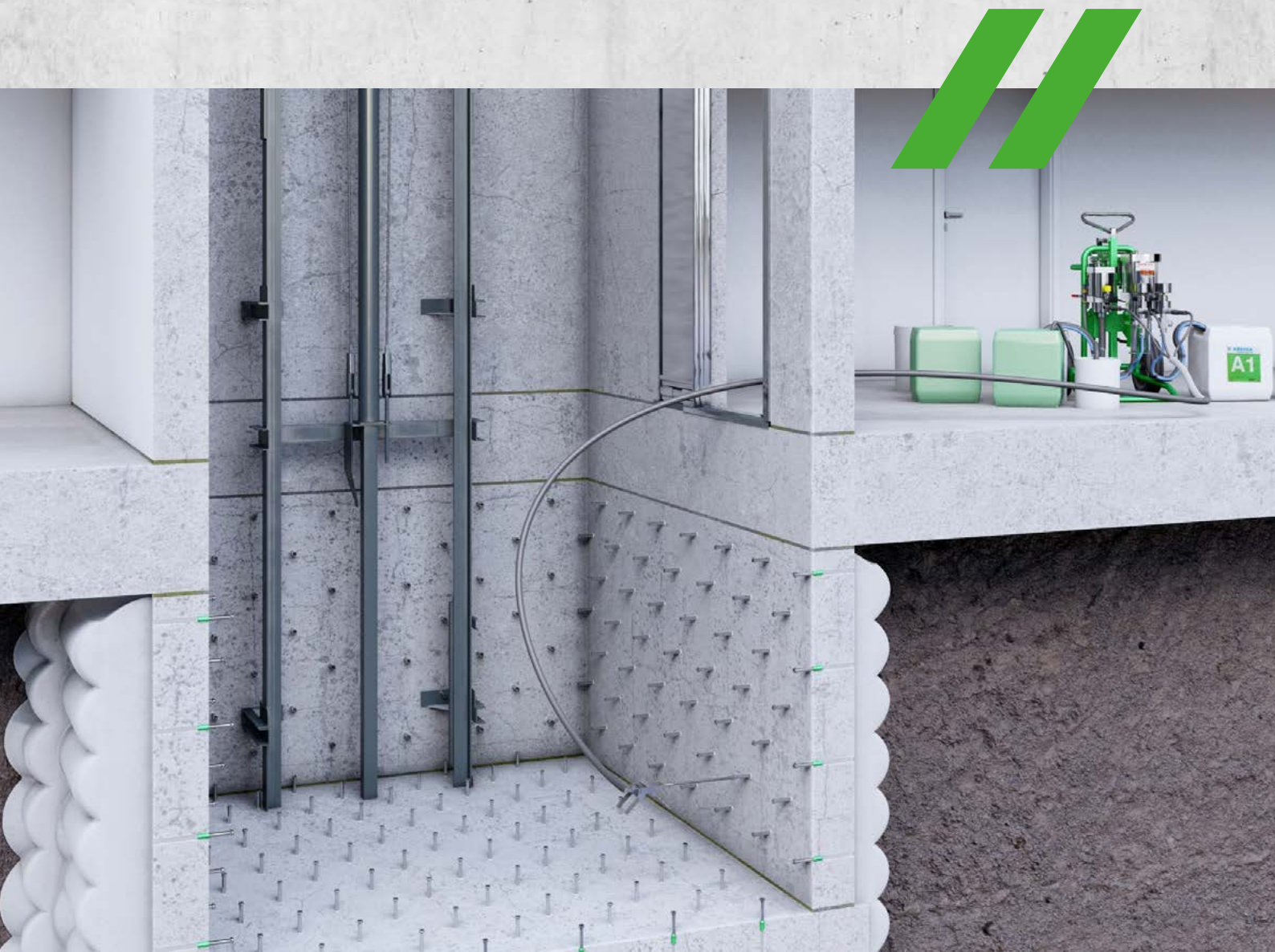


Method Statement

Acrylic Gel Injection



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1 General information

1.1 Scope

This method statement is intended for use by developers, contractors and applicators as a general guideline for the application of the KÖSTER acrylic gels.

While this document describes the tools, equipment, materials and process for preparing and installing the

injection system products, it must be used and referred to, in combination with all other relevant technical information available for the products and their components.

1.2 Manufacturer

KÖSTER BAUCHEMIE AG

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D-26607 Aurich Fax 04941/9709-40

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KÖSTER
Waterproofing Systems

1.3 Definitions

Compressive strength

Capacity of a material to withstand axially directed pushing forces. When the limit of compressive strength is reached, materials will collapse.

Gel Formulation

Gel is a Visco-elastic material in a state between a liquid and a solid.

Corrosion

Water and oxygen enter the construction member made of concrete. The steel reinforcements start to corrode. The corroding steel reinforcements expand and blast the covering concrete off.

Elasticity

Elasticity is the ability of a material to return to its original form, after been exposed to external forces, e.g. stretching or compressing.

Elongation at break

It is a measurement that shows how much a material can be stretched — as a percentage of its original dimensions — before it breaks. This is also referred to as percent elongation, which is a measurement of the amount a material will plastically and elastically deform up to fracture. The material's final length is compared with its original length to determine the percent elongation and the material's ductility.

Swelling ability

A polymer's ability to swell is determined by the amount of liquid material that it can absorb.

ECO friendly

Common expression and marketing term widely use referring to articles and services, policies, regulations, laws, among others, declaring a minimal or no impact to the environment or ecosystem..

Exothermic reaction

A reaction that releases energy from the system to its surroundings, usually in the form of heat, but also in a form of light. This depends upon the reactant materials.

Curtain injection

A curtain injection is an injection method used to waterproof existing underground construction elements affected by moisture, in cases where it is not possible to expose the exterior walls through excavation, or when the economic cost of excavation is deemed too high to reestablish a positive side waterproofing system. The construction element to be waterproofed is drilled in a certain pattern, and acrylic gels are injected through the wall in multiple steps to create a waterproof elastic body on the positive (outer) side of the wall.

Construction joints:

Those are joints formed due to the different casting timing of two adjacent construction elements. This could be also considered the case for joints between vertical elements (like walls) and horizontal ones (like slabs), which are considered to be important weak points that could lead to water leakage, especially when subjected to negative water pressure.

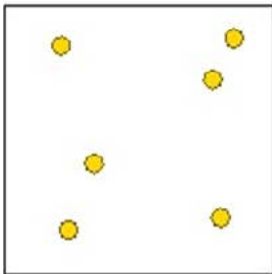
Expansion joints:

Expansion joints are joints that were implemented intentionally into the structure to give the chance for the concrete to expand and contract without cracking. Expansion joints subject to negative water pressure required injection because traditional joint sealing systems cannot not withstand the demands over time.

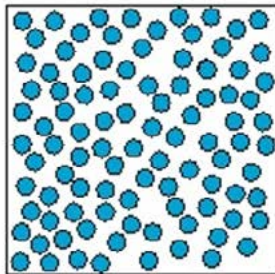
2 What are acrylic gels?

Gels are visco-elastic materials in a state between a liquid and a solid. In reacted state, acrylic gels form a non-fluid colloidal network or polymer network that is expanded by a fluid in its entire volume.

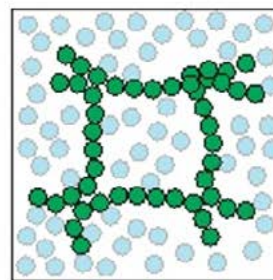
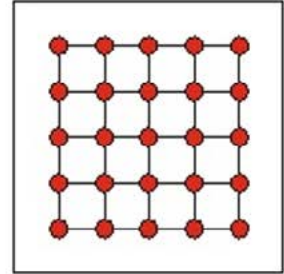
Gas



Liquid state



Solid state

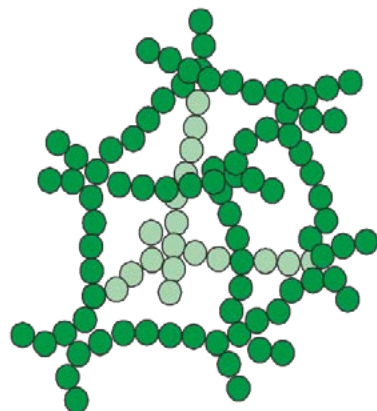
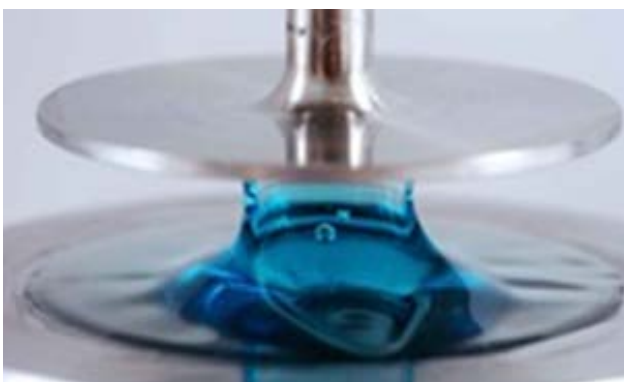


Gel

Acrylic gels are predominantly distinguished by their extremely low initial viscosity (similar to water), allowing the deepest penetration in the pore structure among all other injection materials.

