Bauer Jet Grouting Process and Equipment

Process

BAUER

Bauer 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.

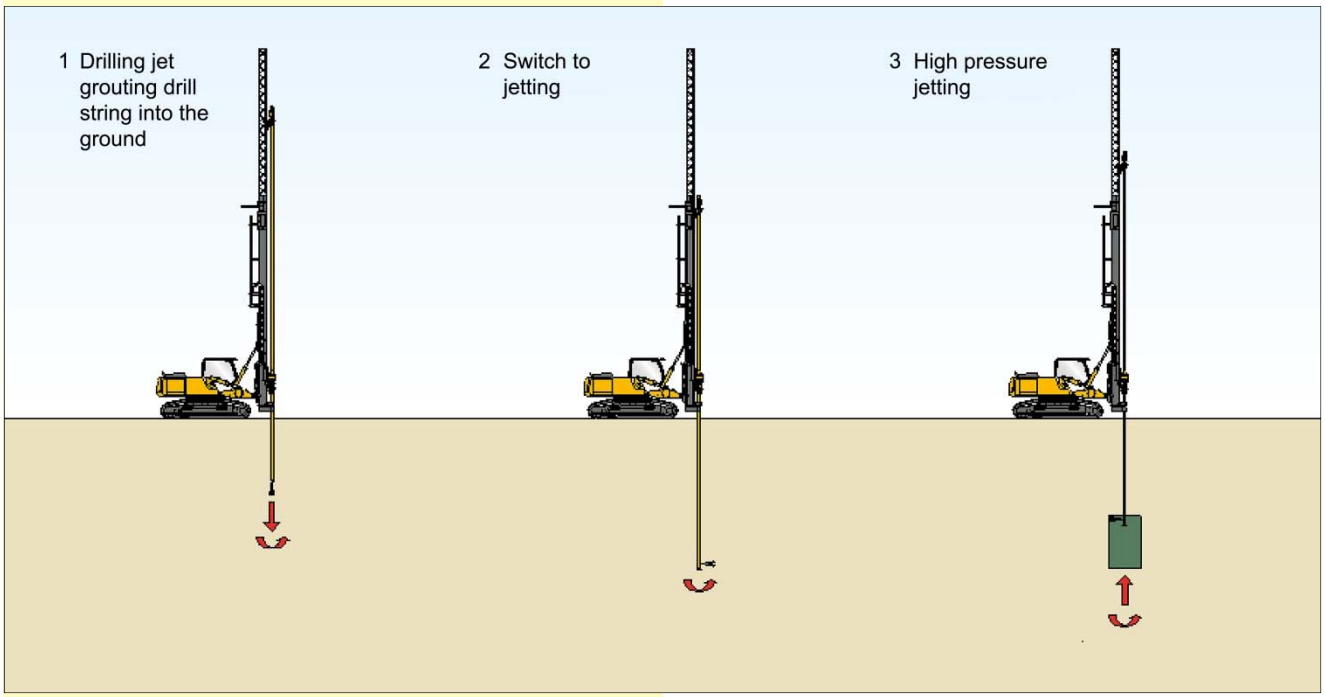
Applications:

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

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 erosion distance of the jet is determined by the density and the type of soil.

Step 3:

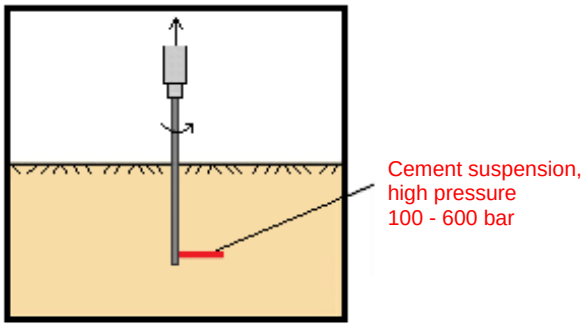
By rotating and simultaneously retracting the jet grouting drill string, the cutting jet describes a tightly-spaced helix in the soil, resulting in a column-shaped space filled with binder suspension and soil. The binder causes this mixture to set and solidify, as a result of which load-bearing jet grouting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

