

# Slip Lining of Existing Steel Pipe

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I am going to share the Vincennes District's experiences with polyethylene liner pipe. I will discuss when we use liner pipe, how we select locations, and what criteria we use. I will present a private contractor installation and what INDOT maintenance in Vincennes has done. I will also examine how to size the polyethylene liner pipe. Finally, I will give a cost analysis of open cutting and replacing with fiber bonded or bituminous coated pipe versus using the polyethylene liner for various sizes of pipes and heights of fill sections.

When using polyethylene liners in lieu of fiber bonded or bituminous coated pipe, we have certain criteria we try to meet. These are listed below.

1. **Scouring.** If we have heavy scouring in a location, we may choose to use polyethylene liner. Scouring by rock will wear off the coating, exposing bare metal and scouring the metal itself.
2. **Acid Conditions.** Southwestern Indiana has extensive mining causing acidic conditions from sulfuric acid. A study done by the Division of Research and Testing conducted in 1982 showed that a PH of five or less was extremely detrimental to metal, aluminum, and galvanized steel pipe. A fiber bonded or equivalent pipe would be required for longevity. Polyethylene pipe is not damaged by most acids. It is highly acid resistant.
3. **Deep Fill Sections & High Traffic Volumes.** In some locations, we have fill sections under the interstate as deep as eighty feet. Excavating these areas to replace the pipe would not only be extremely costly, but almost impractical. Also, the inconvenience to the public must be considered in any replacement that would cause a closure of the roadway.
4. **Resurfaced Roads.** Although all bad pipes on a road are to be replaced prior to a resurfacing, we are not infallible. Also, the motoring public looks unkindly toward having the road cut soon after being resurfaced. Therefore, this may be a good location for a polyethylene liner pipe on this merit alone.
5. **Cost.** The cost of Polyethylene liner pipe can be competitive when compared to open cutting and replacing with bituminous coated or fiber bonded pipes, which I will show later in this paper.

We use these five criteria in selecting possible polyethylene liner locations. However, other criteria are used before final selection is made. The existing pipe must have retained its roundness and must be fairly straight or the polyethylene liner pipe will not slide through. Also, the pipe must be clean or have the capability of being cleaned. If the pipe is not clean, material will collect in front of the new pipe, causing it to be shoved to the top against the existing pipe, becoming stuck. You must have a working area approximately twenty-five feet long at inlet or outlet, so the liner pipe may be laid in a trench to be pushed. Although the pipe

can be manufactured in lengths from two to forty-five feet, we try to use twenty foot sections because the machining of each male and female end adds to the price. This is an additional criterion you must consider in selecting polyethylene liner locations.

After establishing these criteria, we began looking for locations to use the polyethylene liner on contract. We found four locations. Three of these were on US 231 approximately two to three miles North of the Ohio River in Spencer County. The joints were separated, and this is a heavily travelled road. To close the road for pipe replacement, the detour would be approximately sixty miles. The first structure was a 24-inch, 111 foot long vitrified clay pipe. The next structure was a set of twin 24-inch clay pipes, each 111 feet long. The last one on US 231 was again a 24-inch vitrified clay pipe, which was 72 feet long. All of these structures were fill sections under 25 feet.

The fourth structure was on I-64 at the sixty-six mile marker. It was a 460 foot long, 48-inch bituminous coated metal pipe, under a 45 foot fill section. The pipe had numerous small holes in the flowline throughout the length of the pipe (probably caused by acid conditions from a hog farm operation). The pipes were to be pushed inside existing pipe and then grouted around for the full length.

The first section of the polyethylene liner pipe was pushed into the old pipe, leaving about five feet of the section sticking out. A trench was dug to align the sections of pipe. The next section was then placed in the trench and lined up. A choker chain was wrapped around both sections of pipe and come-alongs were hooked on both sides of the pipe to the chains. A lubricant, such as liquid soap, was used on both the male and female ends. The sections of pipe were then snapped together and that new section was pushed in. This was repeated until the pipe was fully lined.