They are typically used for building waterproofing through curtain, masonry, and void injection.

Gels used for building waterproofing are characterized, even in the fully reacted state, by having considerable amounts of water (hydrophilic capabilities), which are physically bound in the polymer network. The binding is sufficient that the water cannot be driven out even by high pressure.



3 System description

3.1 System features

KÖSTER Injection Gel G4

The KÖSTER Injection Gel G4 is a water based, elastic acrylic gel with a very low initial viscosity. It is capable of binding water during the gelation. The swelling ability after full curing allows a 40% uptake of additional water into the gel structure while maintaining a watertight system.

KÖSTER Injection Gel G4 is recommended for waterproofing below ground construction elements on the outside through curtain injection, and for injection into full brick masonry in order to seal the mortar joints against water ingress. This special acrylic gel can also be applied in specialized waterproofing cases, like tunnels, shafts, void and joint injections, concrete injections, as well as for soil stabilization.

3.2 Characteristics/advantages

- Extremely low viscosity: Acrylic gels have an extremely low viscosity that allows for the deepest penetration into the injected body (ie. sand, silt and even some clays). The lower the viscosity, the more pores will be closed.
- Do not react with water: Acrylic gels are the only injection material that takes water in its structure but does not react with it. It only binds it.
- Differentiated reaction profile: The transition between liquid and solid state displaying a "s" form reaction profile revolutionized the injection technique making a multiple-step injection possible.
- Exothermic reaction: The heat generated during the reaction process provides valuable information about the material distribution during the injection.
- Reliable pneumatic machine technique: With a pneumatic pump machine, maintenance is kept simple and work under adverse weather conditions is possible due

KÖSTER Injection Gel S4

The KÖSTER Injection Gel S4 is a reaction time adjustable acrylic gel used for stopping active water ingress, curtain injection and to quickly seal joints. The setting time can be adjusted between 20 seconds and 3 minutes, depending on the waterproofing needs.

By adding an organic dispersion to the B component (KÖSTER B+), the KÖSTER Injection Gel S4/B+ can achieve a particularly high flank adhesion to mineral substrates, an enhanced elasticity and a reduced evaporation.

to the lack of electronic components.

- Chemical composition: Safe application regarding chemical hazards. The material composition shows the least allergic reaction among injection materials, making it safer to work with.
- Corrosion behavior: Fully cured KÖSTER Injection Gels does not interact or promotes corrosion of the reinforcement in concrete.
- Stainless drying: Cured material can be easily removed with simple tools without leaving marks on the substrate.
- Environmentally friendly: With the KÖSTER Injection Gel G4, there is no washing out of substances from the gel harmful to the ground or drinking water, guaranteeing a safe injection into the soil when conducting for example a soil stabilization.

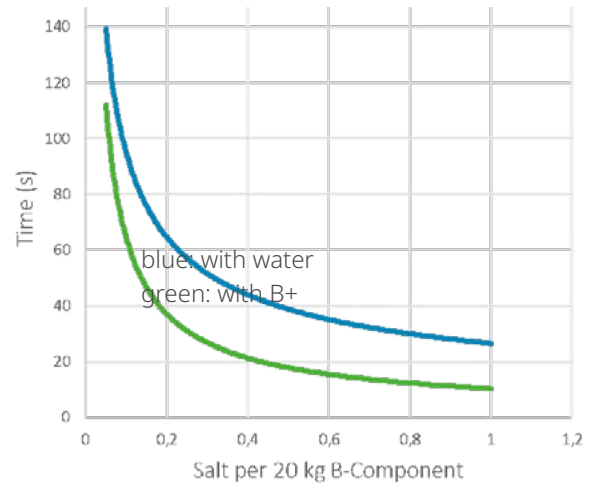
3.3 General properties of gels

Characteristics	KÖSTER Injection Gel G4	KÖSTER Injection Gel S4	KÖSTER Injection Gel S4/B+
Adhesion capacity	> 1.0 MPa	0.04 MPa	> 0.04 MPa
Elongation capacity	> 10 %	70 %	> 70 %
Water tightness	D2	D1 watertight at 2×10^5 Pa	D1
Mixture viscosity	Approx. 2 mPa.s	Approx. 9 mPa.s	Approx. 9 mPa.s
Application Temperature	> +5 °C	> +5 °C	> +5 °C
Corrosion behavior	No corrosive effect	No corrosive effect	No corrosive effect
Dangerous substance	NPD	NPD	NPD
Final curing time	8 min.	30 – 180 sec.	20 – 150 sec.
Adhesion properties	Excellent adhesion properties	Excellent adhesion properties	Excellent adhesion properties
Negative waterproofing	up to 7 bar	up to 2 bar	up to 2 bar
Suitable for applications in drinking water	Test report	-----	-----
Ground water interaction	Certificate of approval Non- toxic	Certificate of approval Non- toxic	Certificate of approval Non- toxic
Isocyanate content	No	No	No
V.O.C	No	No	No
Durability	No failure during compressive tests	No failure during compressive tests	No failure during compressive tests
Injectability into dry medium	Class 0.1	Class 0.1	Class 0.1
Injectability into non-dry medium	Class 0.1	Class 0.1	Class 0.1
Adjustable reaction time	No	Yes, by changing the amount of salt.	Yes, by changing the amount of salt.
Components	Component A1 - 20 kg Component A2 - 1 kg Component B - 0.4 kg Component water - 21 kg	Component A1 - 20 kg Component A2 - 1 kg Component B - 0.4 kg Component water - 21 kg	Component A1 - 20 kg Component A2 - 1 kg Component B - 0.4 kg Component(B+) - 18 kg
Recommended Pump	KÖSTER Acrylic Gel Pump	KÖSTER Acrylic Gel Pump	KÖSTER Acrylic Gel Pump
Fields of applications	- Injection in elevator shafts - Injection in concrete slabs - Diaphragm wall - Injection in concrete or masonry tunnels - Curtain injection in case of tubbing tunnel injection - Void filling in masonry tunnel construction - External basement waterproofing with curtain injection - Vertical and horizontal curtain injection - Concrete injection - Soil stabilization	- Vertical and horizontal curtain injection - External basement waterproofing with curtain injection - Masonry Tunnel construction - Tubbing tunnel construction	- Injection of expansion joints - Joint sealing in tunnel construction.

3.4 Adjusting the reaction time

3.4.1 According to the amount of the B component

By changing the amount of the B component (salt) used in the mixture, the reaction time of the KÖSTER Injection Gel S4 can be adjusted. By increasing the amount of salt, the reaction can be accelerated until a final curing of approx. 30 seconds. By reducing the amount, the reaction can be adjusted for a final curing of approx. 3 min. When mixing the B component with the organic dispersion KÖSTER B+, the reaction times are faster and range between approx. 20 seconds and 2.5 minutes.

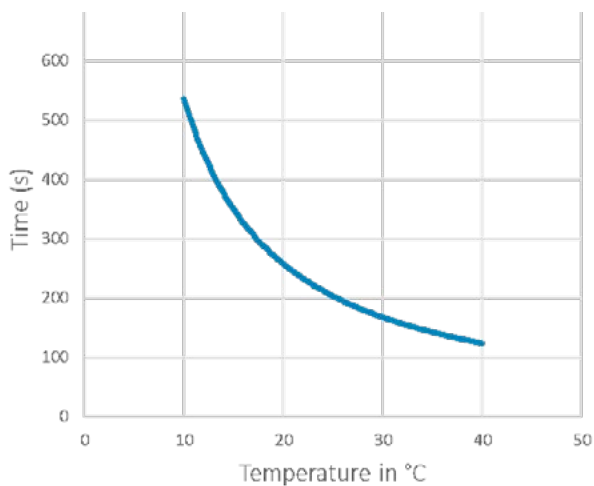


KÖSTER Injection Gel S4 & S4/B+

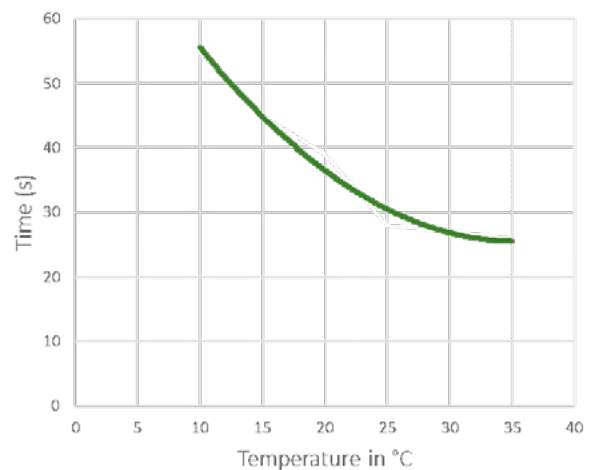
3.4.2 According to the temperature

The reaction time of the KÖSTER Injection Gels can also be influenced by temperature fluctuations. At high temperature, the reaction time is accelerated and at lower

temperatures the reaction time is delayed. This condition applies to the material, ambient and substrate temperature.



