Putting a Round Plug in a Square Hole

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Being a diver for the past 24 years, I've been asked numerous times how to fix leaking joints in pipes and conduits. I normally respond back with a dozen more questions such as:

How bad is the leak? Can you drain the pipe/conduit? How long can it be shut down? How far up in is the leak, 50 feet or 500 feet? What does it have in it, potable water, raw water or sewer water? If it can't be shut down, is there flow? What is the access like? What material is the pipe/conduit made of? What is the budget? Does the pipe/conduit see any type of dynamic loading like a nearby road? And a new question that I will be asking from NOW ON, "What time of year are you planning on doing these repairs?" We'll talk about that more later on.

An Ohio water treatment plant asked me this same question about their leaking conduit joints in 2012. Surprisingly I must have portrayed myself as being semi-intelligent about the topic (that doesn't always happen). The plant and a nearby engineering firm invited my company back in 2013 to perform underwater inspections of all their underground conduits and clearwells. This particular water treatment plant, its underground conduits and clearwells were constructed at various times from 1941 to 1976. The concrete conduits connecting the plant to the clearwells and the high service pump building were either 5-foot square or 54-inch square and are the focus of this article.

The plant's staff was well aware of some of the leaks prior to our dive inspection. The swampy area in the middle of the dry field was a dead giveaway for one of them. The others were not so obvious. Some of the older maintenance guys even joked about how, "Those conduits have leaked since the day they were put in." At first I thought he was kidding and later found out he was serious. The smaller leaks are identified underwater using food coloring dye. Once the flow in the conduit is stopped or slowed down, the food coloring is squirted around the leaking joint by the diver. If squirted anywhere close to a leak, the dye will point directly to it. The same approach works for leaking clearwells, water storage tanks and your backyard swimming pool.

In the summer of 2013 after a few weeks on site and a couple of miles of swimming, five damaged leaking conduit joints were identified. Because it was potable water, everything to enter the water including the divers' drysuits and helmets needed to be cleaned and disinfected daily per AWWA C652-92. The quantity of finished water lost through these leaks, 24 hours a day, 7 days a week, year after year is staggering. In addition to the water leaking out, untreated ground water was leaking into two of the conduits. Repairs were needed to "stop the bleeding". Unfortunately whoever performed these repairs would need to do so while the conduits were filled with water. 40+ years ago water plants would typically drain the conduit and send some brave sole (the new

guy) crawling hundreds of feet up the conduit with a bucket of mortar or a tube of calking from the local hardware store to do a temporary, band aid repair. This was prior to the days of formal confined space training and NSF-61 standards. To their credit, I see a lot of these repairs in water plant conduits and some are still working well.

The next step in the process was for the engineering firm to design repairs, create plans and specs and to put the project out for bid. Usually this is the end of our participation.

However unlike other projects, this engineering firm chose to keep us involved with the design phase. They welcomed our input and implemented many of our suggestions about the reality of what could or could not be done underwater. My hat is off to them.

Working together we came up with installing HydraTite internal EPDM rubber joint seals made by HydroTech Engineered Products of Cincinnati, Ohio. These rubber seals are successfully used to cover leaking joints in cylindrical pipes. The rubber seal is compressed against the smooth, curved walls of the pipe using stainless steel retaining bands and a hydraulic expander. Once the retaining bands are expanded, wedges are installed in the gaps and bolts are tightened up to hold the assembly in place. Photos of all of these parts are attached. It sounds pretty straight forward and simple, right? What about the corners? In addition to the round pipes, the seals have been used above water in rectangular shaped culverts with 45-degree corners. In these cases additional anchor bolts were installed in the flat sections and the corners were rounded with epoxy or grout. This would be the "maiden voyage" for a square conduit with sharp corners installed completely underwater. The engineering firm again impressed me by suggesting the use of pre-fabricated stainless steel radiuses in the corners.

