# Still Going Strong 17 Years Later:
## Successful Sewer Structure Rehabilitation

Ron Moore, PMP

### Project combines Permacast® with Con$^{MIC}$Shield® to Repair AND Prevent Damage from MIC

In the year 2000 one of the Metropolitan St. Louis Sewer District's major sewer structures, the Maline Drop Shaft, had been so severely degraded by microbiologically induced corrosion (MIC) that structural failure was a very real possibility. This would have been a disaster for all the obvious reasons, not least the proximity of the Mississippi River and St. Louis' famous Chain of Rocks Bridge. But at the time, there was no obvious way to rehabilitate the drop shaft that would restore it structurally and also prevent future MIC damage. Even replacement of the Maline Drop Shaft—which would have cost $3-4 million—would not necessarily have eliminated MIC.

We ended up rehabilitating with a new technology based on a spraycasted concrete system called Permacast®, mixed with an antimicrobial additive called Con$^{MIC}$Shield®. At the time it seemed like a fairly radical experiment—I believe we were one of the very first sewer districts to apply Con$^{MIC}$Shield® in such a large-scale project. But seventeen years later, the Maline Drop Shaft is still in beautiful shape; it's structurally sound and there appears to be no MIC damage of any kind. I'd like to describe what we did in 2000, and what we've learned since. The repair process worked, and I still don't know how else we would have successfully completed the repair.

### Drop Shaft Details

The Maline Drop Shaft is a roughly 10' by 8' concrete shaft about 50 feet in length—more than 20 of this is below grade, with 36" and 40" inlets and, at bottom, a 60" outlet feeding Bissell Point, one of the District's oldest and largest treatment plants. For flood mitigation reasons (to be sure we never put sewage into the Mississippi) the shaft is built up 20 feet above grade. Walls are about 18" thick—or they were when the drop shaft was built.

In 2000, the Maline Drop Shaft was 40 years old, and looked much older. For much of the year, flows are not especially high and conditions are not good for *thiobacillus*, the acid-producing bacteria that put the 'corrosion' in microbiologically induced corrosion. But several times yearly, flows create so much volume and turbulence that several feet of churning water will be in the bottom of the shaft for days at a time. This churning water, which is oxygen-rich and full of organic matter, is ideal for the production of hydrogen sulfide gas and also fosters huge colonies of *thiobacillus*. This is simplified; there are actually many species of *thiobacillus* that thrive in different conditions, and MIC is usually caused by successive populations of different species that ultimately create the conditions for the appearance of *thiobacillus concretivorous*, which is Latin for "eats concrete". This organism has been known to grow well in the laboratory while exposed to a 7% solution of sulfuric acid. This is equivalent to a pH of approximately 0.5.

Basically, *thiobacillus concretivorous* eats hydrogen sulfide gas and turns it into sulfuric acid—it's the acid that eats concrete, not *thiobacillus*. Here's how one paper (*CORROSION CONTROL IN CRETE*

William E. Shook Leonard W. Bell, P.E.) describes the results:

"*Sulfuric acid attacks the matrix of the concrete, which is commonly composed of calcium silicate hydrate gel (CSHG), calcium carbonate from aggregates (when present) and un-reacted calcium hydroxide. Although the reaction products are complex and result in the formation of many different compounds, the process can be generally illustrated.*

*The primary product of concrete decomposition by sulfuric acid is calcium sulfate (CaSO4), more commonly known by its mineral name, gypsum. From experience with this material in its more common form of drywall board, we know that it does not provide much structural support, especially when wet. It is usually present in sewers and structures as a pasty white mass on concrete surfaces above the water line.* ***In areas where high flows intermittently scour the walls above the water line, concrete loss can be particularly fast.*** *It is generally believed by most investigators that the surface coating of gypsum paste somewhat protects underlying sound concrete by providing a buffer zone through which freshly produced sulfuric acid must penetrate. Because Thiobacillus bacteria are aerobic, they require free atmospheric oxygen to survive. Therefore, they can only live on the thin outer covering of any surface. This means that acid produced on the surface must migrate through any existing gypsum paste to reach sound concrete.* ***By washing off the "protective" coating of gypsum with high flows or wet weather flows, fresh surfaces are therefore exposed to acid attack, which accelerates the process.*** *Sewer cleaning practices and equipment should be checked to determine the degree of gypsum layer loss during cleaning and the effects of such cleaning on the ultimate pipe life.*" (**emphasis added**)

So in our shaft, the sporadic, intermittent nature of the heavy flows were actually a big part of the problem—they scoured off the accumulating gypsum layer several times a year and enabled *thiobacillus* to keep attacking newly exposed concrete.