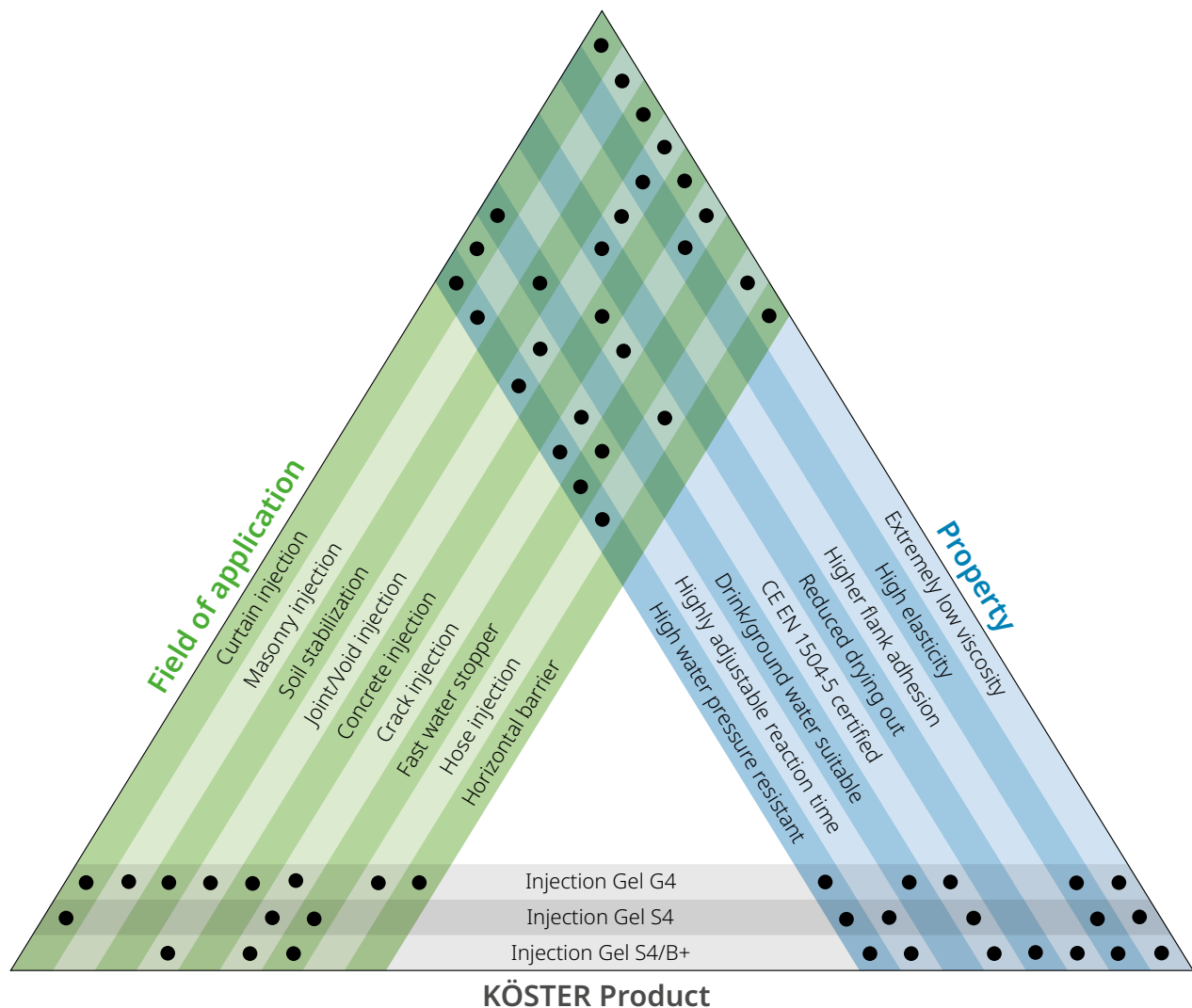
KÖSTER Injection Gel G4



KÖSTER Injection Gel S4 & S4/B+

3.5 System selection guide for acrylic injection gels

The following matrix serves as a general guideline for the selection of the appropriate KÖSTER Injection Gel according to the application and the main property required for the intended use.



Generally:

- Creating a **curtain injection** requires a fine material that can travel through the finest voids in the soil, and bind them to create a waterproofed barrier. This type of application is easily carried out with the KÖSTER Injection Gel G4/S4. Taking advantage of the low viscosity of the gel, injection into difficult soil conditions like fine sand, silt and some clays is possible. Water present behind the wall does not represent a challenge for the KÖSTER injection gels since they do not react with it, but instead it is bound in its matrix.
- To reduce the loss of the fines from the underground, caused by changes in the ground water level or the presence of water currents within the soil structure, a **soil stabilization** must be performed. This stabilization is carried out through the injection of KÖSTER Injection Gel G4 through special injection lances. The low viscos-

ity of the gel allows a deep penetration and distribution of the material between the grain's matrix, binding the soil and water into an elastic gel-soil body. The result is a more stable, waterproofed soil composition without the risk of washing out of fines.

- The KÖSTER Injection Gel S4 with the KÖSTER B+ component is a specially designed gel for the **injection of joints** providing a higher flank adhesion, enhanced elasticity and a reduced drying tendency when in contact with moving air such as wind. The injection of joints represents a fairly quick method and minimally invasive way to repair failing waterproofing systems. By injecting the joint, it is not necessary to excavate underground parking garages or other underground building components. Moreover, since a low number of packers are sufficient in most cases, the drilling effort is reduced and time and costs are saved.

3.6 Main products and components

3.6.1 KÖSTER Injection Gel G4

Component A1: 20 kg

Component A2: 1 kg

Component B: 0.4 kg

[See online](#)



3.6.2 KÖSTER Injection Gel S4 & S4/ B+

Component A1: 20 kg

Component A2: 1 kg

Component B: 0.4 kg

Component B+: 18 kg

[See online](#)



3.7 Associated products



KÖSTER KB-Fix 5

[See online](#)



**KÖSTER KD 2
Blitz Powder**

[See online](#)



KÖSTER Repair Mortar

[See online](#)



KÖSTER Injection Barrier

[See online](#)



KÖSTER Superpacker
10 mm x 115 mm CH

The KÖSTER Superpacker provides a very high contact pressure to the borehole due to the cone-shaped center of the tightening mechanism. Four fins and two ridges on the rubber gasket prevent rotation during tightening and facilitate the optimal fixation of the packer in the borehole. It has a firmly mounted cone-head fitting for pressure injection and is galvanised.

[See online](#)



KÖSTER Packer
13 mm x 130 mm CH

The KÖSTER Packer is particularly suitable for pressure injections. The arrangement of the split packer rubbers results in excellent contact pressure in the borehole. The surface of the clamping rubber easily digs into the borehole, adapts to the borehole wall and thus increases its tightness. It has a firmly mounted cone-head fitting for pressure injection and is galvanized.

[See online](#)



KÖSTER One-Day-Site Packer
13 mm x 120 mm CH

The screw packer for pressure injection has a firmly mounted cone-head fitting and two non-return valves. Immediately after injecting, that part of the port which protrudes from the wall can be unscrewed and removed. The central part of the port stays in the wall sealing the borehole so that no injection material can flow out of the borehole even under high pressure. The borehole can then be closed immediately after injection.

[See online](#)



KÖSTER One-Day-Site Packer
13 mm x 120 mm PH

The screw packer for pressure injection has a firmly mounted pan-head fitting and two non-return valves. Immediately after injecting, that part of the port which protrudes from the wall can be unscrewed and removed. The central part of the port stays in the wall sealing the borehole so that no injection material can flow out of the borehole even under high pressure. The borehole can then be closed immediately after injection.

[See online](#)



KÖSTER One-Day-Site Packer
13 mm x 90 mm PH

The screw packer for pressure injection has a firmly mounted pan-head fitting and two non-return valves. Immediately after injecting, that part of the port which protrudes from the wall can be unscrewed and removed. The central part of the port stays in the wall sealing the borehole so that no injection material can flow out of the borehole even under high pressure. The borehole can then be closed immediately after injection.

[See online](#)



KÖSTER One-Day-Site Packer
13 mm x 90 mm CH

The screw packer for pressure injection has a firmly mounted cone-head fitting and two non-return valves. Immediately after injecting, that part of the port which protrudes from the wall can be unscrewed and removed. The central part of the port stays in the wall sealing the borehole so that no injection material can flow out of the borehole even under high pressure. The borehole can then be closed immediately after injection..

[See online](#)



KÖSTER Gel Packer (Base)

Impact packers for gel injection using pan-head fitting and non-return valves. With connection threads for an extension pipe. 18 mm x 115 mm.

[See online](#)



KÖSTER Gel Packer extension pipe 800 mm

Extension pipe for KÖSTER Gel Packers. Length: 800 mm

[See online](#)



KÖSTER Gel Packer (End Piece)

Patented end piece for gel packers with four sideways facing outlets for curtain injection (German patent 599 10 808.8, European patent No. 0 980 935). With connection threads for the KÖSTER Gel Packer Extension Pipe.

[See online](#)



KÖSTER Grip Head

with 4 jaws for cone-head fittings.

[See online](#)



KÖSTER Cutting Device for Gel Packers

Cutting device for reducing the length of KÖSTER Gel Packer Extension Pipes as well as KÖSTER capillary rods.

