Public Quarterly Report

Date of Report*:* 3rd Quarterly Report – June 30, 2023
Contract Number: 693JK322RA0001
Prepared for: US Pipeline and Hazardous Materials Safety Administration
Project Title: Rapid Ultraviolet (UV) Cured Adhesive for Gas Main Cured-in-Place-Lining (CIPL)
Prepared by: Progressive Pipeline Management
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For quarterly period ending: June 30, 2023

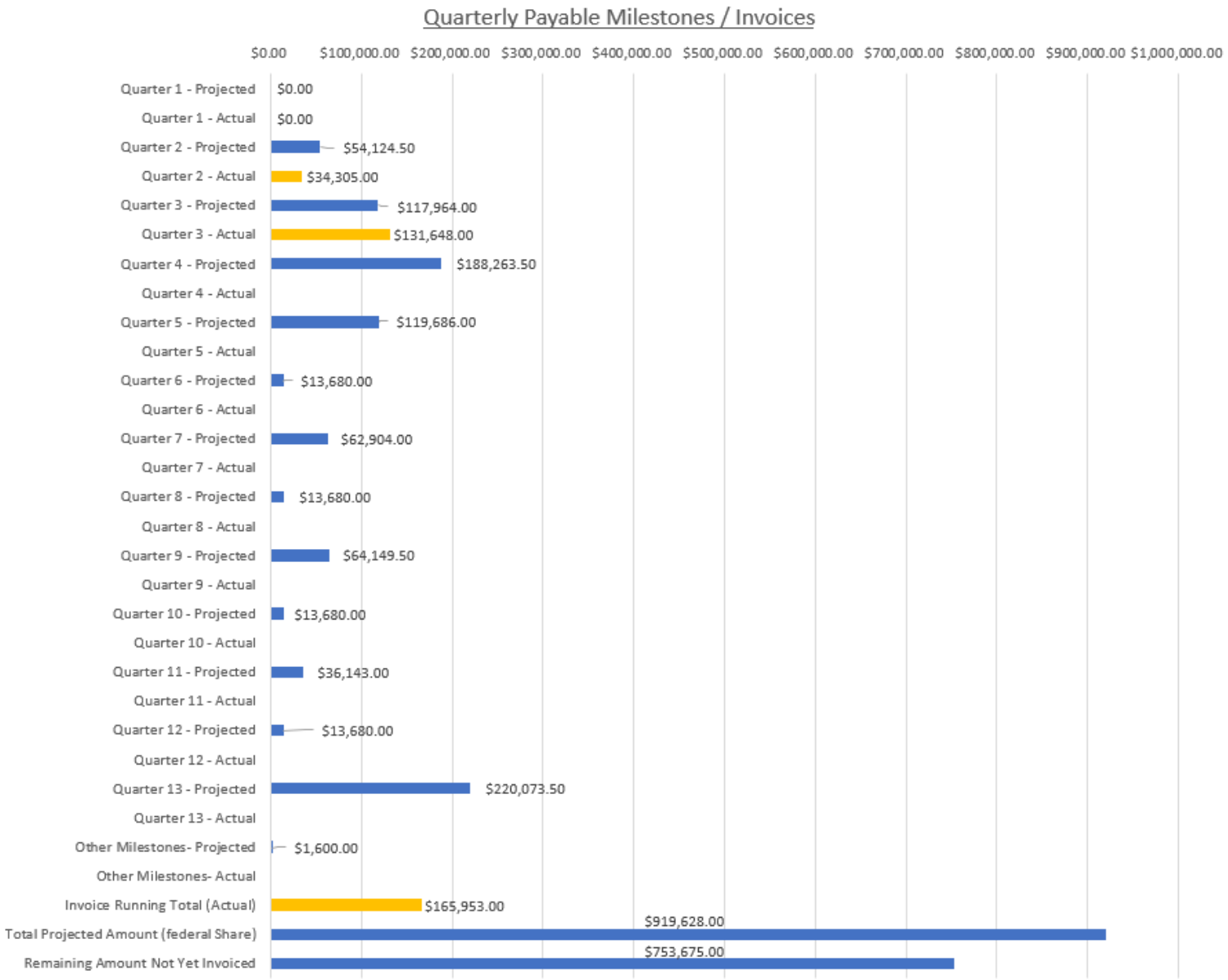
1: Items Completed During this Quarterly Period:

