Bauer
Jet Grouting

Process

BAUER

Advantages of the Jet Grouting Process

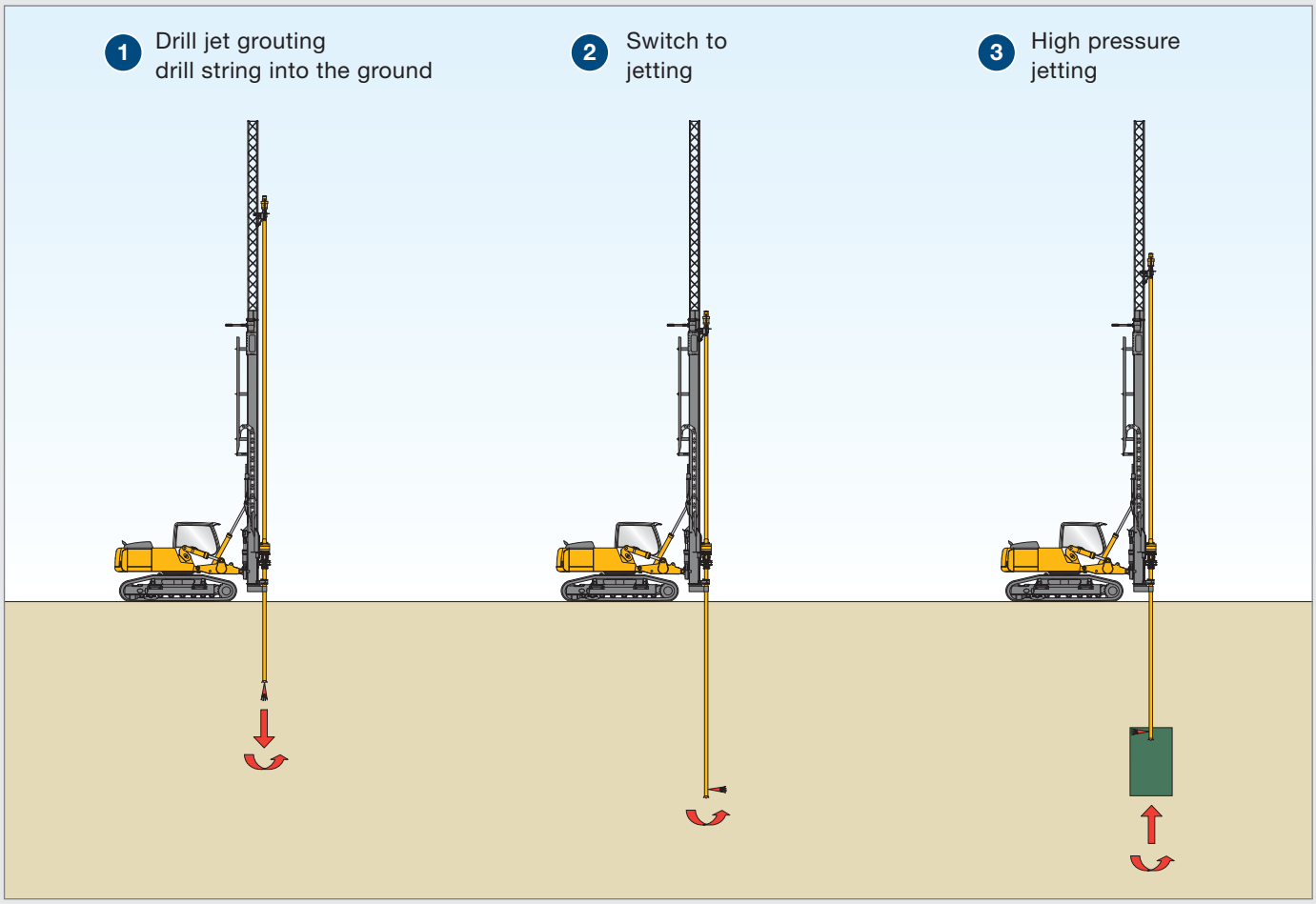
During the jet grouting process, the soil surrounding the drill string is eroded by a high energy fluid jet and mixed with a self hardening cement suspension.

The main advantage of this process is that large solidified jet grout elements can be produced in the ground by a relatively small drill rod (borehole diameter approx. 15 cm). The applications are virtually unlimited.

