of reducing driving resistance. It can also be used to predrill in hard strata that impede the further driving of the pile and also for breaking up and penetrating glacial erratics that might be found, which would obstruct proper pile installation.

System and work description:
The Dive Drill can either be installed on a specially modified crawler crane (preferably BAUER MC 128), which contains all controls, power and umbilical winches to operate the Dive drill or it is stationed on a vessel with a crane, operated with an external power pack (preferably HD/HE 1400) and hose drums that are located on deck of the vessel. The Dive Drill itself will be lifted with the vessel crane.





It is lowered into the casing and clamps itself to the sidewalls.

There are two clamping systems for transferring the torque and the thrust forces to the casing: one is located at the torque unit and the second one at the drill head.

The drilling torque is generated in the rotary drive and transmitted to the drill head with a telescopic drill string.

A specially designed drilling tool loosens the soil/rock. The dissolved cuttings are fed to the cone crusher by a screw flight and hydraulic support, where larger cuttings are broken down. In the mixing chamber, located above the cone crusher, the cuttings are mixed with seawater and pumped to the surface.

After drilling of one feed length, the clamp at the drill unit is fixed and the clamp at the torque unit is released and lowered down.

The drill process continues by clamping the torque unit aigain and releasing the drill unit. Thus a continuous vertical advancement of the Dive Drill is reached inside of the casing until it reaches the desired depth.

Dive Drill – Advantages:
- Easy and fast switching from pile driving to relief drilling.

- Direct installation into the casing regardless of the position of the top of the casing (above or below the water table).

Different teeth configurations allow drilling in various soil conditions.

Technical specifications	
Operating weight (for drilling diameter 2.0 m)	35 t
Drilling diameter	2.0 - 3.5 m
Max. water depth	250 m
Torque (rotary drive) max.	440 kNm
Crowd force	1,300 kN
Pump capacity	450 m^3/h

The Fly Drill method is a new concept for bored piling. The drilling unit with rotary head, Kelly bar and drilling tool is suspended by the hoist rope of the base carrier crane. The hydraulic power for the drill unit is provided from the base crane (e.g. BAUER MC crawler cranes) or from an external power pack.

The drill head is fixed on the casing with a hydraulically operated clamping system during the drilling operation. When emptying the drilling tool, the clamp cylinders are opened and the complete unit is swung sideways.

Main features of the Fly Drill:

- The suspended drill, free from base machine, has high versatility when working in different ground levels and with varying working radius (e.g. piles in slopes). The Fly Drill system is ideally suitable for shallow offshore piling from a floating barge.
- It is a highly versatile 'mobile' pile-top drilling system for applications in Kelly mode in all types of soil and weak rock. The key advantage of the system is the ability to operate pile driving equipment and drilling equipment in an alternating sequence whenever driving would be stopped by refusal before reaching the terminated depth.
- The main components of the drill, in particular the rotary drive and the Kelly bar originate from the well established BAUER BG series.
- The Fly Drill system can be operated with a lockable three-fold Kelly bar or with a four-fold friction Kelly bar
- The unit can be rigged-up without external assistance.
- When working in mixed soil conditions, where soil is underlain by rock, the Fly Drill can also be combined with full-face RCD systems for rock drilling.

Reference example

On a large offshore wind farm in UK coastal waters in the East Irish Sea, 30 wind towers had to be installed, resting on monopiles. The tubular steel piles have a diameter of 4,750 mm and are up to 61 m long with a penetration depth from 30 – 40 m below seabed level.

The geology of the area beneath the wind farm site comprises variable sequences of medium dense to very dense sands, firm to stiff and very stiff to hard clays and weathered mudstone, siltstone and sandstone.

Whilst these conditions are generally suitable for pile driving with ultra-heavy piling hammers, formations such as completely weathered mudstone and weak to moderately weak siltstone/sandstone at elevations above the toe levels of the monopiles have the potential to result in refusal of monopiles during driving.

The majority of monopiles installed could be driven to their terminated penetration depth. Nine piles refused further driving and thus required drilling to facilitate full penetration by subsequent driving.

The aim of drilling out the core from inside monopiles that refused above their final elevations is to reduce both frictional and end resistance. By drilling the soil material out from inside the tubular steel pile, the skin friction acting on the internal surface of the monopile is eliminated over the drilled-out length.