Item #	***Task #***	***Activity/Deliverable***	***Title***	***Federal Cost***	***Cost Share***
5	5	ASTM D543 Chemical Resistance with chemicals from ASTM F2207	ASTM D543 Chemical Resistance with chemicals from ASTM F2207	$19,819.50	$19,819.50
8	8	Initial Testing of Adhesive & Liner Plate Samples	Initial Testing of Adhesive & Liner Plate Samples	$-	$-
9	3	Conduct in-house preliminary coupon testing (Adhesive & Liner) - Cure - UV light intensity, wave length and light penetration of liner (5 coupons per adhesive version) - ASTM D2240 Hardness (5 coupons per adhesive version) - ASTM D4541 Pull off strength testing using steel plate (5 coupons per adhesive version)	Conduct in-house preliminary coupon testing (Adhesive & Liner) - Cure - UV light intensity, wave length and light penetration of liner (5 coupons per adhesive version) - ASTM D2240 Hardness (5 coupons per adhesive version) - ASTM D4541 Pull off strength testing using steel plate (5 coupons per adhesive version)	$1,125.00	$1,125.00
10	9	Prepare and ship coupon samples for initial testing - Prepare 15 coupons per adhesive version	Prepare and ship coupon samples for initial testing - Prepare 15 coupons per adhesive version	$600.00	$600.00
12	11	ASTM D3167 Peel Resistance (5 coupons per adhesive version - up to 15 samples)	ASTM D3167 Peel Resistance (5 coupons per adhesive version - up to 15 samples)	$2,045.00	$2,045.00
13	12	Internal Vortex meetings to update on progress (2hr x 4 ppl) - Review of results & Circle back to Task 2.1, if needed	Internal Vortex meetings to update on progress (2hr x 4 ppl) - Review of results & Circle back to Task 2.1, if needed	$14,400.00	$14,400.00
14	13	Prepare and ship adhesive for bench testing to PPM (2x40ft @ 8"x6mm)	Prepare and ship adhesive for bench testing to PPM (2x40ft @ 8"x6mm)	$1,064.50	$1,064.50
15	14	Travel to PPM for bench testing phase 1	Travel to PPM for bench testing phase 1	$950.00	$950.00
16	15	Optimize PPM light train speed & intensity - Radiometer and Cure Chart	Optimize PPM light train speed & intensity - Radiometer and Cure Chart	$1,500.00	$1,500.00
17	16	Radiometer Utilization	Radiometer Utilization	$350.00	$350.00
18	17	Review results of initial testing of adhesive with Vortex	Review results of initial testing of adhesive with Vortex	$16,457.00	$16,457.00
19	18	UV Light Train Utilization (i.e. equipment upgrades)	UV Light Train Utilization (i.e. equipment upgrades)	$59,657.00	$59,657.00
20	7	3nd Quarterly Status Report & Data Analysis	3nd Quarterly Status Report & Data Analysis	$13,680.00	$13,680.00

2: Items Not-Completed During this Quarterly Period:

Item #	*Task #*	*Activity/Deliverable*	*Title*	*Federal Cost*	*Cost Share*
11	10	ASTM D790 Flex Mod/Strength (5 coupons per adhesive version - 15 samples) ASTM D638 Tensile (5 coupons per adhesive version - 15 samples) ASTM D695 Compression Strength (5 coupons per adhesive version - 15 samples)	ASTM D790 Flex Mod/Strength (5 coupons per adhesive version - 15 samples) ASTM D638 Tensile (5 coupons per adhesive version - 15 samples) ASTM D695 Compression Strength (5 coupons per adhesive version - 15 samples)	$6,135.50	$6,135.50

3: Project Financial Tracking During this Quarterly Period:



4: Project Technical Status –

Item No. 5.5 (ASTM D543 Chemical Resistance with chemicals from ASTM F2207)