Construction Sequence

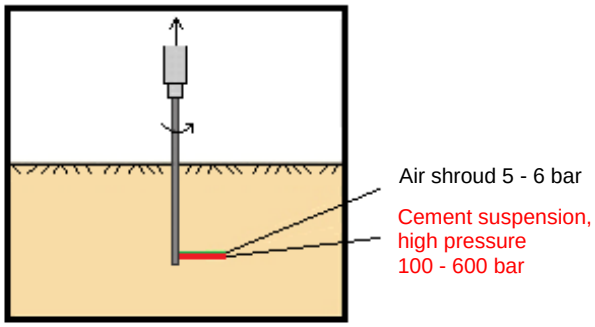
Depending on the prevailing soil conditions, different jet grouting methods are employed.

BAUER definition		Definition in accordance with EN 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

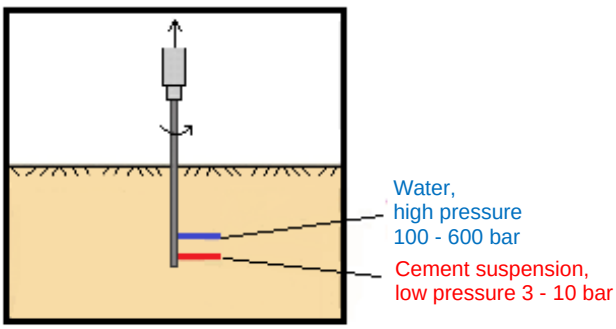
Jet Grouting Process **B**



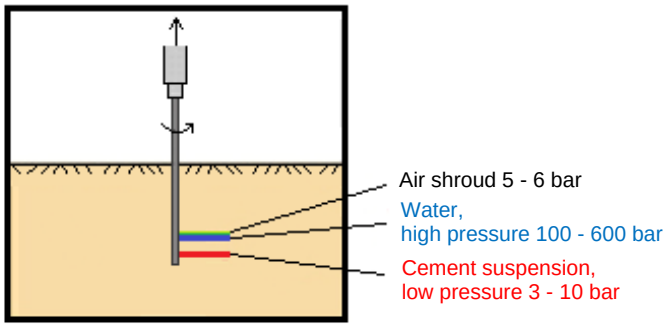
Jet Grouting Process **BL**



Jet Grouting Process W**B**



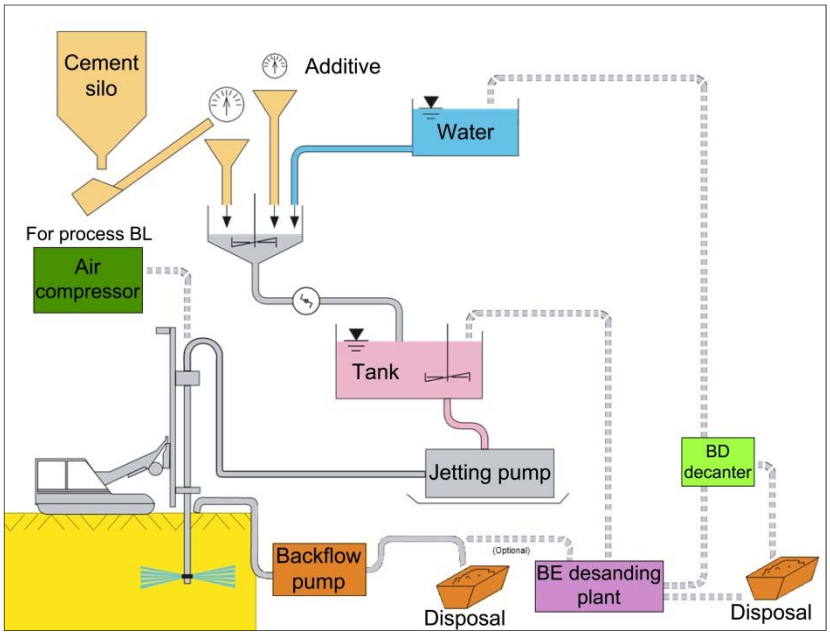
Jet Grouting Process WL**B**

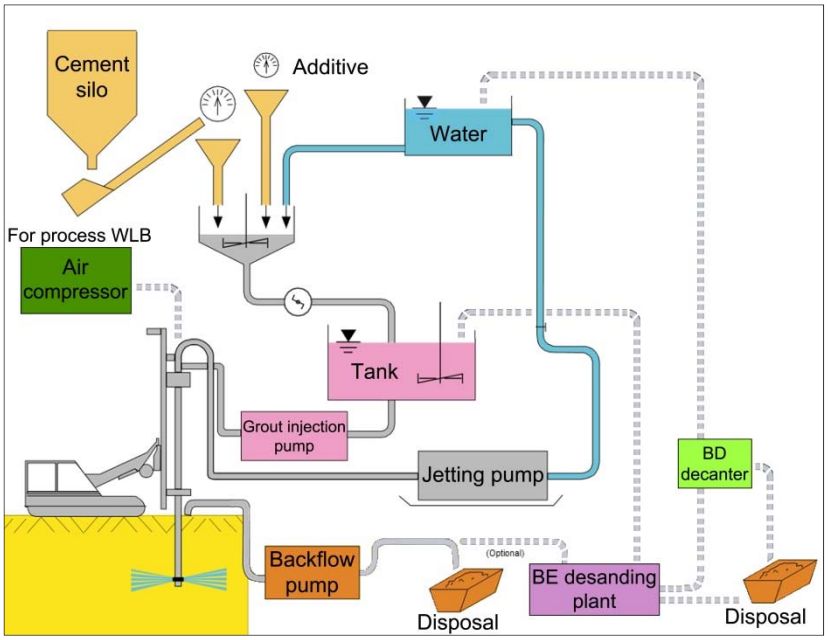


Site Installation

Procedure Process B