Applications:
- **Underpinning / Foundation support**
- **Gap closure**
- **Deep and high level sealing slabs**
- **Tunnel crown stabilisation**
- **Sealing and cut-off walls**

- **High level of safety as jet grouting is carried out prior to any excavation (e. g. sealing slabs and underpinning)**
- **Load-bearing capability as result of compressive strength**
- **Application in restricted site and limited headroom conditions**
- **Virtually unlimited drilling depths and complicated geometrical shapes possible**
- **Underpinning by jet grouting enables excavations adjacent to the building line**
- **Low-vibration process**

Construction Sequence



Step 1:
A string of jet grouting rods is drilled into the ground to the required depth by a rotary drilling rig. The lower end of the drill string is fitted with a nozzle holder and a laterally mounted jet grouting nozzle.

Step 2:
A jetting fluid (water and/or binder suspension depending on the type of jet grouting process) is pumped through the jet grouting nozzle at high pressure (400 - 600 bar). This produces a high-energy "cutting jet" which erodes the soil from its natural position and mixes it with the binder suspension. The diameter of the column (up to 5 m) is determined by the density and type of soil as well as the jet grouting parameters.

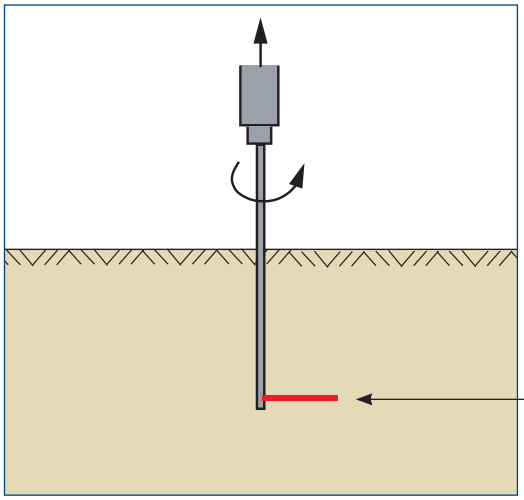
Step 3:
By rotating and simultaneously retracting the jet grouting drill string, the cutting jet describes a tightly-spaced helix in the soil, resulting in a column-shaped space filled with binder suspension and soil. The binder causes this mixture to set and solidify, as a result of which load-bearing jet grouting columns are formed.

Different jet grouting methods

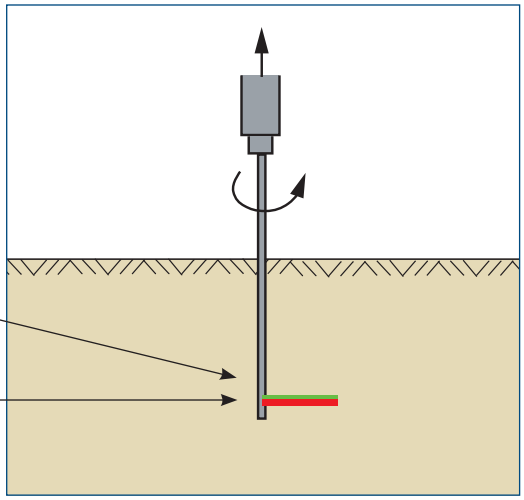
Depending on the prevailing soil conditions, different jet grouting methods are employed.

BAUER definition		Definition in accordance withEN 12716:2001
B	**B**inder cutting. In granular soils for small to medium column diameters	**1**-Phase System
BL	**B**inder cutting with air shrouding. In granular soils for medium to large column diameters	**2**-Phase System (suspension and air)
WB	**W**ater cutting and filling the soil with binder. In cohesive soils for small to medium column diameters	**2**-Phase System (water and suspension)
WLB	**W**ater cutting with air shrouding and filling the soil with binder. In cohesive soils for medium to large column diameters	**3**-Phase System

