Since 1991 Production until today

INTRODUCTION

The **INJECT SEAL** system has been developed to provide grouting capabilities beyond that available with conventional grouting materials and systems which use water soluble chemicals or a Single Component system.

The principle and the basic features of **INJECT SEAL** system are considerably different form conventional chemical grouting systems. The pints of these differences are summarised in the following illustration (FIG.1). The **INJECT SEAL** system is especially effective for jobs involving water cut-off and high hydrostatic pressures underground because of its reaction with water and rapid high strength gain against these pressures.

In Fig. 1 the items in ellipses indicate the process of chemical grout solidification, while the other item in squares indicate various merits that each stage of the process brings about. The **INJECT SEAL** system is a one-liquid system which utilises the pore water in the soil as one of the two reactants. The chemical grout injected as the other reactant captures grout water and reacts with it to form an insoluble and infusible gel.. The gel thus formed is different from that of the conventional two-liquid system that it is essentially hydrophobic and unhydrated. Therefore, neither swelling nor softening occurs in the groundwater after gelation. Another important feature of the **INJECT SEAL** system is that the chemical grout itself causes an expansion during reaction. This enables the chemical grout to actively penetrate into the soil and enlarge its permeation area without being affected by the underground seepage flow of water. The **INJECT SEAL** system is, therefore, very effective in stablilizing soil which contains considerable ground water.

In the conventional Single Component system, the chemical reaction starts at the moment when the water and liquids are mixed; consequently the mixed liquid causes continuous transition from the liquid to the solid phase. During this phase transition, viscosity increases.

In **INJECT SEAL** system, no reaction takes place until the chemical grout comes into contact with groundwater. Until then, no viscosity increase occurs, nor is the chemical grout diluted. In addition, the viscosity remains low enough to permit easy permeation of the chemical grout into the soil for a certain induction period, even after the chemical grout contacts with water. The viscosity increases after the induction period gives way to the reaction period. At the same time, the chemical grout keeps expanding and permeates into the soil. This process of expansion and permeation concludes automatically when the gelling pint is reached with the end of aqua-reaction.

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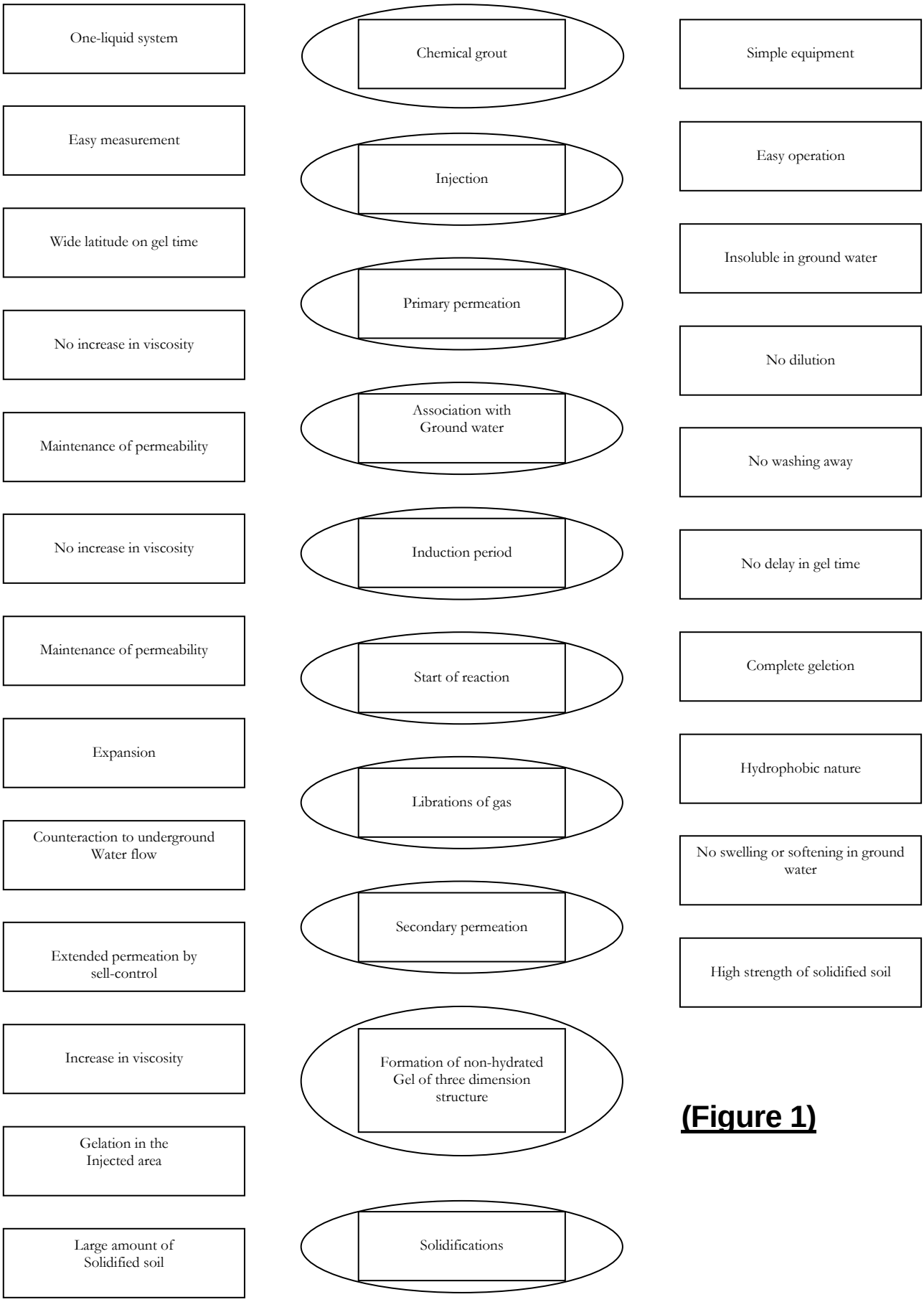
Solidification process of chemical grout in **INJECT SEAL**