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

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.

Advantages of the Jet Grouting Process

- 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

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

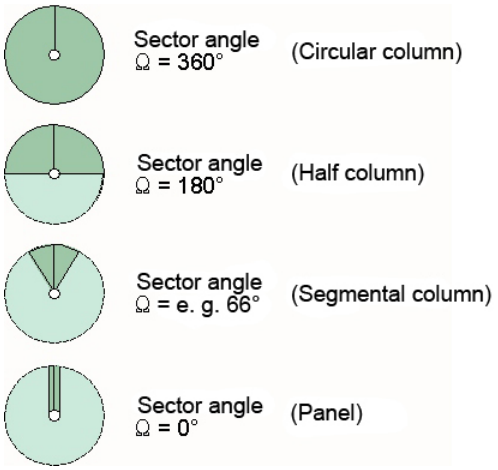
In general, jet grouting requires only water and binder suspension (generally in the form of cement). Selection of the appropriate binding agent is determined by the following requirements:

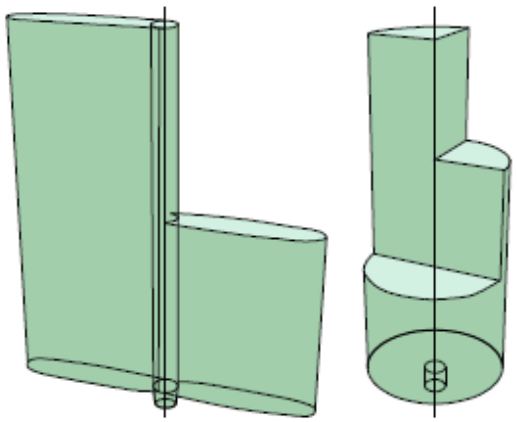
- Strength
- Impermeability
- Erosion resistance
- Workability

