

FINAL REPORT
R335-01

**INVESTIGATION OF THE SHIELDING BEHAVIOR
OF TWO PIPELINE COATING SYSTEMS**

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INTRODUCTION

Standard tape wrap coatings can provide corrosion protection for pipelines but generally do not allow cathodic protection current to pass through them, creating an undesirable condition in which steel under disbonded tape will have no corrosion protection because the tape shields the steel from the CP current. This work was designed to determine if Polyguard RD-6 coating system shields CP relative to a “standard” pipeline tape such as Polyguard 610.

EXPERIMENTAL PROCEDURE

Two separate tests were set up in order to measure the amount of CP current passing through the tape and/or overlap joints, determine the change in local environment under the tape and/or overlap joint, and analyze the pH behavior of the local environment. Task 1 used flat round plates with machined voids to facilitate electrochemical measurements; Task 2 used wrapped pipe sections with machined grooves to provide more realistic lap joints for test.

Task 1 – Lap Joints on Machined Plates

The purpose of Task 1 was to make detailed electrochemical measurements through a tape-coated plate sample, into which a shallow void was machined to simulate a disbonded region under an otherwise intact pipeline tape.

Four different test cells were set using the supplied test cells, Polyguard 600 primer, and the two different coatings (RD-6 and 610). A cut-away diagram of the setup is shown in Figure 1. A photo of the basic cell setup is shown in Figure 2.

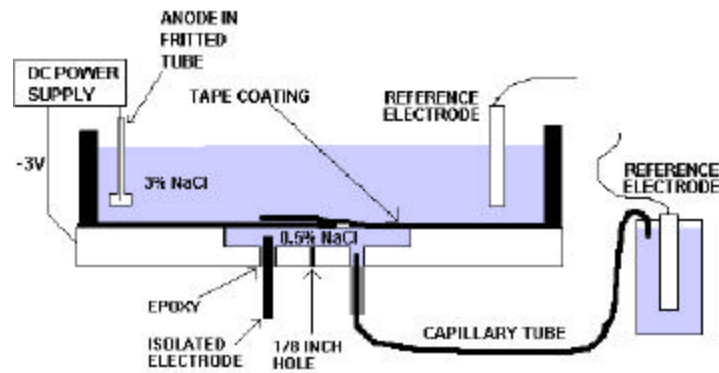


Figure 1. A schematic of the setup used for each of the 4 cells.

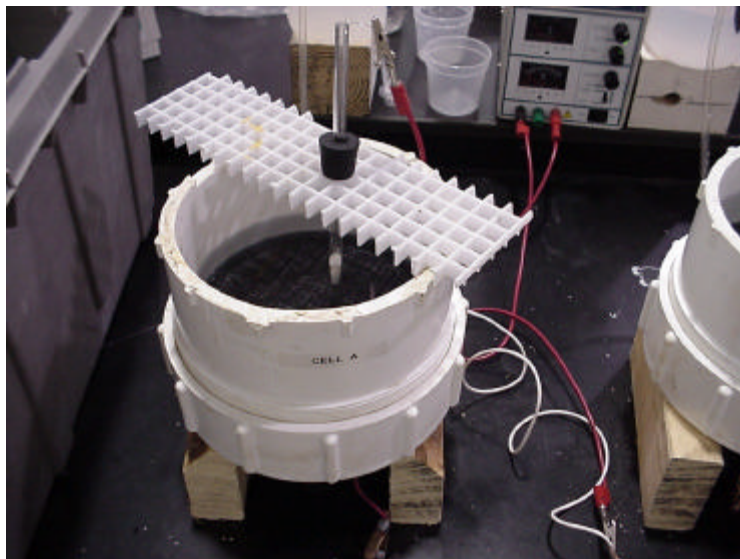


Figure 2. The setup of Task 1 showing Cell A attached to a power supply. And this is how it will look for 2 or more lines of a detailed caption.

Cell A consisted of RD-6 coating system with no existing lap joint over the void. Also, the primer was not applied to the area within the void. (Does CP pass directly through the tape?)

Cell B consisted of RD-6 coating system with a one-inch lap joint over the void and again no primer was applied to the area within the void. (If it cannot pass through the tape in (A), does it pass through the lap joint?)

Cell C consisted of RD-6 coating system with a one-inch lap joint over the void; however the primer was applied to the area within the void. (With minimal surface area to protect under the lap joint, is there still evidence of CP passing?)

Cell D consisted of 610 tape coating with a one-inch lap joint over the void and no primer was applied in the area within the void. (Does a lap joint in the standard polyethylene tape also allow CP current?)