Three ultraviolet cure adhesives were developed by Vortex. These adhesives are UVMH, UVL200, and QCUV. The adhesives were manufactured into 0.125in thick dogbone coupons for future tensile testing. Chemical reagents used are listed in Table 1 of "ASTM F2207-19: Standard Specification for Cured-in-Place Pipe Lining System for Rehabilitation of Metallic Gas Pipe", minus Mercaptan to manage project cost. These are: distilled water (DI), gasoline (GAS), gas condensate (GCON), methanol (MNOL), triethylene glycol (TGLY), brine solution (SALT), mineral oil (MOIL), isopropanol (ISOP), sulfuric acid (SULF), and surfactants (SOAP). For each chemical and adhesive combination, five samples were tested for a total of 150 samples.

Tests were conducted following "ASTM D543-21: Evaluating the Resistance of Plastics to Chemical Reagents" (Practice A – IMMERSION TEST: Procedure 1 – Weight, Dimension, Appearance, and Color Changes). Weight and thickness were recorded prior to immersion and after 7 days. Changes in color or physical appearance were noted. Data for change in weight is shown in Table 1, as a mean value and as a mean change in percentage while thickness data for percent change, as well as the mean and standard deviation of the change can be found in Table 2. Changes in coupon thickness were less than 0.06% mean value for all adhesive/chemical combinations.

The test results showed that all chemicals had a positive weight gain after 7 days of testing. This weight gain is hypothesized to be due to chemical absorbance. All adhesives showed the largest weight gain due distilled water and surfactants except for QCUV which had the largest weight gain for gasoline. For all other chemicals, UVMH coupons had less than 1% weight gain. By contrast, UVL200 had 5/10 chemicals with less than 1% weight gain and QCUV had 3/10 with chemicals had less than 1% weight gain. Based on these 7-day results, UVMH has the most favorable chemical resistance as an adhesive for CIPL.

For additional details and test results, please see Appendix: Chemical Reactivity Testing of UV Curable Adhesives (Draft Report) on page 9 of this report.

Table 1. Percentage, Mean, and Standard Deviation of Weight Change After 7 Days of Immersion

Weight Data						
	UVMH		UVL200		QCUV	
	Change (%)	Mean/SD of Change (g)	Change (%)	Mean/SD of Change (g)	Change (%)	Mean/SD of Change (g)
DI	1.7208	0.1669 ± .0237	2.4420	.2365 ± .1123	1.5231	.1512 ± .0606
GAS	.1904	.0186 ± .0055	2.1446	.2105 ± .0085	8.5919	.8589 ± .0338
GCON	.0497	.1699 ± .0057	.0606	.0060 ± .0009	2.8499	.3075 ± .0060
MNOL	0.7327	.0593 ± .0055	1.3227	.1292 ± .0038	1.7794	.1762 ± .0026
TGLY	0.5260	.0522 ± .0012	0.7435	.0728 ± .0009	0.9243	.0915 ± .0019
SALT	0.9066	.0892 ± .0004	1.3133	.1282 ± .0439	1.2864	.2149 ± .0014
MOIL	0.5024	.0493 ± .0717	0.5655	.0546 ± .1825	.8157	.0802 ± .1338
ISOP	0.5975	.0593 ± .0049	0.5072	.0496 ± .0982	1.2423	.1221 ± .0029
SULF	0.7022	.0693 ± .0234	0.8402	.0821 ± .0068	0.9285	.0908 ± .0024
SOAP	1.6488	.1637 ± .1087	1.4512	.1420 ± .0018	1.6508	.1627 ± .0454

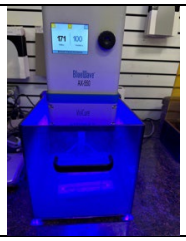
Green = ≤ 1% Mass Increase
Yellow = 1 % – 2 % Mass Increase
Red = >2% Mass Increase

Table 2. Percentage, Mean, and Standard Deviation of Thickness Change After 7 Days of Immersion