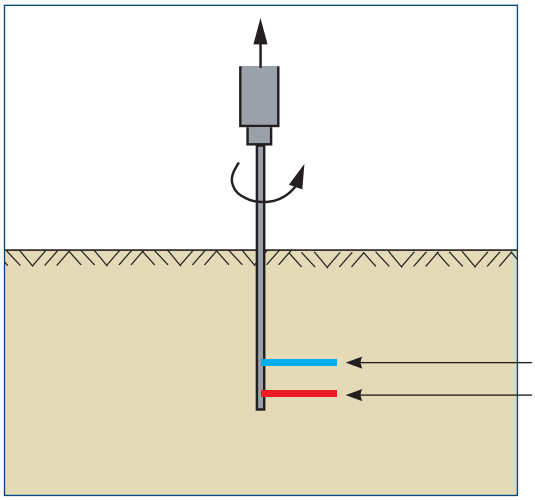
Jet Grouting Process **B**



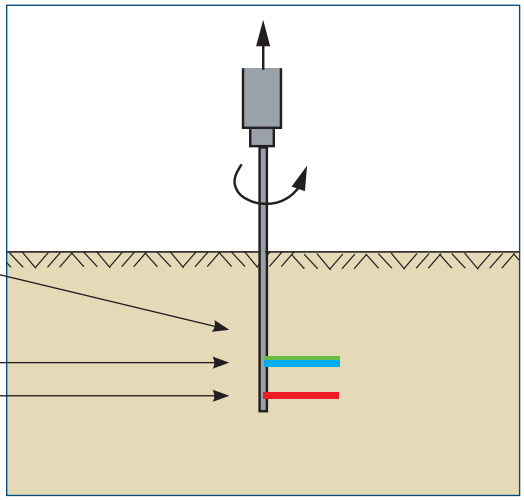
Jet Grouting Process **BL**



Jet Grouting Process **WB**

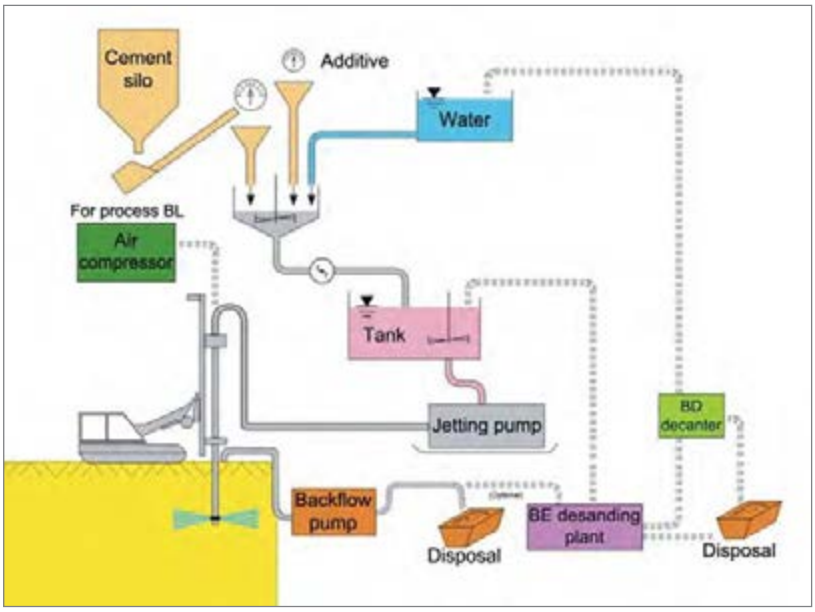


Jet Grouting Process **WLB**

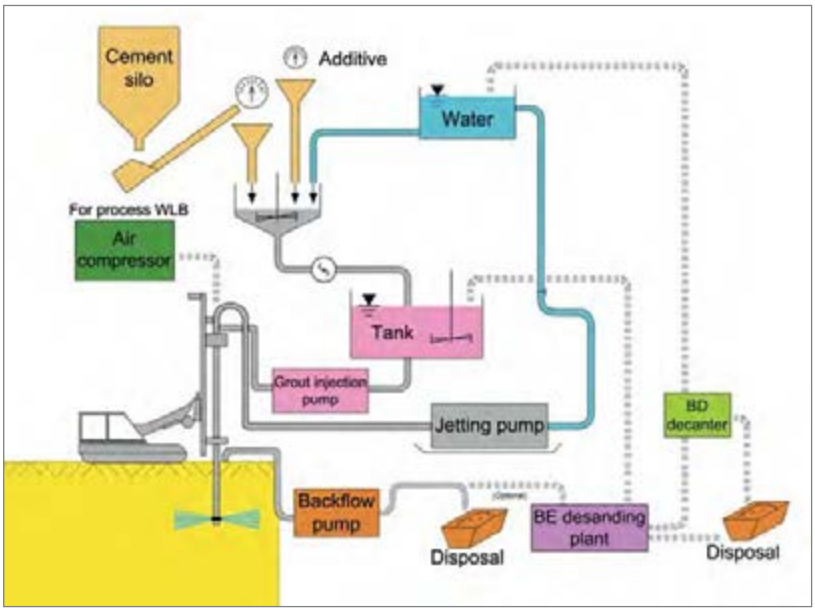


Site Installation

Procedure Process B and BL
The B and BL processes are primarily used in non-cohesive soils.
In the BL process, air shrouding increases the range of the grout jet.



Procedure Process WB and WLB
The WB and WLB processes are primarily used in cohesive soils. In both processes, the soil structure is eroded by the high pressure water jet and subsequently mixed with the binder suspension.



Jet Grouting Parameters

The essential parameters which are reponsible for the result are:
- High pressure pump 100 – 600 bar
- Number of nozzles 1 – 2
- Nozzle diameter 2 – 7 mm
- Drill string rate of extraction 1 – 12 min/m
- Air shrouding 4 – 12 bar
- Drill rod speed of rotation 2 – 15 rpm
- Binder suspension W/B ratio 0.5 – 1.5
- Injection rate 100 – 400 l/min
- Injection pressure 3 – 10 bar

Materials

