



For Every Corner of Your World

Tennessee Avenue & Beach Thorofare
Ocean City, NJ 08226
Tel 609/399-2417 • Fax 609/399-5233

July 9, 2000

Mr. Brian Roberts
National Corrugated Steel Pipe Association
155 Twenty-third Street, NW
Washington, DC 20037-1174

Re: Inspection of Corrugated Steel Pipe in Michigan

Dear Mr. Roberts:

Following is our report on inspections of corrugated steel pipe installed at two locations in the Upper Peninsula of Michigan. Should you have any questions, do not hesitate to contact me.

Introduction

Innovative materials are continually being developed for corrugated steel pipe to improve their durability. One of the best ways to determine the durability of these materials is long-term exposure in a "real-world" installation. Periodic evaluation of the materials over many years increases our comfort at projecting service life. Two such installations exist in the Upper Peninsula of Michigan – Hantz Road in Chippewa County and Charles Moran Road in Mackinac County. At each of these locations there are three pipes installed in parallel runs – Dow Trenchcoat (polymer laminated) galvanized steel pipe, aluminum pipe, and standard galvanized pipe. The side-by-side installation of these products allows for comparison of their durability in identical environments. This report details the performance history of these pipes and their present condition at a June 16, 2000 inspection.

Installation Details

A program to evaluate alternative corrosion resistant culvert materials was initiated and sponsored by Bark River Culvert and Equipment Company in conjunction with the Michigan Corrugated Steel Pipe Association and Kaiser Aluminum. Culvert sheet was provided by participating companies and fabricated at the Bark River facility. Installation was completed by county forces in July of 1977 in accordance with MDOT Standard Specifications (1976).

The two sites selected for the program are located on Hantz Road (Chippewa County) and Charles Moran Road (Mackinac County). Both locations are within a few miles of I-75 in the Upper Peninsula of Michigan. At each location, three culverts are installed in parallel:

- 48-inch, 12-gage plain galvanized (G210) corrugated steel pipe (Republic Steel)
- 48-inch, 12-gage plain galvanized with 10 mils of Trenchcoat polymer film laminated on each side prior to corrugating (Inland Steel Blac Klad)
- 48-inch, 0.105-inch thick corrugated aluminum alloy pipe (CAP-Kaiser Aluminum)

Abu Dhabi	Billings	Calgary	Denver	Fl. St. John	Jakarta	Los Angeles	Montreal	Perth	San Diego	Sydney
Adelaide	Bahrain	Caracas	Delroit	Halifax	Liberal	Lyon	New Orleans	Philadelphia	Seattle	Taipei
Anchorage	Bogota	Charlotte	Dhahran	Hong Kong	Lisbon	Melbourne	New York	Phoenix	Sharjah	Toronto
Atlanta	Boston	Chicago	Edmonton	Honolulu	London	Midland	Ocean City	Regina	Singapore	Tulsa
Bakersfield	Brisbane	Cleveland	Farmington	Houston	Longview	Milwaukee	Orlando	San Francisco	Stockton-on-Tees	Washington, DC

All details regarding the installation of the culverts are documented in a report prepared for the Bark River Culvert and Equipment Company by G.A. Harris, P.E. (consultant), *Report on Installation of Test Culverts in Mackinac & Chippewa Counties, Michigan.*

Summary of Previous Inspections

These culverts have been inspected a number of times by various individuals since their installation in 1977. The following excerpts summarize the results of four of these inspections:

An MDOT report dated April 5, 1979 (R.W. Noyce) describes the condition of these pipes observed during three inspections in 1978. It summarizes the conditions as follows:

The aluminum culvert at the Hantz Road site exhibits the most severe corrosive attack. Most of the corrosion activity on the polymeric coated culverts is probably attributable to the exposed rivets. The plain galvanized C.M.P. shows the highest initial corrosion rates at both sites.

A September, 1981 MDOT report (P.W. O'Rourke) presents the results of a detailed inspection conducted in May of that year. The report includes the following summary comments:

The polymeric coated culverts at both sites are in excellent condition. Corrosion activity is limited to the rivets which are not protected. The coating is adhering properly and has not blistered or delaminated. It appears to be inactive with respect to both the water and soil and has sustained four seasonal cycles with no apparent damage. There is no question that polymeric coatings under normal conditions will extend the service life of corrugated steel pipe. It should be understood that these pipes are still very young and additional time will be required to determine whether or not the added expense of using these coatings can be justified on a cost benefit basis. The full measure of their effectiveness will not be understood quantitatively until failure has been reached.

