Injection Chemicals
For Civil Engineering Applications
<table>
<thead>
<tr>
<th>Type</th>
<th>Product Designation</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water Ingress</td>
<td>High Pressure Water Ingress</td>
</tr>
<tr>
<td>PUR</td>
<td>Fast Setting Polyurethane Resins</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Medium and Slow Setting Polyurethane Resins</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>Fast Setting Polyurethane Foam Resins</td>
<td>+++</td>
</tr>
<tr>
<td>SIL</td>
<td>Organo-Mineral Silicate Resins</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>Organo-Mineral Silicate Bolting Resins</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>Organo-Mineral Silicate Foam Resins</td>
<td>+</td>
</tr>
<tr>
<td>SCR</td>
<td>Fast and Medium Setting Polyurethane Resins</td>
<td>+</td>
</tr>
<tr>
<td>(1C)</td>
<td>Slow Setting Polyurethane Resins</td>
<td>-----</td>
</tr>
<tr>
<td>ACR</td>
<td>Acrylic Resins</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>Acrylic Gel Resins</td>
<td>-----</td>
</tr>
</tbody>
</table>

1) See separate brochure “Bonding Agents for Bolting”

“+++” Recommended, “+” Not recommended
Introduction

DYWI® Inject product line comprises injection resins used for Civil Engineering applications. 2-component polyurethane systems (PUR) are the most versatile injection resin system and are mainly used for stopping water ingress and ground consolidation.

2-component silicate systems (SIL) have a broad application range featuring excellent bonding capabilities. However, they cannot be applied at low temperatures. Single-component resins (SCR) are widely used for smaller scale repair works, acrylic resins (ACR) have been successfully used for ground consolidation and curtain sealing applications.

All DYWI® Inject Systems are processed with 2-component or 1-component high pressure pumps, tailored for each project and application. Mixed and cured DYWI® Inject Systems are ecologically inoffensive – CFC and halogen free – and suitable for application in ground water areas.
Grouting Fundamentals

Step 1: Identify the Application
- Sealing
- Consolidation and stabilization
- Filling

Step 2: Determine the Grouting Material

Three Commonly used Types of Grouting Material
- Suspension
  - Water + cement (e.g. microcements, ultra fine cements, etc.)
  - Water + cement + fillers (e.g. sand, fly ash, etc.)
- Solution
  - Chemicals diluted in water (e.g. water glass + hardeners)
  - Polyurethanes (e.g. 1C one component, 2C two components)
  - Acrylates
- Emulsion
- Silicates

Limitations in the Application of Cementitious Grouts
- λ < 1
- Dilution in general
- Partial penetration
- Large-size openings
- Permeability range below 10⁻⁶ [m/s]
- Difficult application at low temperatures

Application Window for Injection Resins
Polymer resins must be used if at least one of the following criteria applies:
- Discontinuities
  - Large-size joints or caverns
- Permeability and hydraulic conductivity
  - Lugeon < 15 - 20
  - K < 10⁻⁶ [m/s]
- Groundwater
  - Water velocity > 20 [mm/s]
- Water and ground temperature
  - Below 3 - 5 [°C]

Step 3: Method Statement
- Qualified and experienced expert(s)
- Type of injection resin
- Material properties with reaction profile
- Application team
- Equipment

Step 4: Application and Verification
- Implementation according to the method statement
- Continuous data monitoring
- Attention to pre-defined stop criteria
- Qualitative and quantitative evaluation of injection results
- Determination of further steps, if required
Fields of Application

Sealing

- Water ingress:
  - Temporary or permanent
  - Amount of water
- Pressing water:
  - Temporary or permanent
  - Pressure range
  - Amount of water
- Leaking gas:
  - Gas type
  - Amount of gas
  - Escape ways
- Product range:
  - PUR Fast Setting
  - PUR Foam
  - SIL Foam
  - SCR

Consolidation and Stabilization

- Consolidation:
  - Ground type
  - Required grade of improvement
- Stabilization:
  - Ground type
  - Temporary or permanent
- Product range:
  - PUR Med-Slow Setting
  - PUR Foam
  - SCR
  - SIL
  - SIL Foam
  - ACR

