Northern Pulp – Effluent Pipeline Issues

Prepared for:

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Introduction

SJC Materials Engineering was approached by NS department of Environment (NSDOE) Inspection Compliance & Enforcement Division to comment on the history of inspection and repair of the effluent line that took untreated effluent from the North Pulp bleached kraft pulp mill at Abercrombie point, to the effluent treatment plant at Boat Harbour. The pipeline had leaked on a number of occasions and had been repaired each time. The latest leak had been on the morning of October 21st 2018. Since the leak occurred and the pipeline was repaired, the mill has ceased operation and the effluent pipeline had been decommissioned. It is currently abandoned in place and plans for an entirely new effluent treatment plant with new transfer piping are being developed.

Background

The effluent pipe was installed in 1966 when the pulp mill was first built. The original effluent pipe was installed in the mid 1960s and was a 36” diameter FRP line that began at the pulp mill effluent pump station and ran about 12,000 feet (3.6 km) to the separate effluent treatment plant at Boat Harbour. A section of the line ran under the east river and this portion was originally 42” diameter. This underwater portion was replaced in 2009 with 36” dimeter High Density Polyethylene (HDPE) because of repeated failures of this portion of the pipe.
At the time, the effluent treatment and all the associated equipment was the responsibility of and owned by the province of Nova Scotia. The pipeline was made of fiber reinforced plastic FRP. The original specifications and engineering drawings for the piping system are no longer available.

BEAK drawing 3828-2B-1 (01-060830-0007.pdf) dated 14th Feb 1972 indicates the that the joints in the pipe are made of :

“7 layers of chopped strand mat + 6 layers of woven roving 12” wide impregnated with bisphenol fumarate resin and painted with resin containing air-dry additive”
This is consistent with the understanding of Samson Industrial who state in their correspondences that the pipe is “*a filament wind[wound] structural construction with a 0.4 to 0.5-wall thickness. A v/m/m .10 corrosion liner on interior. Joints have an interior corrosion liner v/m/m 0.10 T.K [thick] and a 0.4 to 0.5 T.K [thick] structural laminate on the exterior*.” “v” is taken to mean c-glass veil and “m” is taken to mean chopped strand matt.

The use of Bisphenol-A Fumarate resin is outmoded by todays standards but appropriate for the time at which the pipe was fabricated. Vinyl ester resins were not brought to market until the late 1960s and only then began to find gradual

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acceptance. These resins are now the standard for effluent treatment and pollution control systems. Bisphenol-A fumarate resin had a proven track record of application in the chemical industry but were limited in terms of chemical resistance to some conditions. The broader range of chemical resistance of the vinyl ester resins and their improved workability led to them replacing the older technology. When repairs were done to the effluent pipeline in the later years, they were made with vinyl ester resins.

History

The earliest records available for review show that some work was done in 1972 and the joints shown in the drawing do not conform to what would be considered to be acceptable or standard practice today.

The extract below is taken from BEAK drawing 3828-2B-1 (01-060830-0007.pdf) dated 14th Feb 1972. The drawing of the pipe joints seem to show that there is a neoprene insert in the gap between the pipe ends and what seems to be a collar that fits over outside of the pipe ends such that the pipes are then slid into it (see excerpt in Figure 1) which shows *"FRP Coupling 3/16" thick ID=OD of Pipe" is then over-wrapped with "7 layers of chopped strand mat + 6 layers of woven roving 12" wide impregnated with bisphenol fumarate resin and painted with resin containing air-dry additive*".

It is not clear if the coupling is bonded to the pipe with resin or not. If it is not, then the butt and strap overwrap on the outside of the pipe is not fully bonded to the pipe but to the coupling and is only bonded to the pipe past the edge of the coupling. This is not a common approach. Normally the bare ends of the pipe that are being joined together are put as close together as practical. The outsides of the two pipe ends is ground to a 6:1 taper and the exposed joint is wrapped with structural FRP laminate sequence and a resin rich layer (corrosion barrier) is then applied on the exterior. If there is access to the inside of the pipe, the remaining gap in the inside of the pipe is then filled with a "putty" mixture of resin and milled fiber and a corrosion liner is applied to the inside over the joint to prevent wicking of the pipe contents into the putty plug and the structural laminate on the outside of the pipe.