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:

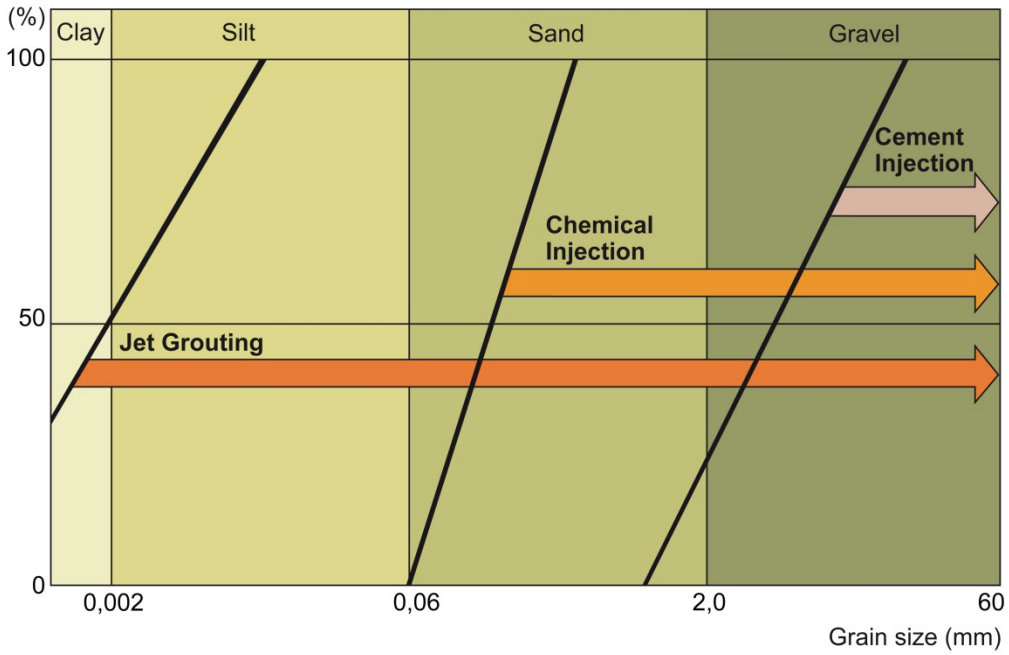
- Circular columns
- Half columns
- Segmental columns
- Panels





