ENERGY & ENVIRONMENTAL SERVICES

Lab Report

ASTM B117 Corrosion Test on EMC and Competitors' Coatings

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1. Summary

Endurobond, Competitor "A" and Competitor "B" coatings were subjected to the ASTM B117 salt spray test to measure their resistance to corrosion, and to measure the corrosion rate. 2"Ø x 4" coated pipe nipples along with an uncoated Steel pipe nipple were subjected to the salt spray test for ~3000h. The pipe nipples were photographed and weighed weekly to track their performance during the test. The Endurobond coating was found to perform the best out the pieces tested and did not lose any significant mass. Steel was found to perform the worst.

2. Objective

Two objectives were targeted for this test;

1.) To validate the efficacy of the Endurobond (EB) coating against a corrosive atmosphere.
2.) To measure the rate of corrosion on EB coating, Competitor "A" (CA) Epoxy Coated Pipe, Competitor "B" (CB) Epoxy Coated Pipe, and Steel (STL).

3. Equipment, Methods and Materials

Equipment used:

- Salt Spray Chamber – Custom Construction 30L aquarium with Foam Insulation.
- Plastic Standoff
- Plastic Misting Nozzles
- Peristaltic Pump (Hayward AC035)
- Tank Heater (Nat. Geo.)
- Balance (Denver Instruments)
- pH Meter with temperature probe (Mettler SevenPro)

Reagents:

- RO Water
- USP Sodium chloride (Honeywell)

Methods:

- ASTM B117-2011

4. Experimental Notes

Procedure:

Construction of Insulated Tanks:

ASTM document B117-11 was used for the design specification of the tanks and the spray architecture. 30L glass aquarium tanks were purchased and outfitted with opaque foam to aid in maintaining the temperature of the brine, and to keep out light that may have led to microbial growth. A PVC scaffold was constructed inside the tank to position the fog nozzles over the test pieces. A plastic standoff was placed inside the tank to keep the samples from coming into contact with the brine solution. A salt-water compatible immersion heater was placed in the bottom of the tank to heat the brine solution. A ceramic collector was placed near the heater to pick up warm brine water and PVC lines were run to a peristaltic pump to supply the misting nozzles.

Preparation of Tanks:

A 5% solution of brine was made with USP grade Sodium chloride by measuring the salt and dissolving into RO water. The tanks were filled with brine water ~1" from the top of the standoff and ran for 1 day to check for pH and temperature of the brine. Adjustments were made with high purity NaOH as specified in the ASTM document.

Preparation of Samples:

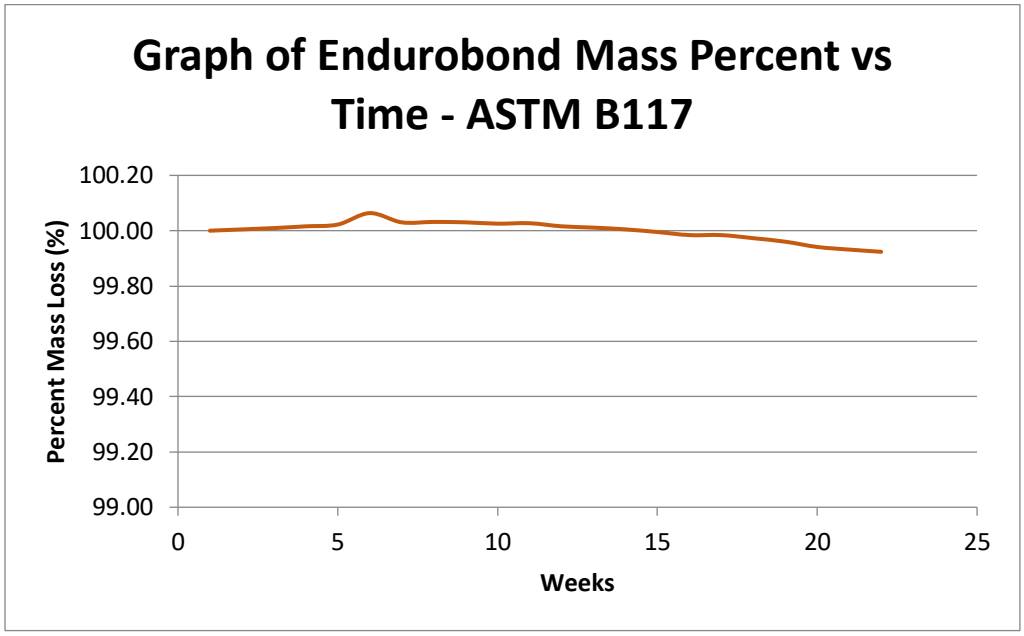
The test pieces were washed with 1% Tergazyme, rinsed with RO water, and dried with paper towels. The washed pieces were placed on the dehumidifier vent for ~5 min to allow them to come back to room temperature before weighing. The test pieces were weighed and photographed. The test pieces were then placed into the salt spray chamber, and the misting nozzles were adjusted to be parallel to the long side of the pipe nipples, and for the spray cone to contact the top of the pipe (≤1/4" from the top) and drip down the inside.