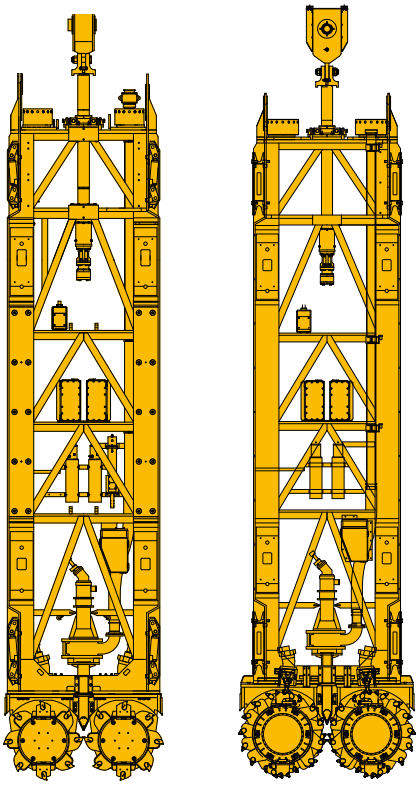
Technical specifications BFD 1500 – BFD 3500		
Torque	kNm	147 - 360
Stroke crowd cylinder	mm	1,000 - 1,500
Crowd force (push/pull)	kN	2 x 70 - 2 x 120
Clamping force	kN	2 x 230
Drilling diameter*	mm	1,000 - 3,500
Weight (w/o kelly bar and tool)	t	(approx.) 5 - 15
Drilling depth (depends on base carrier)	m	20 - 60

* other diameters on request

The trench cutter is an excavating machine which is usually used in the foundation engineering for constructing underground walls. It operates on the principles of reverse circulation. It is made up of a heavy steel frame with two gear boxes at the bottom of the frame. Cutting wheel drums fitted with a series of teeth are fixed to the gearboxes. They rotate in opposite directions, break up the soil and mix it with the bentonite suspension. As the cutter penetrates, soil, rock and bentonite slurry are conveyed towards the openings of the suction box, from where they are pumped by a centrifugal pump through the slurry pipe incorporated in the cutter's frame, to a desanding plant on the surface. There, solid soil and rock particles are separated from drilling fluid which is pumped back into the trench or for storage and later reuse.

The use of trench cutter technology for removing obstacles inside of monopiles

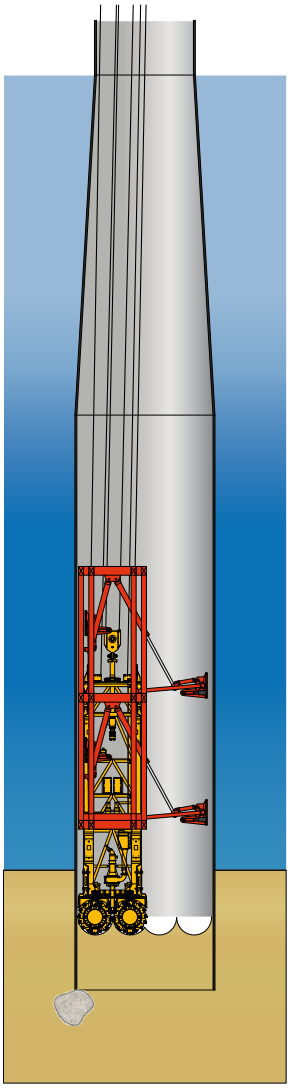
During the installation process of large monopiles it is possible to encounter erratics of big dimension (volume of at least one cubic metre) in glacial submarine sediments. They would impede the proper pile installation. The

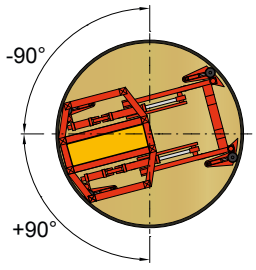


pile would be driven to refusal and that would prevent the reaching of the design depth.

The BC trench cutter might be used in order to mill the rock. The torque output of the cutter wheels in combination with the weight of the cutter is sufficient to cut into any type of soil, to crush cobbles, small boulders or rock. From a jack-up barge, the trench cutter would be immerged in the water by a crane (i.e. MC 128).

The cutter is fixed in a special guide frame. There it can slide in x-direction, while the frame system can be rotated ± 90° inside of the monopile. Thus, erratics or boulders, which impede pile driving, can be cut and milled at any position inside of the circular borehole. The weight of the guide frame is about 30 tons.