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

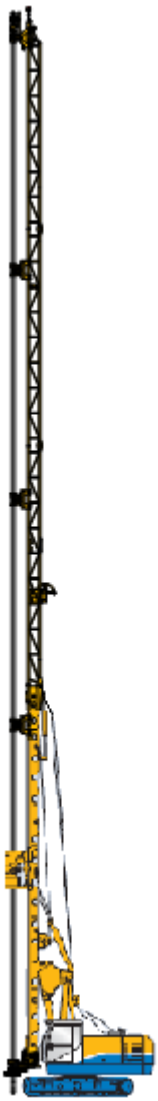
Foundation support

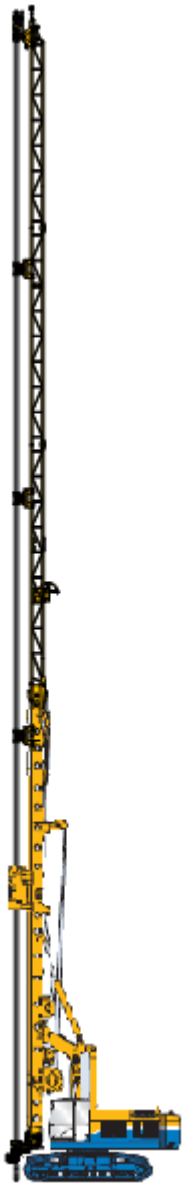
Jet Grouting Plant

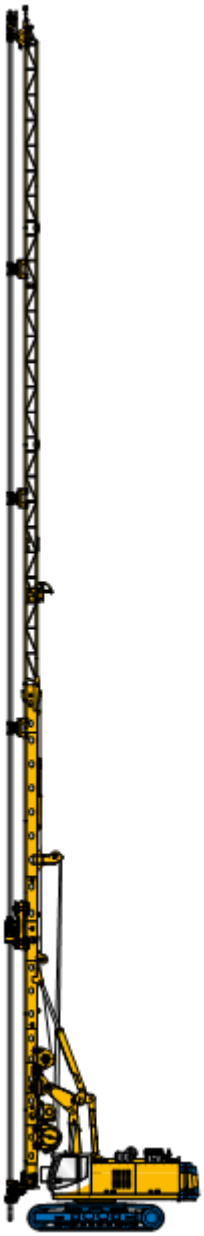
Bauer Plant

BG Series

The universal 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.







	BG 15 H	BG 24 H	BG 28 H
Length[(1)]	6.2 m	7 m	8.4 m
Width[(1)]	3 m	3 m	3.3 m
Overall height[(1)]	38 m	45.2 m	52 m
Weight	49.5 t	77.5 t	98 t
Power output	168 kW	261 kW	354 kW
Rod diameter [mm][(2)]	89/133 HDI	133 HDI	133 HDI
Mast inclination	± 5°	± 5°	± 2°
Jetting depth[(3)]	30 m	36.7 m	42.5 m
Rotary drive	KDK 10 S	KDK 10 S	KDK 10 S

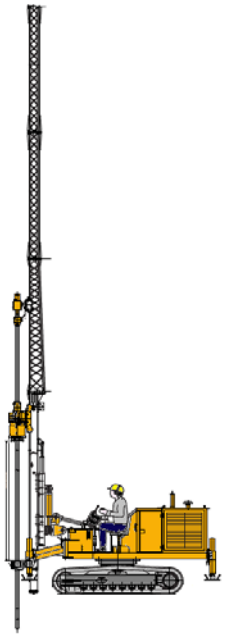
(1) Dimensions during operation
(2) The rod diameter can be changed to suite requirements
(3) Max. drilling depth attained on past projects

Klemm Plant

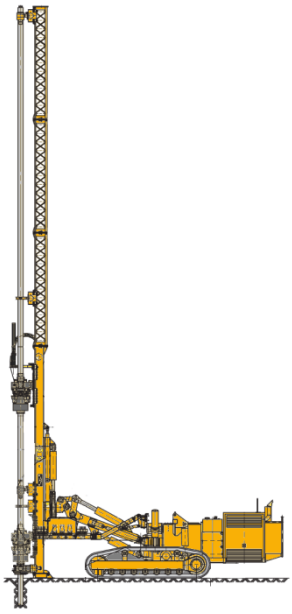
Klemm, our Subsidiary

KLEMM Bohrtechnik 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 E/D



KR 401-2



KR 806-2

KR 714

	KR 704 E/D[4]	KR 401-2(B)[5]	KR 806 2	KR 714
Length[1]	3.9 m	4.75 m	8 m	8.85 m
Width[1]	0.75 – 1.2 m	2.4 m	2.5 m	2.5 – 3.3 m
Overall height with feed[1]	2.15 – 3.5 m (up to 6 m)	15.9 m	15.6 m	14.6 – 24.2 m
Weight	4.3 – 4.6 t	11 t	15 – 16 t	28 t
Power output	48.1 kW	74.5 kW	129 kW	173 kW
Rod diameter [mm][2]	88.9 – 114.3	up to 88.9	88.9	114.3
Mast inclination with feed	± 10°	± 15°	± 10 °	- 3°/+ 5°
Jetting depth[3]	20 m	12.5 (Single Pass)	20 m	20 m
Rotary drive, recommended	KH 9/KH/13/KH 13S	KH 9SK	KH 9SK/KH 12 SK	KH 12 SK

(1) Dimensions during operation
(2) The rod diameter can be changed to suite requirements
(3) Max. drilling depth attained on past projects
(4) Electric or diesel powerpack
(5) KR 401-2B operator cab

Additional Equipment

Jet Grouting Drill Rods

Bauer and Klemm both provide different diameter drill rods for all three jet grouting systems.