Thickness Data						
	UVMH		UVL200		QCUV	
	Change (%)	Mean/SD of Change (mm)	Change (%)	Mean/SD of Change (mm)	Change (%)	Mean/SD of Change (mm)
DI	-0.0155	-0.0053 ± .1055	-0.0405	-0.1367 ± .0230	-0.0263	-0.0947 ± .0793
GAS	-.0144	-0.0480 ± .0847	0.0103	0.0333 ± .0419	0.0564	0.1993 ± .1376
GCON	-.0101	-0.0353 ± .0751	-0.0147	-0.0480 ± .0685	0.0169	0.0633 ± .0450
MNOL	-.0114	-0.0347 ± .0326	-0.0053	-0.0173 ± .0274	0.0141	0.0473 ± .0726
TGLY	-0.0108	-0.0360 ± .0435	-0.0220	-0.0713 ± .1462	0.0104	0.0347 ± .0458
SALT	-0.0092	-0.0313 ± .0669	-0.0403	-0.1353 ± .0582	-0.0152	-0.0547 ± .0868
MOIL	0.0022	0.0073 ± .0395	-0.0040	-0.0140 ± .0428	-0.0061	-0.0220 ± .0534
ISOP	0.0589	0.2007 ± .4090	-0.0464	-0.1580 ± .0780	-0.0088	-0.0313 ± .0556
SULF	-0.0173	-0.0587 ± .0396	0.0023	0.0067 ± .0665	-0.0107	-0.0367 ± .1121
SOAP	-.0108	-0.0413 ± .0910	-0.0478	-0.1620 ± .0548	-0.0312	-0.1107 ± .0889

After analysis of the CUB chemical resistance testing along with Vortex in-house testing. The UVLH400 (UVMH) has been selected as the adhesive to be used for the remainder of the project due to superior chemical resistance. The next steps were to verify finding and run similar battery of tests used in Q2 of the project to substantiate findings. We were successful in the verification process and are confident in our selection of the UVLH400 adhesive. Matt Peterson traveled to PPM to assure the UV light train that will be used is compatible with the UVL400. The trip was successful and PPM's UV light train will be used to prepare pipe sample in the following quarters.

Exhibit A 9.3, 10.9, and 12.11

UV Light Intensity Light Penetration AKA Depth of Cure	
Production of coupons	
Coupon Molds	
Pull of Testing	

Hardness Testing *All sample tested over the minimum hardness of 70*	

Item No. 13.12 (Vortex Internal Review)

Vortex Team which is comprised of Matt Peterson, Scott Podhaisky and Andrew Gonella met multiple times during Q3 the final meeting held on June 23, 2023 to discuss test data and come to the decision of which of the 3 adhesive formulas was the be fit to be used in UV CIPL.

5: Project Schedule –

- Items not complete in Q3, expected to be included in the Q4 report are as follows:

Item #	Task #	Activity/Deliverable	Title
11	10	ASTM D790 Flex Mod/Strength (5 coupons per adhesive version - 15 samples) ASTM D638 Tensile (5 coupons per adhesive version - 15 samples) ASTM D695 Compression Strength (5 coupons per adhesive version - 15 samples)	ASTM D790 Flex Mod/Strength (5 coupons per adhesive version - 15 samples) ASTM D638 Tensile (5 coupons per adhesive version - 15 samples) ASTM D695 Compression Strength (5 coupons per adhesive version - 15 samples)

APENDIX

Chemical Reactivity Testing of UV Curable Adhesives

Draft Report

Submitted to:

PHMSA

Quarterly Report 3 Addendum

Prepared by:

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June 30, 2023

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1. Introduction

This report details the findings of the CIEST department while performing the ASTM D543: "Evaluating the Resistance of Plastics to Chemical Reagents" (2021) (Practice A – IMMERSION TEST: Procedure 1 – Weight, Dimension, Appearance, and Color Changes) testing. The test involves three different adhesives: UVMH, UVL200, and QCUV curable plastic adhesives for use in cured-in-place pipe liners (CIPL) for future repair use. Current cured in place pipe liners are available on the market, however these systems take multiple days to cure before the pipe can be deemed safe and usable. Ultraviolet curable plastic adhesives aim to drastically cut down on the curing time of these pipe liners and allow for pipelines to minimize their downtime and potential negative effects of taking a pipeline out of service for an extended amount of time. The procedure focuses on the weight change, thickness, and color change of the plastic adhesive coupons after 7 days of being submerged in different chemical solutions.