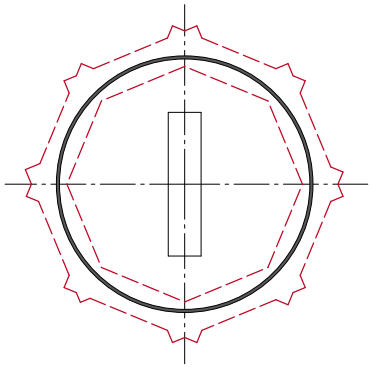


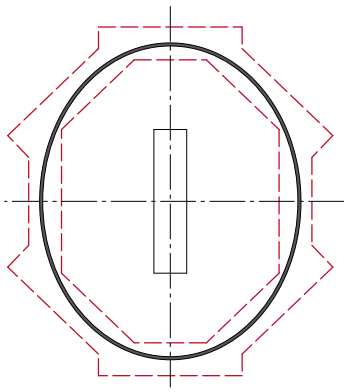
Technical specifications BC 40	
Gearbox	2 x BCF10
Torque max.	100 kNm
Speed of rotation	0 - 25 rpm
Cutter length	2,800 - 3,200 mm

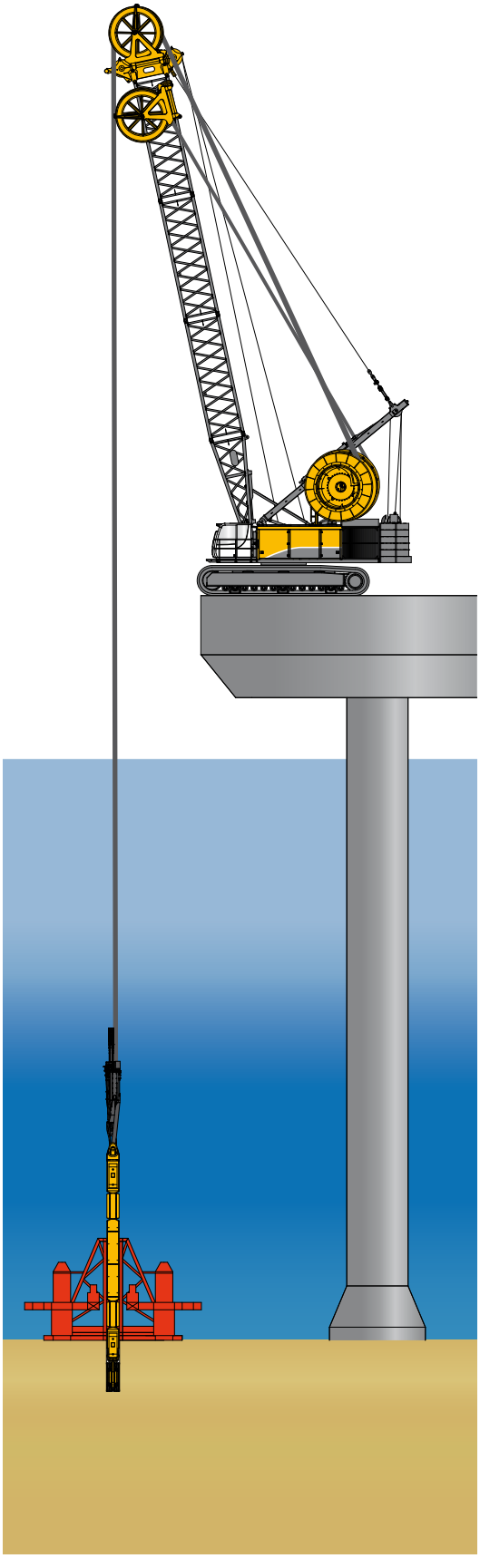
Circular trench cutter technology (CTC)
The CTC technology is a new option of the trench cutter technology for offshore monopile installation. The idea is to create an annular ring cut where the steel tubular structure is inserted and possibly fixed by grouting. The CTC arrangement and the template is deployed on the seabed from a jack-up barge.

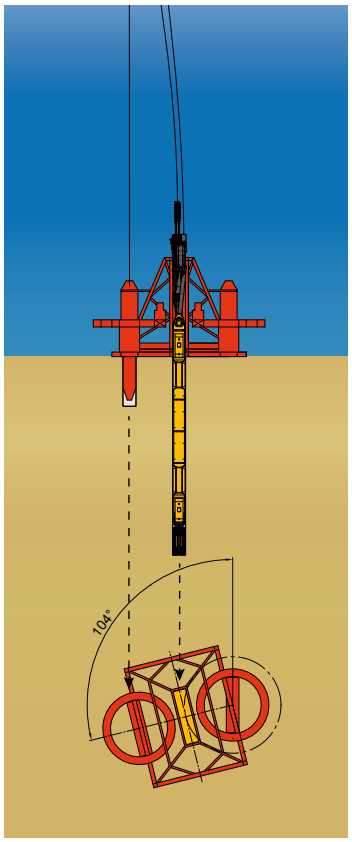
A central pilot trench is excavated with a depth of approximately 2.5 m. The spike 1 (or 2) is inserted in the pilot trench and acts as pivot for the rotation of the CTC. When the first trench is finished, the whole template is rotated around the spike in the pilot trench and the next trench is cut. This process is repeated until a continuous annular ring is excavated.