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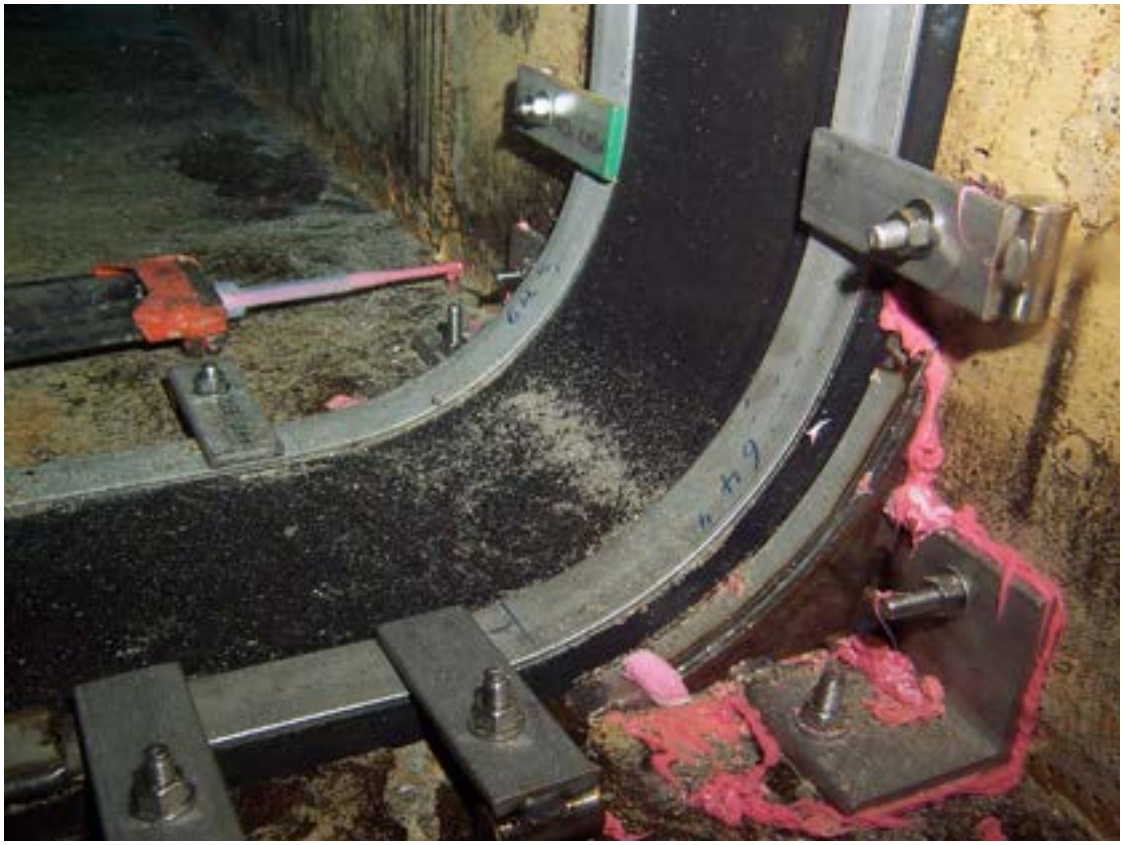


This would give the stainless steel bands a curved surface to press the rubber liner against creating a tight seal. A total of eight radiuses were needed for each liner, four on either side of the joint.

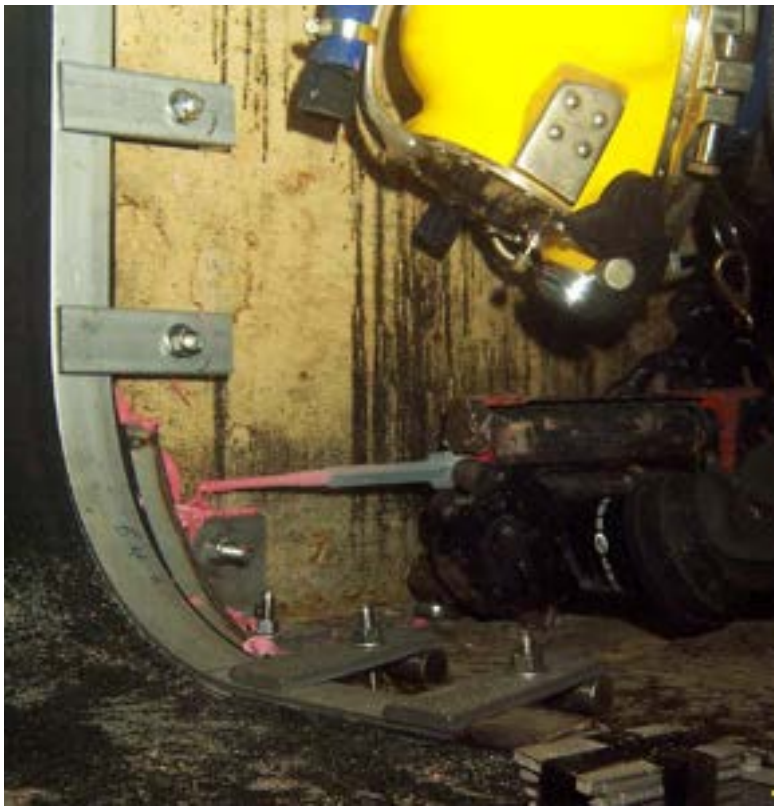
When the job was advertised I said to myself, "We've done the inspection and helped with the design of repairs. It would be a shame not to be the divers who did the actual repairs." It was an interesting project that we wanted to be involved with. I bid the job and won.