1.1 Test Specimens

All test specimens were made and shipped to the University of Colorado Boulder by Vortex. The coupons were made of previously mentioned UVMH, UVL200, and QCUV plastic adhesives. Each adhesive was tested using 10 different chemicals, with five samples per test group. A total of 150 samples were sent from Vortex and tested. These adhesives were manufactured as 0.125inch thick coupons with a dogbone shape following recommendations for Type IV ASTM D638 Tensile coupon samples for future tensile classification. The next step of the process was to get baseline data for the specimens before any testing occurred. To start, all the test specimens were marked by their respective adhesive (5-UVMH, 3-UVL200, 1-QCUV).

In addition to marking the coupons, small physical notches were made in order for us to identify the individual samples in case the writing faded away during the chemical tests. For our baseline data we measured: weight (grams), thickness of each tab (mm), and thickness of the inspection area (mm). The scale we used measured to a precision of .0001g and when weighing a standard 100-gram weight read a mass of 100.0000g which falls within the standards set of 0.05% accuracy for test specimens under 100g.

To measure thickness, we used calipers which measured to a precision of .02 mm. These measurements were performed on each individual testing coupon and the results can be seen in. We followed the "ASTM D543-21: Evaluating the Resistance of Plastics to Chemical Reagents' test standard as referenced in "ASTM F2207-19: Standard Specification for Cured-in-Place Pipe Lining System for Rehabilitation of Metallic Gas Pipe". These standards require a 0.125 in. thickness for all of the test specimens.

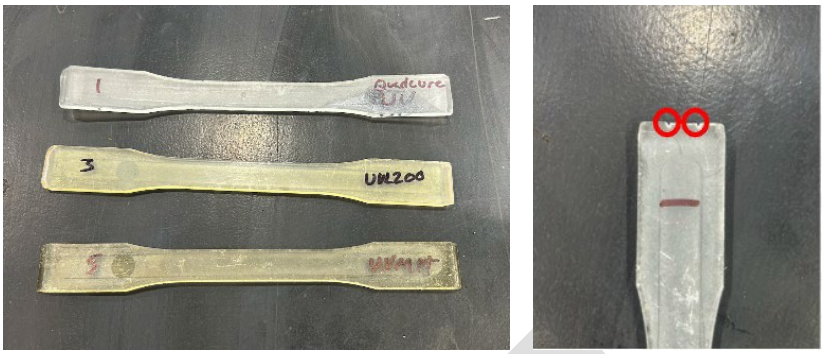


Figure 1.1. Sample coupon of the three adhesives and the QCUV specimen with identification markings.

2. Chemical Test Setup and Procedure

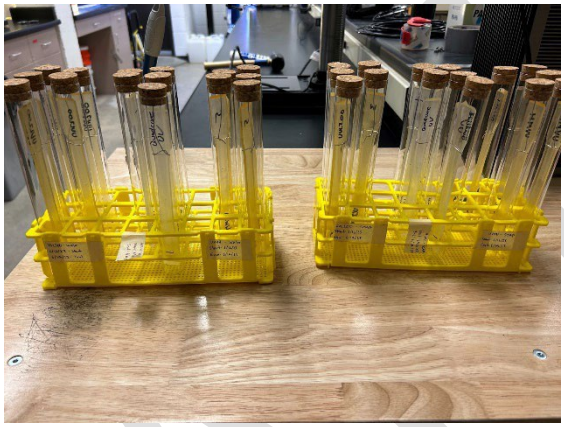
This section regards the coupon test setup, storage, and handling of the chemical reactivity testing as mentioned in ASTM D543 for the specific procedure we are performing.

