Backfill Grouting

1 Liquid type（From Europe）

And

2 Liquid type（From Japan）

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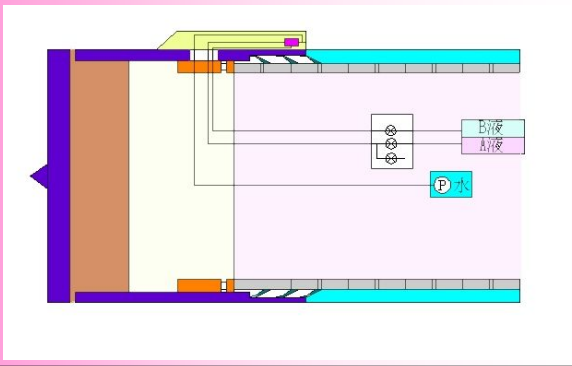
1. Purpose of Backfill Grouting

- It prevents collapse of Tail-void, then stabilizes looseness of soil-condition, keeps settlement.
- It stabilizes Segment-structure as soon as possible.
- It makes tunnel-track stable.
- It protects gap of segment from water.

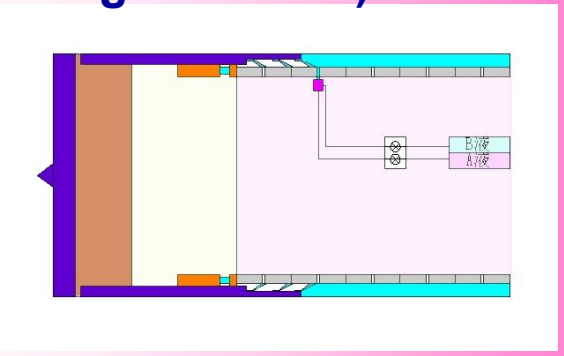
2. Injection ways of grouting

- Injection way is due to injection timing and layout of injection hole.
- Simultaneous injection is the most effective.

Simultaneous Injection (From TBM's pipe)



Immediate Injection (From segment hole)



	Layout of injection hole	Timing
Simultaneous Injection	TBM's Pipes (With automatic system)	Simultaneous Injection with Excavation
Immediate Injection	Segment holes (With manual system)	Injection behind Excavation

3. Type and Character of Materials

Material

1 Liquid type

Common Type in the World
Cement Sand Bentonite Fly-ash Water
Need many injection point
Because of less Fluidity
Some Composition uses Lime
instead of Cement
Transports Liquid by truck