From the drawings 01-060830-0007.pdf it is not clear if the dry coupling and neoprene gasket method is how the entire pipeline is made or if it just refers to the 1972 modifications. If the entire pipe was made like that, it goes some way to explaining why there were problems with the joints. If this is how the pipe was joined together, inspection of the leak-free path (the bond between the external FRP wrap and the pipe) even from the outside would be extremely difficult. Once

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the effluent in the pipe was able to breach the corrosion liner on the inside and passed the neoprene insert (which may or may not form an effective seal) attack of the external over-wrap could easily result. This would not be obvious to the designers if they assumed that the neoprene "insert" was acting as a "seal" and would not be at all apparent to the pulp mill owners of the pipe if they were not aware that the pipe had been constructed by this non-standard means when the system was owned by the Province.

Work was done in 1976 (Montreal Engineering Co. Ltd. Drwg. F63506 (01-060830-0018.pdf) to repair "*Faulty Joint by inside butt and strap joint*" (Figure 2), which means there was no replacement or modification of the joint on the outside of the pipe. This is a practical approach given the difficulty (and therefore the cost) of finding the exact location, excavating around and under the pipe then cleaning it and providing safe access and egress for the workers. When excavating buried pipe there is also a risk of damaging the pipe and this is particularly true for non-metallic pipe which are more at risk of mechanical damage than steel or concrete pipe. Application of an "inside butt and strap" implies that a significant strength layer was added on the inside, which should be at least as strong as the joints described in 1972. It is also assumed that by 1976, repairs would be made with vinyl ester resin, which would have improved chemical resistance to the bisphenol-A fumarate that the original pipe was made from.

Inspection and Maintenance Regime

Inspection reports from as long ago as 2013 were provided by NSDOE for review. There is also a copy of a four sentence long e-mail that describes an observation of the submerged pipe from a boat on April 11, 2011. These documents are best described as summaries of activity rather than reports. Videos of internal camera inspections that were done in May 2019 and April 2020 were also provided. These video inspections were performed by Industrial Hydrovac of Moncton NB and accompanying documentation includes some key observations. The Connors Diving report of September 2019 also includes some general observations of the condition of the pipe from the pulp mill to the point at which the FRP pipe transitions to the submerged HDPE section of the pipe, which is a distance of 1830 feet (558m).

The mill (Scott Maritimes, Kimberly Clark and then Northern Pulp) engaged an FRP inspector to do their regular inspections of the effluent pipeline. This individual, [redacted] of Samson Industrial, operates an FRP fabrication business and provides engineered FRP products to industries in the Atlantic provinces so it is reasonable to assume that this individual is sufficiently knowledgeable to perform inspections on FRP equipment. On July 22 2019, [redacted] stated in a letter to the mill that he has been doing inspections for "the last 25 years [1], so at least since 1994, when the mill was owned by Scott Maritimes. This means that while [redacted] had no input into the design or installation of the pipeline but they would have had a good understanding on the progress and history of any changes and repairs in the pipe between 1994 to the present day. This is important because the inspection report [1], states that all of the failures in the line, with the exception of the 2014 leak were at pipe joints and were attributable to "*improper secondary bonding during original installation (i.e. very little or no grinding and/or damp conditions to the existing pipe)*….". So with one exception, all of the leaks/failures since 1994 were at joints made in the mid 1960s. Thus is consistent with the description of the drawing in Figure 1 (the excerpt from the BEAK drawings of 1972) that shows a non-bonded coupling with an FRP overwrap.