[See online](#)

3.8 Associated literature

- [Product Declaration of Performance Injection Gel G4](#)
- [Product Declaration of Performance Injection Gel S4](#)
- [Fields of application for KÖSTER Injection Packers](#)
- [KÖSTER Injection matrix: Acrylic Gels](#)
- [Product Flyer Acrylic Gel Pump](#)
- [Product Flyer Curtain Injection](#)
- [Product Flyer Masonry Injection](#)

4 Tools and Equipment

4.1 Tools



Measuring tool



Trowel



Pencil



Tools for packers



Ring wrench



Mixing vessel

4.2 Equipment



Driller



KÖSTER Drill Hole Cleaner



Single Paddle Mixer



Air compressor

4.2.1 KÖSTER Gel pump

Pneumatic pump made of stainless steel for the application of KÖSTER Injection Gel G4 & S4.



Technical data of the machine

Technical Data	KÖSTER Acrylic Gel Pump
Maximum pressure	220 bars
Transmission Ratio	26 : 1
Maximum inlet pressure	8 bars
Material hose length	10 m
Max. material hose length	50 m
Max. delivery rate	10 l/min.
Output per piston cycle (double stroke)	85 ml
Mixing and output ratio A : B	1 : 1
weight	45 kg

Air compressor requirements

Optimal air output	> 500 l/min.
Minimum air output	
Curtain injection	> 300 l/min.
Vertical area injection	> 250 l/min.

Important consideration when using the pump

Working with high pressure requires extra security measures.

Do not change the machine's construction or function.
Check all connections before use.

Wear safety gloves and goggles when using.

Observe all governmental, state, and local safety regulations when processing the material.

Storing the pump

In winter the cylinders must be filled with oil if the pump is exposed to frost even for one night. This keeps residual rinsing water from freezing and damaging the seals.

The protective caps on the uptake hoses should always be used when the pump is not in use.

Do not contaminate the uptake screens with sand.

4.3 Cleaning

Clean the pump immediately after use with clean water. For this, the three intake hoses are placed in the three clean buckets. The buckets are filled with clean water and pumped through the machine and the pump is rinsed for approximately 30 seconds.

Please consult the KÖSTER Acrylic Gel Pump manual for further instructions concerning setup, functioning, troubleshooting and cleaning of the pump.

A video for a Quickstart with the pump is also available online.

5 Environmental, health and safety

5.1 Personal Protection Equipment (PPE)

The following is a short overview of Personal Protective Equipment and serves only as a guideline. Contractors and Employers are responsible for meeting the occu-

pational safety guidelines in their countries, states, and localities.



Eye protection

Employers must be sure that their employees wear appropriate eye and face protection and that the selected form of protection is appropriate to the work being performed and properly fits each worker exposed to the hazard.

Head protection

Employers must ensure that their employees wear head protection if any of the following apply: Objects might fall from above and strike them on the head; they might bump their heads against fixed objects, such as exposed pipes or beams; or there is a possibility of accidental head contact with electrical hazards.

Foot and Leg Protection

Employees who face possible foot or leg injuries from falling or rolling objects or from crushing or penetrating materials should wear protective footwear.

Hand Protection

When selecting gloves to protect against exposure hazards, always check with the manufacturer or review the manufacturer's product literature to determine the gloves' effectiveness against specific workplace chemicals and conditions. Gloves commonly used are: Coated fabric gloves and Chemical - and Liquid - Resistant Gloves.

Hearing protection

Suitable hearing protection must be provided for the job environment.

5.2 Material safety & First Aid

Every KÖSTER product is labeled with specific information and symbols as to the related dangers. Please consult the respective Material Safety Data Sheet for specifics.

If inhaled:

Provide fresh air. When in doubt or if symptoms are observed, get medical advice.

In case of contact with eyes:

In case of contact with eyes flush immediately with plenty of flowing water for 10 to 15 minutes holding eyelids apart and consult an ophthalmologist.

You can access the Material Safety Data Sheets by scanning the QR codes on the packagings.

After ingestion:

Observe risk of aspiration if vomiting occurs. Rinse mouth immediately and drink plenty of water.

After contact with skin:

After contact with skin, wash immediately with polyethylene glycol, followed by plenty of water. Take off immediately all contaminated clothing and wash it before reuse. Medical treatment necessary.

5.3 Waste disposal

Disposal recommendations

Do not allow to enter into surface water or drains. Dispose of waste according to applicable legislation.

Contaminated packaging

Completely emptied packages can be recycled.

6 Fields of application for KÖSTER Injection Gel G4

6.1 Curtain injection in tubing tunnel case



1. Injection needle

2. Curtain injection:

KÖSTER Injection Gel G4

3. Gel pump:

KÖSTER Acrylic Gel Pump

Injection Process:

Tunnels consisting of tubing elements which are built with a tunneling shield or tunnel boring machine (TBM), represent the most advanced method used in tunnel construction. However, despite heavy reinforcement, cracks can appear on the concrete surface due to high pressure from hydraulic stresses on the tubing elements.

A common problem in tunnel construction is the partial failure of the outer seal and consequent leakage through the tubing element joints. Very often curtain injection behind the tubing element is the chosen method of repair.

In order to protect the integrity of the concrete elements, special injection needles are placed through the joints, and the acrylic gel KÖSTER Injection Gel G4 is injected. The injection material solidifies the adjacent layers of soil and waterproofs the building component from the back-side. Voids between the soil and the tubing elements are also filled with the waterproofing gel and the outer seal is therefore restored.

6.2 External basement waterproofing with curtain injection



- | | |
|-------------------------|---|
| 1. Pump: | KÖSTER Acrylic Gel Pump |
| 2. Injection packers: | KÖSTER Packer 13 mm x 130 mm CH
KÖSTER Superpacker 10 mm x 115 mm CH
KÖSTER Superpacker 13 mm x 120 mm CH
KÖSTER Superpacker 13 mm x 90 mm CH
KÖSTER Superpacker 13 mm x 90 mm PH
KÖSTER Superpacker 13 mm x 120 mm PH |
| 3. Waterproofing layer: | KÖSTER Injection Gel G4
KÖSTER Injection Gel S4 |

Injection Process:

Exterior basement waterproofing from inside the building? In the case of renovation, it is not always possible to expose the exterior walls through excavation. For example, where the area to be excavated is built upon, traffic concerns impede the excavation, or the economic cost of excavation is deemed too high. You would first think of an internal (negative side) basement waterproofing, but in some cases, such as in historical buildings or buildings with special architectural requirements, this may not be desirable.

In these cases, a curtain injection with KÖSTER Injection Gel G4 is possible: The resin is injected through the wall

from the inside to the outside. The injection is carried out in multiple steps, to guaranteed that the injected material behind the wall creates an overlapping waterproofed barrier.

Water present behind the wall does not represent a challenge for the KÖSTER injection gels since they do not react with it, but instead it is bound in its matrix, resulting in a waterproof elastic solid body.

The injection is performed with the special two-component pump, KÖSTER Acrylic Gel Pump, and through special KÖSTER injection packers.

6.3 Soil stabilization injection



1. Pump: KÖSTER Acrylic Gel Pump
2. Injection lances
3. Injection and stabilization layer: KÖSTER Injection Gel G4

Injection Process:

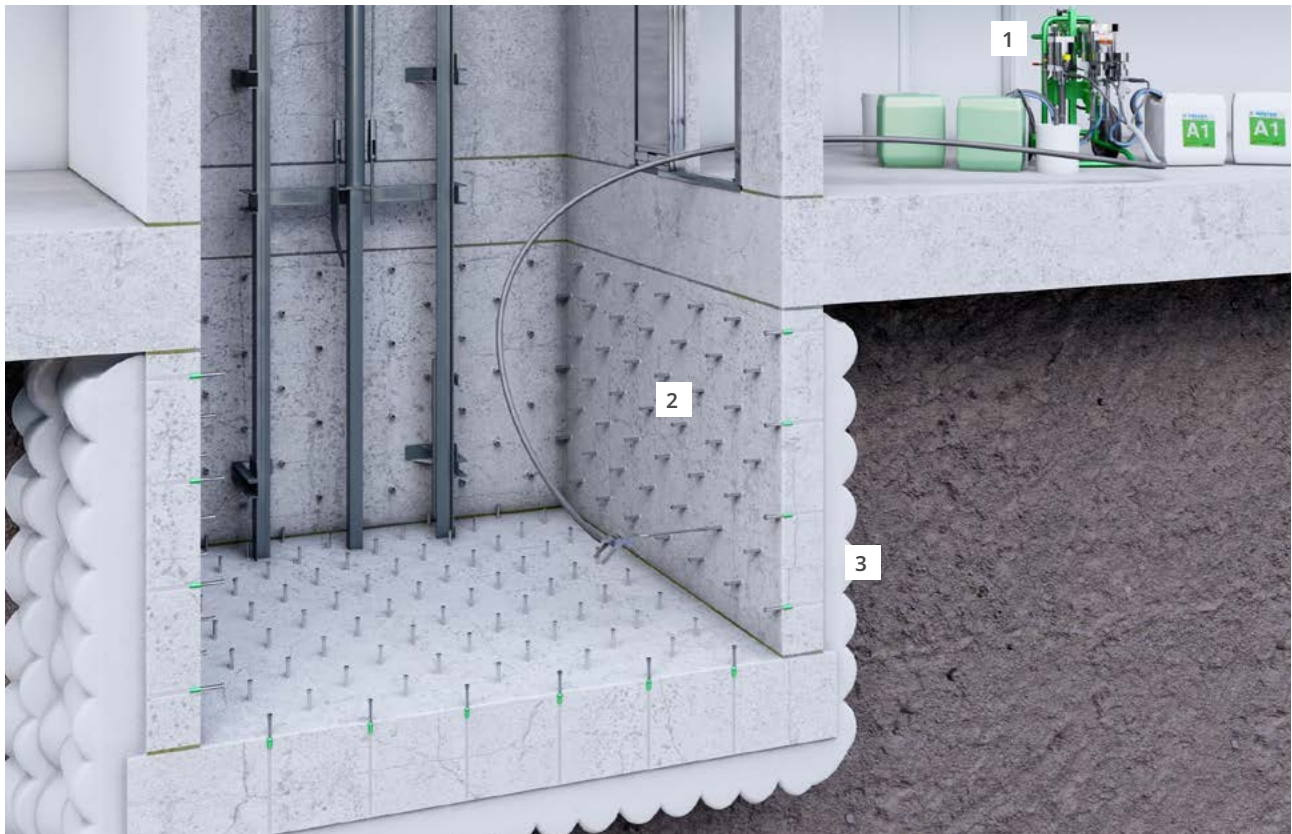
By changes in the ground water level or the presence of water currents within the soil structure, the fine substance from the underground can be washed out, creating voids in the soil. These voids can reduce the integrity of the soil structure until it collapses. Evidence of this phenomena is usually seen through the settlement of the structures, or in worst cases, through the formation of cavities or hollow chambers in the ground.

