



Madrid
13-15 October 2014

Paper Ref 134

Pipe Grouting Longevity Effectiveness Evaluation

James W. Shelton, PE, ARCADIS, King of Prussia, PA

1. ABSTRACT

There have been many debates regarding the long term effectiveness of a sewer grouting approach. To provide actual field data based proofs of the long term effectiveness of pipeline grouting (aka test and seal), ARCADIS selected 12 sewer segments that had been grouted under various sewer rehabilitation projects in 2005 for which detailed records of testing and grouting were collected. These grouting projects were implemented using specifications largely consistent with the new NASSCO grouting specifications. This paper will review the requirements for testing and grouting under which the original work was done (to provide context for the effectiveness numbers). Under this Longevity Evaluation, pipe mainline joints and tap connections from several projects spread over a single large utility's service area were retested 7-9 years after initial testing and grouting. Joints that failed to pass this second round of air testing were grouted, and the volume of grout used recorded. This paper/presentation presents these findings, including percentage of joints/taps that had been previously grouted that failed after 7 years; percentage of joints/taps that had not failed in 2005, but which were found to fail in 2012 and 2013, and how much grout it took in each instance to achieve seal both initially and in the retesting phase.

2. INTRODUCTION

New Castle County Department of Special Services (NCC) owns and operates a sewer system that contains approximately 1,800 miles of gravity sewer and interceptors. NCC is implementing a 15 year comprehensive rehabilitation program, called the Brandywine Hundred Sewer Rehabilitation and Capacity Assurance Program, to prevent groundwater and rainwater entry (i.e., infiltration and inflow, or I/I) into the collection system in order to reduce wet weather-related collection and transmission system performance issues.

As part of this comprehensive program, ARCADIS conducted significant hydraulic condition assessments, including extended flow metering; nighttime weiring; above-grade storm inflow observations; door-to-door basement inspections; smoke testing; data mining through asset management software, and transfer of knowledge through interviews with operations staff were used for this to identify and prioritize the leakiest areas for rehabilitation. Three of these areas are called SP24, NCA, and NA2. A Physical Condition Assessment (PCA) was conducted on the mainline pipes in these areas to identify the best method of rehabilitation to use based on the pipes structural condition. As expected, the predominantly clay sewers showed numerous cracks and fractures, and several instances of broken, distorted, or collapsed pipe. Unexpectedly, many of the segments of clay pipe were in perfect structural condition, suffering only from leaking joints. For pipe segments with multiple structural defects, cured in place mainline lining and lateral lining were selected as the holistic rehabilitation methods. For pipe segments with no structural defects, packer injection chemical grouting of the mainline joints and first 3 lateral joints were selected as the holistic rehabilitation methods.



Figure 1
Structurally Compromised Pipe

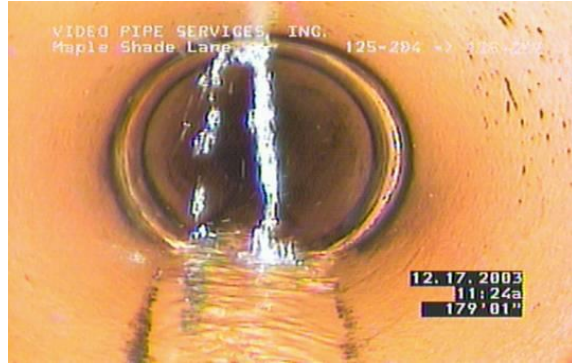


Figure 2
Structurally Sound, but Leaking Joint

3. ORIGINAL TEST AND SEAL WORK

Between the three project areas, approximately 7500 mainline joints and 450 laterals connected to sewers (LCS) over 35,000 lf of sewer were tested and, where indicated, grouted. The SP24 work (~13,000 lf) was conducted in 2005 by a combination of New Castle County and VideoPipe Services. The NCA work (~4,000 lf) was conducted in 2006 by VideoPipe Services. The NA2 work (~18,000 lf) was conducted in 2005 by VideoPipe Services.

All pipes and taps were cleaned to remove grease and debris. Roots were mechanically removed using chain flails. All mainline joints and lateral tap connections were then air tested using an air pressure set at packer delivery pressure equal to ½ psi per vertical foot of pipe depth plus 2 psi; test pressure did not exceed 10 psi. Joints and laterals that failed the pressure test were grouted.