(Figure 1)

EQUIPMENT AND MATERIALS FOR INJECTION

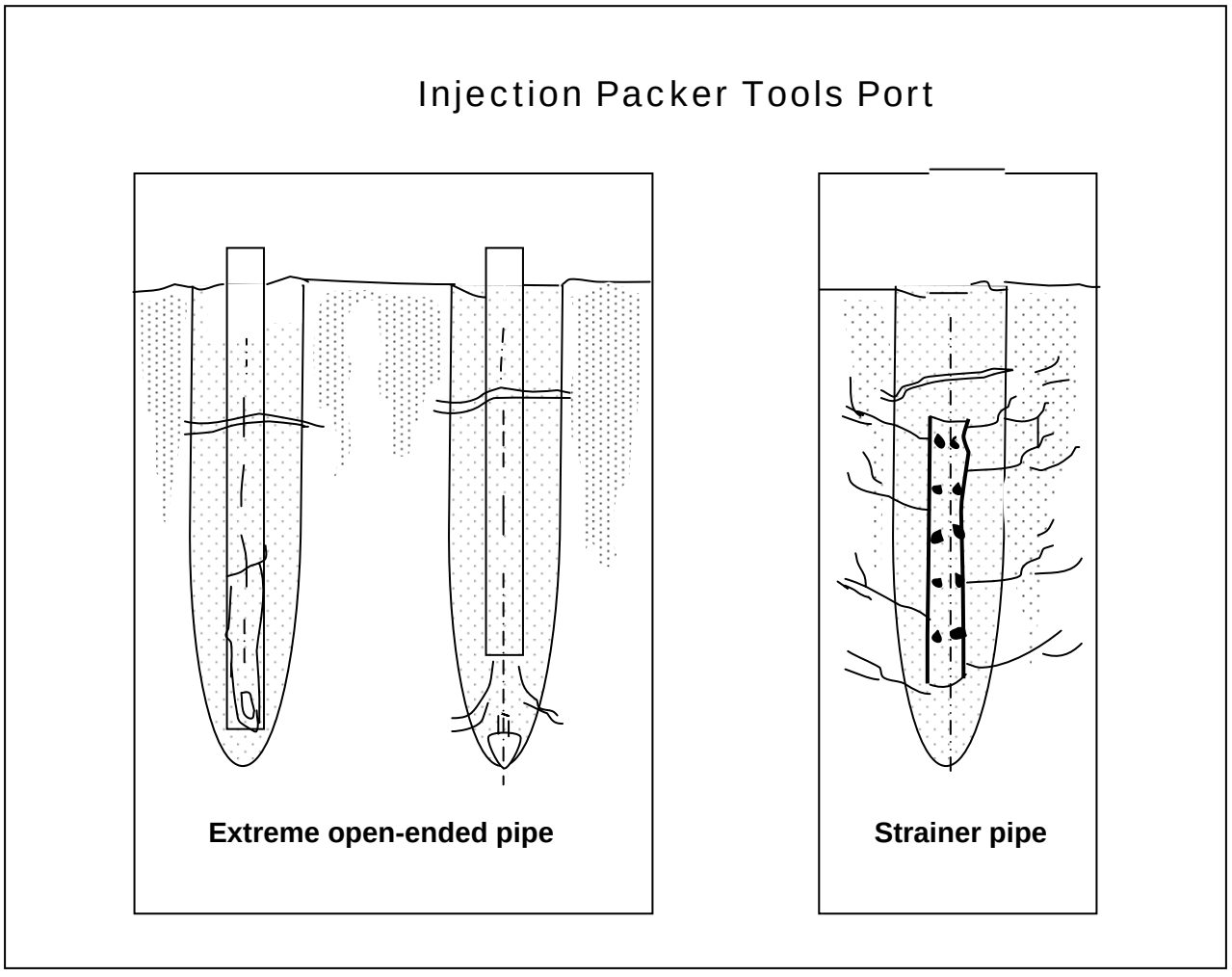
The equipment and materials for injection in **INJECT SEAL** system are comparatively simple and compact. Because of the grout's expansion accompanying the aqua-reaction, a small quantity of grout provides a greater amount of solidified soil than with other grouts. Low injection pressure may be used. Standard equipment currently being used may be used with the **INJECT SEAL** system if desired, so purchase of additional equipment is not necessary.