To reduce the loss of the fines from the underground, a soil stabilization must be performed. This stabilization is carried out with the injection of KÖSTER Injection Gel G4 through special injection lances. The low viscosity of the gel allows a deep penetration and distribution of the

material between the grain's matrix, binding the soil and water into an elastic gel-soil body. The result is a more stable, waterproofed soil composition without the risk of washing out of fines.

Soil stabilization with acrylic gels can be performed for example underneath house or building footings to prevent settlement from loss of fine from the ground and allow further construction, through walls to stabilize material behind and conduct structural repairs or drainage replacements, or inside dikes to enhanced the filled material and reduce water filtrations, among others. All applications required specific planning and must be considered individually for the most suitable procedure.

6.4 Injection in elevator shafts



- | | |
|-------------------------|--|
| 1. Pump: | KÖSTER Acrylic Gel Pump |
| 2. Injection packers: | KÖSTER Superpacker 13 mm x 120 mm PH
KÖSTER Superpacker 13 mm x 120 mm CH |
| 3. Waterproofing layer: | KÖSTER Injection Gel G4
KÖSTER Injection Gel S4 |

Injection Process:

The subsequent waterproofing of building components which are not accessible due to neighboring construction or other considerations (such as tunnels, underground parking garages, elevator shafts, or concrete base slabs), is commonly carried out through the waterproofing method referred to as curtain injection.

The graphic above shows an elevator shaft being subsequently waterproofed through horizontal curtain injection (underneath the concrete base slab) and through vertical curtain injection (through walls).

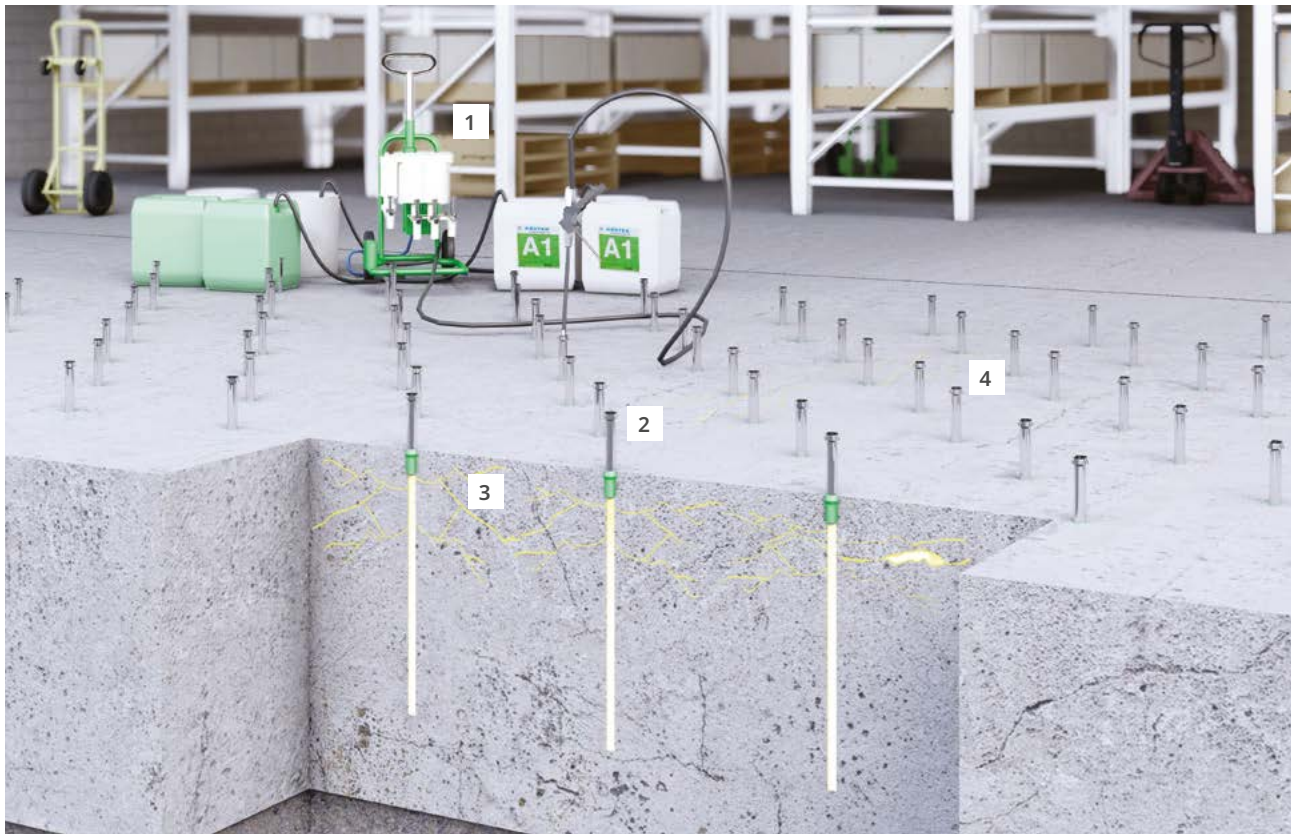
A quadratic, surface-centered grid of standard packers has been drilled into the building component. KÖSTER Injection Gel G4 is injected in numerous phases through

the drill holes, resulting in hemispherical areas of waterproofing on the positive (outer) side of the wall, separating the building component from groundwater.

For this particular field of application, KÖSTER Injection Gels G4 and S4 have received a general construction approval from the Deutschen Institut für Bautechnik (German Institute for Structural Engineering).

Curtain injection of building components with perforated bricks, bricks with finger holes, aerated concrete blocks, or double-wall constructions require the use of special gel packers. These long packers can bridge cavities within the wall and discharge the injection material into the ground on the outer side of the building component.

6.5 Concrete injection



- | | |
|---------------------------|--|
| 1. Pump: | KÖSTER Acrylic Gel Pump |
| 2. Injection packers: | KÖSTER Superpacker 13 mm x 120 mm PH
KÖSTER Superpacker 13 mm x 120 mm CH |
| 3. Waterproofing layer: | KÖSTER Injection Gel G4 |
| 4. Filling the boreholes: | KÖSTER KB-Fix 5 |

Injection Process:

Concrete structures exposed to extreme conditions, like intense heat, are subject to higher damaged in its micro structure, which can result in a higher porosity and cracking. Bad concreting or poor vibration can as well be causes of unwanted honeycombs or cracks on the surface. All these situations required an intelligent system with the capacity to fill the finest cracks and voids and stop water filtrations through the structure.

Although concrete injection is not the most commonly injection performed, it belongs to the fields of applications of the acrylic gels. Once again, the low viscosity of the material and the safe curing without affecting the steel

reinforcement, make concrete injection a specialized field of application for the KÖSTER Injection Gels.

KÖSTER Injection Gel G4 is an extremely low viscosity acrylic gel that follows the paths of water ingress, and after curing, seals filtrations effectively from the source. The structure is drilled in a specified pattern, depending on the dimensions and conditions, and KÖSTER Superpackers are inserted into the drill holes.

The KÖSTER Injection Gel G4 is injected in one or multiple phases until a pressure resistance is achieved. Afterwards the packer holes can be filled with KÖSTER KB-Fix 5.

7 Fields of application for KÖSTER Injection Gel S4 and S4/B+

7.1 Joint sealing in tunnel construction



1. Pump: KÖSTER Acrylic Gel Pump
2. Special rubber sealing system
3. Injection needle
4. Joint sealant: KÖSTER Injection Gel S4/B+
5. Joint protection

Injection Process:

The complex construction of tunnels entails great challenges for the waterproofing system. Even with the highest application standards, there could be special situations or extraordinary occurrences that could cause leaks inside the tunnels.

