

## ADVANCED APPLICATIONS FOR HDPE PIPES WITH NEW PE-RT MATERIAL

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### SHORT SUMMARY

Canfor's Prince George Pulp & Paper Mill in Prince George, BC, Canada operates a bleach plant effluent system for the production of Bleached Kraft Pulp. The original underground fiberglass reinforced pipe (FRP) presents an elevated risk to both environment and production targets. Over the past five years there have been over 10 repairs required to maintain integrity of the pipeline. The primary objective of the project was to create a more reliable pipeline and reduce the risk of a major leak event and subsequent consequences. With temperatures up to 75°C, standard PE4710 materials were not suitable for this application. A brand new PE-RT product that expands the use of PE into larger diameter industrial applications allowing continuous operating range from -45°C to 82°C with intermittent temperatures up to 95°C was selected to replace the underground fiberglass piping.

### KEYWORDS

PE-RT, HDPE, PE4710, Raised Temperature, Fiberglass, FRP

### ABSTRACT

Canfor, a producer of lumber, pulp and paper needed a solution to replace aging 30-inch (760mm) fiberglass reinforced pipe. A new PE-RT product now expands PE into industrial applications requiring resistance to high temperatures and having an HDB of 800psi at 180°F (82.2°C).

Through chemical processes, Canfor cooks, washes, and extracts pulp fiber from wood that results in both acidic and caustic effluent with temperatures normally in the 50-60°C range or as high as 70-75°C. Traditional brittle fiberglass pipes have experienced repeated joint failures over time, whereas heat-fused HDPE pipe provides solutions reducing unnecessary maintenance and a longer service life. Standard PE4710 HDPE pipes have pressure ratings limited to 140°F (60°C) and are not normally acceptable for such high temperature acidic and caustic effluent. Additionally, the potential for higher ORP's from residual chlorine levels and bleaching also justified turning to a different material based on the potential oxidative attack at high temperatures. The new PE-RT

Resin protects against oxidative attacks at high temperatures and the flexible heat-fused HDPE pipe provides considerable cost savings during installation. Compared to fiberglass, up to eight 40-foot lengths of HDPE pipe can be joined by heat fusion per day, whereas only one 6-meter length of FRP can be wrapped per day.

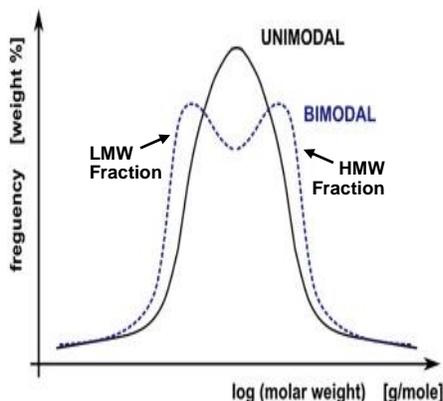
The presentation will highlight photos during the installation process and report the advantages of using the new pipe material. This project provides reference for expanding HDPE pipe into new applications using PE-RT materials.

## INTRODUCTION

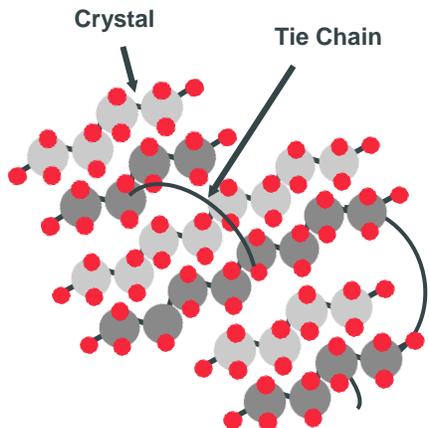
The adoption of new PE pipe materials has continued to evolve. In the United States, PE pipes are categorized by ASTM standards. In the early 1980's, PE3408 materials were introduced followed by more advanced PE4710 materials in 2005. Last year, another significant advancement occurred. New PE4710 PE-RT materials were introduced in the United States. A PE-RT material, Polyethylene of Raised Temperature Resistance, designation applies to PE materials that have an established HDB at 180°F (82.2°C) in the Plastics Pipe Institutes TR-4. TR-4 is PPI Listings for Hydrostatic Design Basis (HDB) For Thermoplastic Piping Materials or Pipe.