Records and Adjustments:

Following the ASTM protocol, the salt spray chambers were checked every day, once a day, Monday – Friday to ensure that pH, temperature, and solution levels were maintained. A 5% Sodium chloride solution was prepared and added as needed. The pH was adjusted primarily with 1M NaOH solution. The pH and temperatures were recorded in a log for each sample chamber every day. On Mondays, the test pieces were removed from the chamber, photographed, washed, and weighed. They were then returned to the sample chamber within an hour of removal to continue the test.

Endurobond Results

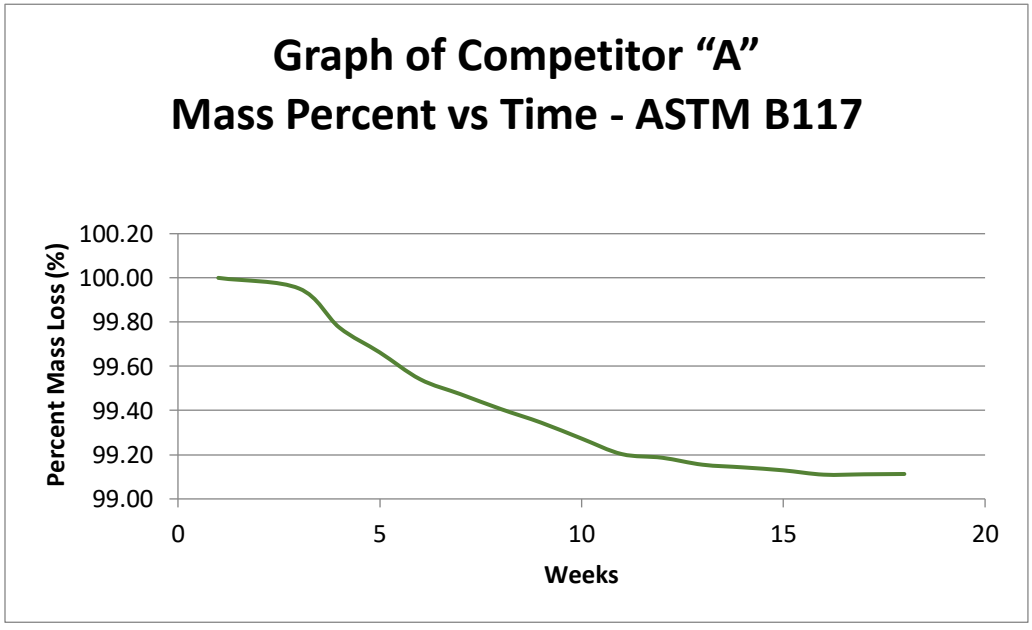
A graph of the percent mass change over time was constructed using the collected data. It can be seen in the figure below.



The graph shows an overall negligible loss in mass over the course of the test. A slight increase in mass was observed starting at week three. It finally lost a small amount of mass after 15 weeks. Threads were coated.