Setup Procedure for Task 1

1. The supplied metal discs were abrasive blasted (black beauty medium abrasive) to a near white finish with an anchor profile of 2-4 mils.
2. After blasting, a 1/8 inch hole was drilled into the void area of the metal discs to enable air to escape while filling the void. The existing 1/4" threaded holes in the center of the metal discs were cleaned using a 1/4 inch NPT drill tap by hand.
3. The metal discs and PVC test apparatuses were de-greased with methanol to clean the surfaces.
4. A carbon steel rod was epoxied into one of the existing tapped holes in order to create an isolated electrode for electrochemical measurements. The isolated electrode was checked to ensure electrical isolation using a resistance meter.
5. A wire was then spot welded to the metal disc on the side without the void to connect the cathodic protection system.
6. Polyguard 600 primer was applied to the raised surface of the discs on the void side for all four cells. Cell C also had the primer applied within the void as specified above.

On several occasions, the connection between the void and the 0.5% NaCl solution in the 100 ml beaker was blocked by an air gap within the capillary tube. To reconcile the situation, a syringe was inserted into the capillary tube (between the air gap and the void) and 0.5% NaCl solution was injected into the tube. As a result, the air was forced out of the capillary tube and into the container with the 0.5% NaCl solution.

Measurement Procedures for Task 1

The measurements for Task 2 were taken using the following procedure:

Potential Readings (for both the : 3% and 0.5% NaCl solutions)

The potentials were measured by placing an electrode in both the 3% NaCl solution and the 0.5% NaCl solution. A Fluke Multimeter and buffer were attached to the electrode and negative connection of the power supply.

Current Readings

The current readings were measured by using a Fluke Multimeter and a zero resistance ammeter (ZRA). First, the negative connection to the power supply was broken and attached through the ZRA. Then, the other ZRA lead was attached to the isolated electrode thus providing a current path measuring current down to 1 microamp.

pH Measurements

pH measurements were taken after 14 days using a pH probe (Corning pH meter 140). These measurements were taken in the following locations: the 3% solution above the coating, the void solution that was originally 0.5% NaCl, and the 0.5% NaCl solution of the salt bridge.

Task 2 – Wrapped Pipe Samples

Task 2 consisted of 4 pipe samples to determine the permeability of the tape to CP current as-wrapped. The pH under RD-6 and 610 coatings placed over wet pipe surfaces, with and without primer, were monitored.

Setup Procedure for Task 2

Four 18-inch long, 3-inch diameter carbon steel pipes were used to test the pH under Polyguard's RD 6 and 610 tape coatings. The following procedures were used in the setup of Task 2:

1. Each of the four 18-inch long, 3-inch diameter carbon steel pipes had 4 grooves (~1/8" deep) machined into them using a Dremel tool.
2. The pipes were abrasive blasted with black beauty abrasive medium to obtain a near white finish with an anchor profile of 2 to 4 mils.
3. An insulated copper lead wire was cad-welded onto each of the pipes.
4. The pipes were de-greased using methanol.
5. Two of the four pipes were primed using the supplied Polyguard 600 primer. Primer was not allowed to coat the inside of the machined grooves.

A photograph of the setup for Task 2 can be seen in Figure 3.



Figure 3. The four 18-inch long, 3 inch diameter pipes coated in either RD-6 or 610 coatings and submerged in 3% NaCl solution for Task 2.

Measurement Procedure for Task 2

The measurements for Task 2 were taken using the following procedure:

Potential Readings

The voltage being applied to the 4 pipes was measured daily at 3.0 volts. These measurements were not recorded; however, if the measurement taken was <2.9 volts or >3.1 volts, the output of the power supply was adjusted back to 3.0 volts.

pH Measurements

The pH of the water within the machined grooves was measured after 14 days of testing using pH paper.

RESULTS AND DISCUSSION

Task 1 Data

The tabular data from Task 1 is shown in Tables 1 and 2. The initial pH of the 0.5% NaCl solution was 6.9.

Table 1. The recorded potentials and current values for Cell A through D.