Before the HydraTite seals could be installed some of the spalled concrete at the joints needed repaired. The divers cleaned the loose concrete from the damaged areas, cleaned the corrosion from the exposed reinforcing steel and installed steel forms. The concrete was pumped into the forms and filled the voids on the floors and walls well. One of the conduit joints had a honey-combed area at the ceiling drawing a large amount of water. Several unsuccessful attempts were made to pump the concrete into this small void on the ceiling but the material kept getting sucked out.

Bureaucracy and red tape held up ordering the internal joint seals. The warm summer weather came and went. Fall brought a bitterly cold November with snow and air temperatures in the mid-teens along with a water temperature of 36 degrees F. Someone finally placed the order and guess what showed up? You've got it, 5 HydraTite internal joint seals. Perfect conditions to start a dive project! In the cold water commercial divers usually use a special wet suit flooded with hot water. The hot water is supplied through a hose from a diesel water heater on the surface. The divers keep warm and they are able to focus and be productive. Unfortunately this was not an option in the potable water. The divers' bodies needed to be isolated from the water with drysuits. My list of divers eager to go swimming just shrunk.

After the materials arrived, HydraTech's engineer provided onsite "dry run" training for my crew. A 54-inch plywood box was built to simulate the conduit. The photo taken during the training shows the simulated plywood conduit, the rubber seal, the stainless steel retaining bands, the wedges, and the hydraulic expander. As you can see, there were a lot of small light parts in the assembly process. That would come back to haunt us later on.

On November 10, 2014 the first pre-fabricated stainless steel radiuses were installed. A thick layer of Hilti RE-500 two part epoxy was applied underwater between the radiuses and the concrete corners. This epoxy filled imperfections in the concrete and helped secure the stainless radiuses to the conduit. Although the Hilti epoxy was not designed for this application, epoxies that can be applied underwater and that are NSF-61 approved for potable water are scarce. The Hilti epoxy worked well and came in an easy-to-use double barrel calking gun. Stainless steel wedge anchor bolts were used to attach the radiuses and the stainless steel bands to the concrete.



Fitting the radiuses in place proved to be difficult at some of the leaking joints. Several of the joints had up to a 1 inch concrete height mismatch. Also four of the radiuses were installed on a curved wall of the conduit. Both situations caused the sharp corners of the radiuses to rub the soft rubber seal potentially damaging it. After a little love with the underwater torch and a lot of concrete chipping, the tedious job of custom fitting the radiuses was complete. It took one day to attach the radiuses for each joint. The epoxy was then given all night to solidify. The following day was devoted to installing the HydraTite internal joint seal. Overall 56 anchor bolt holes were drilled at each leaking joint. The drill ran nonstop for almost 4 hours. While the first diver was drilling the holes on one side, the second diver worked on the opposite side assembling and expanding the stainless steel bands. Each of the two retaining bands had four locations that enabled the retaining bands to be expanded to compress the EPDM seal. Once expanded, wedges were installed locking the bands in place.

The divers worked quickly to keep warm. My dive supervisor (in the heated trailer) kept telling us over the radio, "The heat is in the tools." I'm not sure what that meant as I was cold the whole time! We wore 4 layers of clothes under our drysuits. Remember Ralphie's little brother from the Christmas Story movie who had so many layers of clothes on he couldn't move his arms? Yep, that was us. Now add in thick 3-fingered mittens with tiny 5/16-inch bolts and two dozen other small light parts washing away in a fast moving current. Oh yea, I forgot to tell you that one of the conduits was active with a strong flow that would carry away any small unsecured parts or tools. My list of divers eager to get in the water just shrunk again.

Like all new projects, there was a learning curve filled with 'challenges': the conduit height mismatch, the curved conduit walls, working in the strong flow and dealing with 36 degree F water. Just to name a few. Regardless of the 'challenges', we successfully installed five HydraTite internal joint seals over the leaking joints underwater. Yes, with the right amount of persuasion, 56 anchor bolts and a half dozen tubes of epoxy a round plug will work in a square hole.