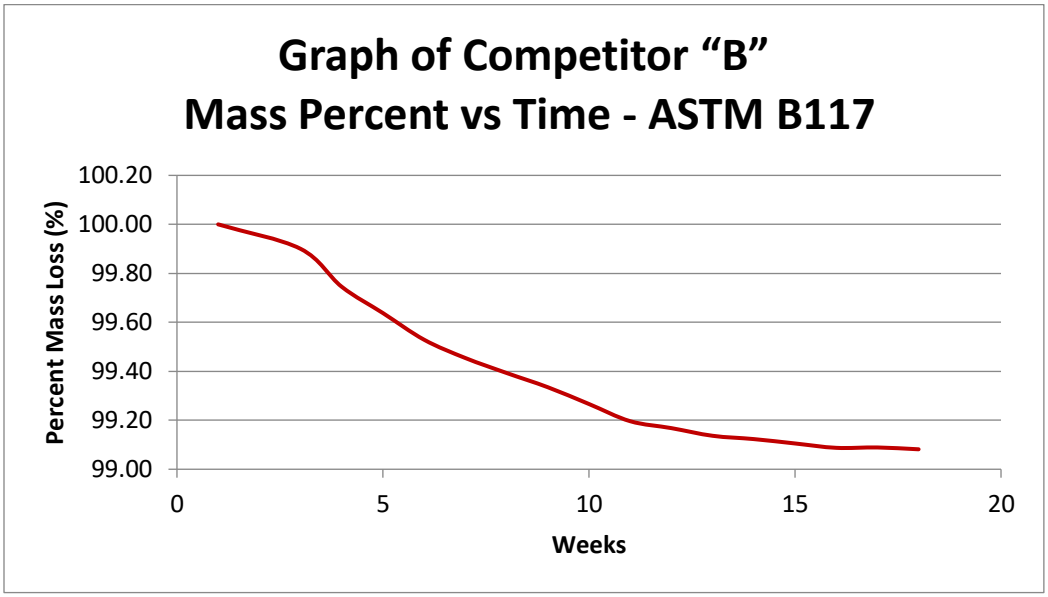
Competitor "A" Results:

A graph of the percent mass change over time was constructed using the collected data. It can be seen in the figure below. Mass was lost through the uncoated threads.



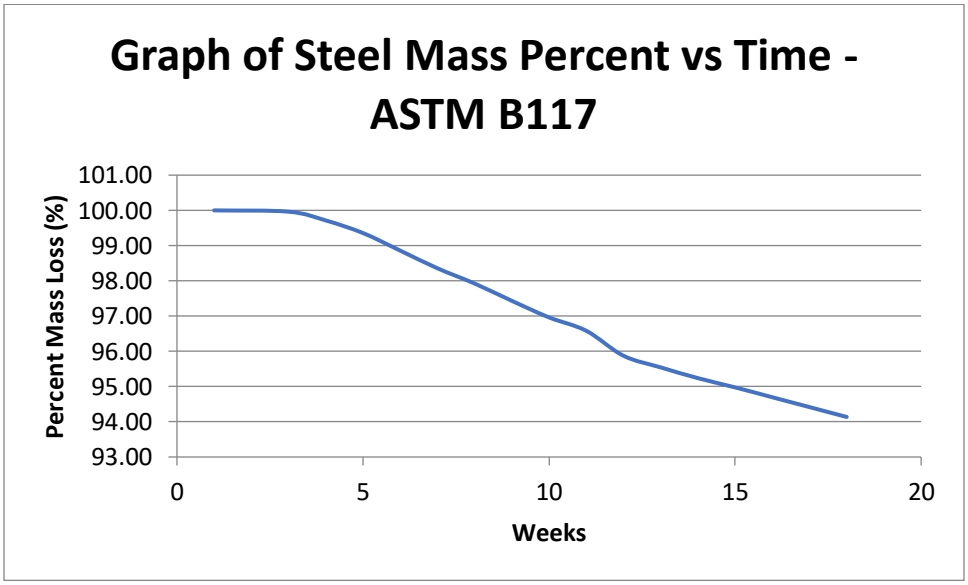
Competitor "B" Results:

A graph of the percent mass change over time was constructed using the collected data. It can be seen in the figure below. Mass was lost through the uncoated threads.