2.1 Submersion Test Setup

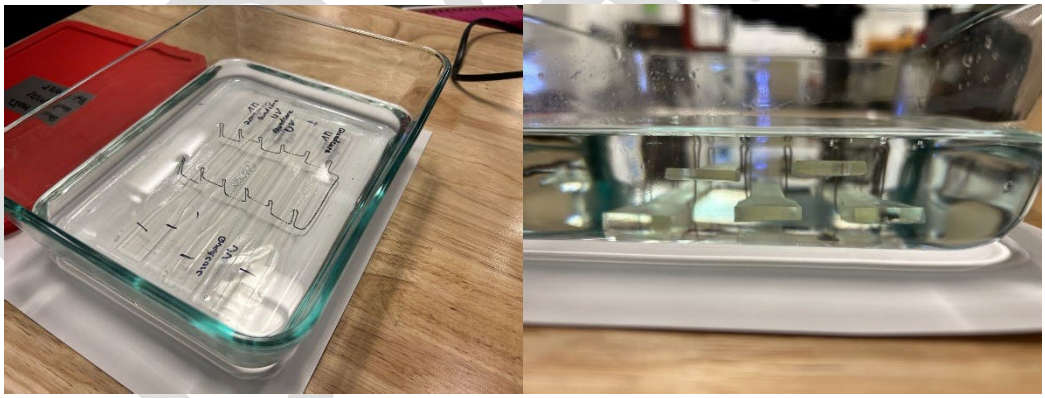
Chemical solutions were made per ASTM F2207-19 standards. If a chemical is possibly corrosive, ASTM D543-21 states that 40mL/in^2 of solution should be used. These chemicals required 2400mL of each solution. This quantity of solution required a scale with a higher capacity. This scale can measure grams to an accuracy of 0.1 g. When calibrated with a test mass of 100g, the scale reads 99.6g. The scale has an accuracy of 99.6% which is sufficient for this test.

There are two setups for the chemical immersion tests depending on the corrosiveness of the chemicals being used. Noncorrosive chemicals (Distilled Water, Soap Solution) were individually in 80mL test tubes. Noncorrosive specimens require 10mL/in^2 of solution per coupon per ASTM D543-21. All the other reactants require 40mL/in^2 of solution per coupon. For these tests, each adhesive will be tested in groups of 5 specimens of the same adhesive type (see Figure 2.1 for clarification). The ASTM standards allow for tests of the same adhesive and reactants in the same container as long as enough solution is present to adhere to the standards mentioned above. To keep the specimens from touching other specimens, the sides of the container, or the bottom of the container, testing rigs were built out of nichrome wire to keep the samples suspended in the solution. Nichrome is the recommended material to use as mentioned in the D543.

The testing procedure is outlined in ASTM D543-21: Practice A. It consists of getting baseline values of the weight, and thickness at 3 points on the test specimen. The 3 points that were chosen to take thickness was at each of the tabs of the coupon as well as the middle inspection area of the coupon. Following the initial baseline values, we submerged the coupons in their respective chemical solutions for 7 days, stirring the solution every 24 hours (excluding weekends when the lab was closed) and then taken out following the 7 days and measured again for weight and thickness.



(a) Test Tube Setup



(b) Corrosive Chemical Setup

Figure 2.1. Testing Setup

2.1.1 Chemical Reagents

The following table is the chemical reagents that were made and used in the testing of the coupons. These were given via the ASTM F2207 standards for these specific plastic coupons being tested, minus Mercaptan which was omitted to manage project costs.

These chemicals followed the 'immersion' testing procedure opposed to the 'wet patch' procedure for Procedure B. The immersion means we are fully soaking the coupons in the reagents and not a specific area of the coupon.

2.1.2 Control Values

This section contains all of the averages of the control samples before any chemical testing was done to the samples.

Table 2.1. Chemical Solutions Being Tested

Liquids	Test Composition
Water (External and Internal)	Freshly prepared distilled water (in accordance with Practice D543)
Gasoline (External)	Gasoline-Automotive Spark-Ignition Engine Fuel per Specification D4814
Gas Condensate (Internal)	70 % volume isooctane + 30 % volume toluene
Methanol	20 % volume methanol + 80 % volume distilled water
Triethylene Glycol	10 % volume triethylene glycol + 90 % volume distilled water
Brine Solution	10 % mass NaCl solution made up with a balance of distilled water
Mineral Oil	100 % White Mineral Oil USP, specific gravity 0.830 to 0.860, Saybolt at 100°F: 125 to 135 s, in accordance with Practice D543
Isopropanol	10 % volume isopropanol + 90 % volume distilled water
Sulfuric Acid	5 % weight (of total solution) H_2SO_4 in distilled water
Surfactants	5 % mass (of solution weight) dehydrated pure white soap flakes (dried 1 h at 105°C) dissolved in distilled water, in accordance with Practice D543