	1-Phase	2-Phase	3-Phase
Ø 88.9 mm	X	X	X
Ø 108 mm			X
Ø 114.3 mm		X	
Ø 133 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 [l/min]	550
Max. power output [kW]	600
Weight [t]	14 - 15
Max. pressure [bar]	900

Mixing Plant

Our subsidiary, MAT Mischanlagentechnik GmbH, 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-20C	SCC-30K	SCC-40K
Mixing capacity [m^3/h]	20	30	40
Total power input [kW]	34	40	63
Weight [t]	4.5	3	4.7
Mixer volume [dm^3]	1000	1500	2500
Mixer scale capacity [kg]	2000	3000	5000

Grout Pump (Eccentric Screw Pump)

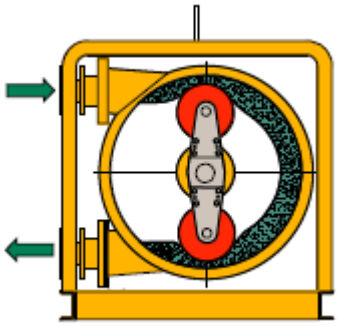
MAT‘s eccentric screw pumps are ideally suited for the injection of cement suspension in the 2- and 3-phase processes with water jetting (WB or WLB).

	EP-12-400	EP-12-600	EP-24-400
Delivery rate [dm^3/min]	400	600	400
Delivery pressure, max. [bar]	12	12	24
Power input [kW]	18.5	30	30
Weight [t]	0.95	1.5	1.76

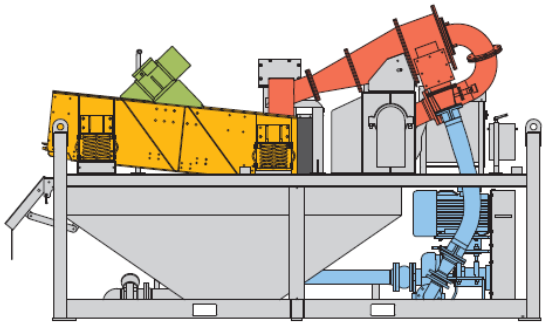
Additional Equipment

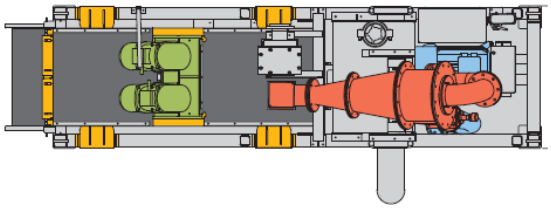
Backflow Pump

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	HP – 70
Delivery rate [m^3/h]	30	50	70
Delivery pressure [bar]	8	8	6
Weight [t]	1	1.8	1.8
Power input [kW]	18.5	30	30
Grain size, max. [mm]	24	32	32





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 50 - 50 and BE 100 - 60 are 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 50 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 50 – 50	BE 100 – 60	BD 50
Delivery rate [m^3/h]	50	100	50
Power input [kW]	11	24	45
Cut point (BE) or Grain size, max. (BD) [mm]	0.05	0.06	8
Weight [t]	2.6	2.8	5

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 50	BP 85	BP 125	BP 250
Delivery rate [m^3/h]	50	85	125	250
Power input [kW]	11	18	22	55
Weight [t]	0.5	0.55	0.78	1.39