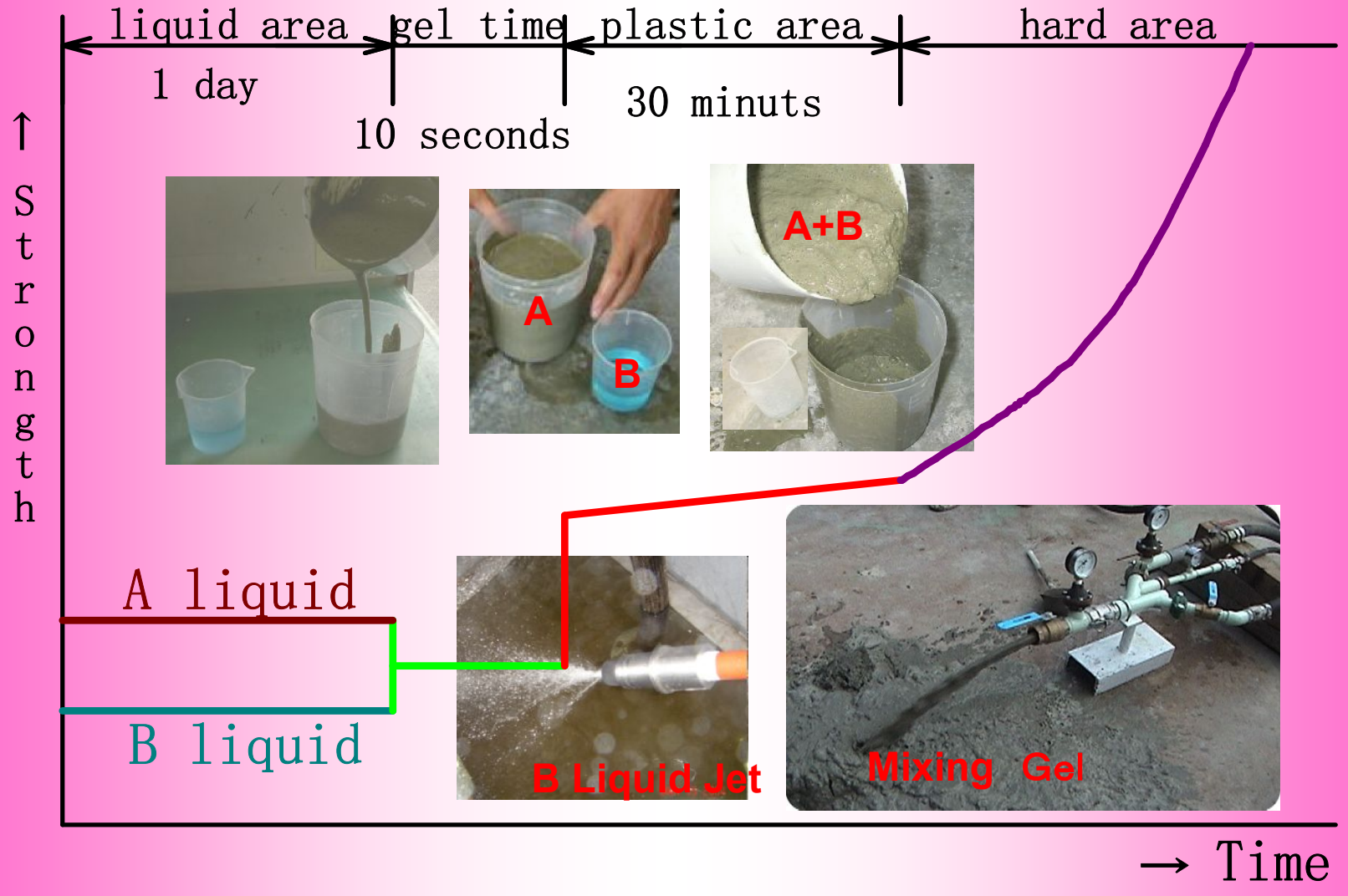
2 Liquid type

Invented in Japan and expand to Asia
Cement Bentonite Water
+ Sodium-Silica
Plenty of Fluidity,
Only few Injection point
After Mixing of 2 Liquid,
Quick plastic gel and early hardening
Transports Liquid by long way pipes

1 Liquid type

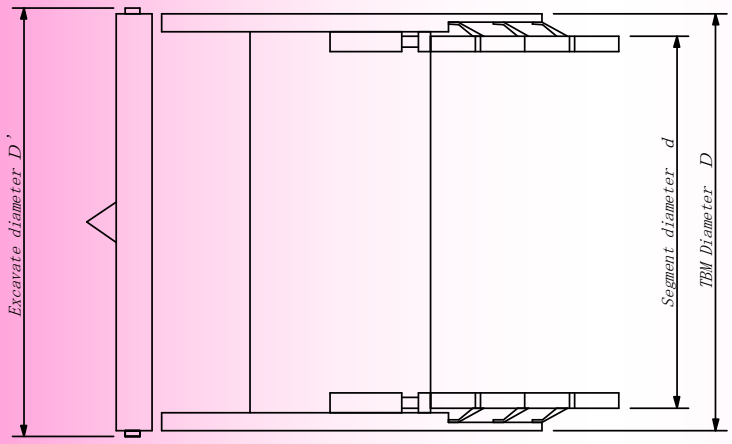
- Sticky
- High density
- Less Fluidity
- Long time hardening

2 Liquid type



4. Design ways of Equipment 1

1. TBM and Tail-void



A Unit of Tail-void Volume
$= \pi/4(D^2 - d^2)$

2. Calculation A Unit of Tail-void Volume

＜General＞ Injection Volume L（1m unit）＝ Tail-void Volume ×Rate

Rate is usually 130% due to looseness of soils

＜Considering soils＞ Sometimes Rate depend on soil types

	Hard Clay	Loose Clay	Sand Gravel	Stone Gravel
Rate（%）	130	130～150	130～150	140～160