Filling

- Filling of cavities:
  - Cavity size
  - Required grade of improvement
- Backfilling:
  - Gap width
  - Presence of water
- Product range:
  - SIL Foam
**Competence in Application**

**Permeability in Soil and Jointed Rock Mass**

<table>
<thead>
<tr>
<th>Penetration Capacity</th>
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</thead>
<tbody>
<tr>
<td>Ground Type</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Gravel</td>
</tr>
<tr>
<td>Coarse</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>Fine</td>
</tr>
<tr>
<td>Silt</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>Grain Size [mm]</td>
</tr>
<tr>
<td>100,000</td>
</tr>
<tr>
<td>2,000</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>250</td>
</tr>
<tr>
<td>75</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>Crack Width [mm]</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0.5</td>
</tr>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>Permeability (k) [mm/s]</td>
</tr>
<tr>
<td>$10^0$</td>
</tr>
<tr>
<td>$10^{-1}$</td>
</tr>
<tr>
<td>$10^{-2}$</td>
</tr>
<tr>
<td>$10^{-3}$</td>
</tr>
<tr>
<td>$10^{-4}$</td>
</tr>
<tr>
<td>$10^{-5}$</td>
</tr>
<tr>
<td>$10^{-6}$</td>
</tr>
<tr>
<td>$10^{-7}$</td>
</tr>
</tbody>
</table>

**Grouting Material**

- Cement-Based Suspensions
- Chemical Solutions
- Polymer Injection Resins

**Method Statement**

Contrary to the design of ground support elements, the application of injection chemicals can rarely be planned in advance.

Certain default applications where access to the future application site, excavation dimensions, and other influencing factors are known – such as filling of identified cavities or sealing of segmental linings – can be scheduled and prepared in advance.

The unknown part in each underground construction are unpredictable ground and groundwater conditions, which might lead to a so-called emergency application situation. For an emergency application, project-specific method statements for mastery of challenging conditions must be prepared.

Influencing factors on the design include the magnitude (size) of application area, underlying ground conditions, temperature, water flow rate and pressure. Data acquisition and a sound probing approach are key to gain further information for the preparation of an emergency method statement.
Technology

Over the past decades, injection chemicals for civil engineering applications have undergone major developments and improvements. One key aspect was the diversification of the portfolio with regards to the development of new products and systems, which feature an optimized adaptation to specific injection applications.

The toolbox of today’s injection resins also shows enhanced performance characteristics, thanks to advancement of chemical raw materials and compounds. Besides an enhancement in the mode of action, state-of-the-art injection resins feature a significant reduction of the environmental impact, for example with regards to groundwater compatibility.

Beyond the improvement of injection chemicals, the entire application chain has been improved continuously. Hoses, fittings, and valves have been enhanced; tailored mixing elements ensure a sound interaction of single components. Standardized manipulation procedures ensure a safe and reliable working process.

Equipment and Accessories

- Case-specific design and dimensioning
- Supply of package solutions
- Wide range of toolbox accessories
Selection and Design Criteria

Product Properties

Introduction
There are several parameters used for describing the properties and assessing the suitability of injection resins in terms of their proper application. These parameters include reactivity, viscosity, reaction time, mechanical strength, adhesion, foamability, and water miscibility – just to mention the most important ones. They determine the scope of use of a certain resin system and, even more importantly, the success of the application. Undoubtedly, a detailed parameter analysis has to be an integral part of each case study in order to achieve the intended purpose of the application, i.e. sealing, stabilisation, filling, or bonding.

Setting Time
Setting time is the system parameter which shows the reactivity of the material, e.g. the point when the reacting liquid stops to flow. After that time the material starts to set, i.e. the hardening process begins to develop.

Setting time can vary from seconds to hours. Practically, the systems are divided into fast, medium, and slow. Setting time mainly affects the penetrability of the injected ground and the ability to stop water outflow.

