



THE ROLE OF CHEMICAL GROUTING IN WASTEWATER SYSTEMS:

How to Reduce I&I and Prevent
Structural Damage with Intelligent
Use of Chemical Grout

Prepared by:
Angus W. Stocking, L.S.
www.InfrastructureWriting.com

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THE ROLE OF CHEMICAL GROUTING IN WASTEWATER SYSTEMS: How to Reduce I&I and Prevent Structural Damage with Intelligent Use of Chemical Grout

Premise: Chemical grouting is a mature technology that stands on its own or complements various methods of trenchless pipe or sewer structure repair. When applied properly and used in appropriate conditions, chemical grouting is a long-lasting, cost effective solution that stops infiltration caused by leaks and failing joints, and helps prevent structural damage from developing in leaking pipe that is otherwise sound. As such, chemical grouting should be incorporated into nearly all wastewater maintenance and rehabilitation programs.

The chemicals now used to repair underground wastewater pipes were first developed in the 1950s and 1960s by American Cyanamid and Dow Chemical Company. Initially, the new technology was used to stabilize soil to form underground dams; for example, it was used to make trenching possible in soils with very high groundwater.

Beginning in the 1960s, different firms began to use chemical grouts in wastewater maintenance applications. Urethane grout formulations were created that reacted with water and moist soil to form tough, rubber-like balls or collars that filled external voids caused by leaks or acted as gaskets in leaky joints. The technology was attractive because it was relatively inexpensive, easy to apply, and used non-toxic chemicals that did not cause problems in wastewater treatment plants. At first, resinous grout formulations were directly injected into leaks or into holes drilled through problematic pipe sections. Concurrently, low viscosity 'solution grouts' were developed that could be applied by means of remotely operated 'packers'. Packers are, essentially, inflatable two-part plugs that isolate short sections of underground pipe so that grouts can be pumped into the isolated section and forced through leaks and failing joints into surrounding soil. With the introduction of solution grouts and packers, chemical grouting became one of the first trenchless pipe rehabilitation solutions.

Today, resinous grouts are still commonly used in some situations, especially those that require man entry or manhole repair. But the majority of chemical grout is used in a water solution, applied by means of truck-mounted systems. Packing system technology has evolved to handle pipe diameters up to 144-inches and specialized packers are able to seal laterals efficiently. Dick Schantz, a past chairman of the Infiltration Control Grouting Association (ICGA) estimates that more than 200 truck-mounted packers now operate in the United States, and that the majority of these are combination trucks that can also be used to apply grout to lateral connections.

Chemical grouting is a mature, flexible, cost-effective technology that has been refined by decades of use. However, persistent misconceptions about chemical grouting

have prevented its full adoption by some wastewater systems.

Common Misconceptions About Chemical Grouting

Chemical grouting can be effective, or ineffective, depending on the circumstances in which it is applied. Ironically, grouting's very effectiveness has, at times, contributed to its being *underestimated* as a solution. And, inexpert use of chemical grouting has led to quality and longevity concerns. Let's address some common misconceptions about chemical grouting:

Misconception #1: "Chemical grouting doesn't last very long."

In fact, chemical grouts don't biodegrade, and there are multiple documented cases of grout applications lasting 20 years or more. In the right conditions (discussed below), leaks sealed by chemical grout will stay sealed for decades. Larry Neitzel, Superintendent of Public Works in the Village of Brown Deer, Wisconsin, systematically applies chemical grout to several miles of 8-inch vitrified clay pipe annually, and says, "Based on our own experience, and data from Europe and other municipalities, we're anticipating **grout repairs that last 35-40 years.**"

The misconception that chemical grout on the surface of the pipe seals the pipe joint is an example of chemical grouting being a victim of its own success. How so? Well, keep in mind that after proper application, a grout repair is filling and sealing voids outside the pipe and is invisible from inside the pipe. That is, when inspecting with CCTV, or visually, a leak or joint repaired with grout may not be spotted, because *little to no grout remains inside the pipe*. So if a chemical grout application was undocumented (as was often the case in the '70s and '80s) it may have been doing its job perfectly for decades, and all current system operators can see is a pipe that's in good repair and doesn't need maintenance. Meanwhile, more obvious rehabilitation techniques, like cured in place pipe (CIPP), are visually obvious and are credited with long-lasting structural repairs.