The new PE-RT materials are designed with bimodal resin technology. **Graphic 1** illustrates when dual reactors (versus one) are utilized to create PE resin with bimodal (two) molecular weight peaks to produce pipe resins that achieve excellent raised temperature performance – without the need for cross-linking. The new PE-RT material contains a greater number of high molecular weight chains than ordinary PE4710 materials. Higher molecular weight determines the durability of the material. Long-term strength, toughness, ductility, and fatigue resistance all improve as molecular weight increases. However, the higher molecular weight makes resins more difficult to process. The bimodal technology provides the ability for an increased number of high molecular weight chains while at the same time improving extrusion processability.

**Graphic 1: Shows Bimodal vs. Unimodal Property Distribution**



**Graphic 2: Shows the Molecular Structure of PE-RT Pipe**



In **Graphic 2**, tie chains in the high molecular weight fraction connect the crystalline structure in the polymer, which toughens the material and gives it superior strength at high temperatures. Through the use of additional co-monomer in the high molecular weight fraction, more tie chains are formed that make the resin tougher and more temperature resistant. New additive technology gives the new PE-RT material the oxidative resistance required for demanding applications.

## DISCUSSION

Canfor's Prince George Pulp & Paper Mill bleach effluent piping system conveys effluent from the plant to the Prince George biobasin. The main process effluent streams leading to the Prince George biobasin are:

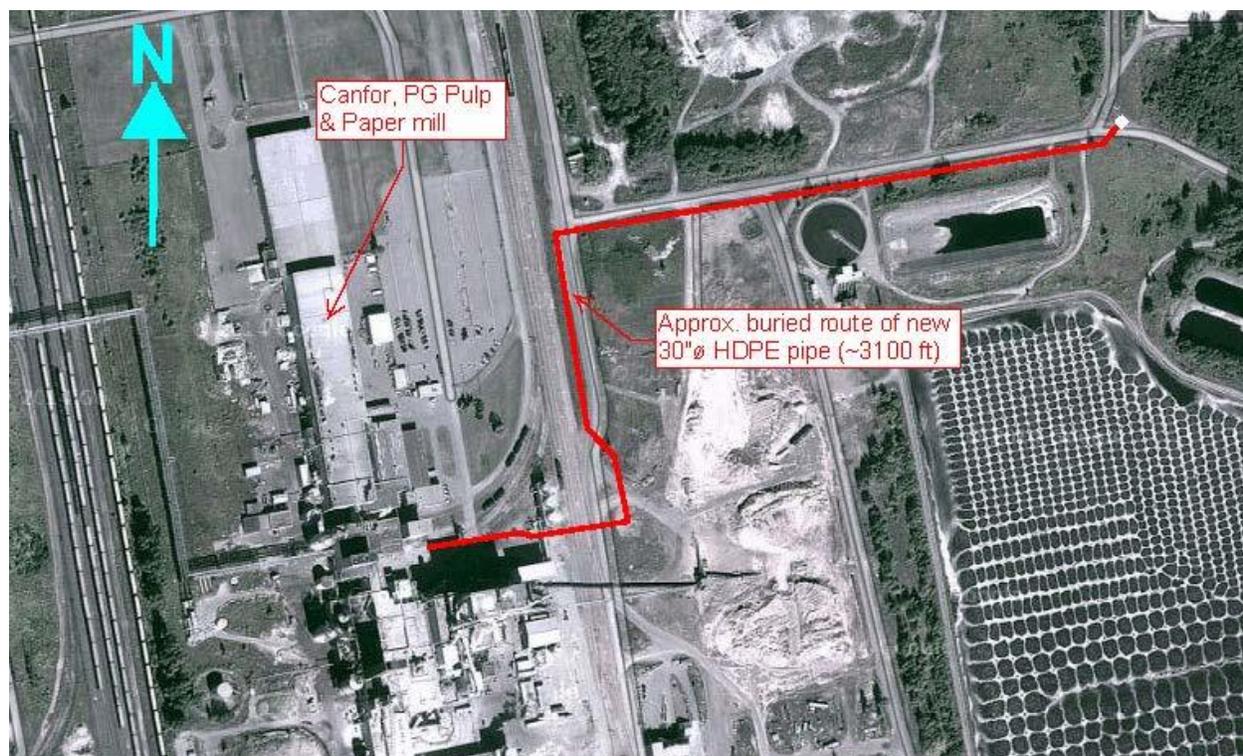
- bleach plant acid filtrate
- bleach plant caustic filtrate
- steam plant boiler feedwater acid and caustic effluents
- chemical containment basin effluent