In general, jet grouting requires only water and binder suspension (generally in the form of cement). Selection of the appropriate binding agent is determined by the following requirements:
- Strength
- Impermeability
- Erosion resistance
- Workability

Forms of Jet Grouting Elements

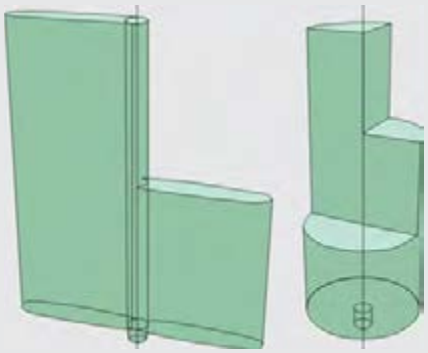
Depending on the rotation and movement of the drill rods, different geometric forms of jet grouting elements can be created, such as:
- Circular columns
- Half columns
- Segmental columns
- Panels


Sektor angle Ω = 360°
(Circular column)


Sektor angle Ω = 180°
(Half column)


Sektor angle Ω = e. g. 66°
(Segmental column)

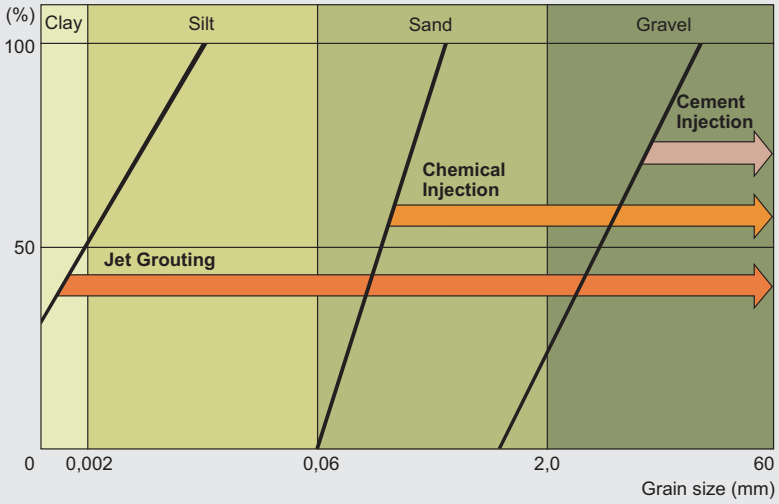

Sektor angle Ω = 0°
(Panel)



Limits of Application

The erosion capability of the cutting jet renders the jet grouting process suitable for use in virtually all types of soil. The process is, however, not suitable for hard soil and soft rock formations in which stabilization is not generally required and would also not be economical.

The "Bauer Jet Grouting Process" can be used in non-cohesive or cohesive soils and also in slightly organic soils and fill materials.