The aluminum culverts at the Moran Road...sites are also in excellent condition. They contrast with the aluminum culvert at Hantz Road which appears to be more active and displays initial signs of corrosive attack. Differences appear to be related to higher concentrations of chlorides and effluent.

The plain galvanized culverts at all three sites were observed to be the most active. Corrosive attack is occurring near and below the flow line. The rate of metal loss appears to be greater at the Moran Road site than it does at the Hantz Road site and is believed to be related primarily to the difference in the average water level.

On July 22, 1993, an inspection of these pipes was jointly conducted by MDOT and the Great Lakes Corrugated Steel Pipe Association. MDOT Materials Testing Section Report 93 T-7 had the following finding with regards to the polymer coated pipe, aluminum pipe, and plain galvanized pipe:

Polymer coated culverts at Moran Road (16 years old) and Hantz Road (16 years old) are in excellent condition. No delaminations or blisters are present in the coating and the coating is adhering properly. Corrosion activity is limited to the rivet heads only, which are not polymeric coated.

The aluminum culverts at Moran Road (16 years old)...are in excellent condition without any signs of corrosion activity. Aluminum culverts at Hantz Road (16 years old)...are in good condition with only minor pitting present at the water line.

The report goes on to note the condition of several galvanized culverts, describing one of the two sites we inspected as "fair" condition ("Corrosion products cover the invert of the pipes with near complete loss of coating between the water line") and one pipe in "poor" condition ("Heavy scale is present in the pipe invert and there is complete loss of zinc coating between the water lines. It was noted that none of the pipes had perforations.

As part of a comprehensive survey of corrugated steel pipe sponsored by Dow in 1997, Corpro Companies, Inc. described the condition of these pipes as follows:

Charles Moran Road

The aluminum pipe contained 12 inches of sediment and water. Invert observations were not possible. Minimal general corrosion and minor (barely discernable with the naked eye) pitting corrosion were present on the interior and the soil side of the pipe.

The only coating damage to the G210/polymer pipe was minor underfilm corrosion (1/4-inch maximum) at the edges of the pipe sections under the water line and minor abrasion to the invert coating (coating was roughened slightly). All other areas of polymer on this pipe were in good visual condition. Minor corrosion was present on cut edges and rivet heads.

The G210 pieces were severely corroded on the lower 50% of the interior side. The remaining interior surfaces showed minor visual corrosion of the zinc coating. The soil side showed no pitting corrosion, but minor general corrosion of the zinc.

Hantz Road

The aluminum pipe contained stagnant water. The invert showed minimal corrosion, minor pitting, and little, if any abrasion damage. Minimal general corrosion and minor (barely discernable with the naked eye) pitting corrosion were present on the interior and the soil side of this pipe.

The only degradation found on the polymer coated culvert was minor underfilm corrosion (3/8-inch maximum) at the edges of the sections making up the pipe under the water line. All other areas of polymer on this pipe were in good visual condition. Minor corrosion was present on cut edges and rivet heads.

The G210 pipe was severely corroded on the lower 50% of the interior side. The remaining interior surfaces showed minor visual corrosion of the zinc coating. The soil side showed no pitting corrosion, but minor general corrosion of the zinc.

Present Inspection Findings

On June 16, 2000, representatives from Corpro, Dow, National Corrugated Steel Pipe Association, St. Regis Culvert, and Michigan DOT inspected the pipes at the Hantz Road and Charles Moran Road locations. The inspection included a visual and physical examination of the pipes, collection of soil and water for analysis, measurement of corrosion potentials, and other observations. This report presents our observations of the pipe condition.

All observations of our inspection on June 16, 2000 were consistent with the historical inspections presented above. Specifically, the Trenchcoat coated pipe was in excellent condition, with only minor rusting of the rivets and minor cutback of the polymer at the edges of the plates. The aluminum pipes showed minor pitting and staining at both sites, though the Hantz road pipe was in

noticeably worse condition. The galvanized pipes at both locations were severely corroded, but did not exhibit any penetrations. The following details our observations at each site.

Hantz Road

Environmental – The water resistivity and pH were measured as 1022 ohm-cm and 7.0, respectively. The soil water and resistivity were measured as 4475 ohm-cm and 7.8, respectively. These data are not significantly different from historical resistivity and pH measured at this site.