The approach of using a fabricator to do inspections is common in the process industries because:

- The fabricator is familiar with the materials being inspected
- The fabricator can identify areas that need to be repaired and immediately make plans to do those repairs and execute the work during the short shutdown window. This eliminates the time lag of the mill having in inspector produce a report, which is then sent to the fabricator for a quotation.
- At subsequent shutdowns and inspections, the same contractor can review the condition of the repair and if required, make additional repairs.

If there is a shortcoming to this approach it is that often there is a lack of documentation because the inspector is (or is part of) the same entity as the fabricator, then the step of writing a report and producing detailed repair drawings is often eliminated and the fabricator effects the repair with few drawings. This lack of documentation makes a review of historical damage and repairs, such as this report, difficult. Nevertheless, having the same inspector and fabrication company perform inspections and repairs over an extended period of operation can be invaluable, especially if records of what was done are kept by the operator of the equipment or in this case the pipeline.

In the case of the October 2018 report, there is no failure analysis on the fracture, that could be used to identify the root cause of the failure. The only documentation is a repair report provided to Northern Pulp by [redacted] that describes the repair of the leak [2]. The report does not make any mention of how the leak may have occurred. This is a very short report that does little more than provide the general “recipe” for the repair process but there are key sentences: “*A 3” by approximately 18” long by 1/16” to 3/16” deep scuff mark was revealed along one side of the pipe. This scuff mark was most likely done during the digging process*”. This underscores the risks associated with external inspection of a buried pipe. There is a very real risk of damaging the pipe, just by the process of exposing it.

<u>WECO Seals</u>

At some time in the history of the pipe, a decision was made to use WECO seals as a method of preventing leaks and/or repairing damage. Five of the seals were installed by Connors Diving Services in September 2014 [3]. These seals were installed at locations that had been observed to be areas of “*concern due to delimitation* (delamination?*) of the internal fiberglass wrap*”. These seals are proprietary devices that used a moulded elastomeric ring that is held in place by stainless steel hoops. The hoops clamp the rubber seal to the inside of the pipe by using wedges to expand the stainless steel hoops and drive the hoops into the elastomer. Grease is used between the rubber insert and the inside of the main pipe to provide a watertight seal. This design of seal is not intended to add to or improve the strength of the pipe, it is only intended to seal. The hoop stresses that are applied by the stainless steel clamping rings to the FRP pipe mean that the forces between the rings and the seal are borne by the pipe and will be additive to any internal pressure on the inside of the pipe, but will act against external forces from overburden in the case of buried pipe. This type of seal is used extensively in wastewater systems and has a proven track record. At each shutdown the seals were inspected, and more seals were added as needed. The six seals that were installed in 2014 were located:

- 40’ towards the pump house from manhole #2
- 80’ towards the pump house from manhole #2
- 260’ towards the pump house from manhole #2
- 480’ towards the pump house from manhole #2 (two seals)
- 175’ towards the pump house from the standpipe

The same inspection during 2014 describes three other WECO seals that were installed at some time prior to 2014. The inspection indicates that these three existing seals “*all appeared to be in good condition with no visible damage or corrosion to the pressure bands*”.

Review of the video inspection data shows that in 2019 some of the seals showed bulging of the elastomer. It is not clear if this is due to swelling of the elastomer due to chemical attack by the effluent, or from the void behind the rubber seal filing up with ground water from outside the pipe. As long as in either case, the seal is not breeched, there would be no leaking of the pipe contents to the outside.

AMEC Recommendations

In 2013, as part of the mill Environmental Permit that was granted in May 2011, a pipeline inspection plan was developed for the mill by AMEC (now Wood PLC). This plan included the FRP pipeline and the underwater section which was replaced in 2009 and is made of HDPE. The AMEC recommendations relied heavily on a standard that was developed by the Technical Association for the Pulp and Paper Industry (TAPPI). The particular standard "*TIP 0402-28, Best Practice for Inspecting Used Fiber-Reinforced Plastic (FRP) Equipment*". This document refers to "FRP Equipment including tanks, piping, stacks, ducts, etc." so while there is no specific mention of buried pipelines it could be applied to the case of the effluent pipeline at the Northern Pulp site.