Steel (Control) Results:

A graph of the percent mass change over time was constructed using the collected data. It can be seen in the figure below.



The Steel was observed to corrode within the first week of testing. At week 4, while the steel was being cleaned for weighing and inspection, there was sub-surface (bulk) oxidation that could not be removed from the interior and exterior of the pipe. This extra mass will slightly decrease the observed rate of mass loss. It is notable that the bulk oxidation probably results in weakening of the Steel under pressurized applications.

5. Conclusions

Coating Efficacy

All of the coatings, were effective at reducing corrosion of the test pipe. The following table shows the ranking of the coatings from the best performers to the worst.

Rank	Coating	Notes
1	Endurobond	Performed well, slow mass loss after ~17 weeks.
2	Competitor “B”	Performed well, corrosion of the threads and subsequent mass loss.
3	Competitor “A”	Performed well, corrosion of the threads and subsequent mass loss. Bubble.
4	Steel	Performed poorly, steel corroded and flaked, experienced bulk oxidation.

The ranking was based on mass loss or gain, followed by physical appearance, respectively. The Endurobond performed the best of the three and had almost no change in mass.

Competitor “A” and the Competitor “B” were ranked almost exactly the same, but the Competitor “A” had a bubble in the internal part of the coating that made it come in 3rd. Both of these respective coatings were able to resist mass loss where the coatings were applied, but the uncoated threads oxidized within the first week and lead to a mass loss.

The Steel pipe served as a control. It corroded within the first week and showed significant mass loss within three weeks. Within four weeks there was a formation of bulk oxidation that could not be removed with cleaning. Because of this, it brought into question the structural integrity of the pipe. With bulk oxidation that cannot be removed, the pressure rating of the pipe begins to be called into question.

Corrosion Rate

The data collected from the experiment were used to construct graphs of mass percent versus time. The following figures compare each coating to Steel.