Design ways of Equipment 2

3. Jack-Speed and Injection-flow volume

Injection-flow volume（L/min）
＝(Injection volume(L)×JS(mm/min))/100

For 2 liquid type, each volume needs to calculate

4. Choice of Pumps

- Pump's Choice is due to 1Liquid type and 2.
- For 1 Liquid type, Piston type (High Pressure type)
- For 2 Liquid type, any kind of pumps is OK.
  2 pumps are needed (For 2 Liquid, large and small)
- Decide quantity of Pump by points and volume.
- For 1 Liquid type, many pumps are needed because Material is not easy to encircle Segment completly.
- For 2 Liquid type, easy to encircle, proper volume is 100～150L/min by one place.

Design ways of Equipment 3

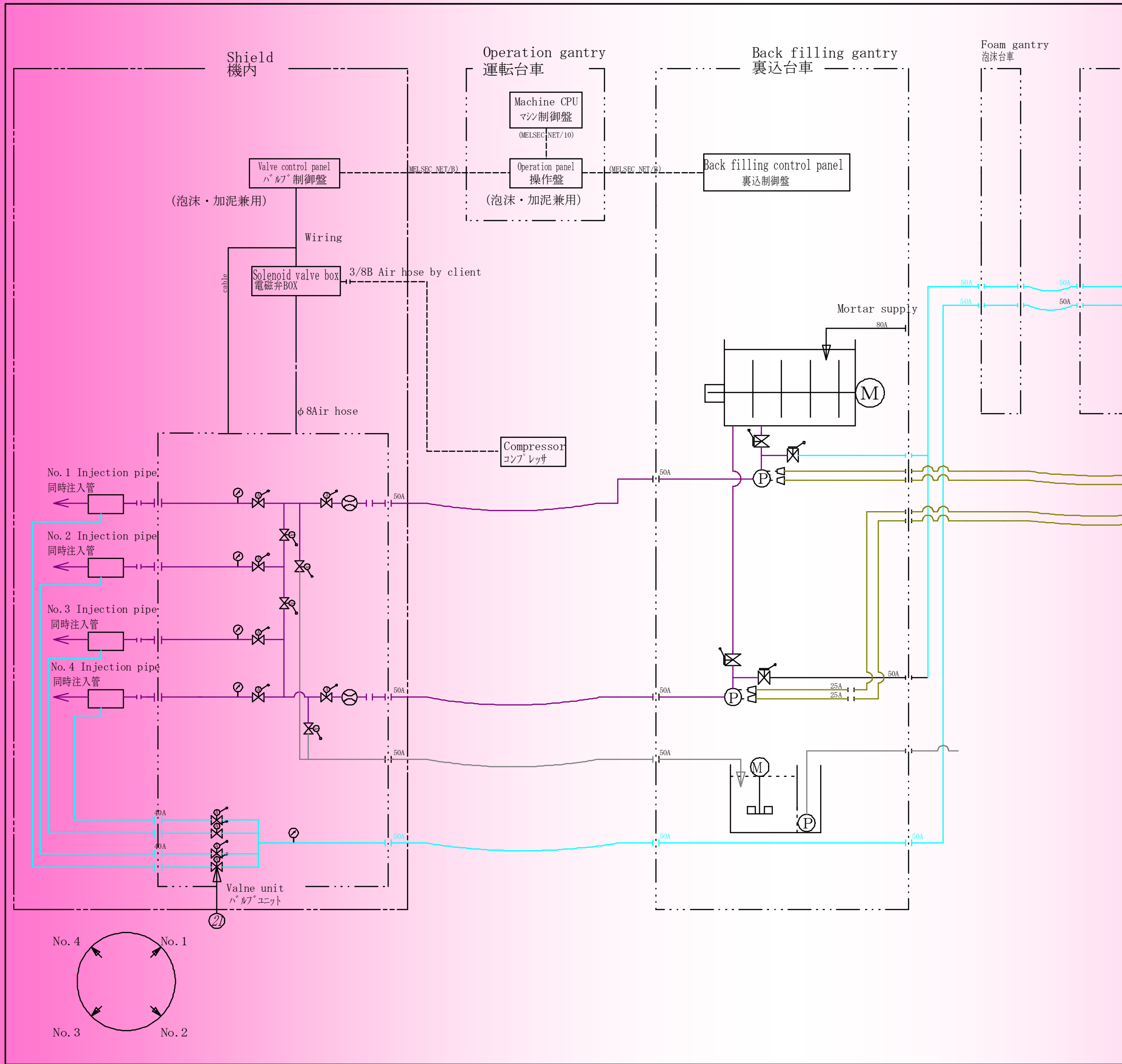
5. **Mixture Plant**
   - **Generally Mixture Plant capacity needs over 120% than theoretical injection volume (by 1 ring).**
   - **For 1 Liquid type, Transports Liquid by truck**
   - **For 2 Liquid type, Transports Liquid by long way pipes**