Ironically, **this very unobtrusiveness is one of chemical grouting's greatest strengths**. For one thing, the pipe's interior diameter is unaffected, so flow is unimpeded. More important, when grout cures, it forms a strong, flexible mass in the soil that completely fills voids and annular space in trench backfill. By filling these spaces, grout can stop water from flowing along the *outside* of pipes and finding new ways to infiltrate sewer pipe. This water migration along repaired pipe is a known problem of some repair techniques. For example, James Shelton, P.E., sits on the Pressure Pipe Committee of the National Association of Sewer Service Companies (NASSCO) and says,

*"... merely lining a mainline pipe is **practically useless from a flow reduction perspective**. I practically cry every time we install a CIPP liner with hydrophilic end seals hermetically sealing out all the leakage that had been pouring into the pipe, only to **watch the water pour in even faster than before** when we cut holes into the liner at every house connection. Post-rehabilitation video visually confirms that once the mainline is lined,*

*the **groundwater simply migrates** to the lateral tap cuts in the liner (through the annular space between the host pipe and the liner), to the laterals and to the manholes. Post rehab-flow meter data quantitatively supports these observations. Therefore, **mainline lining is never a stand-alone fix** when reducing I&I flows.”¹ (emphasis added)*

Since chemical grouting fills soil voids and annular space, and sets in moist conditions, it is an excellent technology for sealing lateral connections and completing mainline rehabilitation projects. This is an example of chemical grouting and other repair techniques working together to reduce I&I.

Misconception #2: “Chemical grouting can fix damaged pipe.”

System operators occasionally try to use chemical grout to repair structurally damaged pipe. This rarely works. Even when gelled, chemical grout remains flexible and doesn't 'patch' pipe. Rather, grout **fills voids in soil and prevents groundwater infiltration**. This is excellent for preventing infiltration due to failed joint gaskets and holes in otherwise sound pipe, but **grout alone can't repair pipe that is collapsing or fracturing**. In these cases, a structural solution is needed.

On the other hand, **chemical grouting is an excellent method for preventing structural damage**. Breaches in pipe integrity allow both infiltration (during storms or other events that load soil with water) and exfiltration (when sewer loads are high, creating positive pressure in sewer pipes). This infiltration/exfiltration cycle washes out fines, creating voids outside weakening pipe seals and joints, which in turn leads to joint and seal failure.

By filling voids and ending the infiltration/exfiltration cycle, chemical grouting **arrests the erosion processes that lead to structural failure**. Put another way, when it comes to sewer pipe maintenance, an ounce of prevention (or grout) really is worth a pound of cure. By taking care of small leaks and failing joints with relatively inexpensive chemical grouting, wastewater departments can help avoid major structural repairs.

Misconception #3: “You should only use chemical grouting if you can't afford CIPP or pipe bursting.”

This misconception assumes that chemical grouting is a technology that *competes* with pipe rehabilitation technologies like relining. In fact, grouting is best viewed as a solution that complements or supplements other pipe rehabilitation methods.

For example, if a long section of sewer mainline is compromised structurally, that pipe needs to be relined or replaced. But, for reasons discussed above, water will continue to flow in both the original sewer pipe trench and in the annular space formed between the interior of the old pipe and the new liner. From there, water will enter wherever

¹ “Trenchless Rehab from the Engineer's Perspective,” *Trenchless Technology*, October 2006, p.66, James Shelton, P.E.

the rehabilitated pipe is tapped for service laterals. Therefore, these taps also need to be sealed, and *chemical grouting is ideal for this purpose*. Since laterals are typically *structurally* sound and above groundwater, replacement or relining of the entire lateral is usually not needed; rather, grout sealing within several feet of the mainline connection is sufficient. By using grout to fill voids and plug leaks at lateral taps, the main source of infiltration in rehabilitated lines is eliminated and the collection system's investment in relining is protected and extended.

Chemical grouting also excels in situations requiring spot repair, rather than manhole-to-manhole repairs. For example, in jointed clay pipes, gaskets often fail at individual joints long before the rest of the pipe is compromised structurally. By using air testing to identify failed joints, and grout packers to repair failed joints only, wastewater departments can significantly extend the working life of the line at relatively low expense. In this case, relining would be expensive and unnecessary.

Misconception #4: "Chemical grouting is expensive, since it's just a temporary repair."

In fact, as shown above, when applied properly and used in appropriate conditions, chemical grout repairs can last several decades. But even if a lifecycle of just 10-15 years is assumed, chemical grout is extremely cost effective compared to other methods. Shelton says, "... at less than one-sixth the cost of replacement, and one-fourth the cost of lining, [chemical grouting] is easy on the pocketbook, quickly reduces I&I, and stabilizes the structural condition [surrounding bedding] of the pipeline."²

Moreover, infiltration can be reduced dramatically if cities own their own packer units. Salem, Oregon (see case study abstract below), has a sophisticated in-house grouting program and reports costs of just \$5.04/foot for some grout repairs. The city considers grouting the most economical pipe repair option for structurally sound sewers.