There are two methods of injection possible with INJECT SEAL system.

a. Bore or drive the injection pipe into the ground with a chuck hammer and then inject **INJECT SEAL** material through the pipe and out of holes near the bottom of the pipe. It is possible to continue injection as the pipe is being removed from the hole in a step-by step process to grout the volume of soil desired. If a chuck hammer machine is used, the injection pipe is attached directly to the chuck. It is also possible to drive an open-end injection pipe into the ground by placing a cap or rivet type piece on the end of the pipe. When the pipe is pulled back a few inches the cap will come off and the grout can be pumped out of the end of the pipe into the ground.

b. Bore the grouting hole first and then insert the grouting strainer pipe. In this case the grouting pipe may be a schedule 80 PVC pipe. The strainer pipe holes should be 2 to 3 millimetres in diameter on a pitch of 40 to 50 millimetres spread over the strainer in a staggered arrangement. If the strainer holes are at an acute axis angle to the axis of the pipe, the holes will not fill up with dirt when the pipe is driven into the ground.

Figure 2



Injection

Conventional grouting pumps may be used by shutting off one of the outlets used in a conventional two-liquid grouting system or extruding the **INJECT SEAL** material through both outlets at the same time for increased flow. A more simple pump may be used since only one outlet is required for **INJECT SEAL**. Normally, only low pressure is required. Small air pumps or hand pumps may be used in some cases.

a. Conventional pumps.

7 to 70 psi is normally adequate unless ground pressure is also a factor. 3 to 15 gallons per minute delivery are normally satisfactory.

b. Air pumps and hand pumps.

Air pumps or hand pumps may be used with a bucket of **INJECT SEAL** material for small jobs or restricted working space.

c. Pressure pots.

Paint tanks or other pressure pots may be used for jobs where a pressure of less than 70 psi is required. Air compressors may contain condensed water which will react with **INJECT SEAL** material so a trap should be included to avoid early gelation in the equipment.

INJECT SEAL Material Storage Tanks

For small jobs a polyethylene plastic bucket can be used if accelerator is to be added for fast gelation. The plastic is easy to clean. For large-scale jobs either a steel or plastic tank may be used. Tanks of concrete or wood should not be used because these materials contain active hydrogen which may react with the **INJECT SEAL** material. If

accelerator is used with the **INJECT SEAL** material it is mixed initially without any reaction occurring until contact with water or ground moisture.

Connecting Hoses And Packers

Hoses should be of Natural Rubber or Neoprene. PVC or Plastic hose should not be used because the **INJECT SEAL** material and the chemical solvent free used to clean equipment will deteriorate PVC or Plastic.

Packers are considered as consumable items so synthetic rubber packing type may be used. Teflon or silicone rubber is resistant to chemicals and is recommended even though considered expendable.

LONG-TIME STORAGE OF **INJECT SEAL** MATERIAL

INJECT SEAL is not affected by metal, glass, porcelain, enamel or polyethylene as long as moisture I not present. Therefore, indefinite storage is possible as long as the container is sealed. If a container is opened and then resealed (a little **INJECT SEAL** material poured around the cap of the container will make a good seal), the only change will be a skin on the top of the **INJECT SEAL** liquid such as is normally formed on the paint in an opened can. This does not cause any problem except a strainer should be used when the liquid **INJECT SEAL** material is used again. It is good practice to place a strainer over the intake funnel anytime the **INJECT SEAL** liquid is poured into a pumping system.