The AMEC recommendations include that the mill should "investigate" the use of acoustic emission testing (AET) as a condition assessment tool to supplement visual inspections. At the time the recommendations were written (2013), AET was in use in some applications such as process vessels, where the acoustic sensors could be easily fixed (taped) to the outside of a vessel and then is filled with water. The sounds (the "acoustic emissions") that were generated by fracturing fibers or resin were recorded by instrumentation and the results compared to a baseline measurement. Since AET was not in use in the mid 1960s when the pipe was installed, there was no baseline measurement, but a "current" baseline could have been developed subsequent to the recommendation being made and used as a comparison for subsequent AET measurements. It would give no information on the state of deterioration from new (1960s) to the condition in 2013, but it could however be used to track deterioration from 2013 and beyond.

AET presents practical difficulties in the case of a buried or submerged pipe because the sensors have to be attached to the surface of the pipe, which for a buried pipe means entry into the confined space to install the sensors, hundreds of meters of wiring then re-entering the confined space to remove the sensors. This alone is the same level of effort as a visual inspection.

Reference to a TAPPI Standard is good approach in many instances because these are consensus standards that are agreed upon by experts from within the industry. TAPPI TIPs are voluntary standards and are non-binding. None of the actions listed in the standard are "required" and there is liberal use of the word "should". This word is used specifically because no company that participates in

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standards development wants to be put in or create a situation where they "must" do specific test or inspections.

TAPPI TIP-0402-28 states: "*In addition to considering chemical aggressiveness of the contents, FRP equipment with any of the following operating conditions or characteristics initially should be inspected at least annually to reliably trend its condition:*

- *The equipment is internally pressurized*
- *Operating temperatures exceed 80°C (l 75°F). [Lower limits apply to some resins.]*
- *The equipment has known defects or damage or was repaired in the previous two years or at the last inspection*."

In the case of the Northern Pulp Effluent pipeline, only the length of pipe between the lift station and the standpipe is pressurized, the rest is under gravity flow and it is understood that the effluent was always below 80˚C. The last requirement, where the equipment must be inspected at least annually if the equipment has known damage or was repaired in the previous two years since the last inspection is more complicated and much more difficult to meet. If we take the repair of the 2014 leak as an example of a "repair" then strict application of the TAPPI requirement would mean "at least annual" inspection in 2015 and 2016.

In October 2019, NSDOE requested a summary of inspections that had been carried out between 2010 and 2019 [4] and in response Northern Pulp provided a list of "inspections" [5]. The list shows that in each year except 2016 Samson Industrial performed some inspection on the line. In 2016, the only "inspection that was done was periodic ("at least quarterly") walking of the route of the buried line and checking for leaks. There was a mill shutdown in 2016 but there was no internal inspection. It is not clear why internal inspection was omitted in during that shutdown. Whether regularly walking the route of the line to check for leaks counts as an "inspection" is debatable, but there was as least some effort to identify if the pipeline was leaking or not. Subsequent to 2016, inspection was done by Samson Industrial at least annually.

Despite the efforts of the mill to perform regular inspections, it is important to note that the leaks in both 2014 and 2018 were identified by members of the public rather than employees of Northern Pulp or their contractors.

Inspections Done by Northern Pulp

Inspections were done at each plant shutdown. We are aware of multiple examples of FRP equipment at pulp mills and other sites that is seldom inspected, and attention is only paid once there has been a failure or something close to a failure. Pollution control equipment (such as this pipeline) is no exception. The lack of detailed drawings and specifications from the original construction or from when ownership was turned over to the operators of the mill (from the Province of NS) are lacking so there are few records of initial condition or the history of degradation and repair over the history of the pipeline. Because the pipe is buried or submerged, it is difficult to gauge the condition of the pipe without actually entering it or using remote monitoring tools.