(a) RD6 tape, overlap not over void area

Cell A			
	Voltage in electrolyte above tape wrap (simulated groundwater)	Voltage measured in void area	Current measured from isolated electrode to reference electrode
Date	(-VCSE)	(-VCSE)	(10 ⁻⁶ Amps)
1/17/01	-	0.727	-
1/18/01	-	0.76	-
1/19/01	-	0.746	0.2
1/22/01	3.028	0.726	0
1/23/01	3.033	0.744	0
1/24/01	3.021	0.737	0.708
1/25/01	3.026	0.739	0
1/26/01	3.020	0.735	0.682
1/29/01	3.020	0.736	0.647
1/30/01	2.439	0.727	0.843

(b) RD6 tape, overlap over void area, void unprimed

Cell B			
Date	3% (-VCSE)	0.5% (-VCSE)	Current (10 ⁻⁶ Amps)
1/17/01		0.799	-
1/18/01		1.018	-
1/19/01		0.89	0.4
1/22/01	2.480	0.871	0.200
1/23/01	2.506	0.941	282
1/24/01	2.601	0.872	235
1/25/01	2.904	0.923	260
1/26/01	2.898	0.896	280
1/29/01	2.739	0.990	630
1/30/01	2.924	0.941	720

(c) RD6 tape, overlap over void area, void primed

Cell C			
Date	3% (-VCSE)	0.5% (-VCSE)	Current (10 ⁻⁶ Amps)
1/17/01	-	0.874	-
1/18/01	-	1.024	-
1/19/01	-	1.062	0.4
1/22/01	3.600	0.783	170
1/23/01	3.077	0.802	125
1/24/01	3.066	0.68	125
1/25/01	2.820	0.687	362
1/26/01	2.847	0.943	234
1/29/01	2.996	1.006	207
1/30/01	3.131	0.793	250

(d) 610 tape, overlap over void area, void unprimed

Cell D			
Date	3% (-VCSE)	0.5% (-VCSE)	Current (10 ⁻⁶ Amps)
1/17/01	-	0.68	-
1/18/01	-	0.709	-
1/19/01	-	0.719	0.5
1/22/01	3.010	0.711	0.700
1/23/01	3.043	0.724	0.313
1/24/01	2.991	0.713	0.002
1/25/01	2.969	0.711	0.000
1/26/01	2.994	0.713	0.605
1/29/01	2.990	0.709	0.001
1/30/01	3.031	0.73	0.001

Table 2: The recorded pH values and chloride concentration for Cells A through D.

pH and Chlorine Concentrations	Initial Values	Tear Down results from 1/30/01			
		Cell A	Cell B	Cell C	Cell D
pH of 3% NaCl Solution	5.9	4.16	8.45	8.71	4.31
pH of the Salt Bridge	6.9	6.3	7.88	8.18	5.93
Choloride Concentration of 3% NaCl Solution	3%	>1%	>1%	>1%	>1%
Chloride Concentration of the Saltbridge	0.50%	0.90%	0.70%	0.70%	0.70%
pH of the Void	6.9	6.45	11.27	10.64	9.72
Chloride Concentration of the Void	0.50%	0.52%	0.78%	0.90%	0.57%

A plot of the amount of current evidenced is shown in Figure 4.

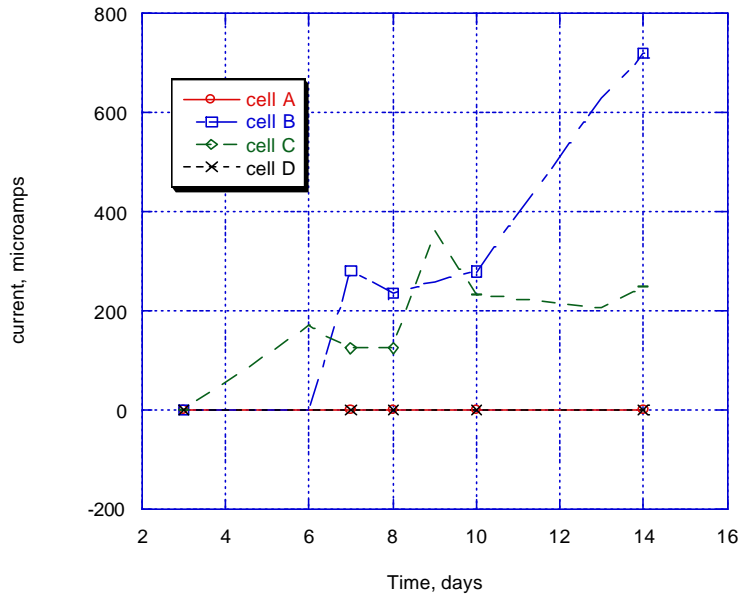


Figure 4. Current readings as a function of time through different tape joints.

Task 2 Data

The results from Task 2 were inconclusive. In all four cases, there was evidence of an increased pH in the machined channels, indicating cathodic protection on the pipes through the coatings. In most cases, the chloride levels measured in the machined channels were higher than could be measured with the indicator strips, indicating that the 3% NaCl water from the bath was able to migrate through the lap joints.