Another term commonly used is tack free time, which defines the point when the surface of the reacting resin is becoming non-sticky.

Thixotropy
Thixotropy describes a fluid nature which can be thick or viscous under static conditions and flows, or become less viscous, when sheared or mixed. The pseudo-plastic behaviour is the specific case of thixotropy, when the liquid regains the high viscosity nearly immediately as the shear force is removed.

A pseudo-thixotropic behaviour of the liquid material can also be featured by the specific reaction control when the gelling is well separated from the solidification process. Thixotropic behaviour is necessary in any overhead application to stop outflow of the material after grouting. Another important role of thixotropy is surface spraying in terms of coatings and membranes.

Water Reactivity
The presence of water in the area of application always affects the effectiveness. Water presence must be considered in a range of aspects during material selection process:

- Chemical reactivity with the components
- Physical modification of the material
- Water outflow
- Water pressure

Viscosity
Viscosity is the physical parameter which is characteristic for the individual components and reacting mixture. The higher viscosity of the components the higher is the flow resistance, thus this factor is important for the correct selection of pumps and pumping accessories regarding to the pumping pressure. The viscosity is also an important parameter considering the relationship between the crack size, pumping pressure and penetration distance. There is a direct correlation between viscosity and pumping pressure.

Foaming Properties
For polyurethane and silicate resins, the ability to foam is the characteristic feature of the injection system. Specific formulations allow to control the foaming factor and the foam cell structure – to receive open or close cell foam. The following rules of thumb apply: The higher foaming factor, the lower mechanical strength and cost of unit volume filling. The higher content of the closed cells, the better water tightness of the foam.

Miscibility of Components
The majority of commonly used materials are two component systems. To obtain the final product, the components have to be pumped into the application zone, where separated components must be mixed. The effectiveness of the component’s mixing determines final material properties and reaction parameters. The mixing process takes place under the flow in the static mixer. Design of static mixers may differ for different liquids. Therefore, this item is carefully selected and checked by the material designer – the end user should respect indications of the injection chemical manufacturer.
**Mechanical Properties**

Mechanical properties are distinct features of injection materials, eg. compressive, flexural, or tensile strength. Solid products are very strong when compared to foamed materials. With an increasing foaming factor, the compressive strength will decrease consequently.

If the purpose of the injection is the strengthening of the injection zone (roof, ribs, slabs, concrete, or masonry structure), mechanical parameters are the most crucial ones.

**Application Range**

Once the application (or multiple applications) for an injection project is defined, selection of proper resin type(s) for a given application is key. SCR resins are used for small-scale injection works under manageable conditions. 2-component PUR and SIL injection resins can be used for a variety of applications, DSI Underground features various different product characteristics to ensure an optimum injection result. In mechanized Tunneling, SIL or ACR type injection resins may be the preferred selection due to their characteristics during mechanical removal. Phenolic resins are generally not used in Tunneling due to their chemical composition and their influence on the corrosion rate of permanent installed ground support. However, exceptions are made when dealing with large cavities or temporary excavations. An initial estimation of a suitable product range can be accomplished based on water pressure conditions and ground fracture magnitude.

**Adhesion to the Substrate**

The adhesion is an important factor in case of ground consolidation and surface application. It can remarkably improve the target result of the application – ground improvement, consolidation, and anchoring are good examples.

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**Abbreviations**

- **W**: Water
- **SCR / 1C**: Single-Component
- **LV**: Low Viscosity
- **F**: Fast
- **S**: Slow
- **T**: Thixotropy
- **HA**: High Adhesion
- **HF**: High Foaming
- **HS**: High Strength

[Diagram showing the application range and adhesion to the substrate with various resin types and their characteristics based on water presence and ground fracture magnitude.]
## Product Range