Ideal Uses of Chemical Grouting

As discussed above, chemical grouting is not ideal in *all* situations where sewer pipe needs to be rehabilitated. However, the range of appropriate conditions is broader than many think. An overview of grouting uses in the municipal market include stopping infiltration in mainlines, laterals, main/lateral connections, and in underground structures like manholes, wet wells or lift stations. Additionally, chemical grout is used in conjunction with lining by sealing the annular space between host pipe and liner at the connection to the manhole and when reinstating the laterals. Chemical grouts are also used as a means to prep an underground structure for structural repair. For example, contractors often use grouts outside a manhole in order to stop infiltration so that a coating can be applied to a dry surface, thereby preventing pinholes or bubbles in the coating. Lining contractors

2 "Trenchless Rehab from the Engineer's Perspective," Trenchless Technology, October 2006, p.66, James Shelton, P.E.

frequently use grouts to seal mainline joints prior to lining. By doing so the contractor can stop infiltration, stabilize the soil, and stabilize the pipe by filling voids outside the pipe. Sealing leaking joints with chemical grout prior to lining also gives the lining contractor the best shot at providing a uniform wall thickness of the liner by preventing the possibility of resin washout and future failures.

Here are some factors to evaluate when considering pipe rehabilitation with chemical grouting:

- **Pipe Diameter and Condition:** So long as pipe is not actually failing structurally, chemical grout can be used to stop leaks and infiltration. With the right packers (which can be custom-made), pipes up to 144-inches in diameter can be grouted.
- **Soil Types:** The only absolute requirement for the use of chemical grouts is the existence of an egress that allows the solution to flow out of the pipe into annular space and void before it catalyzes and sets. Once cured, grout will not dry out when in a moist environment. Moreover, since pipe interiors are moist and since groundwater is present *outside* pipe, the grout/soil matrix is almost always exposed to ongoing moist conditions. Therefore, chemical grouting can be used to seal and maintain most sewer pipes, even those set shallowly, in what may be considered “dry” soil. Studies show that most grouts used in the sealing of sewer lines will not dehydrate as long as there is at least 80-90% humidity or moisture in the soil.
- **Presence of Roots:** After removing roots from mainlines and laterals, chemical grout can be used to help prevent future root intrusion by incorporating root inhibitors when mixing grout. Successful grout applications will usually be part of a broader root control program that includes cleaning, cutting, and/or the use of foaming root control chemicals. The root inhibitors used with chemical grout are designed to prevent future root growth for two to three years, forcing the roots to seek their nutrition elsewhere.

Best Practices to Consider

As discussed above, successful chemical grout programs need to be implemented with care. Factors to consider include:

- **Contracting:** If grouting is done by private contractors, care should be taken to create payment systems and contracts that encourage use of the sufficient amount of grout so that the contractor is incentivized to use enough grout to seal the leak for the long term rather than jeopardize the rehabilitation of the pipe by using too little grout in an attempt to reduce their costs. If the void space in the soil outside the leaking joint is not filled entirely with grout, groundwater will continue to flow in the backfill trench and could enter the joint on a different side of the pipe. The ICGA

offers recommended specifications at their website, www.sewergrouting.com.

- **Staff Experience:** Effective inspection of chemical grouting work done by private contractors, or successful in-house grout application, will usually require experienced staff or staff who have attended specialized training. Operators and inspectors need a sense of how much grout should be used in varying situations, how grout is mixed, and when grout application is appropriate.
- **Video Inspection and Testing:** To determine if chemical grouting is the right solution, and to verify that grout application has been successful, grouting should take place within a maintenance program that emphasizes ongoing, scheduled, video inspection and flow testing. Without organized follow up, sewer operators can have no idea if chemical grouting is cost-effective in their system. Ideally, inspection data is linked to GISs and maintenance scheduling programs that enable long-term analysis of chemical grouting (and other) rehabilitation projects. Factors to analyze include what chemical was pumped, how much was pumped at which joints, and pumping pressure.