6. **Gantry system**
   - **Gantry system is structured with Pumps, Agitator-Tank, Switch-Valve, Automatic-Control-system.**
   - **Agitator-Tank Structure is due to 1 and 2.**
   - **For 1, Needs strong mixture structure.**
   - **For 2, Needs easy mixture structure.**
   - **Generally Agitator-Tank volume needs over 120% than theoretical injection volume.**

5. Different Points by Materials

	Injection pumps	Agitator Tank	Injection Pipes
1 liquid	1 Line 1 pump Many Injection Points High Pressure Piston Pump	Mixture power Strong Tank volume Big	Many pipes Bore Big Pipe Washing System Needed
2 Liquid (A+B)	1 Line 2 pumps (Big, Small) Few Injection Points Volume Variable Pump	Mixture power Weak Tank volume Small (if transfer by pipes) Needs B Tank	Few pipes Bore Small Pipe Washing System Prerequsite

6. Grouting Flow Sample for 1 type



Shield
機内
Operation gantry
運転台車
Machine CPU
ﾏｼﾝ制御盤
Operation panel
操作盤
(泡沫・加泥兼用)
Back filling gantry
裏込台車
Back filling control panel
裏込制御盤
Foam gantry
泡沫台車
Slurry pump gantry
加泥ﾎﾟﾝﾌﾟ台車
Valve control panel
ﾊﾞﾙﾌﾞ制御盤
(泡沫・加泥兼用)
Wiring
Solenoid valve box
電磁弁BOX
3/8B Air hose by client
φ8Air hose
Compressor
ｺﾝﾌﾟﾚｯｻ
Mortar supply
Hydraulic gantry
油圧台車
Hydraulic unit
No.1 Injection pipe
同時注入管
No.2 Injection pipe
同時注入管
No.3 Injection pipe
同時注入管
No.4 Injection pipe
同時注入管
Valne unit
ﾊﾞﾙﾌﾞﾕﾆｯﾄ
No.4
No.1
No.3
No.2

F.Valve	21	洗浄水ﾊﾞﾙﾌﾞ	FA-10FCTB		4	
No.10 G.Valve	20	No.10裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.9 G.Valve	19	No.9裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.8 G.Valve	18	No.8裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.7 G.Valve	17	No.7裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.6 G.Valve	16	No.6裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.5 G.Valve	15	No.5裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.4 G.Valve	14	No.4裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.3 G.Valve	13	No.3裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.2 G.Valve	12	No.2裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
No.1 G.Valve	11	No.1裏込ﾊﾞﾙﾌﾞ	FA-300UTB		1	
Water pump	10	配管洗浄ﾎﾟﾝﾌﾟ	40PN 2.75-51	0.75	1	
Drainage pump	9	排水ﾎﾟﾝﾌﾟ	KTV-2-50	2.0	1	
Drainage tank	8	排水ﾀﾝｸ	TO-02-275	1.5	1	2.0m3
Hydraulic unit	7	油圧ﾕﾆｯﾄ			2	Client
Pressure sensor	6	圧力ｾﾝｻｰ			5	0-3.0MPa 0-2.0MPa
Flow meter	5	流量計	50A		2	50A
Grout tank	4	裏込ﾀﾝｸ	TO-350-75	7.5	1	3.5 m3
Grout pump	3	裏込ﾎﾟﾝﾌﾟ	PA-15C φ90		2	120L/min Ave.2.0MPa
Water tank	2	水ﾀﾝｸ			1	2.0 m3
Flushing pump	1.	洗浄水ﾎﾟﾝﾌﾟ	MMK50/4	15.0	1	
	No.	NAME 名称	型式 TYPE	Kw	Q'ty	NOTE 記事