The approach taken by Northern Pulp in keeping with what would reasonably be expected of similar operations, that are operating legacy systems. It may not be ideal (there is always an argument for doing more inspection and more testing, especially after the fact) but there were efforts to determine the condition of the pipeline and repairs were made when defects were identified. A summary of the approach is as follows:

- Frequent inspections (each shutdown as far as can be seen)
- Internal inspections, both visual and remote (except for 2016)
- Repairs as required
- Acceptance that there were certain locations that required prioritized inspections (original butt& wrap joints)
- Using the same company for inspections and repairs over a prolonged period to ensure continuity of the knowledge base

In the specific case of the effluent pipeline at the Northern Pulp operation:

- The original design drawings from the 1960s are no longer available so we cannot be 100% sure of the design or how the original pipeline was fabricated
- The repair history and inspection records prior to 1994 are not available.
- Since 1994, there has been a continuous, if not well documented history of inspections and repairs
- As far as we can determine, inspections were carried out at each plant maintenance shutdown. These were the only times when access to the

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inside of the pipe was possible. Plant maintenance shutdowns typically occur on an approximately annual schedule

- The pipeline was a confined space, and entry into confined spaces presents a safety concern, so as technology became available, remote video cameras were used. This is an appropriate method as it was able to identify damage to the corrosion liner and confirm the integrity of the WECO seals. Where damage was observed by remote video inspection, human inspection could then be done in selected areas
- To perform FRP repairs, the surfaces must be absolutely dry. This is very difficult to achieve in an underground pipe that is partially flooded because humidity will be high, and the walls of the pipe will be cooled by the earth cover. For this reason, a reliance was made on WECO seals
- External inspection of the pipeline was not possible because it is buried. Routine external inspection of buried pipelines is not common practice in any industry

Summary

It is our view that Northern Pulp and its predecessor companies that operated the pulp mill and effluent treatment system did inspections that would be considered acceptable to similar operations in Canada. Since 1994, the operators of the mill had used the same inspection company (Samson) to perform the inspection and repair to FRP and none of their repair work resulted in or contributed to subsequent leaks. The complicating factors in this situation include:

- The pipeline had not been under pulp mill ownership for all the time that the pipeline had been operation, so the complete history of repairs is unclear
- The original design and fabrication drawings/specifications are no longer available, so the joint details and therefore the integrity of the joints are not known. This makes planning for joint inspection and repair difficult
- The length of the pipe (from the mill to the effluent treatment plant at Boat Harbor) is unusually long, which presents a burden for inspection and repair
- Most of the pipe is underground or underwater which makes external inspection impossible (the underwater portion was replaced some years ago with fusion bonded HDPE pipe)

Given the above, it is our view that the frequency and methodologies of inspections (in person and remote video), as well as repairs that were done by Northern Pulp were consistent with what would be expected in similar operations.