Selected Case Studies

Village of Brown Deer, Wisconsin: Brown Deer is a suburb next to Milwaukee, with a population of about 12,000. The Village's wastewater network includes 53 miles of sewer mainline; most of this is 8-inch vitrified clay pipe, typically laid between 1950 and 1980. Brown Deer began using chemical grouting in the 1970s, when they shared a grouting unit with a neighboring municipality. They currently contract for this work, and budget about \$185,000 annually for grouting. An additional \$110,000 is budgeted for lateral repair, which can include grouting; money not spent on laterals is diverted to the annual grouting budget. Superintendent of Public Works Larry Neitzel estimates that **two to five miles of sewer mainline are tested annually and grouted as needed.**

One large, ongoing project is a good example of the value of chemical grouting to Brown Deer. "In the '90s, we identified a large subdivision with serious surcharging," Neitzel explains, "We did a study, and decided that we would air test every joint, and grout those that failed."

In all, about 5,000 joints were tested in the 1990s. **Of those, 44% failed and were repaired with chemical grout.** This reduced infiltration considerably; however, die testing of laterals convinced Neitzel that further work was needed, and laterals were repaired with a mix of grouting, relining, and replacement—this work reduced infiltration to acceptable levels in most rainfalls.

In 2010, 12 years after the original grouting had been completed, all of the subdivision's joints were retested. The results were extremely significant for municipalities considering chemical grouting programs. Of the 5,000 joints retested in 2010, 1,476 failed; **not one**

of the 1,476 failed joints had been previously grouted. That is, when retested after 12 years, just 48% of the originally sound joints were still in good shape, yet **100% of grouted joints—about 2,200 joints—passed tests.**

This was in line with Neitzel's expectations; "Based on our own experience, and data from Europe and other municipalities, we're anticipating grout repairs that **last 35-40 years.**" Additionally, the U.S. Department of Energy concluded that acrylamide chemical grouts have a half-life of 362 years in the soil.³

Neitzel feels that the details are important when setting up a grouting program. For example, contracts should be set up in ways that encourage use of the proper mix and proper amount of grout. "Experienced inspectors are important," says Neitzel, "Ideally, they'll know how grouting and air testing work and know the system and what is required/normal. They'll have a good feel for the amount of grout that a joint requires; otherwise, contractors may skimp on materials."

James Shelton, P.E., cited above, agrees that contracts are important, and must be set up correctly; "In our experience, the best fix for structurally sound pipe with leaking joints is packer injection grouting... [Unsuccessful programs] failed to specify a grouting program and implement a measurement and payment approach that *required and incentivized our grouting contractors to pump grout.*"⁴ (emphasis added)

Northwestern Water & Sewer District (NWSD), Bowling Green, Ohio: NWSD is a regional district that manages 400 miles of sewer mainline. Superintendent Dan Wickard views chemical grouting as a superb solution for spot repair of leaking joints, especially in deep trenches. "It's an economical fix, and it stops water," he says.

Much of NWSD's mainline is PVC or HDPE pipe that is in good shape. "The mains aren't the problem," Wickard says, "It's the laterals, and the manholes, that cause problems."

For manholes, the District commonly injects chemical grout to stop leaks and stabilize soil surrounding the manhole. For laterals, NWSD is a little unusual in that they aggressively repair private laterals with public funds. "Plumbers hate us," Wickard says, "But we're here to keep our customers' rates down." The District uses private contractors operating combination trucks to grout laterals, and reports major reduction of I&I after lateral repair cycles.

To identify leaks, NWSD commonly inspects pipe during, or just after, storms; "I don't want to see good pipe, I want to see leaky pipe!" Wickard explains. There are some legacy

³ Spalding, B. P., S. Y. Lee, C. D. Farmer, L. K. Hyder, P. Supaokit. 1987. *In Situ Grouting of Buried Transuranic Waste with Polyacrylamide*. Martin Marietta Energy Systems, Inc., U.S. Dept. of Energy, under contract no. DE-AC05-84OR21400, Publication no. RAP86-69, Environmental Sciences Division Oak Ridge National Laboratory, Oak Ridge, TN 37831.

⁴ "Trenchless Rehab from the Engineer's Perspective," *Trenchless Technology*, October 2006, p.66, James Shelton, P.E.

lines of vitrified clay that go back to the 30s. Wickard feels that they can be perfectly acceptable lines, when they're in good shape, and will routinely inspect for leaky joints and spot repair with grout. He feels that deep lines are the best candidates for grouting. "We have a high water table, so deeper lines are surrounded by soil that stays moist," he explains, "That's good for grout because, if it stays moist, it won't shrink or crack—**I've done deep grouting that is still in good shape 12 years later.**" Deep lines also have less root intrusion.