Avanti's AV-100® chemical grout was used for all grouting work. A 12% acrylamide base material by weight in the total grout mix was generally used. All grout was mixed with dichlobenil for root retardation. Avanti's IcoSet® was added at a rate of 3 gallons for every 60 gallons of grout to mainline grouting and to some lateral grouting for strength retention. Lateral taps were grouted to their second or third joint using a 6' Logiball lateral packer.



Figure 3: Grout Rig



Figure 4: Logiball Packer

Baseline grout gel time was set using the following formulas, with the goal of introducing 2 gallons of grout into each mainline joint, and 1 gallon of grout into each lateral joint reached by the lateral packer sock.

For mainline joints:

$$Gel\ Time = \left(\frac{\{Volume\ of\ Annular\ Space\ (gal)\} + \{Pipe\ Diameter(inch)/4\}}{Pumping\ Rate(gpm)} \right) \left(\frac{60sec}{1min} \right) + 15\ seconds$$

For lateral taps:

$$Gel\ Time = \left(\frac{\{Volume\ of\ Annular\ Space\ (gal)\} + \{[Socklength(ft)/3]x[PipeDiameter(in)/4]\}}{Pumping\ Rate(gpm)} \right) \left(\frac{60sec}{1min} \right)$$

Actual gel time varied based on grout pump performance. Generally, the grout rigs delivered grout around 5 gallons per minute, so the mainline joint gel time was typically 45 seconds and the lateral tap was typically 60 seconds for 6" taps and 42 seconds for 4" taps. Gel times were checked at the start of the work day, when a new batch was made, and whenever ambient temperatures changed more than 10°F, and were adjusted to maintain baseline gel times.

Mainline joint failure rates varied widely across the three projects, and within each project.

- For the SP24 project area, on average, mainline joints failed the air test at 21% failure rate. Grout volumes varied too, with the grout rate for mainline joints averaging 3.2 gallons. On average, lateral taps failed the air test at 27% failure rate, with the grout rate for lateral taps averaging 2.8 gallons.
- For the NCA project area, on average, mainline joints failed the air test at 15% failure rate. Grout volumes varied too, with the grout rate for mainline joints averaging __ gallons. On average, lateral taps failed the air test at 32% failure rate, with the grout rate for lateral taps averaging __ gallons.
- For the NA2 project area, on average, mainline joints failed the air test at 12% failure rate. Grout volumes varied too, with the grout rate for mainline joints averaging __ gallons. On average, lateral taps failed the air test at 22% failure rate, with the grout rate for lateral taps averaging __ gallons.

At the completion of the sewer line segment (i.e. manhole to manhole), joint grouting verification testing of grouted joints and laterals was conducted for quality control purposes on 5% of the grouted mainline joints (minimum of two repaired joints) and 25% of the grouted lateral taps (minimum of one lateral tap). Within a sewer line segment, if any joints, lateral taps, or laterals connected to a manhole in a pipe segment failed the retest after sealing, all joints and laterals, as applicable, in the sewer line segment were required to be retested. This situation was rarely encountered.

4. LONGEVITY TESTING

In July 2011, Video Pipe Services was contracted to pressure test the mainline joints and laterals in selected segments of these three project areas. The purpose of this study was to assess the longevity of the grout used to rehabilitate sanitary sewer pipes that suffer from groundwater infiltration.

Eight segments containing 415 mainline joints were selected to be air pressure tested and, if found to fail the test, be grouted (or regouted, as the case might be). These eight segments were purposefully selected because of their high rate of mainline joint failure during the initial rehabilitation and because good grouting records had been kept for these segments.

Of the 415 joints originally tested, 207 (50%) had failed in the original test and seal projects. These joints received an average of 4.3 gallons of grout under the initial rehabilitation project. Upon retesting these 207 joints, 13 (6%) were found to again fail. These 13 joints required an average of 4.6 gallons of additional grout to reseal. With an

average of nearly 9 gallons of grout pumped per mainline joint, clearly there are significant bedding voids near these 13 particular joints.

Of the 208 (50%) that had passed the air test originally, on 10 (4%) were found to fail. In total, after 7 years, less than 5% of all the mainline joints were found to have failed. These new failures required an average of 4.8 gallons of grout to seal.