The accelerator is also stored in sealed containers since some evaporation may occur. As with the **INJECT SEAL** material, the accelerator may be stored for extended periods.

Flammability

The INJECT SEAL material are considered non-flammable. The flash point of the **INJECT SEAL** material is about 180° centigrade. The **INJECT SEAL** material having this high flash point is labelled with a suffix such as generally non-flammable under normal conditions.

If the prepared chemical grout is left in the open air for a long time, it will absorb moisture from the air and gradually gel. Therefore it is advisable to prepare and use one batch of grout at a time, especially under conditions of high humidity and temperature, when the surface of the prepared grout may develop a skin. This skin will serve as a barrier against humidity and pre vent further gelation, and should therefore be left in place.

Use With Fillers To Fill Large Voids

As a part of the **INJECT SEAL** system, sometimes filler is added to the chemical grout to make slurry like compound. Powder like fillers such as Portland Cement or Fly Ash may be added little by little to the chemical grout while mixing to easily obtain a uniform slurry-like compound.

The purpose of using a cementitious filler is to filler is to fill large voids where high strength or high bonding is required. The filler must be well dried. Aerated cement may seem dried at a glance, but it may contain moisture that can react with the **TACSS** material because of its partial hydration, so it is advisable to use cement as fresh as possible. Cement itself in general is alkaline and promotes gelation of the **INJECT SEAL** material, so that the dosage of accelerator may be somewhat less than otherwise required.

Ventilation

When using a large amount of **INJECT SEAL** material in restricted areas such as a tunnel or basement, it is recommended that proper ventilation be used to eliminate slight odours.

Toxicity

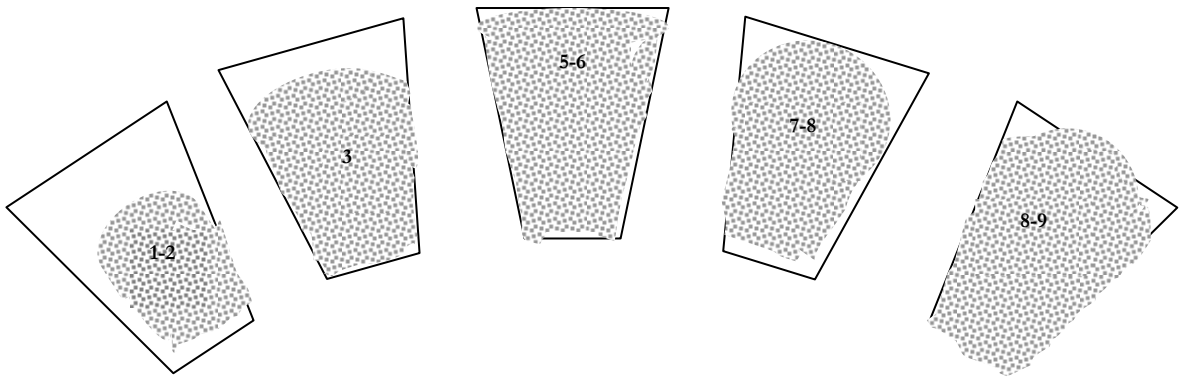
The **INJECT SEAL** material does not normally have any harmful effect on humans or animals; however, there are some people who may be allergic to petroleum products and with such persons a rash may develop on the skin after direct contact with **INJECT SEAL** material. Since the **INJECT SEAL** material absorbs water it is necessary to avoid contact with the eyes or mucus membranes of the body. The **INJECT SEAL** material forms a gel when contracting moisture, even in small amounts; therefore, reasonable protection should be taken to avoid eye or mouth contact. Empty containers should be filled with water to allow any remaining **INJECT SEAL** material to decompose to ensure absolute safety for any one who may later have access to, or destroy the container.