DATE 日付 2004.08.17	Messrs. 注文主	日立造船株式会社
	Site 工事名	北京城建集団
	T.W. 総重量	
REVISIONS 改訂履歴 / 配管受渡場所変更	APPROVAL 認可 / CHECKED / DRAWING T.O	TITLE 名称: 裏込注入ﾌﾛｰ図
	SCALE 尺度 / DATE 作成日 2004年7月8日	
	JOB No. 注文番号: AT8-10085	DRAWING No. 図番: CTNP- 0000

• Calculation Sample for 1 Type

1．Condition

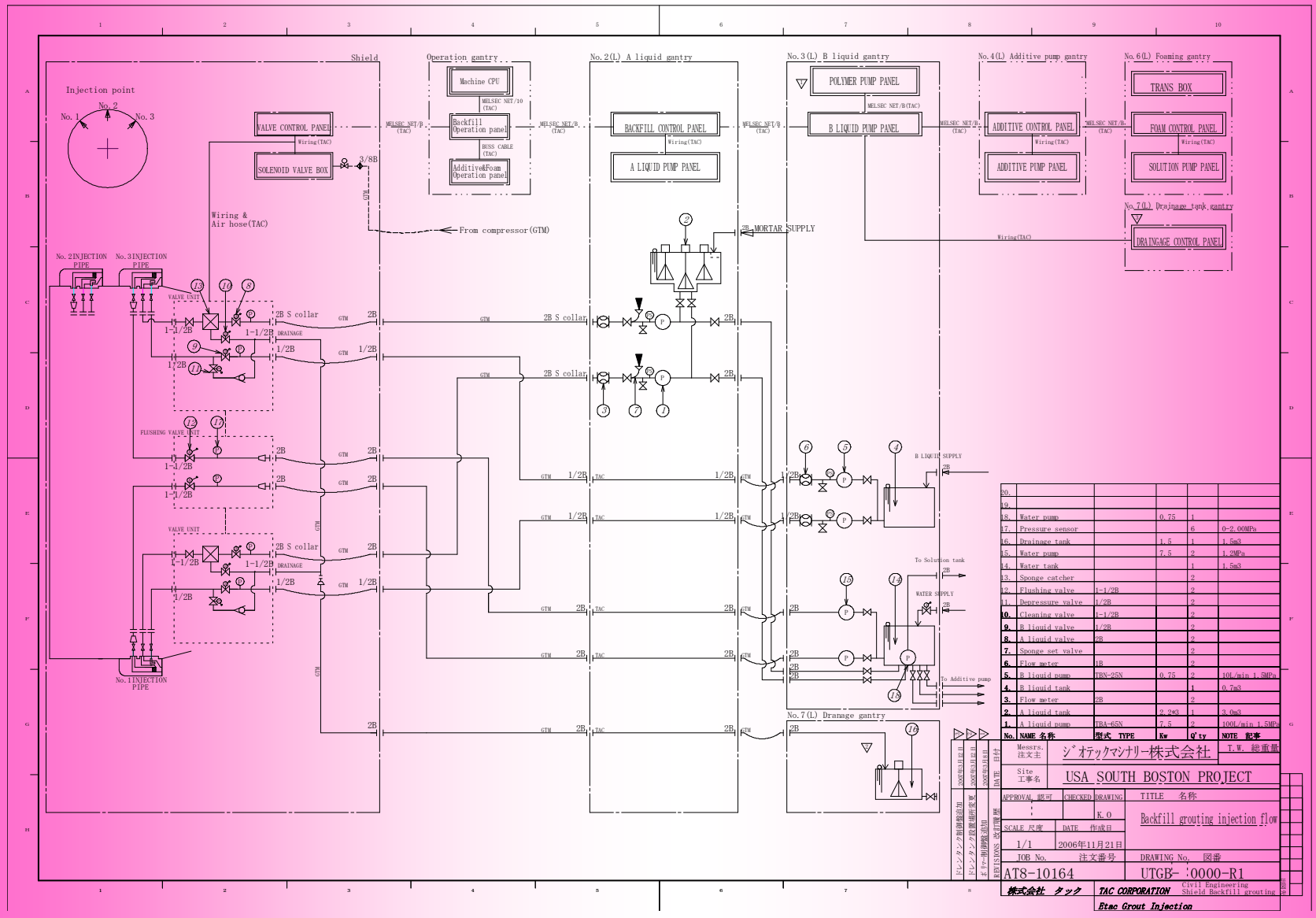
TBM O.D		6.15 m
Segment O.D		6.00 m
Segment width		1.20 m/R
TBM speed		0.080 m / min
Theoretical Tail void /1m	$\pi/4\times(6.15^2-6.00^2)\times 1m$	1.43 m 3
Theoretical Tail void / 1R	1.43 $m^3/m\times 1.2$ m/R	1.72 m3
Backfill injection ratio		130 %
Backfill injection volume / 1m	1.43 $m^3/m\times 1.3$	1.86 m3
Backfill injection volume / 1R	1.72 $m^3/m\times 1.3$	2.24 m3
Backfill injection flow	1.86 $m^3/m\times 0.080$ m / min $\times 1000L / m^3$	149 L / min