Years ago the streams of process effluent were combined in a single 30 inch diameter buried fiberglass reinforced pipe (FRP). In the recent short term, there have been more than ten major repairs required to maintain integrity. In addition, there was a large line failure at the acid injection point location which resulted in a significant production curtailment to effect emergency line repairs. Recent failures in the buried piping can be attributed to pH excursions, to original improper pipe bedding and to original improper joint assemblies. The existing FRP piping showed evidence of spider cracking or complete inner delamination from the outer pipe wall.

Butt-and-wrap is the primary technology that has been used to join FRP pipe. In this method, two plain-end FRP pipes are abutted and a resin-saturated material is wrapped around the joint several times. In butt-and-wrap joints, the resin will become relatively hard within 4-6 hours, although most FRP pipe manufacturers recommend a 24-hour cure time before disturbing or testing the system. These resin-bonded joints are fairly easy to form in a shop or factory with controlled conditions, consistent climate, and trained personnel. However, in the field there are numerous variables that can affect the joining process. Weather plays an important factor. The colder the air, the longer the cure time, and at certain temperatures, curing can stop altogether. Also, the bonding surfaces and wrap material cannot be wet. If optimum conditions do not exist, installation crews must create an acceptable environment by creating shelter, using heaters, and blankets. Adequate conditions must be maintained throughout the 24-hour cure time to ensure a properly cured joint. Another variable that can be encountered in the field is the availability of skilled, trained installers to complete the joints.

With the effluent piping temperatures up to 75°C, the Prince George Mill decided to replace 3,200' of buried 30" FRP piping with new 30" PE-RT piping. The plot plan for newly installed 30" PE-RT pipe is shown in **Photo 1**.

**Photo 1: Shows Approximate Buried Route of New 30" PE4710 PE-RT HDPE Pipe**



**Photo 2: Shows Aging FRP Piping Replaced with New PE-RT Piping System**



**Photo 3: Shows Heat Fusion of New PE-RT Piping System**



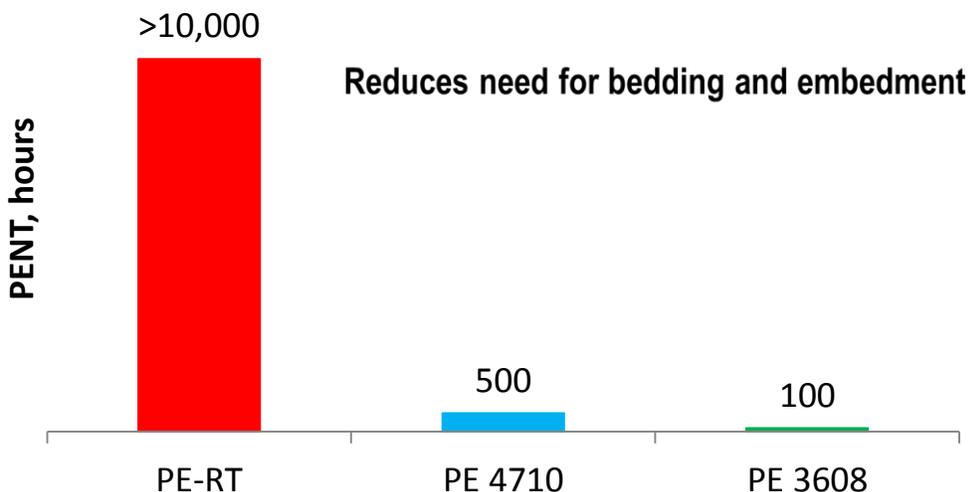
**Photo 4: Shows Heat Fused Joint of PE-RT Pipe**