Preparation Of **INJECT SEAL** Material For Use

In ordinary injection work, manual mixing is sufficient, but in the case of large-scale injection a mechanical mixing may be desirable. When mixing, it is necessary to avoid the presence of any water in the mixing container. (Fig. 3)

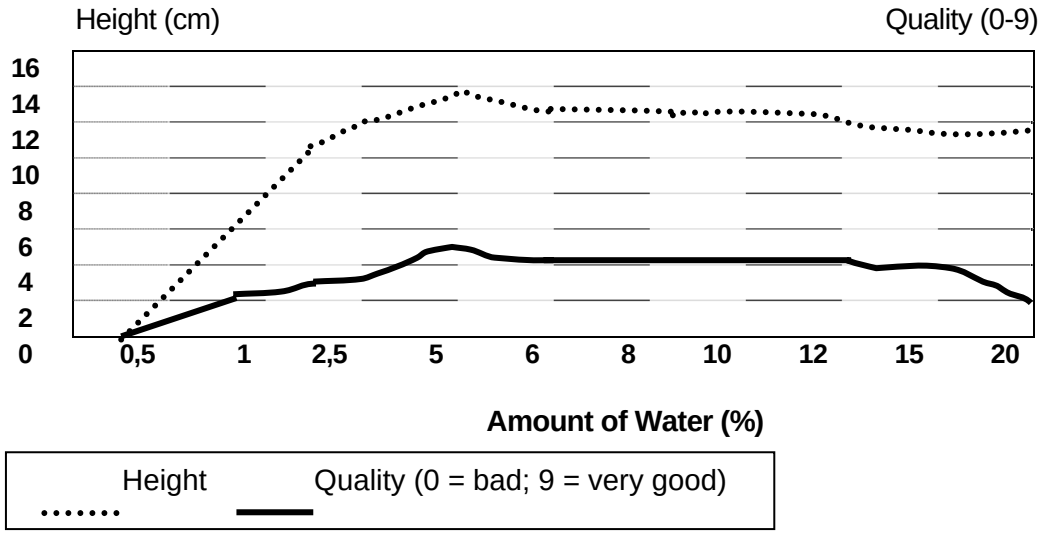
Figure 3

The percentage of Water Content
added and gel time and induction period



5 Numbers of Expand Cured Polyurethane Foam Samples
"LaMaCo-Inject Seal"

Influence of Different Water Amounts on the
Foam Height and Foam Quality



INJECTION

The following points should be remembered when planning injection of **INJECT SEAL** in comparison with conventional techniques.

1. **INJECT SEAL** liquid reacts with water (even moisture) to gel.

2. It is a Single Component and one-shot system.

3. It is normally only necessary to inject the planned quantity of **INJECT SEAL** material under low pressure, at low velocity and uniformly.

4. Injection is followed by expansion of the chemical grout with the generation of CO bubbles.

5. A large volume of solidified soil can be obtained by injection of a small quantity of **INJECT SEAL** material.

In other respects it is similar to conventional processes and techniques.

Setting The Injection Pipe

Injection pipes can be set up by standard methods such as boring, driving-in and jetting as previously described.

Prevention Of Overflow

The overflow of injected grout that occurs at the clearance around the installed injection pipe must be preventing. It tends to occur when boring or jetting method sets up the injection pipe. If the injection pipe is driven into the ground deeper than 5 feet above the injection hole, overflow does not normally occur. The overflow can be prevented by caulking, use of a packer, by stuffing waste or quick setting cement into the portion around the upper end of injection pipe, or by pouring **INJECT SEAL** grout.

Prevention Of Backflush

The injected chemical grout will partially flush back out of the injection pipe by the expansion during gelation. In order to prevent this backflush, the top of the injection pipe must be equipped with a cock or counter-flow valve. By taking advantage of pressure of the CO gas, the chemical grout will expand and penetrate into the soil by secondary permeation if the cock is kept closed for a while after injection. It can be confirmed by slightly opening the cock once in a while to check the extent of backflush as to whether or not the aqua reaction is finished and the secondary permeation is completed.

Injection

Grouting may be done in steps while driving the pipe down or while pulling the pipe back up out of the hole;

1. **Backflush**

When moving to next injection step, if jointing or cutting off the injection pipe is done before the aqua reaction of the grout is completed, backflush of the grout will occur from the joint or cut-off-portions. Therefore, it is necessary to wait for backflush to cease before breaking the pipe unless a stop cock is used. Setting up two or more injection pipes and injecting into each of the injection pipes alternately may save time.

2. Movement of injection pipe

The injection pipe should be moved up or down to the next injection level before the bond strength between the pipe and the solidified soil becomes too great. Therefore, it is advisable to move the injection pipe as soon as the termination of backflush is confirmed. If it is impossible for some reason to move it quickly, the injection pipe can be twisted to break the bonding strength. If the injection is by strainer pipe, the injection depth per step is deeper than in the injection by an open-end pipe. However, if the length of the strainer portion is made too long, the solidified mass of soil that should be like a cylinder in shape will be tapered at the top to form an unequal shape. Therefore, it is recommended that the strainer portion of the injection pipe be less than 4 feet when it is set up vertically.