• Specification Sample for 1 Type

2. Specifications

Tank	3.5 m^3 7.5kw (actually3.0m3)	> 2.24 m3 / R
Grout pump	Piston pump1.0~2.0Mpa (normally using) Maximum 5.0MPa (especially using) Flow Maximum 120L/min (at no-load running)×2	> 149 L/min
Hydraulic unit	By the client 22kw ×2	
Flushing pump	5.5kw 130m	
Water tank	2.0M3	
Drainage tank	2.0M3 1.5Kw	
Drainage pump	2.0kw	
Flow meter	2set	Magnetic flow meter
Pressure sensor	5set	
Valve unit	12 Pneumatic valves system manifold	
Cleaning valve unit	4 Pneumatic valves system manifold	
Operation panel	Touch sensor panel	Auto/hand operation
Backfill system control panel		
Tank control panel		
Valve control panel	Share it with foaming system	
Solenoid valve box	Share it with foaming system	

7. Grouting Flow Sample for 2 type



No.	NAME 名称	型式 TYPE	Kw	Q'ty	NOTE 記事
20.					
19.					
18.	Water pump		0.75	1	
17.	Pressure sensor			6	0-2.00MPa
16.	Drainage tank		1.5	1	1.5m3
15.	Water pump		7.5	2	1.2MPa
14.	Water tank			1	1.5m3
13.	Sponge catcher			2	
12.	Flushing valve	1-1/2B		2	
11.	Depressure valve	1/2B		2	
10.	Cleaning valve	1-1/2B		2	
9.	B liquid valve	1/2B		2	
8.	A liquid valve	2B		2	
7.	Sponge set valve			2	
6.	Flow meter	1B		2	
5.	B liquid pump	TRN-25N	0.75	2	10L/min 1.5MPa
4.	B liquid tank			1	0.7m3
3.	Flow meter	2B		2	
2.	A liquid tank		2.2*3	1	3.0m3
1.	A liquid pump	TRA-65N	7.5	2	100L/min 1.5MPa

Messrs. 注文主	ジオテックマシナリー株式会社
Site 工事名	USA SOUTH BOSTON PROJECT
TITLE 名称	Backfill grouting injection flow
SCALE 尺度	1/1
DATE 作成日	2006年11月21日
JOB No. 注文番号	AT8-10164
DRAWING No. 図番	UTGB-[illegible]0000-R1
APPROVAL 認可	
CHECKED	K.O
DRAWING	