The results were dramatic. The upper portions of the shaft had been eaten away about two inches, and surface layers were mushy. Toward the bottom, more than five inches had been eaten away, walls were mushy, and supporting steel was exposed and corroded. Quite literally, this was a disaster waiting to happen.

**What to do?**

Replacing the drop shaft was ruled out due to expense, so it seemed that mitigation would require some sort of t-lock lining or a coating, perhaps epoxy or polyurea. These weren't appealing options. For starters, neither would address structural concerns. And on such a large structure, MIC mitigation was also a problem—it's easy and common for linings and coatings to develop small punctures or openings, caused either by poor installation or by wear after installation. And a small opening is all *thiobacillus* needs—the colonies can get started and grow *behind* linings, and do just as much damage as when they're exposed. In fact, they can do *more* damage—since linings and coatings hide the damage, inspections don't reveal problems until it's far too late.

Fortunately, ADS Environmental Services (at the time, Specialty Sewer Company) approached us with a new technology they'd been researching—a spraycasting system and high-strength cementitious grouts developed by AP/M PERMAFORM and, for permanent MIC protection, the grout would be mixed with Con$^{MIC}$Shield®, an additive that bonds molecularly with concrete and prevents microbial growth.

Well, I did the research and made some calls, and it sounded like a good solution for us. It was cost-effective, could be completed in a short time frame, and promised to be effective both structurally and against MIC. And, well, I like new things…

**What exactly was done? And how did it work out?**

The entire rehabilitation process is straightforward, and the whole project only lasted three weeks. The work was done in summer, so flows were low and we were able to dewater with bypass pumping and temporary pipes. Then ADS and Spray-Com, another licensed Permacast® applicator with experience in deep structures, did the following:

- Power washed the walls back to solid material
- Installed wire mesh to the walls for structural reinforcement of the worst areas
- Applied several one-inch layers of MS-10,000, a high-strength cementitious grout developed by AP/M PERMAFORM and fortified with Con$^{MIC}$Shield®
- Troweled the surface after each layer was applied to ensure a densely-compacted, uniform finish
- Troweled smooth a final one-inch layer once the entire wall was rebuilt to the plumb line

And basically, that was it. The drop shaft looked like new with smooth walls, and it didn't matter that we reduced the inner dimensions by one inch—the Maline Drop Shaft still has plenty of capacity.

We've inspected regularly since then, sometimes by dewatering and lowering in a basket for visual inspection and measurement by a man equipped with confined-space equipment. And sometimes we'll lower a sledgehammer in and swing it from side to side—the banging tells us that the walls are still firm and sound, with no MIC mushiness, and no faults developing beneath the concrete's top surface. At eight years we conducted a very thorough inspection and found that inner surfaces had eroded down by, at most, 3/32". At seventeen years we find no further erosion, no MIC damage, and the shaft walls are still smooth and sound. On the inside, the Maline Drop Shaft could be taken for a new structure.

Getting the mixing proportion right is important. Lab testing of samples during construction can also be completed to verify that Con$^{MIC}$Shield® is present in the right proportion. Had those tests been available in 2000 we would have used them. And it's important to note that Con$^{MIC}$Shield® is only effective for MIC; if corrosion by chemicals or other agent is the problem, some other solution will be needed. But as it is, it looks like we did everything right and have a flawless, like-new structure as a result.

Of course we've used Con$^{MIC}$Shield® since that initial project. It's specified for all new concrete pipe in situations where MIC is a possibility, and it worked out very well in a tunneling project for a new 84" inch main sewer. I recommend its use in MIC situations, and if you have any doubts I can take you to visit a 50-foot drop shaft that's in near-perfect condition after being near failure 17 years ago—you can see for yourself.

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*Ron Moore, PMP, supervised the Maline Drop Shaft rehabilitation in 2000, and subsequent inspections and evaluations as the Materials Engineer, and recently retired from the Metropolitan St. Louis Sewer District.*