Injection Pressure

Injection pressure into normal ground can be from 7 to 50 psi, depending on the delicacy of the operation. If extreme care must be taken to prevent soil movement close to the surface of the ground, a pressure of 7 psi may be used. If speed is desired in the grouting operation, a pressure of up to 50 psi may be desirable.

When grouting at a depth for tunnels or mines or dams where ground pressure and water pressure are a factor, the pump pressure should be set at 50 to 100 psi above the ground or water pressure.

Volume Of INJECT SEAL To Be Injected

The amount of **INJECT SEAL** material required for a particular job varies according to ground density, porosity, distribution of grain size, pore water pressure, accelerator dosage, etc…. . Generally, in sandy ground the volume of **INJECT SEAL** material required is 1/6 to 1/10 of the volume of ground to be solidified. Another rule of thumb which may be used is that the **INJECT SEAL** material will normally solidify 2.5 times as much ground as conventional grout because of expansion. Additionally, the high strength of **INJECT SEAL** may further reduce the amount of material by a factor of 3 to 10, depending on the job requirement. Since the **INJECT SEAL** does not dilute in the underground water, the amount required may be reduced by another additional factor. All of this reduces the number of borings and injections required which will save time and labour.

CLEANING EQUIPMENT

The grout of the **INJECT SEAL** system produces a very high strength gel of strong binding force by reacting with the water and active hydrogen. However, once formed, the gel is highly stable and will not dissolve in water or most organic solvents. When reacted grout has adhered to injection equipment, cleaning can be difficult.

When using conventional equipment it may be necessary to change some parts which some in direct contact with the chemical grout. For instance, parts made of natural rubber and leather such as gaskets, O-rings, hoses, piping joints or packers. These parts react with the grout causing deterioration or swelling. Therefore, it may be necessary to replace these parts with those made from metal, polyethylene, neoprene rubber, Teflon rubber, silicone rubber, etc….

When the injection is finished, wash off all of these parts which have been in contact with the grout. This should be done within 1 or 2 hours after the injection. Circulating a washing solvent through the injection pump from 10 to 20 minutes by connecting the inlet and outlet to a washing solvent tank can easily perform the washing. In case a pressure pot is used, wash off the grout with solvent.

INJECT SEAL washing agent is preferable since it is not flammable under ordinary conditions.

HELPFUL HINTS IN USING INJECT SEAL

Through experience, it has been found that grouting people who use **INJECT SEAL** for the first time fail to consider the various things, which may occur with a grouting material, which uses water as the reactant and is therefore not soluble in water. The following helpful hints are provided so that adequate consideration may be given to this phenomenon of water reaction.

1. Sump Pumping

When **INJECT SEAL** is injected, some of the liquid may be forced up into the overburden by the grout pressure leaking into the shaft and settling in the bottom of the sump hole.

If this liquid is permitted to be sucked up into the sump pump system it may gel prior to being expelled out of the other end of the sump system. If this occurs it will dissolve in the water and therefore may clog up the sump system. Therefore, the following is recommended :

a. Dig the sump hole 2 feet to 3 feet deeper than normal.

b. Do not use the normal sump system during the actual **INJECT SEAL** grouting injection. Instead, set up a small sump pump, which can pump the water during the period while the **INJECT SEAL** is being injected.

c. Any **INJECT SEAL** liquid, which has freely solidified around the sump hole, will float to the surface as a foam gel. This gel should be scooped up with a net and placed in a container for disposal.

2. Grouting Pump

If water is allowed to be present in the pump at the same time **INJECT SEAL** is introduced into the pump there may be some solidification around certain areas causing pump problems. Therefore, the following procedures are recommended:

a. The pump, which is used, for cement grout or water injection should be a separate pump from that to be used for the **INJECT SEAL** material.

b. Before running my **INJECT SEAL** into the pump, first wash the pumping system with **INJECT SEAL** washing agent. Circulate **INJECT SEAL** washing agent through the pump system. Clean all connector joints and fittings with **INJECT SEAL** washing agent.

c. If any of the parts of the pump or gauges are made from natural rubber rather than synthetic, spares should be available since natural rubber will deteriorate faster than normal when coming in contact with the **INJECT SEAL** material.

d. Be sure cut of f valve provides absolute seal so that no back pressure water can get into the pump as a reverse flow.

e. Injection pressure must always be greater than back pressure when the valve is opened to ensure no back pressure water gets into the pump. It is advisable to have a spare pump available.

f. It is advisable to have a spare pump available.

g. After the grouting is completed the **INJECT SEAL** pump should be disassembled and cleaned with **INJECT SEAL** washing agent and wiping cloths to insure that all **INJECT SEAL** material has been cleaned out of the pump.

h. Grouting pressure readings are ver y important in using **INJECT SEAL**. Therefore, the pump should have a good pressure gauge. Variable air or hydraulic pumps have been preferably used with the **INJECT SEAL**

system. A diaphragm-sensing element in the pressure gauge works best. Piston-type gauges may freeze up.