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

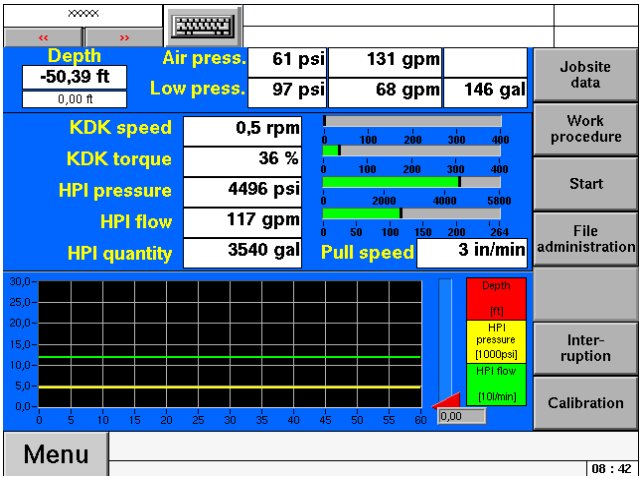
(on monitor of rig operator)

Bauer B-Tronic

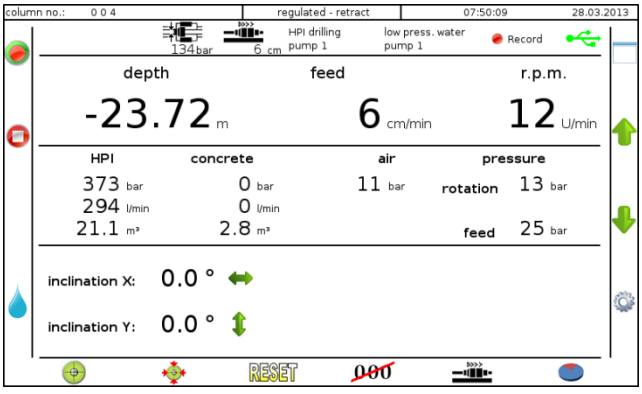
The B-Tronic electronic monitoring and control system can be fitted to all jet grouting plant. This data acquisition system monitors and controls both production parameters and all general equipment functions.