These chemical solutions adhere to the ASTM F2207-19 standards for these specific coupons. The 10 different chemical reagents have been given abbreviations in the tables and the following report. In order they are distilled water (DI), gasoline (GAS), gas condensate (GCON), methanol (MNOL), triethylene glycol (TGLY), brine solution (SALT), mineral oil (MOIL), isopropanol (ISOP), sulfuric acid (SULF), and surfactants (SOAP). Table 2.2 shows all of the averages for each adhesive for each chemical reagent before any testing was completed. There were a total of 5 sample coupons per adhesive per chemical (150 total) and the average weight and thickness for each batch of coupons is seen in the table below.

Table 2.2. Average Weight and Thickness Per Adhesive and Sample Control Values

Control Values						
	UVMH		UVL200		QCUV	
	Weight (g)	Thickness (mm)	Weight (g)	Thickness (mm)	Weight (g)	Thickness (mm)
DI	9.8707	3.4120	9.7081	3.3707	9.9365	3.5373
GAS	9.7736	3.3100	9.8151	3.2333	9.9947	3.5333
GCON	9.8474	3.3580	9.8319	3.2620	10.7908	3.7547
MNOL	9.7533	3.2867	9.7713	3.2553	9.9046	3.4260
TGLY	9.9426	3.3587	9.7921	3.2193	9.8961	3.3880
SALT	9.8401	3.3233	9.7550	3.3760	9.7231	3.4633
MOIL	9.8459	3.3280	9.8475	9.8475	9.8970	3.3893
ISOP	9.9226	3.3347	9.8600	9.8600	9.8270	3.4740
SULF	9.8835	3.3413	9.7707	3.2363	9.7741	3.3833
SOAP	9.8897	3.3720	9.7880	3.3840	9.8742	3.5240

3. Immersion Test Results

The following section reports the results of the 7 days of the immersion test for all the coupons. There were 10 different chemical reagents used, with each adhesive having 5 samples in each chemical reagent.

3.1 Average Percent Increase or Decrease in Weight and Dimensions

For each adhesive, an average of the 5 samples were taken to get the percent increase in weight and thickness. Individual coupon percent increase and decrease along with thicknesses can be found in Appendix B.

Table 3.1. Percentage, Mean, and Standard Deviation of Weight Change After 7 Days of Immersion

Weight Data						
	UVMH		UVL200		QCUV	
	Change (%)	Mean/SD of Change (g)	Change (%)	Mean/SD of Change (g)	Change (%)	Mean/SD of Change (g)
DI	1.7208	0.1669 ± .0237	2.4420	.2365 ± .1123	1.5231	.1512 ± .0606
GAS	.1904	.0186 ± .0055	2.1446	.2105 ± .0085	8.5919	.8589 ± .0338
GCON	.0497	.1699 ± .0057	.0606	.0060 ± .0009	2.8499	.3075 ± .0060
MNOL	0.7327	.0593 ± .0055	1.3227	.1292 ± .0038	1.7794	.1762 ± .0026
TGLY	0.5260	.0522 ± .0012	0.7435	.0728 ± .0009	0.9243	.0915 ± .0019
SALT	0.9066	.0892 ± .0004	1.3133	.1282 ± .0439	1.2864	.2149 ± .0014
MOIL	0.5024	.0493 ± .0717	0.5655	.0546 ± .1825	.8157	.0802 ± .1338
ISOP	0.5975	.0593 ± .0049	0.5072	.0496 ± .0982	1.2423	.1221 ± .0029
SULF	0.7022	.0693 ± .0234	0.8402	.0821 ± .0068	0.9285	.0908 ± .0024
SOAP	1.6488	.1637 ± .1087	1.4512	.1420 ± .0018	1.6508	.1627 ± .0454