Applications

Underpinning

Sealing slabs

Sealing slabs

Foundation support

Equipment for Jet Grouting

The **universal Bauer BG base carriers** can be converted for most of the established specialist foundation construction techniques. Attaching the required jet grouting equipment is also easy.

Numerous jet grouting projects around the world have already been completed with different BGs. Three examples of BG jet grouting configurations are illustrated below.

Bauer rigs can be preset for a grouting pressure of 420 bar (standard) or optionally 560 bar.

	BG 15 H	BG 24 H	BG 30
Rod diameter	89 – 133 mm	89 – 133 mm	89 – 133 mm
Jetting depth [1]	ca. 29.9 m	ca. 35.3 m	ca. 35.5 m
Overall height	39.24 m	45.2 m	45.4 m
Max. power output	230 kW	354 kW	403 kW
Weight	56.1 t	80 t	107 t
Mast inclination	± 5°	± 5°	± 5°
Rotary drive	KDK 10 S	KDK 10 S	KDK 10 S

[1] dependent on level of jet nozzle holder

Klemm Rigs

KLEMM Bohrtechnik GmbH, a subsidiary of BAUER Maschinen GmbH, is a leader in the development and manufacture of hydraulic drill rigs and accessories for all types of drilling jobs for anchoring, overburden, injections and micropiles. The compact Klemm drill rigs can be used for a wide range of jet grouting applications.

	KR 704-1	KR 801-3FS	KR 909-2	KR 714
Length [1]	3.8 m	6.3 m	8.8 m	15.3 m
Width [1]	0.75 – 1.2 m	1.8 m – 2.4 m	2.3 m	2.5 – 3.3 m
Overall height with drill mast [1]	6.1 m	12.9 m	20 m	27.3 m
Weight	5.0 t	12.0 t	13.3 t	27.5 t
Power output	45 kw	115 kW	129 kW	173 kW
Rod diameter [2]	89 mm	89 – 133 mm	89 – 133 mm	89 – 133 mm
Rod inclination with drill mast	-2.5/+10°	-2.5/+10°	-2.5/+10°	-3/+5°
Jetting depth single pass max.	5.5 m	12.5 m	16.5 m	24 m
Rotary drive, recommended	KH9SK	KH9SK/KH14SK	KH12SK/KH14SK	KH12SK/KH14SK

[1] Dimensions during operation
[2] The rod diameter can be changed to suite requirements

Additional Equipment

Jet Grouting Drill Rods
Bauer and Klemm both provide different diameter drill rods for all three jet grouting systems. Depending on the application, drill rods are either equipped with srew or plug couplings.

Diameter	1-Phase	2-Phase	3-Phase
88.9 mm	X	X	X
114.3 mm		X	

High Pressure Jetting Pump
The MP7 high pressure jetting pump has been specially tailored for the requirements of Bauer jet grouting plant.

	MP7-MP7ST
Max. flow rate	550 l/min
Max. power output	600 kW
Weight	14 – 15 t
Common operating pressure approx.	450 bar

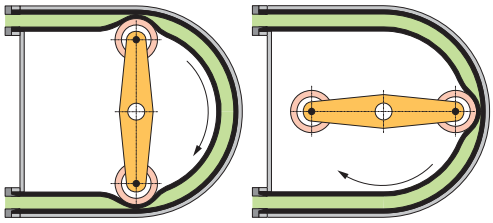
Mixing Plant
Our branch company MAT supplies compact injection plant units for colloidal mixing and injection of suspensions for a range of different applications. The SCC and SCA range of mixing plants covers all project sizes.

	SCA-20K	SCA-30K	SCA-40K
Mixing capacity	20 m^3/h	30 m^3/h	40 m^3/h
Total power input	43 kW	43 kW	63 kW
Weight	2.8 t	2.9 t	4.7 t
Mixer volume	1000 dm^3	1500 dm^3	2500 dm^3

Grout Pump (Eccentric Screw Pump)
MAT's eccentric screw pumps are ideally suited for the injection of cement suspension in the 2- and 3-phase processes with water jetting (WB or WLB).

	EP-12-400	EP-12-600	EP-14-400
Delivery rate	400 dm^3/min	600 dm^3/min	400 dm^3/min
Delivery pressure, max.	12 bar	12 bar	12 bar
Power input	18.5 kW	30 kW	30 kW
Weight	0.91 t	1.4 t	1.78 t

Backflow Pump
The backflow of excess water-soil-mixture resulting from the jet grouting process can be removed by MAT's robust hose pump.