3. Injection

When an injection plan is laid out it is advisable to plan to inject in alternate points of the plan, and then testing can be accomplished to see if additional grouting is required. When injecting it is advisable to first inject on one side of the area with one hole and then go to the other side of the area to inject a second hole, providing adequate time for the first hole to gel and gain strength before injection an adequate hole.

a. Injection pressure is normally only slightly higher than ground hydrostatic pressure. This provides the opportunity for the **INJECT SEAL** material to capture water as a reactant rather than pushing all of the water out in front of the **INJECT SEAL** material. The low pressure also permits gelation close in rather than wasting material beyond the area necessary to solidify with this high strength material. However, once an injection has been started it should be completed without stopping to insure proper coverage before gelation.

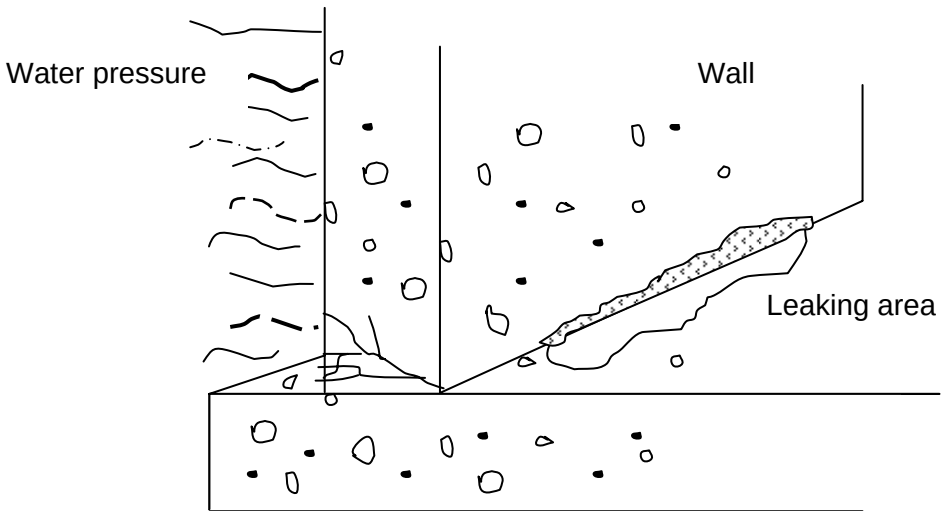
b. On a job with high hydrostatic backpressure and after insertion of packers and standpipes, normal procedure is to use water injection to check the seal around the packer and to check the under ground flow of water between boreholes. A fluorescent dye is normally put in the water for easy vision.

c. After injection of the **INJECT SEAL** material is completed, change pumps and inject some water to insure gelation of the last portion of the **INJECT SEAL** material, which was injected. This is required since the material remaining in the injection hole must be displaced into the surrounding area close to the injection hole.

PROCEDURES FOR SEALING LEAKING CRACKS

For sealing cracks with polyurethane grouts (**INJECT SEAL**) the following steps are generally followed:

1. Clean crack surface
2. Drill injection holes
3. Install injection ports
4. Flush crack
5. Injecting **INJECT SEAL** polyurethane grouts



1. Cleaning / Sealing Crack Surface

When crack is contaminated at outside, it will be necessary to clean the crack surface, so the crack can be exactly located. If it is a wide crack or high waterflows are encountered, it will be necessary to seal the surface of the crack with a surface sealing material (example: hydraulic cement; epoxy gel; oakum saturated with polyurethane grout). The surface sealing can be done before or after drilling the injection holes (depending on particular situation).

2. Drilling The Injection Holes

There are different diameter, depths, and angles of injection holes. Standard is a 5/8" diameter hole. The angle of drilling is 45° to the surface and the depth of the hole will be 1/2 the thickness of the concrete (see figure 2).

Spacing of the injection ports depends on the width of the crack, but normally varies from 6 inches to 3 feet. Injection holes should always be staggered from one side of the crack to the other (if possible).