In all, Wickard estimates that **chemical grout is used for about 25% of sewer line repairs.** "We have different tools, and grout is an important one—when the situation is right, grout is definitely the way to go."

Abstract⁵—Salem, Oregon: Service population of 227,000. Sewer mainlines, consisting mostly of 4-inch to 75-inch concrete pipe with some brick and vitrified clay tile, totaled 785 miles. The city determined 65% of the mainline is compromised by grease, roots, structural damage, and/or defective laterals. Salem has been grouting with in-house equipment and crews since 1971. Supervisor Jeff Winchester says, "Bringing the work in-house instead of hiring contractors saves taxpayers thousands of dollars a year." Sanitary sewer overflows (SSO) reduced from an annual average of 50, to 15 in 2009 (mostly due to blockages, not storms). Salem owns two dedicated grouting vans in addition to four TV trucks. City-owned units can grout pipes from 8-inches to 36-inches in diameter, and laterals. In 2008, an asset study identified defects in 11,475 joints and 1,803 manholes; the study concluded that I&I defects had been historically under-reported.

In 2007, Salem hired a contractor to air test 87 joints in 760 feet of 36-inch concrete pipe. Twenty-two defective joints were grouted. The project took two days and cost tens of thousands of dollars. Winchester says the city now has its own 36-inch packer, and using their existing equipment would save the city a significant amount of money.

Responding to a sinkhole in a major intersection, a two-man Salem crew worked manhole-to-manhole for three nights to air-test and seal 440 feet of 18-inch concrete pipe with clay backfill. Pipe barrels were sound, but 175 of 176 joints leaked and were grouted with a total of 616 gallons of grout. Because there was no soil for the grout to create a gel/soil matrix, the grout essentially filled the thin void space between the exterior of the pipe and the clay. The option to add a liner to the pipe would have radically increased costs, and replacement of the pipe would have skyrocketed the cost of the project to several hundred thousand dollars. By the end of the project the city had effectively sealed their concrete pipe for about \$7,000 using chemical grout. Winchester says that experienced staff are important for successful grouting programs: "A city is wise to search for an experienced technician, because the money he will save taxpayers will more than cover his salary."

5 See original article, "Secure Connections," Municipal Sewer & Water, April 2011, p.20, Scottie Dayton

Abstract⁶—Newtown, Pennsylvania: Service population of 8,000 in 2006, up from 2,800 in 1984. 110 miles of sewer mainline, a mix of vitrified clay, PVC, and ductile iron. Prior to 1988, Newtown used chemical grout reactively, to fix obviously leaking pipe. Beginning in 1988, Newtown began to proactively air test and grout. "Before, inspection would be called for only when routine checks for blockages revealed excessive flow or a clear water stream at a particular spot. With the new program, we divided the system into drainage areas, started at the top of each one and made comprehensive checks of all manholes, mains and laterals, making repairs as needed." – Joint Municipal Authority Manager Warren Gormley. The Authority says that the program reduced metered sewage from 96 million gallons per month to 60 million gallons per month, a 40% reduction.

Proactive grouting accounts for 85% of reduction. User rates are less than a quarter of surrounding systems, and have held steady despite a rapidly increasing customer base.

The Solution is Part of the Solution

As has been shown, chemical grouting has a supporting role to play in nearly all collection system maintenance programs. It is cost-effective, durable, fast, and does not reduce pipe inner diameter. Though it is not itself an effective way to rehabilitate structurally compromised pipe, it can suspend the processes that lead to pipe failure and is a necessary complement to structural solutions like relining; in fact, chemical grouting is sometimes used to firm and seal faulty lines in order to create optimum conditions *prior to* relining. Truly, America's oldest trenchless pipe repair technology is still the best solution available for many situations.

⁶ See original article, "City Uses Pro-Active Grout Program to Reduce Volume Treatment Costs," *Underground Construction*, September 2006, p.76

Sponsored by the ICGA

This white paper on the use of chemical grouting in I&I reduction programs is sponsored by the Infiltration Control Grouting Association (ICGA), a division of NASSCO, Inc. (National Association of Sewer Service Companies). Within the last few years, PACP has been expanded and now includes many grouting codes.

ICGA is a coalition of suppliers, contractors, engineers and public works representatives who work together to share resources and experience, and to educate sewer engineers and owners about the proper use of chemical grouting as a safe, economical, and effective means to reduce ground water infiltration into sewer collection networks.

To learn more, and to access training programs, case studies, and recommended specifications, go to www.sewergrouting.com.