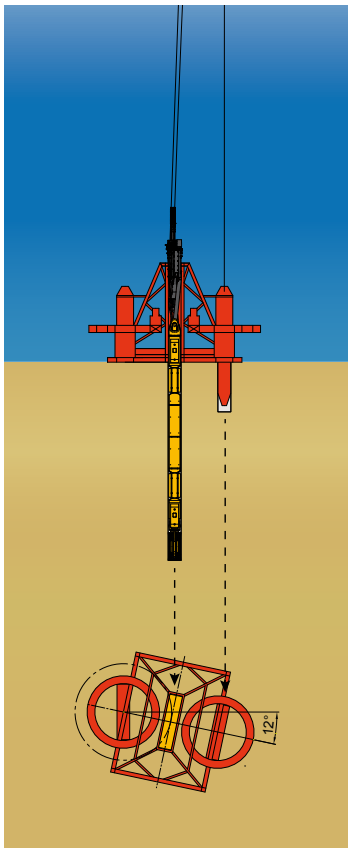
After installing the monopile, the cutter together with the template is removed. The weight of the CTC frame is about 30 tons. The system allows the construction of circular or ellipsoidal rings.











MeBo – Sea Bed Drill Rig

The original drilling system MeBo for scientific investigations was developed by the MARUM Center for Marine Environmental Sciences at the University of Bremen. It includes, besides the drill rig, the complete system such as operator's cabin, launch and recovery system and umbilical winch. Based on experiences with the first MeBo (drilling depth 80 m), MARUM and BAUER Maschinen GmbH built a second drilling system for drilling depths of up to 200 m (MeBo 200). MeBo 200 was tested successfully in October 2014. Since 2016 it has been in operation for several scientific research excursions with Marum.

The MeBo sea floor drill rig is a portable rig which is remotely operated from a vessel. It can be deployed in water depths up to 4,000 m for conducting core drilling down up to 200 meters below sea floor.

Main applications
Soil sampling from soft sediments to hard rock.

Geotechnical exploration for offshore foundation installation.

Searching of minerals in marine environment (e.g. diamonds).

Drilling for natural resources offshore (e.g. gas or oil).

Exploration of marine sulfide deposits.

The possibility of drilling tests for gas hydrate are currently studied.

Work sequence
1. Remote controlled from a vessel, the MeBo is deployed to the sea bed, using a steel armored umbilical to depths up to 4,000 m.

2. Four legs are extended before landing to increase the stability of the rig and leveling due to possible unevenness of the sea bed.

3. The mast with the feeding system and the power swivel forms the central part of the drill rig. It is mounted on a guide carriage that moves up and down the mast with a maximum push force of 5 tons.

4. A water pump provides sea water for flushing the drill string, for cooling of the drill bit, and for drill cuttings removal. The system utilizes rotary core barrels with diamond or tungsten carbide bits.

5. The MeBo stores drilling rods and core barrels on two rotating magazines that may be loaded with a mixture of tools as required for a specific task. With a storing capacity for core barrels with a length of 3.5 m, the MeBo 200 is capable of drilling down

to 200 m into the sea floor, recovering cores with 54 – 63 mm diameter.

The MeBo might also be equipped with a rotary vibratory drill which is capable of high drilling speeds as well as accomplishing tasks, such as continuous coring that cannot be carried out by any other equipment.
Sea bed drill rigs are not affected by any ship movements due to wind or waves. Since they operate from a stable platform on the sea bed, optimal control of drill-bit pressure can be achieved, which is prerequisite for optimal core quality.