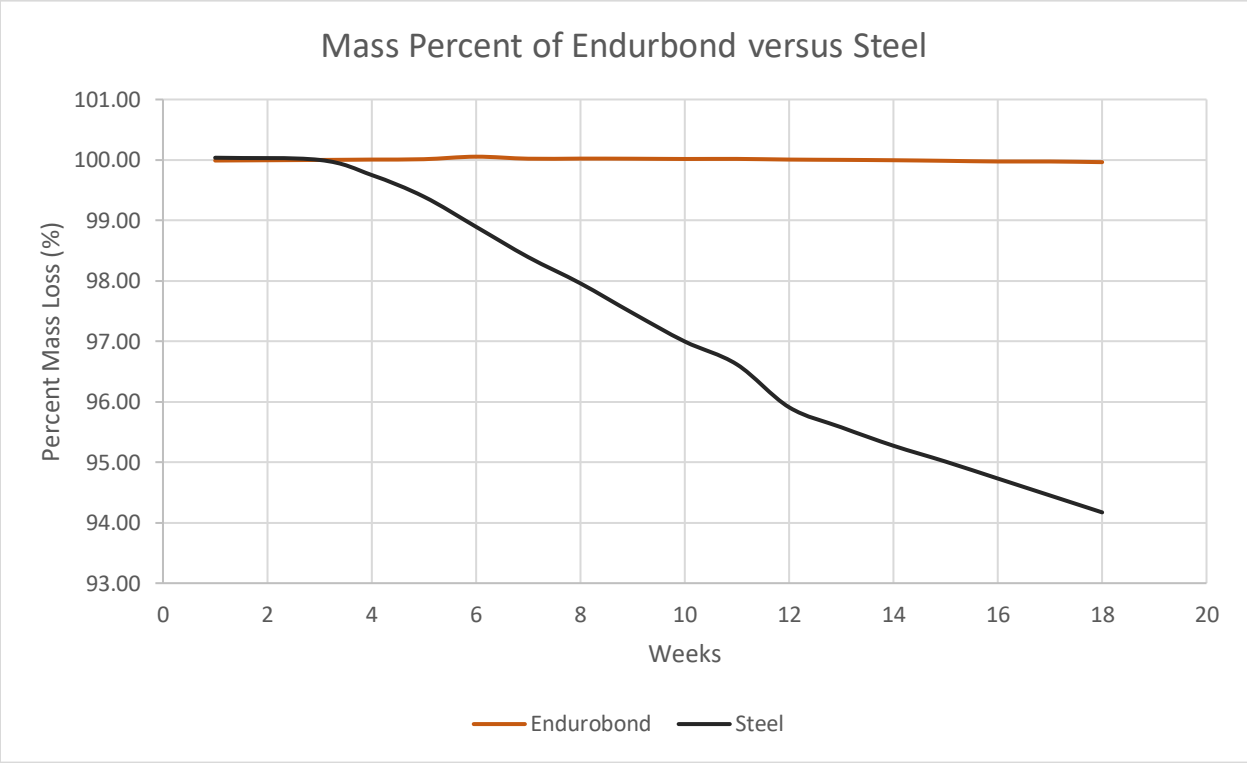


Figure 71: Endurobond versus Steel. Observed loss of mass for Steel was 2.78g/168h after week 4.