3. Install Injection Ports Or Packers

Place the packer in the drilled 5/8" hole so that the top of the sleeve is just below the concrete surface. Tighten by a ratchet as socket or open-end wrench by turning clockwise as tightly as possible.

Packers or injection ports are supplied with a one way ball check valve.

4. Flush Crack

Sometimes it is necessary to flush the crack with water to remove debris and drill dust out of the cracks. Flushing will tell you how the crack will behave during grout injection.

If the some pump is used for flushing and grouting, make sure that all water will be completely removed from the pump before pumping the **INJECT SEAL** grouts.

5. Injection Of INJECT SEAL Grouts

Depending on nature of the crack, different polyurethane grouts can be injected.

Begin the injection at the lowest packer on a vertical crack, or at the first packer flushed for a horizontal crack. During injection, you will notice that water is displaced from the crack by the **INJECT SEAL** grout.

Keep injecting until **INJECT SEAL** grout appears at the adjacent packer. Disconnect and start injection an adjacent packer. After injecting a few packers, come back to the first packer and inject all the ports for the second time. Some of the ports will twill take some grout which fill up and density the crack.

Injection pressure will vary from 250 to 3500 psi depending on the width of the crack, thickness of concrete and condition of concrete.

After injection, the packers or injection ports can be cut flush with the concrete surface or can be removed out of injection holes. Don't forget to let the **INJECT SEAL** grout totally cure before removing the packers.

EXPANSION JOINT REPAIR BY INJECT SEAL SINGLE COMPONENT POLYURETHANE CHEMICAL GROUT

INJECT SEAL polyurethane grout can repair leakage in expansion joints due to defective waterstop system by the following procedures.

A) Packer/Point Grouting Method

B) SEAL OFF TUBE/Reconstruction Method

It may be necessary to combine the two methods in certain situations.

A) PACKER/POINT GROUTING METHOD

This method aims to fill the voids around the existing waterstop, which are passages to leakage. The procedures involved are as follow: -

1) Verify expansion joint details and position of defective waterstop.

2) Drill injection ports at 400mm c/c along the expansion joint to intercept the waterstop as shown below :-

3) Flush out injection ports drilled with water

4) Correct interception is marked by leakage being channelled through the injection ports drilled.

5) Install injection packers and begin grouting from the lowest point.

6) Begin grouting with minimum dosage of non catalyst to allow for optimum travel/working time. Continue grouting until a prescribed back pressure equal or higher than the service pressure is achieved. In any case, such pressure shall not be less than 45 bars (652 psi).

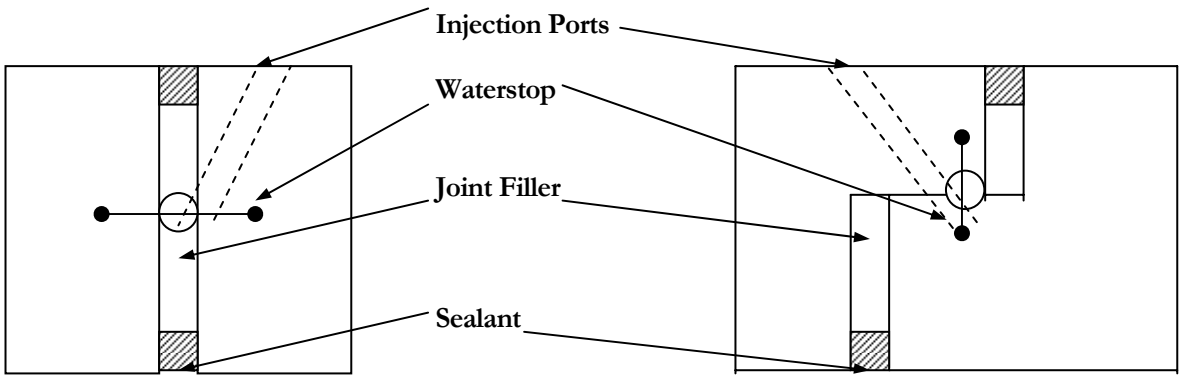
7) The extend of grout travel shall be visually inspected to ensure continuity from packer to packer.

8) Move to next packer when both grouts back pressure and travel continuity is achieved.

9) As the polyurethane expands during its reaction with water and results in deeper penetration and further travel of grout. It is therefore necessary to re-check that the prescribed backpressure is sustained before grout is cured.

10) Stuffing voids with absorbent fibre material such as untreated spun yarn or polyester **fibrewool** shall immediately check any excessive grout percolation from the expansion joint during grouting.

11) After grout has fully cured, remove packer and fill up injection ports as required.



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