These leaks are mostly located along the joints of the tubing elements, and if not treated in time, could cause severe damages to the structural integrity of the tunnel. The KÖSTER Injection Gel S4 with the KÖSTER B+ component is a specially designed acrylic gel for the injection of joints, providing an outstanding elasticity, a higher

adhesion to the flanks, and a reduced drying tendency when in contact with moving air currents.

The adjustable reaction time acrylic gel is injected inside the joint using injection needles, inserted through a special rubber sealing system placed in the joint.

To avoid material losses on the back and prevent the material from running down the drainage system, a backing rod is inserted to create a defined injection area.

When the injection is completed, the special rubber sealing system can be removed and the gel protected with the highly elastic, MS Polymer technology KÖSTER MS Joint Sealant.

7.2 Injection of expansion joints



- | | |
|-------------------------|---|
| 1. Injection packer: | KÖSTER Packer 13 mm x 130 mm CH
KÖSTER Superpacker 10 mm x 115 mm CH |
| 2. Joint waterproofing: | KÖSTER Injection Gel S4/B+ |

Injection Process:

The injection of joints represents a quick method and minimally invasive way to repair failing waterproofing systems.

Hidden expansion joints, for example in an underground parking garage above a support beam, usually require a small number of injection packers. The placement of these packers is determined so that existing waterstops are preferably not perforated. This is particularly important for existing internal or external sealing bands.

In the case of overhead expansion joints (dilation joints), boreholes should be ideally drilled towards the top third of the joint.

In cases of floor expansion joints, boreholes should be ideally drilled towards the lower third of the joint. KÖSTER Superpackers are inserted into the boreholes. At overhead joints, a polymer, cementitious or mechanical barrier may be necessary to seal the joint before injection, in order to avoid losses of material.

By injecting the joint with the elastic acrylic gel KÖSTER Injection Gel S4/B+, it is not necessary to excavate underground parking garages or other underground building components. Moreover, since a low number of packers is sufficient in most cases, the drilling effort is reduced and time and costs are saved.

8 Mixing of components

8.1 Preparing the KÖSTER injection Gel G4

8.1.1 Prepare component A:

The A2 component is added into the A1 component canister. Afterward both components are thoroughly mixed through rocking/seesawing the canister (mixing time is 3 minutes).

8.1.2 Prepare component B:

The B component is filled into the additional green canister and afterwards filled with 21 liters of water. Both components are thoroughly mixed through rocking/seesawing the canister (mixing time is 3 minutes).



Component A1 + A2

Component B + water

8.2 Preparing the KÖSTER Injection Gel S4 & S4/B+

8.2.1 Prepare component A:

The A2 component is added into the A1 component canister. Afterward both components are thoroughly mixed through rocking/seesawing the canister (mixing time is 3 minutes).

8.2.2 Prepare component B:

Component B for the KÖSTER Injection Gel S4 can be prepared either by mixing with clean water or the polymer dispersion KÖSTER B+.



Component A1 + A2



Component B + water

I. Mixing with water

The B component is filled into the additional green canister and afterwards filled with 21 liters of water (mixing time is approx. 3 min.)

Mixing with water provides a fast reaction useful for curtain injection in the presence of large voids or strong water currents and to quickly stop large water leakages, among others.

II. Mixing with KÖSTER B+

Mixing the KÖSTER Injection Gel S4 with KÖSTER B+ is highly recommended for the elastic sealing of dilatation joints. The B component is added to the polymer dispersion KÖSTER B+ and mixed through rocking/seesawing the components. (mixing time approx. 3 min.) The use of the polymer dispersion provides a gel with a higher flank adhesion, elongation and less tendency to dry out.



Component B + KÖSTER B+

8.3 KÖSTER recommended mixing ratio for the KÖSTER injection Gel S4 & S4/B+

Standard mixture

Component A (Mixture 1)		Component B (Mixture 2)		Reaction time in seconds at +20 °C
A1	A2	B	water	70 sec.
20 kg	1 kg	0.4 kg	21 kg	
A1	A2	B	B+	30 sec.
20 kg	1 kg	0.4 kg	18 kg	






Slow mixture

Component A (Mixture 1)		Component B (Mixture 2)		Reaction time in seconds at +20 °C
A1	A2	B	water	180 sec.
20 kg	1 kg	0.05 kg	21 kg	
A1	A2	B	B+	150 sec.
20 kg	1 kg	0.05 kg	18 kg	






Note: slower mixtures are not recommended to be adjusted with the amount of salt due to the danger that the reaction does not even start under real conditions due to impurities in the injection area.

Fast mixture

(2.5 containers of the B-salt)

Component A (Mixture 1)		Component B (Mixture 2)		Reaction time in seconds at +20 °C
A1	A2	B	water	30 sec.
20 kg	1 kg	1 kg	21 kg	
A1	A2	B	B+	20 sec.
20 kg	1 kg	1 kg	18 kg	






8.4 KÖSTER Acrylic Gel Pump set up

To prepare the KÖSTER Acrylic Gel Pump for injection, place the mixed component A next to the A side of the pump, and the B component in the green container next to the B side. Place also a clean container on the back of the pump and fill with clean water.

Insert the suction hose of the A side of the pump into the A-component. Insert the suction hose of the B side of the pump into the B-component. Make sure that the suction fitting rests on the bottom. **INTERCHANGING THE HOSES MUST BE AVOIDED!**

Place the single suction hose, labeled "S" inside the clean container filled with water. This suction hose is used for

flushing the pump and does not have a transparent hose attached.

Before injection begins, open the valves below the two pressure gauges (A & B side) to vent the pump, and remove air entrapment from the intake hoses. Pump material into a clean vessel to test the equipment and verify the actual reaction times.

Consult the operating manual and the quickstart video of the pump for further instruction.

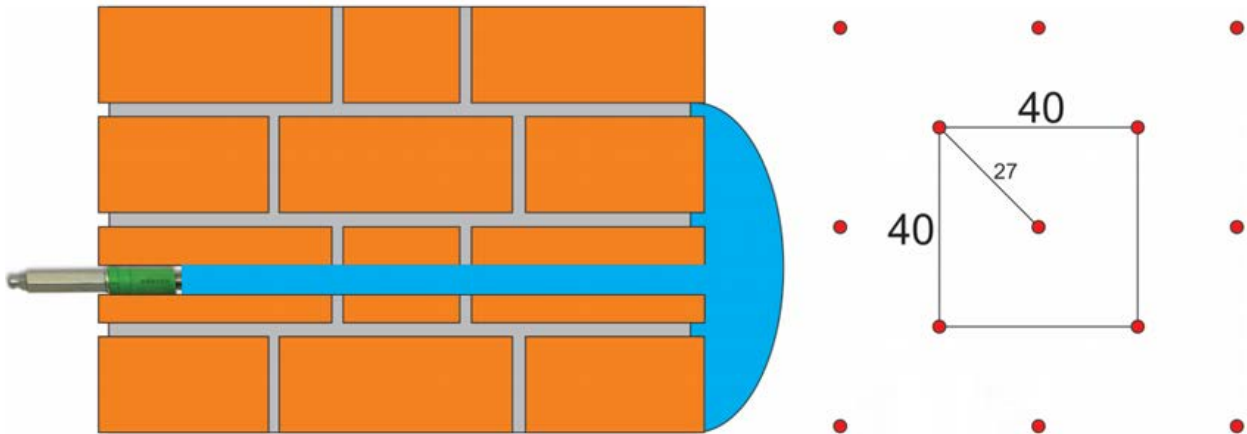
9 Injection process

9.1 Curtain injection

The drilling is to be done in a certain pattern, shown in the illustration below:

Suitable material:

KÖSTER Injection Gel G4, KÖSTER Injection Gel S4



The typical spacing is 40 cm in a square shape with a central drill hole in the middle. The drill holes should begin at a distance of 5 cm from the lowest corner where the slab and side walls meet.

The use of 10-18 mm packers, e.g. KÖSTER Superpackers, is recommended. In the case of perforated bricks, KÖSTER Gel Packers are used.

The injection is typically done in a multiple step application, where the amount of material is split up according to the application parameters. The multiple step appli-

cation considers the machine's output and the reaction times of the gel.

As reference value for the consumption of a curtain injection is min. 40 kg/m² (standard 50 kg/m²).