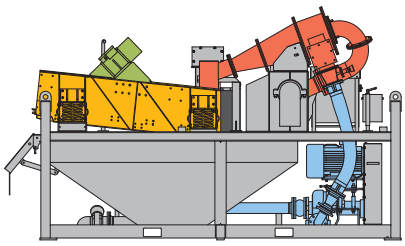


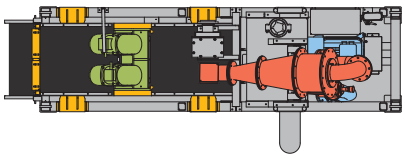
	HP – 30	HP – 50
Delivery rate	30 m³/h	50 m³/h
Delivery pressure	8 bar	8 bar
Weight	1 t	1.8 t
Power input	18.5 kW	30 kW
Grain size, max.	24 mm	32 mm

Desanding Plants
The BE range of compact desanding plants facilitates the efficient separation of the backflow into its constituent parts, making partial recycling of cement suspension possible.

The BE 100 - 60 is small, very compact units for small volumes of suspension. Cost-effective operation on small construction sites due to minimal installation time and low electricity power supply.

The Bauer BD 90 decanter can be used for removing fine solids up to silt fraction from a suspension. If required, the residual suspension can be separated into solids and water by the addition of a flocking agent.





	BE 100 – 60	BD 90
Delivery rate	100 m³/h	90 m³/h
Power input	24 kW	75 kW
Cut point (BE) or Grain size, max. (BD)	0.06 mm	2 mm
Weight	2.8 t	12.5 t

Bauer Pumps
The Bauer BP 50 to BP 250 centrifugal pumps are used to feed the various Bauer desilter units. They can also be used for numerous other pumping operations. The pumps which are mounted inside a protective base frame are driven by an electric motor and V-belt. The entire unit can be controlled via an electric cabinet.

	BP 85	BP 125	BP 250
Delivery rate	85 m³/h	125 m³/h	250 m³/h
Power input	18 kW	22 kW	55 kW
Weight	0.75 t	0.78 t	1.39 t

Quality Assurance in general

Quality assurance of jet grouting elements is divided into the following headings:

- Accurate setting out of jet grouting position – tape measure, inclinometer and optical levelling instrument
- Jet grouting production parameters – pressure, speed of rotation and flow rates are monitored throughout the entire work process by the B-Tronic (Bauer) or the MB S-4 (Klemm) electronic control system
- Element diameter – by taking core samples from test columns, rod level or measuring umbrella
- Strength – by way of core or backflow samples
- Impermeability – by laboratory testing
- Movement control – particularly for underpinning operations by way of optical or laser levelling instruments

Control of Production Parameters

(on monitor of rig operator)

Bauer B-Tronic
The B-Tronic electronic monitoring and control system can be fitted to all jet grouting plant. This data acquisition system monitors and controls both production parameters and all general equipment functions.

The following production parameters can be continuously acquired, visualized and stored:

- Depth
- Volume
- In-line suspension pressure
- Speed of rotation
- Flow rate
- Suspension scale
- Inclination in 2 directions