株式会社 タック TAC CORPORATION Civil Engineering Shield Backfill grouting Etac Grout Injection

- Calculation Sample for 2 Type

TBM O.D		5.86 m
Segment O.D		5.69 m
Segment width		1.219 m/R
TBM speed		0.080 m / min
Backfill injection ratio		135 %
2 liquid combination	A : B =0.909: 0.091	10 : 1
Theoretical Tail void / 1m	$\pi/4\times(5.86^2-5.66^2)\times 1m$	1.80 m3
Theoretical Tail void / 1R	1.80 m^3/m ×1.219 m/R	2.19 m3 / R
Backfill injection volume / 1m	1.80 m^3/m ×1.35	2.43m3
Backfill injection volume / 1R	2.43 m^3/m ×1.219	2.96 m3
Backfill injection flow	2.43 $m^3/m\times 0.080$ m / min×1000L / m^3	194 L / min
Injection volume /1m of A liquid	2.43 $m^3/1m\times 0.909$	2.21m3
Injection volume /1m of B liquid	2.43 $m^3/1m\times 0.091$	0.22m3
Injection volume /1R of A liquid	2.96 $m^3/1R\times 0.909$	2.69m3
Injection volume /1R of B liquid	2.96 $m^3/1R\times 0.091$	0.27m3
A Liquid flow	2.21 $m^3/m\times 0.080$ m / min	177 L / min
B Liquid flow	0.22 $m^3/m\times 0.080$ m / min	17.6L / min

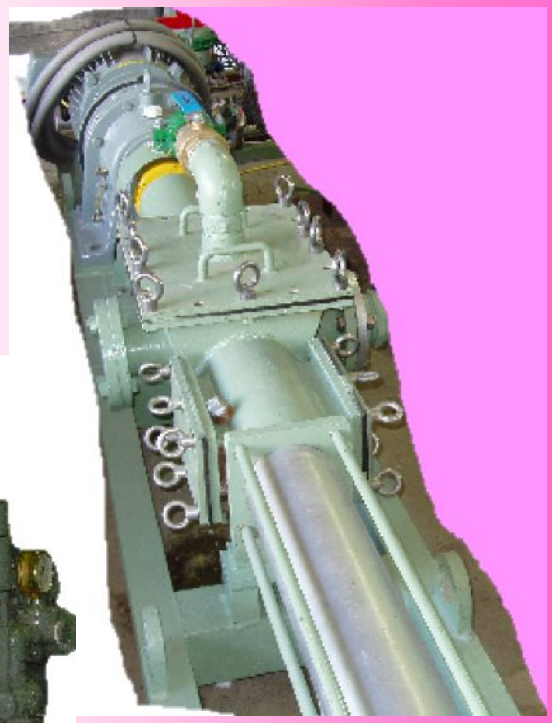
- Specification Sample for 2 Type

A Liquid Tank	3.0 m^3	> 2.69 m3 / R
B liquid tank	0.7 m^3	> 0.27 m3 / R
A liquid pump	Tube pump 7.5kw Max 1.5Mpa Max 100L/min×2nos. = 200L/min	> 177 L/min
B liquid pump	Tube pump 0.75kw Max 1.5Mpa Max 10L/min×2nos. = 20L/min	> 17.6 L/min
Pressure sensor	A×2nos. B×2nos.	
Flow meter	A×2nos. B×2nos.	
Valve unit	2nos.	
Valve control panel	1no.	
Solenoid valve box	1no.	
Backfill control panel	1no. Control by the pressure	
Operation panel	1no.	