The contractor had a problem with this procedure on US 231. Apparently the sections of the vitrified clay pipe had separated to such an extent that the polyethylene liner pipe would not readily go through. The contractor took the bucket of the track hoe and beat it through. This is not a recommended practice. However, it did work with no damage to the pipe with the exception of some minor distortion. The contractor then formed up both ends to pour grout. A hole was cut on top of both ends of the existing pipe and a two foot stand pipe with a quick couple was placed over each hole. The grout was made by a mobile mixer and pumped into the pipe. The grout is used as a filler to fill the annular space between the existing structure and the polyethylene liner pipe.

On the twin structure, we started pumping grout into one structure and the grout came out the other. Apparently there was a void between the two, but the void should be filled by the grout. We realized a 20 percent overrun in the grout, and it was suggested that we pay for grout on an actual basis instead of a theoretical basis. The contractor used a grout design that consists of:

- 395 lbs. cement
- 79 lbs. flyash
- 1421 lbs. dry sand
- 229 lbs. water (includes water in sand)
- 11.9 cu. ft. preformed foam

Specifications require that the filler grout make a minimum of 150 psi at 28 days. The grout didn't make the specified 150 psi and the contractor was penalized. This contract was completed in March, 1989 at a cost just under \$92 thousand. The estimated cost for open cutting and replacing just the 48-inch pipe under the interstate was \$800 thousand. So far all of the polyethylene pipes are performing fine, and we don't anticipate any problems for the next fifty years.

Vincennes District Maintenance thought that we might be able to use the polyethylene liner pipe for some of our maintenance replacements. So we selected some locations using the previously mentioned criteria. However, we decided to do smaller pipes only since we do not readily have access to a trackhoe. Also, we needed a new grout design since we do not have a pump and would have to gravity flow the grout. Our initial grout mix did not work well as it was found to have too much sand. The sand would settle out and pile up at the inlet causing the annular space between the liner and existing pipe to stop up. After a couple of changes, we came up with a grout design that would work. It consists of:

- 300 lbs. cement (Type I)
- 1500 lbs. fly ash (Type C or F)
- 1200 lbs. fine aggregate (SSD)
- 156 oz. super plasticizer (Rheobuild 1000)
- As needed air entraining admixture to obtain 10% air content
- 45 gal. water

The grout was approximately \$50 per cubic yard, and the compressive strength tested at 4000 psi. After pushing the pipe through, we sealed both ends by placing a six inch thick duracal plug in the annular space between the liner and the existing pipe. We then proceeded to dump the grout in the upper end of the pipe through a stand pipe and watched for it to come up the stand pipe at the lower end. We also vibrated the mix with a portable vibrator to help the mix flow.

The stand pipe consists of a piece of six inch PVC pipe. A hole smaller than the diameter of the stand pipe is cut on each end of the existing pipe and duracal is poured to hold the pipe in place. They are then removed after grouting.

Vincennes District Maintenance has replaced approximately ten pipes with polyethylene in the Dale and Paoli Sub-Districts since March of 1989. The local maintenance crews are very happy with this new procedure. We have replaced a polyethylene liner pipe and grouted a sixty foot long, twenty inch pipe in three hours.

If we have several locations for pipe replacement in the same area, we slip line a number of locations and then come back and grout all the locations later. This makes for a more efficient operation and saves money on the hauling costs for grout. The polyethylene liner pipe is sized by determining the flow of the pipe to be lined and then finding the flow of the polyethylene liner, the flow of the polyethylene should be at least equal to the flow of existing pipe.

A cost analysis comparing the cost of fiber bonded bituminous coated pipe the polyethylene pipe liner was done. The list price of the polyethylene liner pipe is more expensive than the actual cost of the bituminous coated pipe for all sizes. The savings come from reduced excavation cost, installation time, and inconvenience to the public. The cost comparisons indicate that liners are cost effective in many situations.