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Product Name</th>
<th>Product Description</th>
</tr>
</thead>
</table>
| **Fast Setting Polyurethane Resins** | PUR W | - Fast setting resin  
- 100% solid system (solvent free)  
- Well balanced and adjusted viscosity of the components  
- Low initial viscosity  
- Easy to mix under different temperatures  
- Excellent mechanical properties  
- Good adhesion to the substrate in wet and dry conditions  
- Insignificant environmental impact |
| | PUR WF | - Faster version of PUR W |
| | PUR WT | - Thixotropic version of PUR W |
| | PUR HS | - Very fast setting resin  
- 100% solid system (solvent free)  
- Well balanced and adjusted viscosity of the components  
- Excellent enhanced mechanical properties  
- Good adhesion to the substrate in wet and dry conditions |
| **Medium and Slow Setting Polyurethane Resins** | PUR HA | - Medium setting resin  
- 100% solid system (solvent free)  
- Well balanced and adjusted viscosity of the components  
- Easy to mix under different temperatures  
- Good mechanical properties  
- Good adhesion to the substrate in wet and dry conditions  
- Sound resin flowability |
| | PUR S | - Very slow setting resin  
- 100% solid system (solvent free)  
- Well balanced and adjusted viscosity of the components  
- Low initial viscosity  
- Easy to mix under different temperatures  
- Excellent mechanical properties  
- Good adhesion to the substrate in wet and dry conditions  
- Insignificant environmental impact |
| | PUR LV | - Very slow setting resin  
- Well balanced and adjusted viscosity of the components  
- Extremely low initial viscosity  
- Easy to mix under different temperatures  
- Adjustable mechanical properties  
- Good adhesion to the substrate in wet and dry conditions |
| **Fast Setting Polyurethane Foam Resins** | PUR HF-10 | - Fast setting resin  
- 100% solid system (solvent free)  
- Easy to mix in different temperatures  
- Good adhesion to the substrate in wet and dry conditions  
- Insignificant environmental impact  
- System with implemented foaming of up to 20 times |
| | PUR HF-15 | -  
- 
- |
| **Accelerator (Modifier) for Two-Component Polyurethane Resins** | Add Fast | - Additive for two component polyurethane resin  
- Used whenever a faster reaction is needed due to high water ingress or low temperature conditions |
| | Add Thix | - Additive for two component polyurethane resin  
- Increases initial viscosity after mixing which can be useful for decreasing resin leakage in badly fractured ground or in case of massive water ingress |
### Properties: Viscosity and Setting Time

![Graph showing viscosity and setting time]

### Specifications

<table>
<thead>
<tr>
<th>Product</th>
<th>Viscosity after Mixing [mPas]</th>
<th>Reaction Start Time [s]</th>
<th>Tack Free Time [s]</th>
<th>Foam Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUR W</td>
<td>210</td>
<td>5</td>
<td>35</td>
<td>≈ 1</td>
</tr>
<tr>
<td>PUR WF</td>
<td>210</td>
<td>5</td>
<td>25</td>
<td>≈ 1</td>
</tr>
<tr>
<td>PUR WT</td>
<td>&gt; 5,000</td>
<td>5</td>
<td>35</td>
<td>≈ 1</td>
</tr>
<tr>
<td>PUR HS</td>
<td>360</td>
<td>5</td>
<td>25</td>
<td>≈ 1</td>
</tr>
<tr>
<td>PUR HA</td>
<td>450</td>
<td>25</td>
<td>75</td>
<td>≈ 2</td>
</tr>
<tr>
<td>PUR S</td>
<td>210</td>
<td>240</td>
<td>4,800</td>
<td>≈ 1</td>
</tr>
<tr>
<td>PUR LV</td>
<td>100</td>
<td>5</td>
<td>4,200</td>
<td>≈ 1</td>
</tr>
<tr>
<td>PUR HF-10</td>
<td>460</td>
<td>35</td>
<td>90</td>
<td>≈ 10</td>
</tr>
<tr>
<td>PUR HF-15</td>
<td>510</td>
<td>20</td>
<td>135</td>
<td>≈ 15</td>
</tr>
</tbody>
</table>