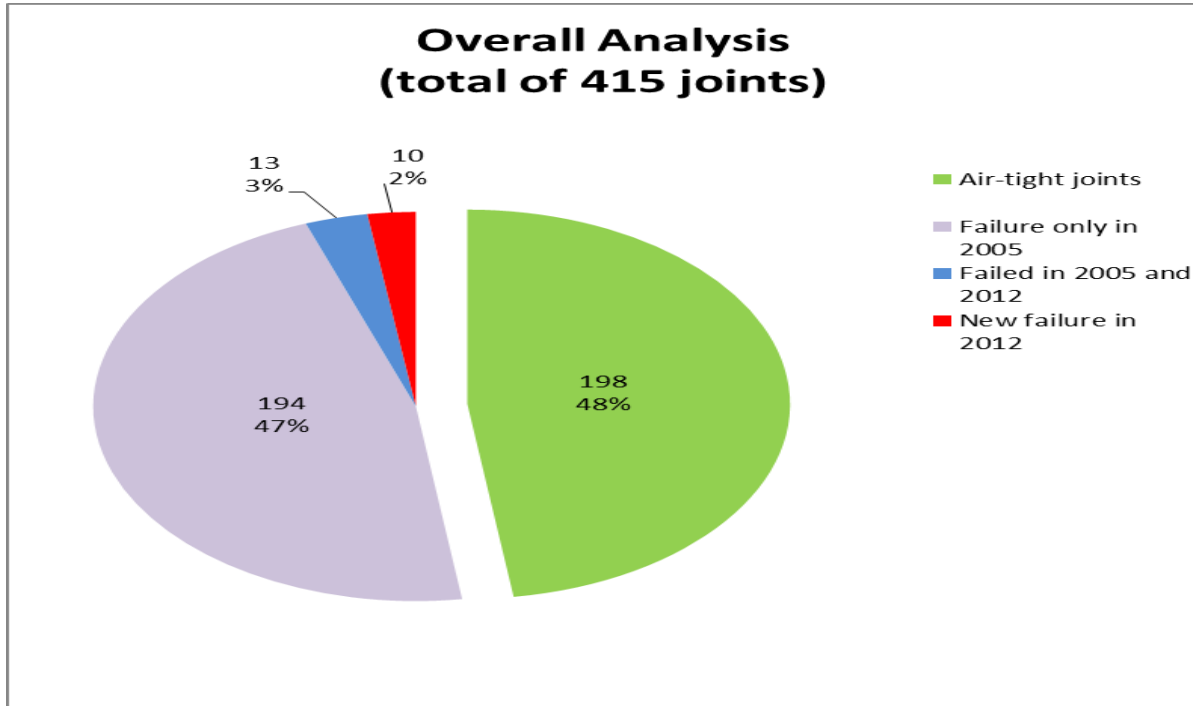


Figure 5: Mainline Joint Test Results

A segment by segment presentation of these data is presented below.