Example application:

1 m² ≈ 12.5 packer

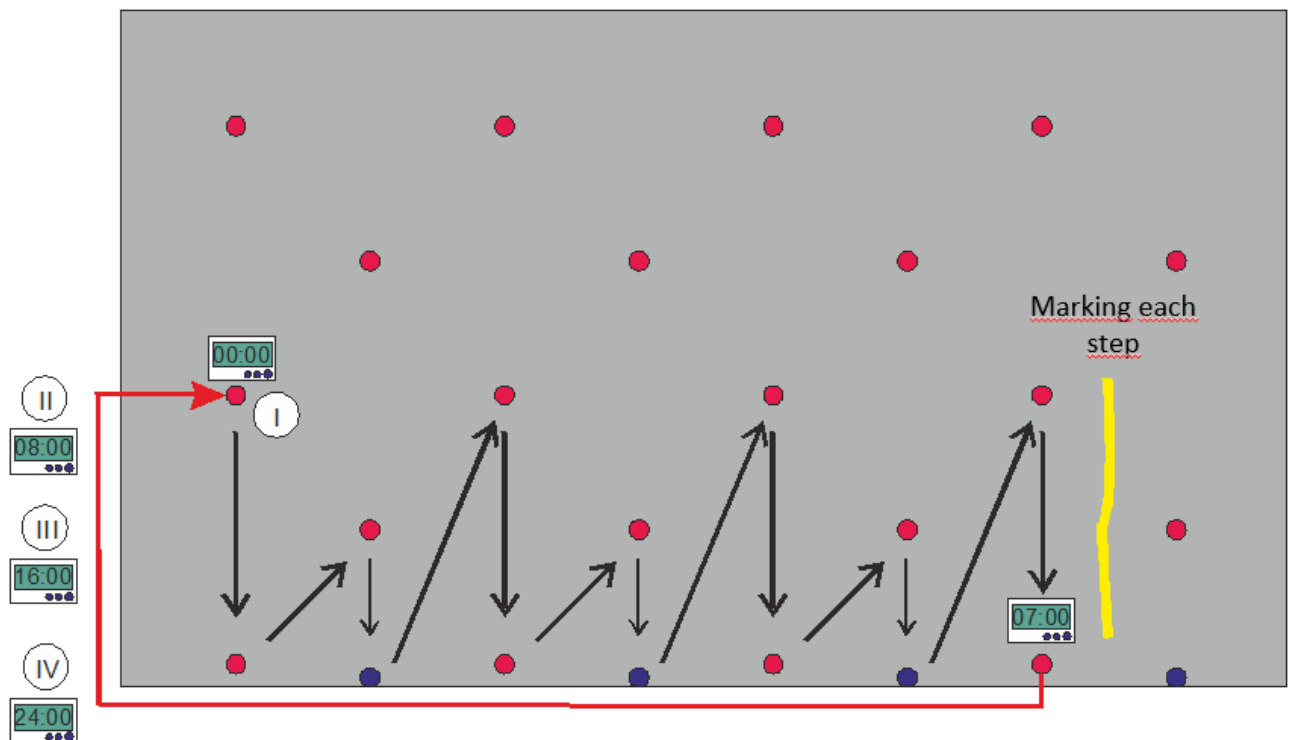
1 double stroke ≈ 80 ml injection

50 double stroke x 80 ml = 4000 ml

4000 ml x 12.5 packers/m² = 50.000 ml

--> (approx. 50 kg/m² of mixed material)

Example of an injection pattern with a reaction time of approx. 8 min.:



In general, each packers receives 10 injection steps. One injection step consists of 5 double pump strokes (approx. 400 ml mixed material).

Why do you need multiple injections steps when conducting a curtain injection?

Curtain Injections are carried out by injecting a very low viscosity material into the underground to create a sealing curtain wall from the inside of the structure. The material is injected through special packer/ports that distribute the material evenly on the back of the structure.

To ensure a complete coverage of the area behind the wall, it is highly important that the injection is carried

out in multiple steps. Each step creates a half sphere in the underground that fills voids and pores and stops the water from reaching our structure.

For a complete curtain wall, all the half sphere must overlap, therefore between 8-10 injection steps (totaling 50 double strokes) must be carried out for a successful waterproofing. The more steps, the more the half spheres will overlap.



Three injection steps (40 kg/m²)



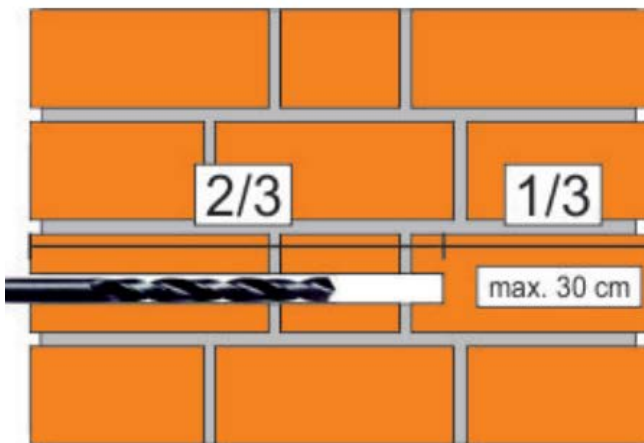
Ten injection steps (40 kg/m²)

9.2 Masonry injection

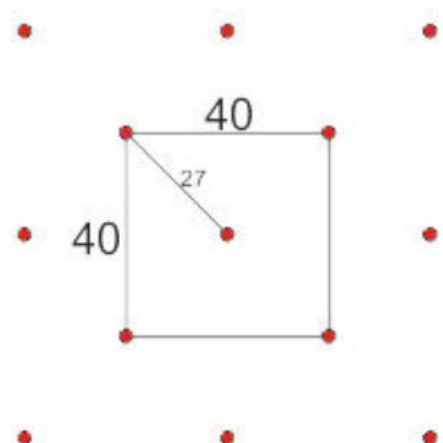
The masonry can be waterproofed by horizontally drilling up to 2/3 of its thickness using a square pattern with a typical spacing of 40 cm with a centered drill hole in the middle.

Suitable material:

KÖSTER Injection Gel G4



Drilling for injection into masonry



Subsequently, an injection barrier is applied using KÖSTER Injection Barrier to prevent the loss of injection material. The boreholes are equipped with packers suitable for high pressure injection, e.g. KÖSTER Super-packers.

The injection is typically done in a multiple step application until the wall is saturated. Defects in the insulation

are immediately repaired using KÖSTER KB-Fix 5.

The injection is performed with a consumption of approximately 4 kg/m² for every 10 cm of brick wall thickness. Saturation of the wall can be determined by stalling or counter pressure in the pump.

9.2.1 Horizontal barrier

A horizontal barrier is a special case in masonry injection. An injected horizontal barrier effectively obstructs the capillaries and with careful execution stops moisture from wicking through the structure. The wall to be treated is drilled with two staggered horizontal rows with a drill hole depth of 2/3 of the wall thickness (see drawing below), but with large wall thicknesses that at most 30 cm of the wall remains un-drilled.

For this KÖSTER Superspackers are recommended. If

necessary, an injection barrier is applied 20 cm above and below the horizontal barrier. The calculated injection quantity is injected evenly in typically 3 stages or until saturation.

It can be used at moisture contents up to 95% and with high salt concentrations.

Suitable material:

KÖSTER Injection Gel G4

9.3 Soil stabilization



Injection lances with or without holes



Connectors



Drive-in aid

By changes in the ground water level or the presence of water currents within the soil structure, the fine grains can be washed out, creating voids in the soil. These voids can reduce the integrity of the soil structure until it collapses. Evidence of this phenomena is usually seen through the settlement of the structures or in worst cases, through the formation of cavities or hollow chambers in the ground. To reduce the loss of the fines from the underground, a soil stabilization must be performed. This stabilization is carried out through the injection of KÖSTER Injection Gel G4 through special injection lances. The low viscosity of the gel allows a deep penetration and distribution of the material between the grain's matrix, binding the soil and water into an elastic gel-soil body. The result is a more stable, waterproofed soil composition without the risk of washing out of fines.

Suitable material:

KÖSTER Injection Gel G4

The process of soil stabilization starts by inserting special injection lances into the ground. The length of the lances depends on the specifics and goals of the project. The lances present lateral outlets every 12.5 cm (diameter of 4 mm) along its length to allow material outflow in multiple directions in the depth.

The injection lances are placed approx. 30 cm apart and the KÖSTER Injection Gel G4 is injected in accordance to the estimated consumption for the specific soil conditions. The lances are pulled out in sections (typically 20-50 cm), while still injecting, to support a more homogeneous distribution of the gel along the lance. In special situations of massive water presence, the lances are not pulled out and the injection is carried out continuously. For further information please contact the Technical Department at KÖSTER Headquarters.

9.4 Joint injection

The KÖSTER Injection Gel S4 with the KÖSTER B+ component is a specially designed gel for the injection of joints providing a higher flank adhesion, enhanced elasticity and a reduced drying tendency when in contact with moving air such as wind.