1) The indicated values are laboratory values and may deviate on-site. 20 °C (68 °F).
Store in original packaging and protected from moisture at temperatures between 5 °C and 30 °C (41 °F and 86 °F).
Data on further mixing ratios and information relevant for application can be found in technical data sheets of DSI Underground.
## Product Range

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Product Name</th>
<th>Product Description</th>
</tr>
</thead>
</table>
| Organo-Mineral Silicate Resins | Bond LV | - Medium setting resin  
- Low viscosity of the components  
- Relatively low initial viscosity  
- Sound mechanical properties  
- Very good adhesion to the substrate in wet and dry conditions  
- Does not react with water and water is not affecting material properties  
- Excellent corrosion resistance |
| Organo-Mineral Silicate Resins | Bond S | - Slower version of Bond LV |
| Organo-Mineral Silicate Resins | Bond T | - Thixotropic version of Bond LV  
- System with increased initial viscosity after mixing  
- Excellent for the application in badly fractured ground |
| Organo-Mineral Silicate Foam Resin | Fill | - High foaming injection resin  
- Very low viscosity of the components  
- Very low initial viscosity  
- Cured resin is easy to cut and drill through  
- Does not react with water and water is not affecting material properties  
- Excellent corrosion resistance |
| Organo-Mineral Silicate Foam Resin | Fill S | - Slower version of Fill |
**Properties: Viscosity and Setting Time**

![Graph showing viscosity and setting time over time.](image)

### Specifications

<table>
<thead>
<tr>
<th>Product</th>
<th>Viscosity after Mixing</th>
<th>Reaction Start Time</th>
<th>Tack Free Time</th>
<th>Foam Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond LV</td>
<td>300 [mPas]</td>
<td>120 [s]</td>
<td>180 [s]</td>
<td>1.0</td>
</tr>
<tr>
<td>Bond S</td>
<td>300 [mPas]</td>
<td>240 [s]</td>
<td>400 [s]</td>
<td>1.0</td>
</tr>
<tr>
<td>Bond T</td>
<td>450 - 10,000 [mPas]</td>
<td>120 [s]</td>
<td>180 [s]</td>
<td>1.0</td>
</tr>
<tr>
<td>Fill</td>
<td>75 [mPas]</td>
<td>15 [s]</td>
<td>45 [s]</td>
<td>= 35</td>
</tr>
<tr>
<td>Fill S</td>
<td>75 [mPas]</td>
<td>40 [s]</td>
<td>135 [s]</td>
<td>= 35</td>
</tr>
</tbody>
</table>

1) The indicated values are laboratory values and may deviate on-site. 20 °C (68 °F).

Store in original packaging and protected from moisture at temperatures between 5 °C (41 °F) and 30 °C (86 °F).

Data on further mixing ratios and information relevant for application can be found in technical data sheets of DSI Underground.

2) Depending on the shear force.
## Product Range

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Product Name</th>
<th>Product Description</th>
</tr>
</thead>
</table>
| **Single-Component Resins (SCR)** | General | - Slow to fast setting resin with adjustable reaction time  
- Phthalate free  
- Sound mechanical properties of the consolidated ground  
- No environmental impact |
| | PUR 1C 50-II | - Slow setting resin  
- Very low initial viscosity  
- Product designed for fine sand injections |
| | PUR 1C 100 | - Rigid and medium setting resin  
- Setting time can be increased using Add Fast 1C  
- Solvent free  
- Can be used in a wide temperature range  
- Insignificant environmental impact |
| | PUR 1C 400 | - Elastic and medium setting resin  
- Setting time can be increased using Add Fast 1C  
- Solvent free  
- Insignificant environmental impact |
| **Accelerator for Single-Component Resins** | Add Fast 1C | - Additive for single-component polyurethane resins  
- Used when faster or slower reactions are required to cope with high water ingress or low temperature conditions |
| | Add Slow 1C | |
**Properties: Viscosity and Setting Time**

![Graph showing viscosity and setting time for different products](image)

**Comparison of Single-Component and 2-Component Resins**

- Easier application of SCR systems
- No static mixer required
- Faster and simpler cleaning procedure