8. Variety of Pumps

Piston Pump（PA型）Hydraulic
For 1 Liquid type

Snake Pump
For 2 Liquid type

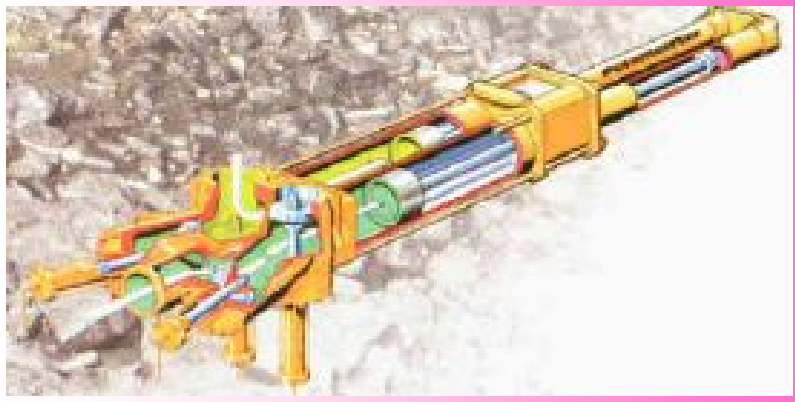


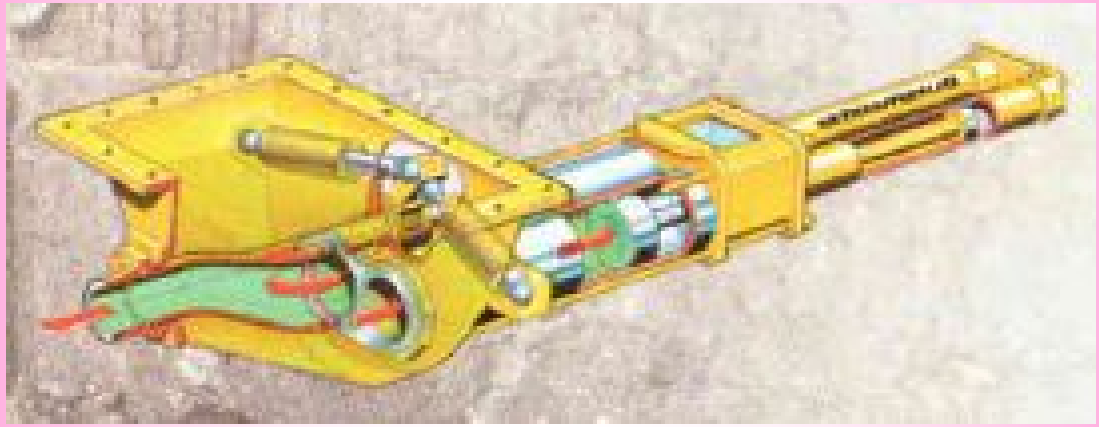
Tube Pump（TBA型）
For 2 Liquid type

Piston Pump（BG型）
For 2 Liquid type

Variety of Pumps ・2

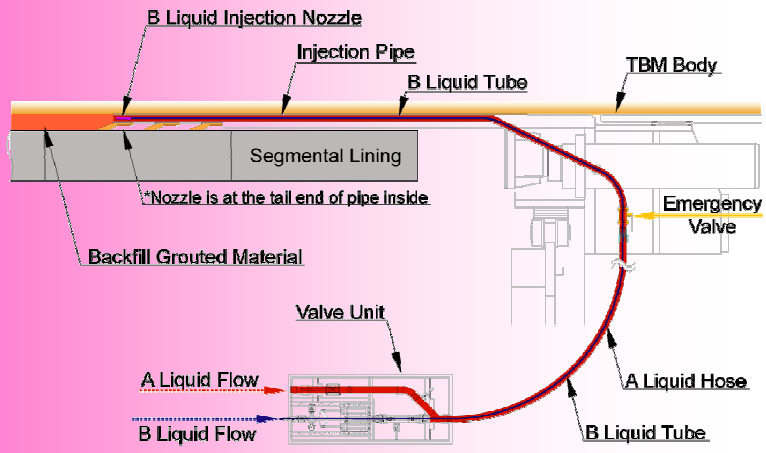
Piston Pump　High Pressure　(Putzmeister社 Schwing社)





9. Variety of Pipes

ETAC system



10. Variety of Agitator-Tank

For 1 Liquid type
Horizontal Type

For 2 Liquid type
Vertical Type