Technical specifications	
Operating weight (approx.) (in air with drill string and core)	17.5 t
Coring diameter	54 - 101 mm
Drilling depth	200 m
Water depth (max.)	4,000 m
Torque rotary drive (max.)	1,800 Nm
Speed rotary drive (max.)	400 kNm
Feed force	50 kN
Pulling force	100 kN
Pump capacity (max.)	160 l/min
Pump pressure (max.)	60 bar
Tool length	3.5 m

Deep Sea Sampling

The Vertical Approach – Seabed Mineral Services Partnership of Excellence

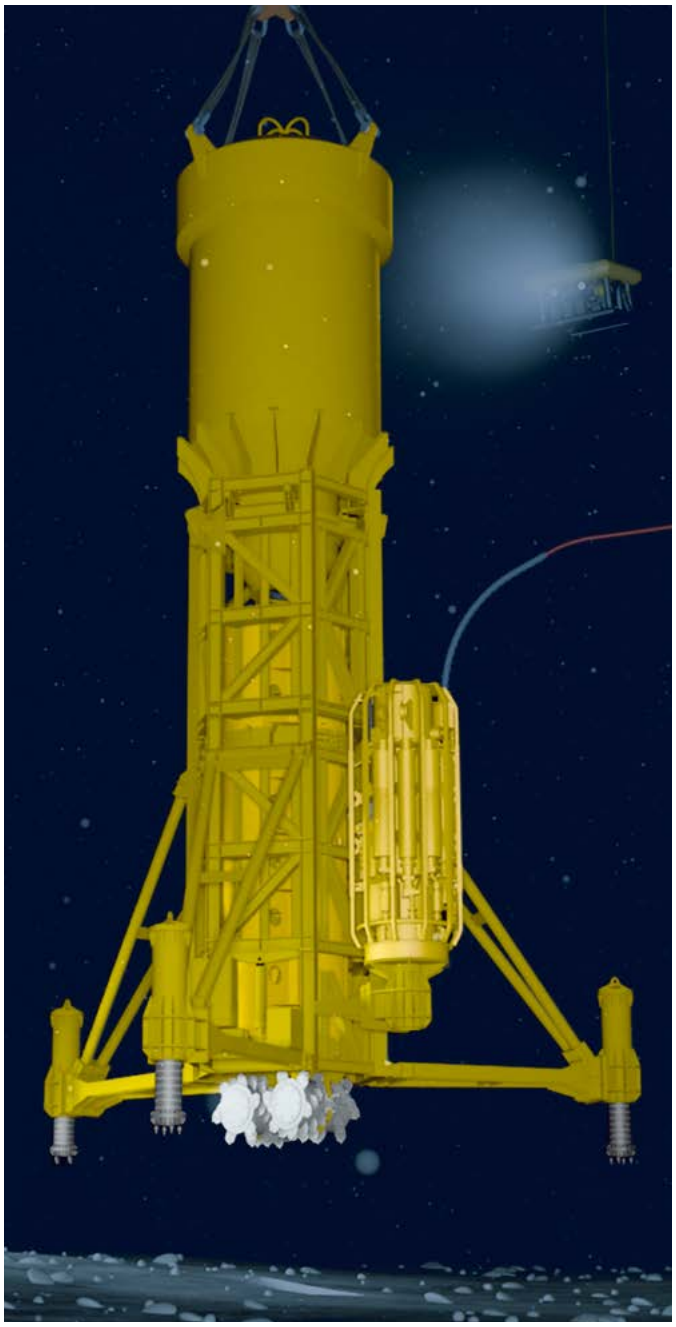
In 2020 a joint venture between BAUER Group, specialist for foundation construction equipment, and Harren & Partner, a Bremen-based shipping group with more than 30 years of experience, was formed. This way expertise in the drilling field and maritime proficiency come together for developing concepts for reliable and responsible deep sea mining.

Our Challenge
Land-based mines are rapidly depleting and new resources need to be made accessible. Access to deep sea deposits of mineral resources and seafloor massive sulfides opens up new opportunities, however, today's conventional mining methods are capital intensive and causing negative environmental impacts. Sustainable and affordable solutions to realize deep sea mining projects are not readily available on the market.

Our Goal
Combining our engineering and maritime know-how to offer innovative technology and methods for exploring and mining the seabed in an environmentally responsible and economically viable way.

Our Solution
Vertical approach for minimized footprint and as a result a minimized impact on the seabed. By using only one universal mining machine consisting of proven components and procedures for all operations on the seabed, technological risk and environmental impact are minimized. In order to provide a sustainable solution, concepts for a closed system to prevent mixing of deep sea water with surface ocean water and minimizing the contamination of the deep sea water with fine particles were developed. Selective mining with high precision equipment cuts only ore, not the surrounding area.

Our Concept
Using the trench cutter technology for producing 7 m deep cuts in up to 2,500 m water depth. The ore will be collected in a container and winched to the deck of the vessel.



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