- New SCR system featured by DSI Underground
- Special integrated accelerator customized to project requirements available upon request

- Limitations SCR systems
- Short reaction times (only)
- Generally low pumping rates [L/min]
- 2-C systems are more flexible with regards to material parameters and have higher strengths

**Specifications**

<table>
<thead>
<tr>
<th>Product</th>
<th>Reaction Start Time [s]</th>
<th>End of Foaming [s]</th>
<th>Foam Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>10 °C (50 °F)</td>
<td>20 °C (68 °F)</td>
<td></td>
</tr>
<tr>
<td>PUR 1C 50-II</td>
<td>80</td>
<td>55</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>20 °C (68 °F)</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≈ 5</td>
</tr>
<tr>
<td>PUR 1C 100</td>
<td>13</td>
<td>45</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≈ 35</td>
</tr>
<tr>
<td>PUR 1C 400</td>
<td>20</td>
<td>55</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>160</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≈ 20</td>
</tr>
</tbody>
</table>

1) The indicated values are laboratory values and may deviate on-site. Store in original packaging and protected from moisture at temperatures between 5 °C and 30 °C (41 °F and 86 °F). Data on further mixing ratios and information relevant for application can be found in technical data sheets of DSI Underground.

2) Reaction times with 0.5% Add Fast 1C and 10% water.
<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Product Name</th>
<th>Product Description</th>
</tr>
</thead>
</table>
| General             | · Low viscosity water solutions of acrylic monomers  
 · Extremely low initial viscosity of mixed components  
 · Easy-to-mix under different temperatures  
 · Minimum environmental impact  
 · Excellent penetration and sound adherence |
| ACR SR 80           | · 4-component system  
 · High-strength resin featuring easy-controlled gelling  
 · Excellent mechanical properties  
 · Suitable for injection of fine sands |
| ACR SR 50           | · 3-component system  
 · Medium strength featuring easy-controlled gelling  
 · Sound mechanical properties  
 · Suitable for injection of fine sands |
| ACR GEL E           | · 3-component system  
 · Rubber-like acrylic resin  
 · Suitable for ground stabilisation and water sealing |
Properties: Viscosity and Setting Time

![Graph showing viscosity and setting time for different products.]

**Special Features**

- 3-component polyacrylate injection gel
- Efficient sealing against ground water
- So-called “curtain sealing”: Waterstop by forming an impermeable layer of sealant in the ground (multiple steps)
- Constant foam factor: 1

**Specifications**

<table>
<thead>
<tr>
<th>Product</th>
<th>Viscosity after Mixing [mPas]</th>
<th>Reaction Time [s]</th>
<th>Mixing Ratio: Parts per Volume</th>
<th>Foam Factor</th>
<th>Compressive Strength [Mpa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACR SR 80</td>
<td>4.0</td>
<td>30 - 360</td>
<td>1 : 1</td>
<td>1</td>
<td>≈ 20</td>
</tr>
<tr>
<td>ACR SR 50</td>
<td>3.0</td>
<td>60 - 300</td>
<td>1 : 1</td>
<td>1</td>
<td>≈ 10</td>
</tr>
<tr>
<td>ACR GEL E</td>
<td>2.5</td>
<td>300</td>
<td>1 : 1</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

1) The indicated values are laboratory values and may deviate on-site. Store in original packaging and protected from moisture at temperatures between 5 [°C] and 30 [°C] (41 [°F] and 86 [°F]). Data on further mixing ratios and information relevant for application can be found in technical data sheets of DSI Underground.

2) Start of gelling.

3) With sand.
Pumps and Accessories

Pumps

Selection of a suitable high-pressure pump depends on the type of application, available infrastructure, and ground conditions. Availability of existing equipment may also influence equipment selection. DSI Underground offers a wide range of high-pressure pumps for underground applications. Further details are described in separate technical data sheets.