The primary benefits of the project include the following:

- Significant installation cost savings were achieved replacing FRP with the new PE-RT
- PE-RT material costs were less than equivalent FRP material cost
- FRP was considered to be very fragile during handling with a more difficult and longer joining process. **Graphic 4** shows a comparison of FRP vs PE-RT joining times
- PE-RT was able to be quickly joined by heat fusion which creates a leak-free continuous monolithic pipe
- The same fusion procedures used for standard PE4710 were able to be utilized with the new PE4710 PE-RT pipes requiring no additional training for HDPE certified fusion technicians
- Fusion joint verification and documentation by data logger eliminated the need for most hydrostatic testing
- The new PE-RT material allowed the use of PE in this large diameter industrial application with ability for continuous operation up to 82°C and intermittent temperatures up to 95°C
- PE-RT liner was considered, but too many bends made this technique impracticable
- Underground installation of PE-RT piping adjacent to existing FRP piping allowed installation to occur during mill operation
- PE-RT could be heat fused eliminating joints and minimizing flanged connections
- PE-RT could be cold bent in the field eliminating many elbow fittings
- PE-RT pipes were available in a full range of pressure capabilities in sizes from ½" to 63" (1600mm), including molded & fabricated fittings
- **Graphic 3** shows where PE-RT provides greater than 20 times the slow crack growth resistance compared to PE4710 requirements

**Graphic 3: Shows Resistance to Slow Crack Growth**



**Graphic 4: Shows FRP vs PE-RT Joining Times<sup>1</sup>**

Hours vs Diameter	2"	3"	4"	6"	8"	10"	12"	14"	16"	20"	22"	24"	26"	28"	30"
FRP	0.5	0.7	0.9	1.2	1.8	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
PERT	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8	0.9	0.9	1.0

## CONCLUSIONS

The Prince George Mill used Allnorth Engineering located in Prince George, BC for their design and installation oversight and inspections. By having the engineering company on-site during construction, the communication between engineering and construction was greatly improved minimizing the number of change orders and associated costs.

Allnorth Engineering and Canfor reported that the material supply and field installation of PE-RT piping reduced the total project cost by 1/3 based on the following:

- PE-RT material costs less than equivalent FRP material cost
- PE-RT installation performed over 11 times faster than FRP
  - Eight to ten 50-foot pipe lengths PE-RT fusions completed per day
  - Two 20-foot pipe lengths butt-and-wrap joining completed per day

Canfor's Prince George PE-RT replacement project illustrates how new pipe material is changing the landscape of industries needing large-diameter, high-temperature, corrosion-resistant pipelines. This project serves as a catalyst for other industries where pipeline reliability is essential and existing pipeline materials are failing.

## ACKNOWLEDGMENTS

<b>Scott Curry</b> Canfor Pulp Prince George, BC, CA	<b>Jason McCannon</b> Allnorth Engineering Prince George, BC, CA	<b>Arlo Johnson</b> Allnorth Engineering Prince George, BC, CA
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## REFERENCES

<sup>1</sup>Pipe Design Considerations, Composites USA, Inc, and McElroy Manufacturing