Trenchcoat/G210 – The polymer coating was intact, well adhered to the metal, pliable, glossy, and had no signs of blistering. There was minor undercutting (estimated to be between 1/8- and 1/2-inch) on most of the edges of the sheets at the waterline and below. There did appear to be consumption of the galvanized coating along some of the edges, but there was not significant metal loss (the corner of the cut edge was still evident). The polymer was tightly adhered to the edges of the sheets above the waterline. The polymer was tightly adhered around the rivets both above and below the waterline. The polymer was also well adhered around the edge of core samples that had been taken during previous inspections. There were indications of minor abrasion in the invert, but coating loss was not apparent.

Aluminum – This pipe was in good condition. It exhibited staining below the high water mark. There was minor pitting above the waterline that was estimated to be a few mils at most. The pipe surface below the waterline felt as if there was slightly worse pitting (greater density and deeper).

G210 Galvanized – The galvanized coating was completely consumed on the lower half of the pipe interior. There was progressively more steel corrosion (i.e., metal loss) toward the invert of the pipe. No perforation was apparent in the pipe. The steel corrosion products could be scrubbed away to reveal bright metal. It was estimated that more than half of the wall thickness was remaining.

Charles Moran Road

Environmental – The water resistivity and pH were measured as 8226 ohm-cm and 6.5, respectively. The soil water and resistivity were measured as 2164 ohm-cm and 8.0, respectively. These data are not significantly different from historical resistivity and pH measured at this site.

Trenchcoat/G210 – The polymer coating was intact, well adhered to the metal, pliable, glossy, and had no signs of blistering. There was minor undercutting (estimated up to 1/4-inch) on some of the edges of the sheets at the waterline and below. There did appear to be consumption of the galvanized coating along some of the edges, but there was not significant metal loss (the corner of the cut edge was still evident). The polymer was tightly adhered to the edges of the sheets above the waterline. The polymer was tightly adhered around the rivets both above and below the waterline. The polymer was also well adhered around the edge of core samples that had been taken during previous inspections. There did not appear to be any indications of abrasion in the invert.

Aluminum – This pipe was in good condition. It exhibited staining below the high water mark. There was no apparent pitting above the standing water/mud in the invert, but the pipe surface felt as if there was some attack below the mudline. There was a bulge in the top of the pipe that was reported during previous inspections. There did not appear to be any cracking or other corrosion problems associated with this mechanical deformation.

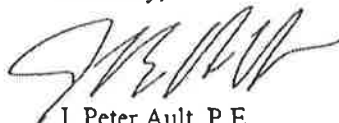
G210 Galvanized -- The galvanized coating was completely consumed on the lower half of the pipe interior. There was progressively more steel corrosion (i.e., metal loss) toward the invert of the pipe. No perforation was apparent in the pipe. The steel corrosion products could be scrubbed away to reveal bright metal. It was estimated that more than half of the wall thickness was remaining. While the condition of the G210 pipe at Hantz Road is reported similarly, the G210 pipe at Charles Moran Road appeared to be slightly more corroded than the G210 pipe at Hantz Road.

Conclusions

1. The Trenchcoat polymer is still intact. The film is well adhered, flexible, and did not exhibit any blistering. The galvanizing under the Trenchcoat polymer is still intact. Obviously, the Trenchcoat polymer film has already added 23 years to the service life of the pipe.
2. The only observed degradation of the Trenchcoat coated pipe was minor undercutting (less than 1/2-inch) at many of the edges of the plate and minor corrosion of the rivets.
3. If one were to assume that the Trenchcoat coating will undercut at a linear rate, it will be several hundred years until the entire coating has delaminated. Other factors will become influential as significant delamination of the coating occurs, but it seems reasonable based on our observations that the Trenchcoat polymer will provide a minimum 50-year extension to plain galvanized pipe in locations similar to the Hantz Road and Charles Moran Road sites.
4. Both of these features that are beginning to deteriorate (cut edges of sheet and rivets) are unique to riveted pipe manufacturing. Since helical pipe does not have exposed cut edges and rivets, this damage would not have occurred with helical pipe. Thus, polymer coated helical pipe would be expected to outperform the polymer coated riveted pipe.
5. The condition of the galvanized steel under the delaminated coating is not as bad as the bare galvanized pipe. It is likely that the coating provides limited protection to corrosion mechanisms (e.g., limits abrasion, limits oxygen access at the surface) even in a loosely bonded state.
6. The galvanized pipe, while experiencing corrosion, has not reached the end of its life. The galvanized pipes will clearly last longer than the projections made at the time of installation.
7. The performance of these pipes is consistent with the author's observations of several hundred Trenchcoat coated pipes throughout the continental United States.

Should you have any questions about any aspect of this report, do not hesitate to contact me at my Ocean City, NJ office.

Sincerely,



J. Peter Ault, P.E.
Senior Engineer