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 monitor

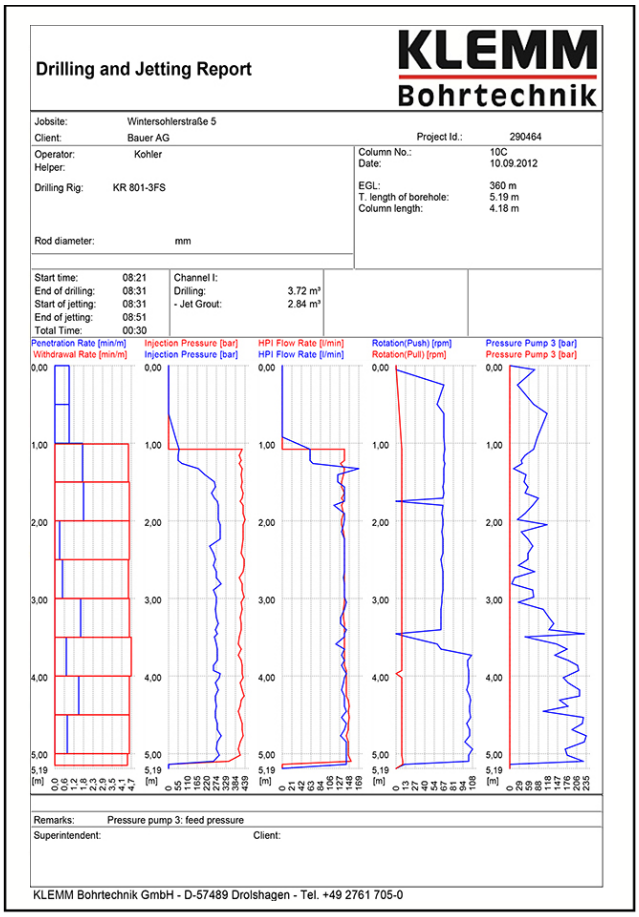
Klemm MBS-4

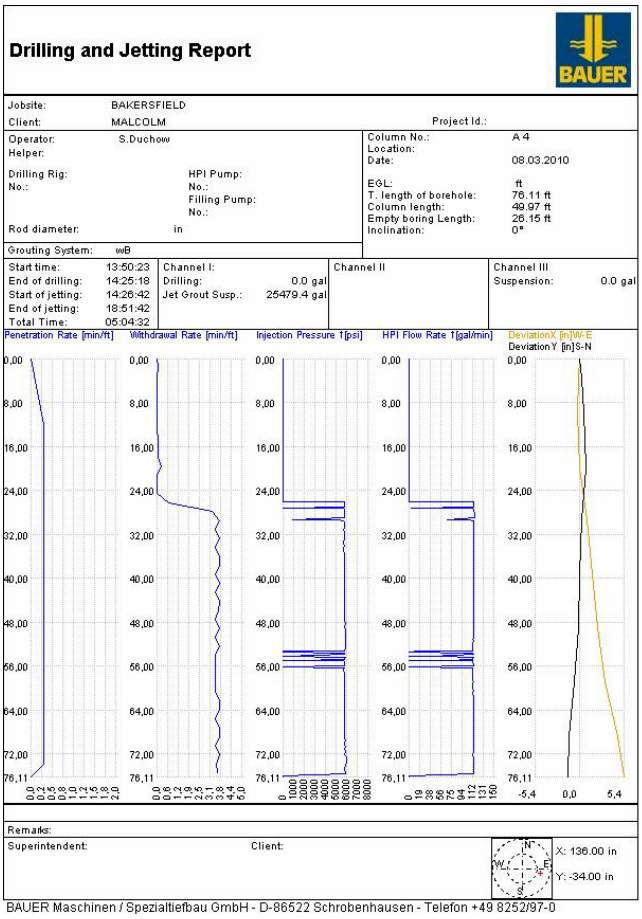
The jet grouting monitoring system MBS 4 is a programmable state-of-the-art recording and control system for daily use on construction sites. Similar to the B-Tronic, the MBS 4 continuously obtains specified production parameters (depth, speed of rotation, pressures etc.).

Quality Control

Documentation

All production parameters are recorded and stored inside the drilling rig throughout the jet grouting process. A printout 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. Left: MB S-4 Production Record. Right: B-Tronic Production Record

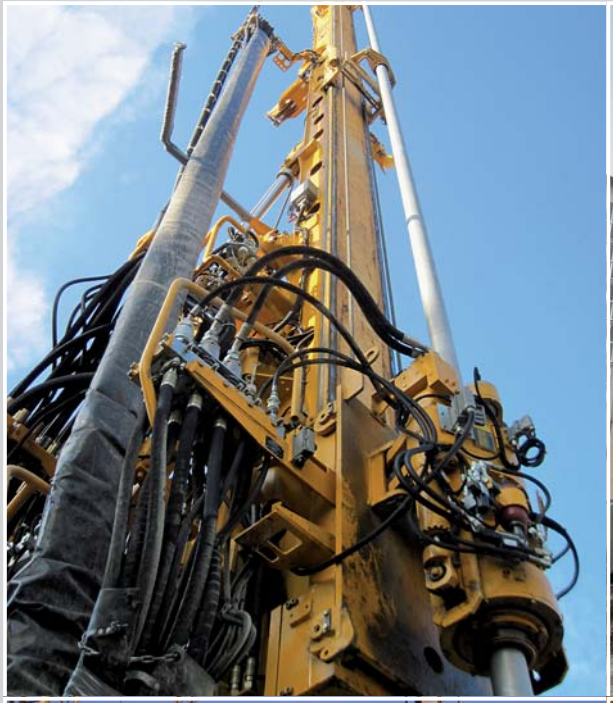




Test Columns

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.

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