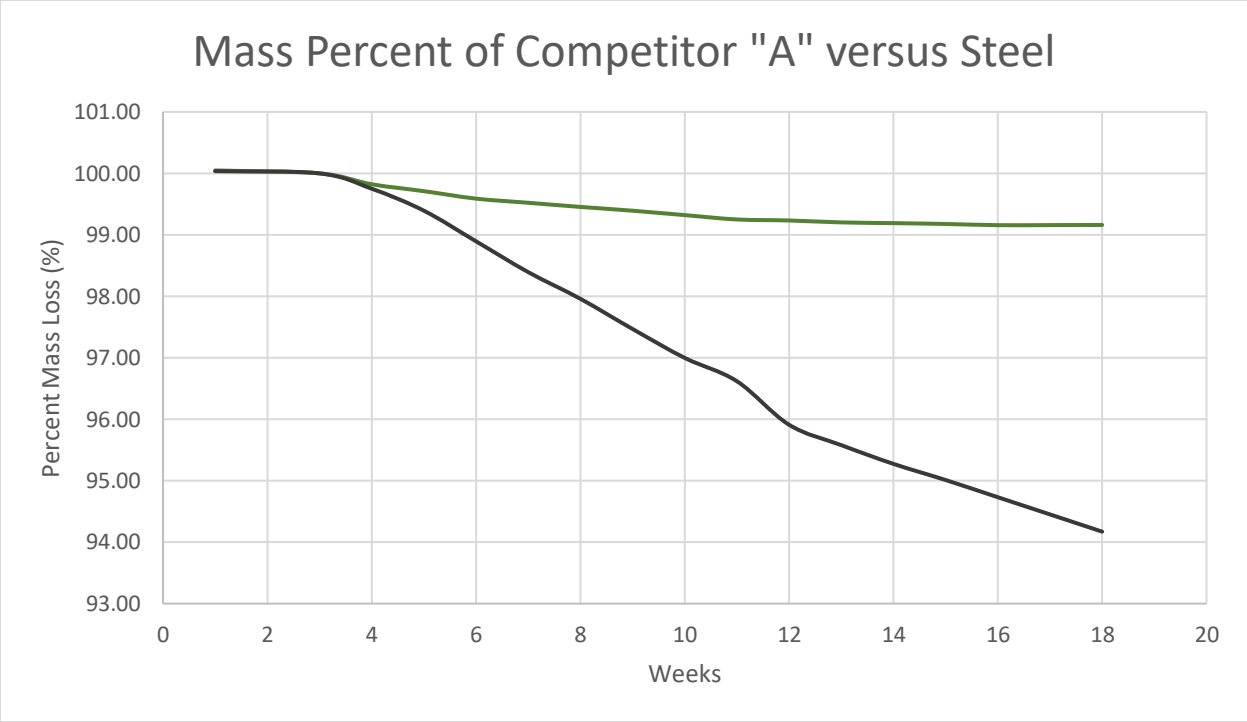


Figure 72: Competitor “A” versus Steel. Observed loss of mass for Steel was 2.78g/168h after week 4 and the Competitor “A” was 0.26g/168h with an exponential decrease in mass loss.

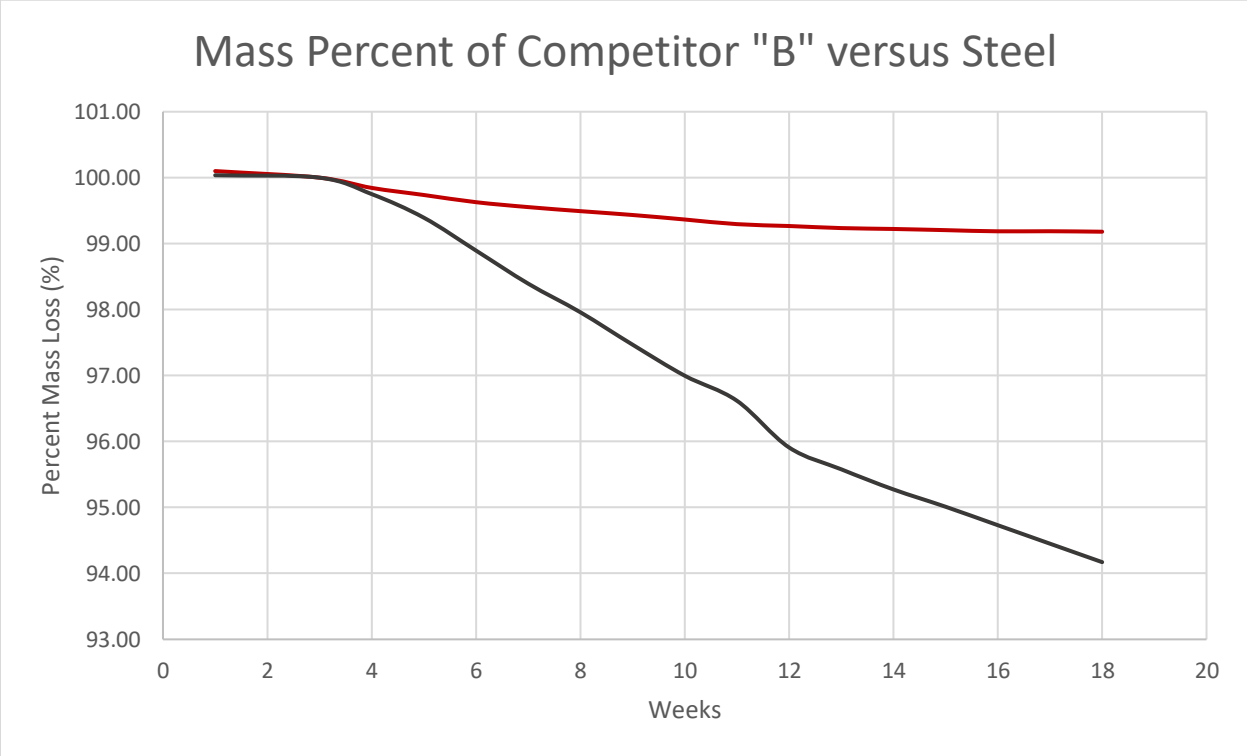


Figure 73: Competitor “B” versus Steel. Observed loss of mass for Steel was 2.78g/168h after week 4 and the Competitor “B” was 0.27g/168h with an exponential decrease in mass loss.