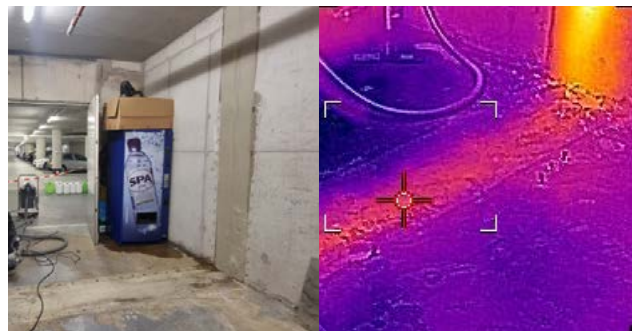
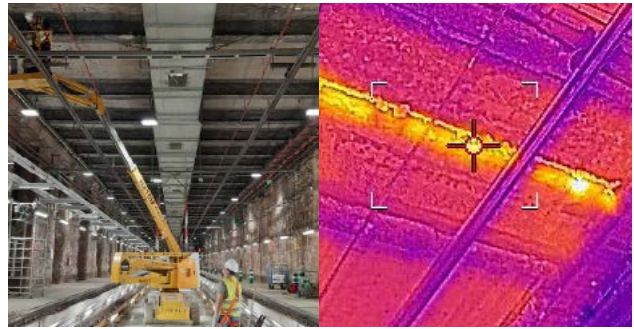
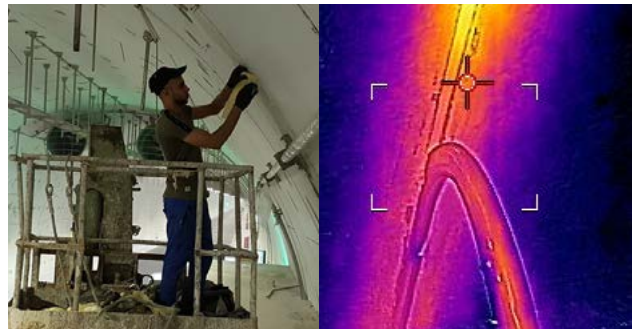
The injection of joints represents a fairly quick method and minimally invasive way to repair failing waterproofing systems. By injecting the joint, it is not necessary to excavate underground parking garages or other underground building components. Moreover, since a low number of packers are sufficient in most cases, the drilling effort is reduced and time and costs are saved. Joint injection must always be adapted to the circumstances. Standardized cases can not be described coherently due to the large number of different joint structures.

In general, the number of packers can often be kept relatively low in the area of joint injection since the gel can spread well within the joint. For overhead work on horizontal joints (e.g. in multi-storey car parks), it is required to temporarily block the joint with e.g. mortar, backing road, foam, etc. to prevent the gel from leaking out of the joint, and then use the KÖSTER Injection Gel S4 with the KÖSTER B+ component added to fill the joint. Finally, the joint is mechanically protected with a joint sealant like KÖSTER MS Joint Sealant, KÖSTER Joint Sealant FS-V/H, or KÖSTER Joint Tape 20/30.

For further information please contact the Technical Department at KÖSTER Headquarters.

Suitable material:

KÖSTER Injection Gel S4/B+



9.5 Concrete injection

Although concrete injection is not the most commonly injection performed, it belongs to the fields of applications of the acrylic gels. Once again, the low viscosity of the material and the safe curing without affecting the steel reinforcement, make concrete injection a specialized field of application for the KÖSTER Injection Gels.

Old concrete which has lost its integrity due to external factors, may be injected to fill the voids and reduce the ingress of CO₂ and water into the structure. Bad concrete as a result of poor vibration, segregation or contamination with soil, may also be injected with the KÖSTER Acrylic gels.

The concrete injection is carried out similarly to the masonry injection in a pattern. The packers are placed at a defined distance, which is determined according to the conditions of the concrete substrate. The KÖSTER Injection Gel G4 is injection in various steps until counterpressure is encountered. During the injection, keen observation is required to adjust the process if necessary. In general, the maximum injection pressure can be estimated as follows:

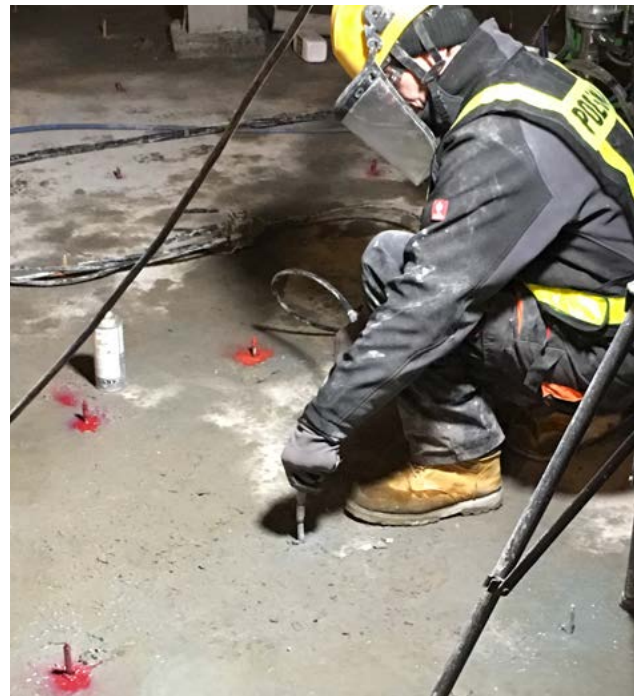
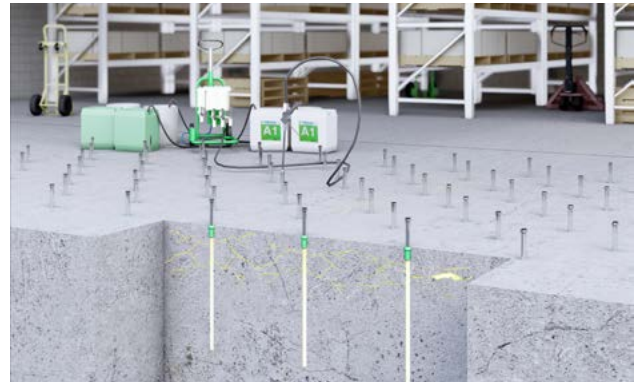
Max. injection pressure = (Concrete strength / 3) x 10

To avoid damaging the structure, the injection pressure should always range below this pressure.

For further information please contact the Technical Department at KÖSTER Headquarters.

Suitable material:

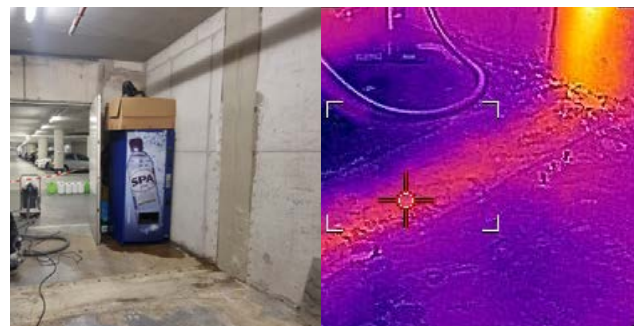
KÖSTER Injection Gel G4



10 Quality control

Infrared test

The reaction of the acrylic gels is an exothermic reaction, so heat is released in a significant amount. The injection progress can be followed by means of thermal imaging camera, showing the displacement of the material inside voids or joints.



11 General notes

11.1 Consumption rate

Depends upon the fields of application and volume of voids filled.

Field of application	Consumption
Curtain Injection:	min. 40 kg / m ² (standard 50 kg / m ²)
Injection into masonry:	4 kg / m ² for every 10 cm of the brickwall thickness
Horizontal Barrier (DPC)	Approx. 2.4 kg / m for every 10 cm of the brickwall thickness
Joint/void injection:	Length x Width x Height x (Safety factor: approx. 1.5-2.0)

11.2 Packaging

11.2.1 KÖSTER Injection Gel G4



A1 component:
20 kg jerrycan



A2 component:
1 kg bottle



B component:
0.4 kg bottle

11.2.1 KÖSTER Injection Gel S4



A1 component:
20 kg jerrycan



A2 component:
1 kg bottle



B component:
0.4 kg bottle



KÖSTER B+:
18 kg jerrycan

11.3 Material storage

11.3.1 KÖSTER Injection Gel G4

Store the material in a cool and frost-free environment. In originally sealed containers the material can be stored for a minimum of 12 months.

Protect the material from direct sunlight.

11.3.2 KÖSTER Injection Gel S4 & S4/B+

Store cool and dry in originally sealed containers. The containers can be stored for a minimum of 6 months under proper storage conditions (dry, +10 °C to +25 °C).

The A components should not be stored in direct sunlight.

11.4 Important considerations

- Always ensure a source of clean and continuous water or buckets with clean water.
- Use scaffolding (if the injection area is inaccessible).
- Use protection system, if the work is in a public place.
- Conduct a safety training if the site is in a hazardous classified area (e.g. in tunnels).
- Work team to help and assist (at least 3 persons for injection – Ports, Pump & Assist).
- Do not apply the injection in a temperature less than +5 °C.
- Since the activated A-component is a highly reactive mixture, particular care must be taken before placing the suction hoses, ensuring that there are no residues of the starter salt caused by splashes or contact contamination. Premature reactions could be the result.
- It is recommended to rinse the hose on the A side with the suction caps thoroughly with clear water before each use.

12 Certifications

Numerous test studies proved the effectiveness and performance of the KÖSTER gels. Such tests certify the material for use in drinking and ground water environment, reinforced concrete, against high water pressure

(up to 7 bar), and even under salt water contact, among others. The available certificates for each material can be viewed in the respective Technical Data Sheet. More information upon request.

13 Declaration of performance

The declaration of performance for the KÖSTER injection Gels can be found under: www.koster.eu

[KÖSTER Injection Gel G4](#) 

[KÖSTER Injection Gel S4](#) 

14 Legal disclaimer

This method statement reflects general cases with standard parameters. It is not suitable as a step-by-step guide for all and each waterproofing projects as the conditions on site at the moment of the application cannot be foreseen. It is solely the applicator's responsibility to

decide on the actual procedure considering the specific situation on the construction site. In any case, KÖSTER's Terms of business are valid and can be viewed under www.koester.eu 