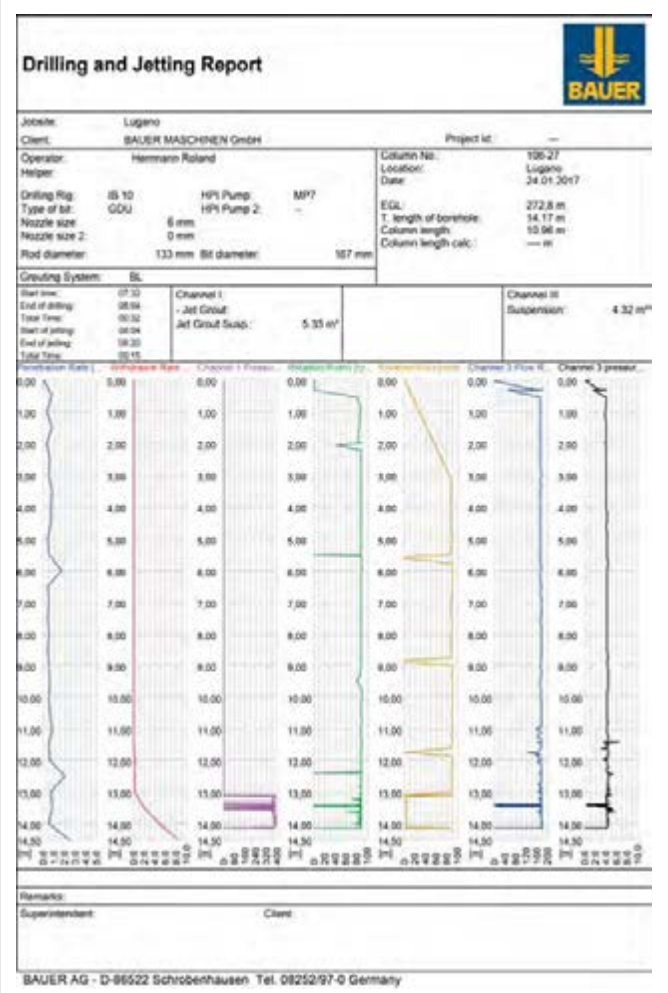
Bauer B-Tronic monitor

Klemm MB S-4
The jet grouting monitoring system MB S-4 is a programmable state-of-the-art recording and control system for daily use on construction sites. Similar to the B-Tronic, the MB S-4 continuously obtains specified production parameters (depth, speed of rotation, pressures etc.).

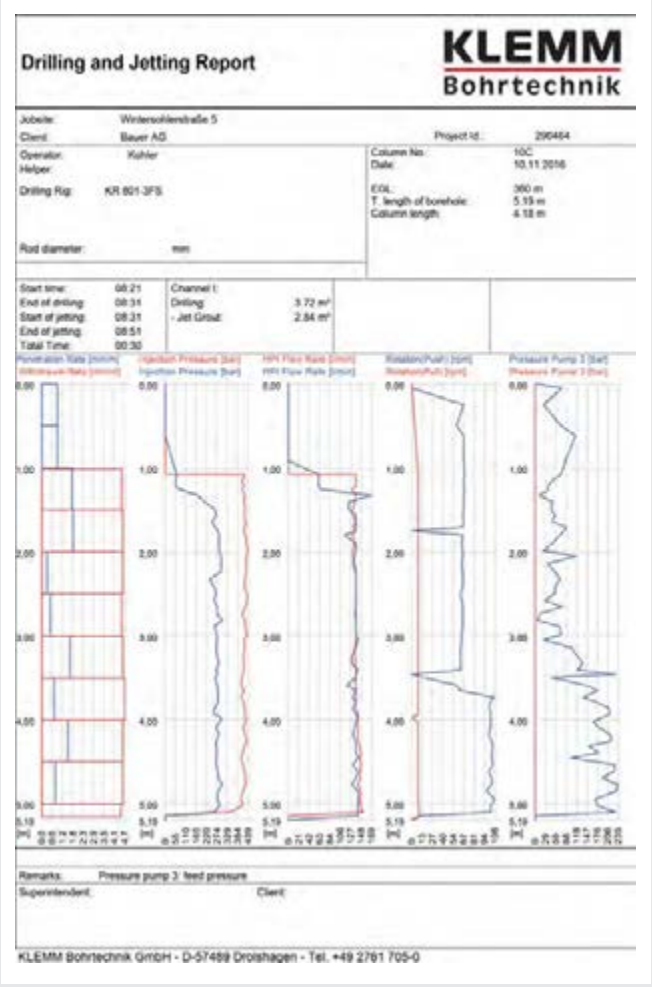
Klemm MB S-4 monitor

Documentation

All production parameters are recorded and stored inside the drilling rig throughout the jet grouting process. A print-out of these data can be produced for every jet grouting element as a quality control document. The presentation can optionally be either time- or depth-dependent.



B-Tronic Production Record



MB S-4 Production Record

Test Columns

Before commencing jet grouting operations, it is essential to construct test columns, if comparable suitability tests are not available.

The average diameter of each test column must be determined and compared with the diameter specified in the design. Based on the results of this comparison, the production parameters may have to be adjusted accordingly.

Process

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