It is likely that, because the wrapping was done by hand on small pipe sections, the tape did not receive adequate stretch and thus the lap seals were not tight in all cases. Thus, water was free to migrate through all lap joints and along the channel under the lap seam in most cases. Thus while CP current was shown to pass through these joints, the integrity of the lap joint was breached to such an extent that any subtleties resulting from the passage of CP current along the RD-6 fibers were masked by the wholesale migration of water through unsealed locations in the lap joints.

Observations During Testing

In Task 1 during the insertion of the 0.5% NaCl solution into cells B and C, a few small droplets of water appeared to leak through the lap joint. This indicated that the lap joint seal was not completely water-tight from the start, providing an preferred path for current.

Bubbles appeared on the surface of the tape in Cell B, which did not have the void primed and was coated with RD-6 system (see Figure 5). Presumably this was hydrogen outgassing due to the cathodic reaction at the surface. The combination of high surface area of the unprimed void and the successful application of CP to this void resulted in the excessive amount of hydrogen production which was evidenced. In the sample where the void was primed, the smaller surface area for the cathodic reaction on the steel resulted in less hydrogen being produced, thus bubbles were not evident.

The lap joint in the 610 tape (Task 1 activity only) began to separate late in the test (see Figure 6). Since the coating application over the flat test specimen did not allow for the proper spiral tension, as would be present if the coating were properly wrapped around a pipe, more pressure or weight for a longer period of time may have been required to provide a better seal. However, this did not appear to cause any leakage when the data from Table 1d is examined.

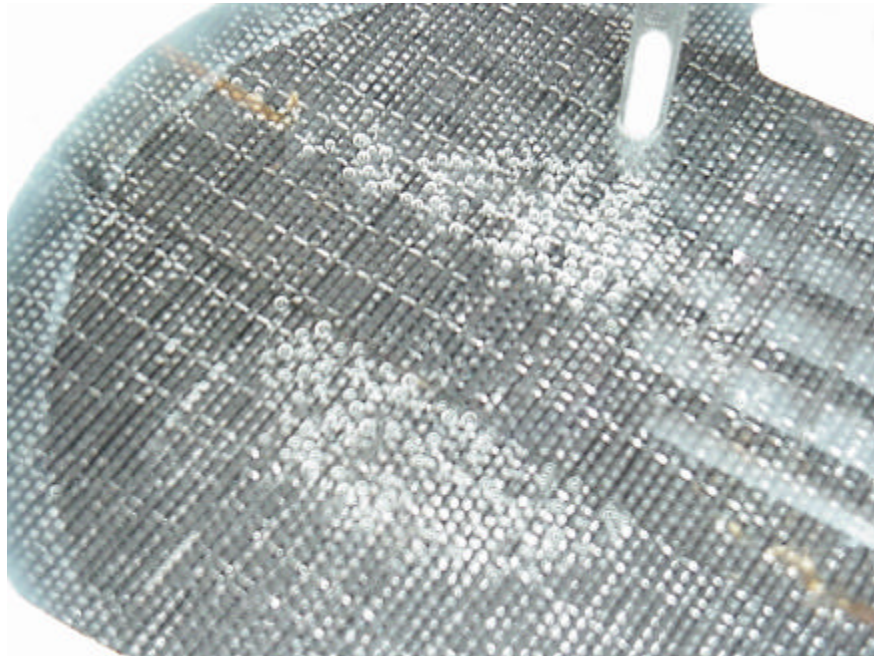


Figure 5. Bubbles framing the lap joint region over the void in Cell B.



Figure 6. The lap joint in Cell D coated with 610 tape, showing partial joint separation.

CONCLUSIONS

The RD-6 coating system was found to allow CP current to migrate through the overlap area from the anode to the steel underneath the overlap. This was confirmed from the fact that the pH was changed during the test from an original 6.9 to 11.27 and 10.64. CP current measured from the isolated electrode to the reference electrode and increased potentials in the voids also confirms CP current was being provided. The mechanism by which the current migrates to the void is not totally understood at this time, but the fibers in the RD-6 geo-textile fabric are thought to be critical to this process.

This protection appears to only occur through the RD-6 overlap. On the RD-6 coating system sample, without the overlap, the pH did not change as significantly and the potentials remained constant in the void. The overlap of the solid polyethylene backed 610 tape system was absent of this current path in the overlap, resulting in CP shielding. The test results of the 610 tape show the pH actually became somewhat more acidic and the potentials had no significant changes.

These test results should be confirmed with other tests and field results. If further testing confirms these results, the RD-6 coating system product would provide a path for CP current to protect under the coating overlap if failure of the product or poor application were to allow water between the coating and the steel pipe.