DYWI® Inject 2-Component High-Pressure Piston Pump
- Brace operated, pneumatically driven piston pump
- 1:1 mixing ratio for processing DYWI® Inject PUR and SIL Systems
- Independent intake of both components
- Robust design and little susceptibility to damage
- Easy operation and handling
- Spare parts and starter set available
- Technical data sheet and operation manual available on request

DYWI® Inject 1-Component High-Pressure Pump
- Small and light-weight aggregate
- Electric or pneumatic versions available
- Low to medium injection pressure range
- Easy to clean and maintain

DYWI® Inject 2-Component High-Pressure GEL Pump
- Robust design and little susceptibility to damage
- Additional flushing pump
- High performance
- Stainless steel pump
- Double piston pump, pneumatically driven
- Independent intake of both components

DYWI® Inject 2-Component High-Pressure Gear Pump
- Adjustable mixing ratio
- High output
- Reliable aggregate for long-term application
- Electrically driven
Accessories

- Mixing tubes and static mixers
- Connectors
  - Injection adapters (DYWI® Drill and GRP)
  - Quick connectors (cable bolts)
- Screw-on nipples
- DYWI® Drill and GRP injection lances
- Steel and plastic injection lances
- Injection deep packers

Mixing Assembly 1 to 1 (Example)
Emergency Kit

Types of Emergency Kits

- Prepared in advance: Default applications
- Just-in-time system solution

DSI Underground as Problem Solver

- One-stop shop: All material from one source
- Quick reaction: Contingency material stock and experience in global logistics
- Support throughout all project phases: From initial evaluation to method statement to material supply to on-site application

Customized Emergency Kits for Conventional and Mechanized Tunneling

- 10 [ft] or 20 [ft] GP Container
- Material: Steel and chemical consumables
- Equipment: Injection pumps etc.
- Support by DSI Underground competence centers
Mechanized Tunneling

Emergency Measures for Challenging Ground Conditions

**Influencing Factors**
- Water ingress
- Instabilities ahead of the face
- Overbreak or cavities

**Limitations**
- Access of cutter wheel and shield area
- Delay of ground support installation
- Excavation geometry defined by the machine

**Boundary Conditions**
- Application
- TBM type and geometry
- Drilling equipment

**Lowering of Water Ingress**

**Sealing Injections**

**Cavity Filling & Strengthening**

**Injection Pipe Umbrella**

**AT – 89 TBM Pipe Umbrella System**
- Installation with attachment drills
- Drilling works can be executed by standard personnel under the supervision of application engineers
- Time-saving installation due to simultaneous drilling and tubing (self-drilling)
- Installation using a preventer is possible
- GRP or steel pipe length may be adapted to the space available
- GRP injection pipes can be cut by a shield and mucked out via a TBM cutting wheel
- Stabilization of fractured ground or fault zones
- Prevention of water ingress
Backfilling and Repair Works

Backfilling

- Filling of voids in the gap between excavation surface and segmental lining
- Limitation of ground material washout
- Secondary sealing effect
- Fast reaction and curing
- Provision of long-term stability

Repair Works

- Sealing of tunnels (primary lining)
- Shotcrete and concrete sealing repair
- Repair waterproofing (injection hoses or drilled packers)
- Default systems:
  - SLR or slow-setting PUR
- Aging tests prove long-term durability of cured DYWI® Inject resin
Approvals and Further References

Approvals

Test Procedures
- Mechanical properties
- Reaction temperature
- Self-rescue filter tests
- Hygienic assessment
- Groundwater compatibility
- Fire testing
- Long-term durability

Approvals
- Product-specific approvals are listed in DSI Underground technical data sheets

Cooperation Partners
- MFPA Leipzig GmbH, Germany
- DMT GmbH, Germany
- Central Mining Institute, Poland
- Hygienic Institute Gelsenkirchen, Germany

Packaging
- Material supply in IBC tanks for large-scale applications
- Steel barrels (200 [kg])
- Manual packages > 20 [kg] product weight are not recommended due to handling and ergonomic reasons

Further References
- Safety data sheets EG No. 1907/2006
- Technical data sheets
- Instructions for mixing and processing, cleaning and disposal, health and safety
Please note:
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