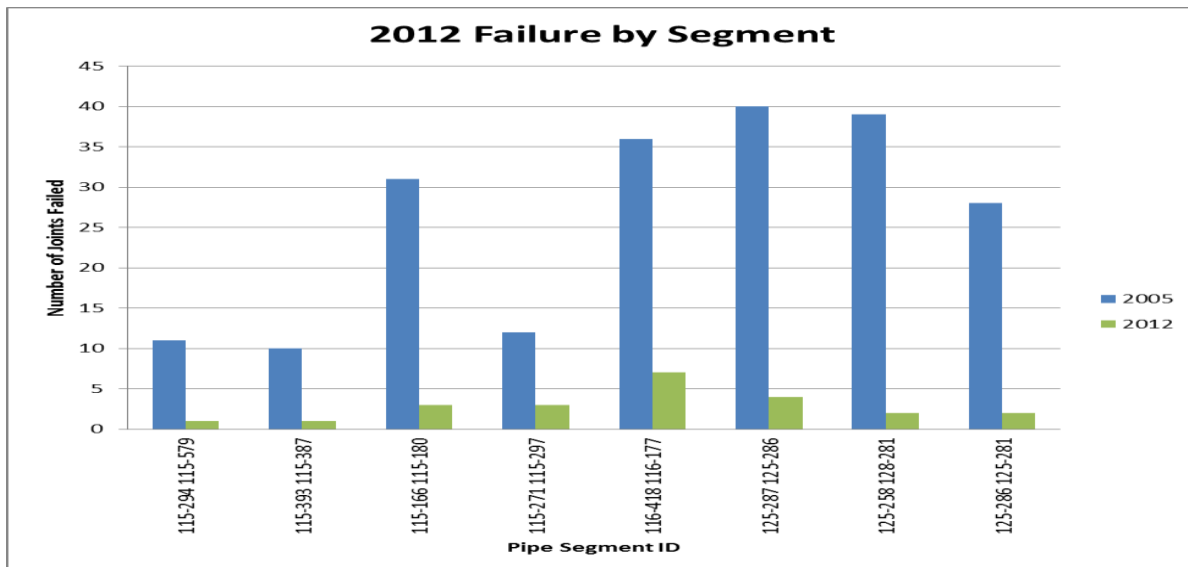


Figure 6: Segment Mainline Joint Test Results

Seven segments containing 31 lateral taps were selected to be air pressure tested and, if found to fail the test, be grouted (or regrouted, as the case might be). These 31 lateral taps were purposefully selected because of their high rate of failure during the initial rehabilitation. Of the 31 lateral taps originally tested, 17 (55%) had failed in the original test and seal projects. These joints received an average of 4.2 gallons of grout under the initial rehabilitation project.

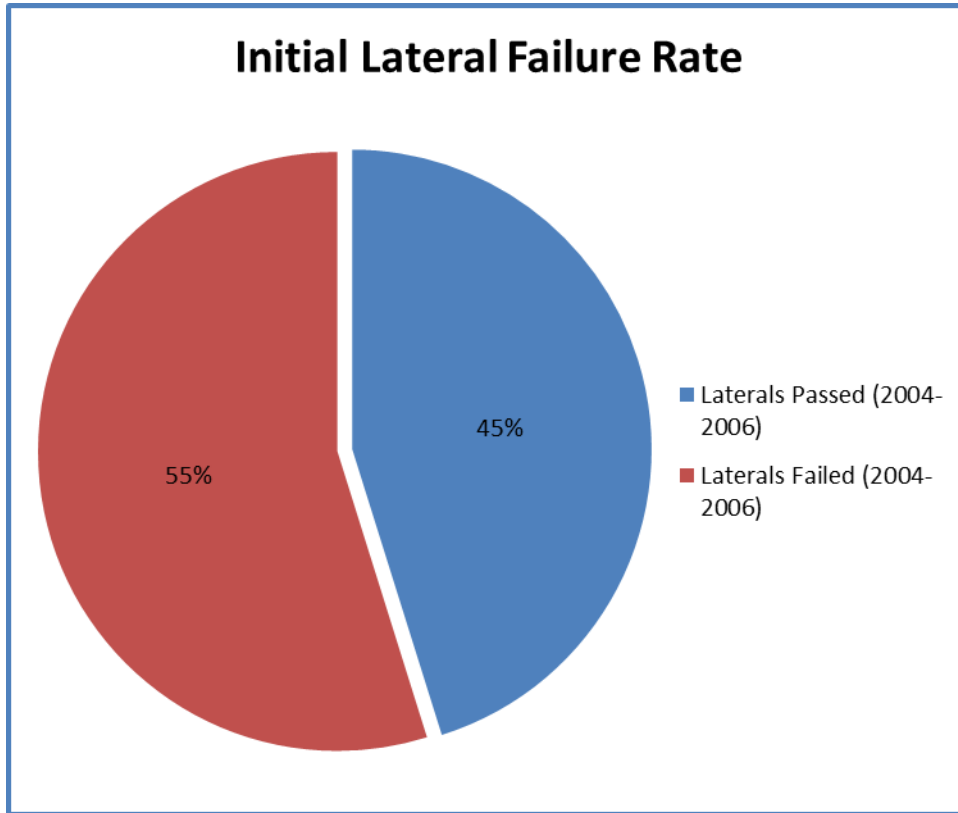


Figure 7: Lateral Tap Test Results

Upon retesting 7-9 years later, none of these taps failed the air test.

4. CONCLUSIONS

This field test shows packer injection grouting, when conducted to rigorous specifications and overseen by experience and qualified inspection staff, continues to be highly effective at sealing mainline joints and lateral taps at least 7 years after installation.