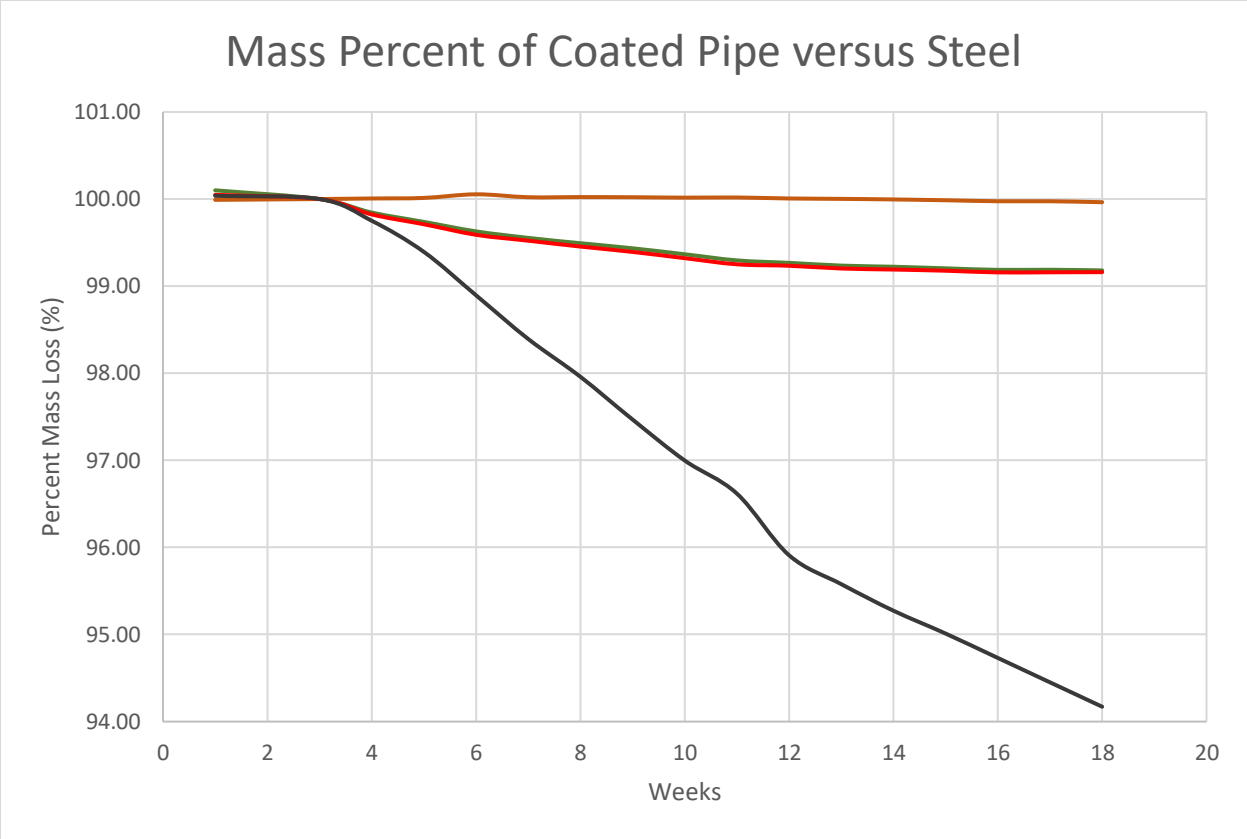


Figure 74: Coated Pipe versus Steel.

The corrosion rates (kinetics) were determined by fitting a model to the mass data excluding the first three weeks of data since this showed an inflection point. Data for Corvel and Dupont was calculated by Equation 1 (pg. 50). The following table lists the corrosion rates fitted to the experimental data.

Coating	**Corrosion Rate (g/168h)**	**Notes**
Endurobond	0.043	Linear regression.
Competitor “A”	0.26	Exponential decay, t=1
Competitor “B”	0.27	Exponential decay. t=1
Steel (Uncoated)	2.78	Linear regression.