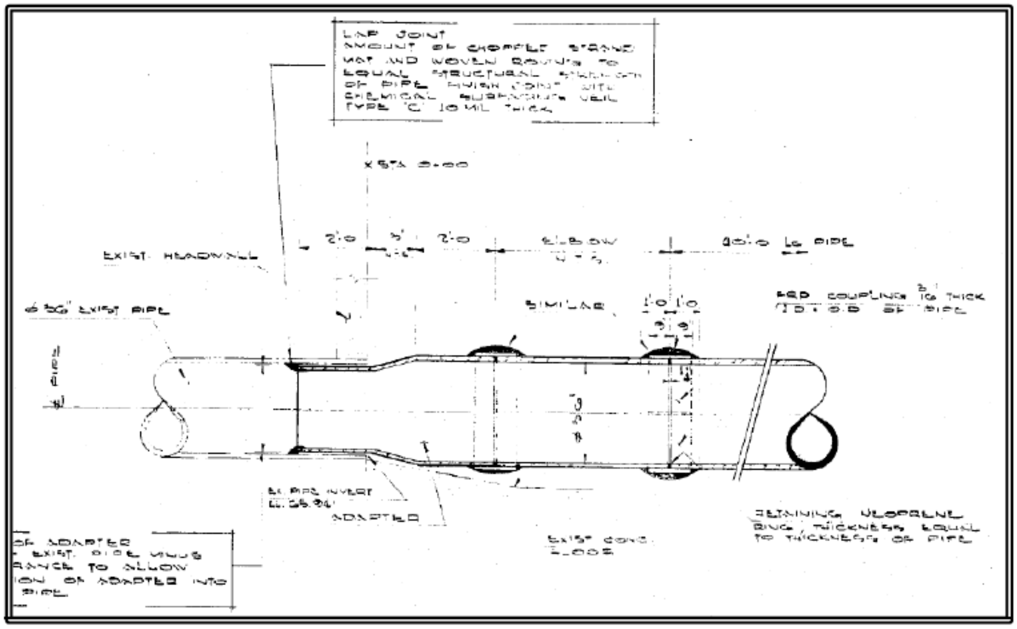

Figure 1. Excerpt from the BEAK drawing of 1972. This shows an unusual jointing detail.

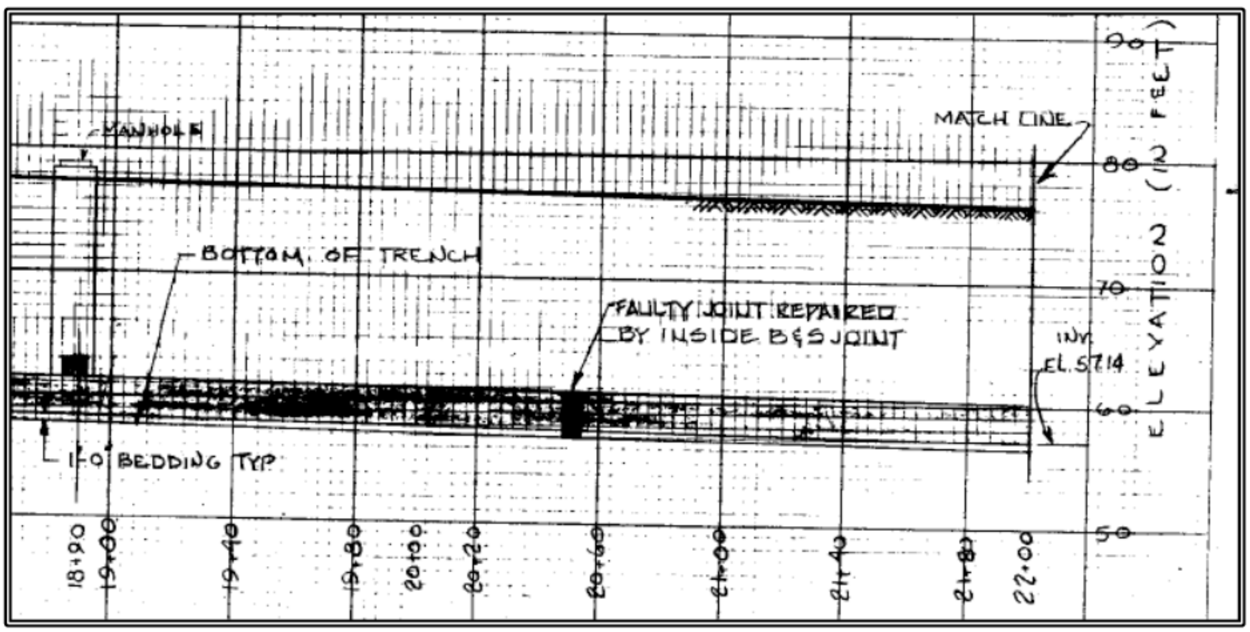

Figure 2. Excerpt from 1976 Montreal Engineering Drawing F63506 (01-060830-0018.pdf) that shows a "Faulty Joint" was repaired.

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3. Connors Diving Pipeline Inspection September 18-19 2014
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