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any of you have specified or used chemical grouting in one of your projects or are planning on using this technology to control groundwater infiltration into structurally sound sewer joints or recently lined sewer service connection cut-outs. Chemical grouting has been used for more than 50 years and

has proven itself to be an effective method to control infiltration and exfiltration in sewers.

Often the capability and installation methods have been misunderstood and thus sometimes grouting has been used in projects with little thought behind the details that make this process work for you.

The most important aspect of chemical grouting is to recognize it is a pipe bedding soil sealing and stabilization process. Chemical grout works outside the pipe, beyond the point of mixing within the injection packer void located over the leaking joint. The objective is to pump the two-part chemical grout down to the point of injection where it is mixed within the packer/pipe void and force this mixed grout through a failed pipe joint into the pipe bedding soil adjacent to the leak. This same injection pressure grouting technique applies to lined pipe service cut out annulus and adjacent leaking service lateral connections. The grout stops groundwater flowing into the sewer through the bedding soil adjacent to the leaking sewer joint or through the annulus between liner and host pipe.

The most common chemical grouts being pumped through remotely operated packers are acrylamide, acrylates, acrylics (referred here as solution grouts) and urethane gels (referred here as the resin grouts). We will review some of the most critical points to consider before starting a project.

Access Points

The chemical grouts chosen must take into consideration the existing access points (joints, cracks, service connections and annular spaces at service connections in relined pipes) through which the grout must be pumped in order to saturate and seal the pipe structure bedding materials. The solution grouts vs. the resin grouts have very different viscosities and the resin grouts may require higher grouting pressures at the packers to be pumped through very small openings or defects within the pipe to access the soil behind the pipe structures.

Concentration and mix of solution grouts is a critical point in the process. Solids level and gel time are the two factors used to confirm a grout is correctly mixed when using solution grouts. The solids level is obtained based on the batch mixing ratio employed i.e. a 50 lbs bag of acrylamide in a 30-gal mix is the 20 percent solids, which is a minimum level common to most grouting. If you reduce the water content, mix a 50-lb bag, adding water to make only a 20-gal mix the result is 30 percent solids or 15 percent in the injected grout. The solids level in the mixed grout is important because mixed grout pumped into the bedding soil

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may be diluted 30 to 50 percent or more by groundwater in the soil and when diluted below about 5 percent solids, this solution grout may not form a solid gel and therefore lose its effectiveness as a soil sealing product.

Most solution chemical grout manufacturers and suppliers recommend a minimum 20 percent solids content within the solution grout tank (when pumped and mixed in equal amounts, 1:1, with the reaction initiator chemical or AP or SP catalyst at point of packer injection the resulting chemical grout will have a 10 percent solids content). This minimum grout tank solids content may need to be increased up to 30 percent where active infiltration is present in order to offset the dilution that will occur when sealing the defects, providing a more concentrated gel mass on the outside of the pipe structure. The grouts and catalyst must be pumped at near equal ratio to provide the best results. The 1:1 ratio can vary (10 percent but verify with grout suppliers) because grout performance is very tolerant of this factor. However, the equal pumping ratio can be confirmed with a quick and easy pumping ratio test, which consists of pumping these two materials into two different buckets confirming the two pump outputs are about equal.

Additives for specific conditions (freeze-thaw cycles, strengthening agents, root inhibitors, etc.) can be added to the grouts. Follow recommendations from grout suppliers on quantities and mixing procedures for optimum results.

Gel Times

The gel times of the solution grouts are affected by temperature and the concentration of the common solution grout tank activator CAT-T and catalyst tank AP or SP reaction initiator. The two-tank mix formulations are usually the same and not changed during a job. Job temperature conditions can change over the life of a project and on a weekly and daily basis. There are five temperatures that could affect changes to the gel time at injection. You may mix at one temperature but be injecting at a very different temperature and how these temperatures effect the process should be considered. When initially grouting under highly varying or different than normal temperature conditions, initial job temperature monitoring and recording should be done for sewer water, ambient air, grout tank, grout mixing water tank and groundwater temperatures. Sewer temperature is the most constant, probably varying less than plus or -5 F from a daily average. Adjustments to the appropriate gel times may be required during the day as ambient temperatures affecting the mix tanks and grout reel hose are subject to change.

Gel times should be adjusted so as to provide the saturation of the mixed grout into the surrounding soil/bedding prior to gelation/reaction of the grouts. This can easily be established by knowing the volume of grout that is needed to fill the packer/pipe void (volume of grout required to fill the volume between the inflated packer and the inside pipe wall (verify with packer manufacturers for this data)). The rate at which the grout is be-



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ing pumped (combine both hose outputs to determine the gpm pumped out). In most cases, a saturation period will be added to this time to allow the grout to saturate the space in between the bedding material fines and travel away from the defect. In pipe sections where heavy infiltration is present, shorter gel times may be required as the grout could be diluted and cooled by ground water below sewer temperature extending the gel time calculated at the mixing tanks on the grout truck.

Once in the pipe, with the packer inflated, the only information the operator can receive is the confirmation of the amount gallons of grout pumped, the void test pressure and the grout pumping pressures as measured by the packer void pressure transducer or visible void pressure gauge mounted on the packer. Pumping pressures as measured at the void will confirm that the grout pump injection pressure is higher than the groundwater table pressure and provide the operator with confirmation the grout is being injected into the soil as this void pressure rises. This void pressure reading confirms that injection pressure has been sufficient to inject grout mix. Monitoring pumping pressure, pausing for gelation to occur then again pumping until pressure refusal or agreed upon void pressure pumping above groundwater pressures is a form of quality control.

In some cases, continuous pumping of the grout will not provide a seal of the defect, as there could be unknown voids behind the pipe structures. At a single or multiple points during the grout injection pumping process, the operator may have to stage his sealing approach by stopping the continuous pumping process after an initial amount of mixed grout has been injected, waiting for it to gel then pumping again an amount of grout until a seal is achieved or it is determined that this defect cannot be sealed by chemical grouting. This process is referred to as stage pumping. The volume of grout pumped per joint above a certain contracted amount per joint or stage should be priced per unit volume with the owner before the work starts.

This leads to a responsible arrangement for grout payment between the owner and contractor. The contractor cannot be held responsible for the soil conditions around the defects and the owner cannot sign a blank check to the contractor. More contracts are being given where the price per gallon of grout is priced as a responsible bid item and estimates for the cost of the work are within a known range.

An experienced contractor will be in a position to understand and adjust to the changing field conditions encountered within the scope of the work to be done. Having an educated inspector on the job will also make it easier to streamline any decisions that need to be done in the field in order to obtain success. Thus it is important that at the outset of the contract the operator and inspector jointly operate and view the performance of the grouting equipment and related tests and instrumentation as required by the grout related ASTM and NASSCO Specifications.

Warranty work will normally consist of either a CCTV inspection during high groundwater conditions within 18 months of the substantial completion of the work or air testing work performed on a percentage of the defects sealed within 11 months of the substantial completion of the work.

Chemical grouting is a long-term repair and maintenance process when done with a sound understanding of the technology and paying attention to operating details.

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