Green = ≤ 1% Mass Increase
Yellow = 1 % – 2 % Mass Increase
Red = >2% Mass Increase

Table 3.2. Percentage, Mean, and Standard Deviation of Thickness Change After 7 Days of Immersion

Thickness Data						
	UVMH		UVL200		QCUV	
	Change (%)	Mean/SD of Change (mm)	Change (%)	Mean/SD of Change (mm)	Change (%)	Mean/SD of Change (mm)
DI	-0.0155	-0.0053 ± .1055	-0.0405	-0.1367 ± .0230	-0.0263	-0.0947 ± .0793
GAS	-.0144	-0.0480 ± .0847	0.0103	0.0333 ± .0419	0.0564	0.1993 ± .1376
GCON	-.0101	-0.0353 ± .0751	-0.0147	-0.0480 ± .0685	0.0169	0.0633 ± .0450
MNOL	-.0114	-0.0347 ± .0326	-0.0053	-0.0173 ± .0274	0.0141	0.0473 ± .0726
TGLY	-0.0108	-0.0360 ± .0435	-0.0220	-0.0713 ± .1462	0.0104	0.0347 ± .0458
SALT	-0.0092	-0.0313 ± .0669	-0.0403	-0.1353 ± .0582	-0.0152	-0.0547 ± .0868
MOIL	0.0022	0.0073 ± .0395	-0.0040	-0.0140 ± .0428	-0.0061	-0.0220 ± .0534
ISOP	0.0589	0.2007 ± .4090	-0.0464	-0.1580 ± .0780	-0.0088	-0.0313 ± .0556
SULF	-0.0173	-0.0587 ± .0396	0.0023	0.0067 ± .0665	-0.0107	-0.0367 ± .1121
SOAP	-.0108	-0.0413 ± .0910	-0.0478	-0.1620 ± .0548	-0.0312	-0.1107 ± .0889

3.2 General Results Analysis

These adhesives are being tested for use in CIPL system. The reagents used are the chemicals suggested by ASTM F2207-19, minus Mercaptan to manage project costs. With that factor in mind, the more chemically resistant an adhesive is to chemicals the more successful it is for this specific application. Since all the adhesives gained some weight over the span of the test it is hypothesized that they all absorbed some of the chemical reagent that they were being submerged in. Percentage of mass increase of each adhesive(

Table 3.1) is the most relevant property for chemical resistance since this value correlates with absorptivity of the regeant by the adhesive. The thickness of most coupons stayed relatively constant over time (less than 0.1% change on average). We hypothesize that the reagent absorbed into the body of the adhesive coupon itself, possibly in imperfections or corroded areas, and this absorption can be seen in the increase in weight of the coupons.

Based on the data presented, UVMH is the best performing adhesive for the application of CIPL. Distilled water and soap were noted as high absorptions for all plastics, however when it comes to the other 8 chemical solutions being tested UVMH saw less than 1% mass increase in. This surpasses UVL200, which only had 5/10 chemicals fall within the 1% increase range, and QCUV fares even worse with only 3/10 of the chemicals falling within the 1% increase range. Furthermore, UVMH had no instances where the coupons gained more than 2% increase in mass, while UVL200 had 1 and QCUV had 2. While other factors may be considered in evaluating an adhesive for CIPL (cost, cure time, etc.), UVMH had the most favorable chemical resistance profile of the adhesives tested.

Acknowledgements

Appreciation is extended to PHMSA and PPM for funding this work.

References

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Appendix A: Testing Setup

The following section shows visuals for the testing setup, which includes how the coupons were measured as well as how the coupons would be physically stored in the chemical solutions so that they meet the ASTM D543 standards.

Figure 0.1. Marking the Test Coupons and Sample Physical Indicators for QCUV Before Testing

Figure 0.2. Calibration of Balance Before Weighing any Coupons

Figure 0.3. Weighing A Coupon

Figure 0.4. Calibrating Calipers

Figure 0.5. Measuring Thickness of Lower Tab

Figure 0.6. Measuring Thickness of Inspection Area of Coupon

Figure 0.7. Measuring Thickness of Upper Tab of Coupon

Figure 0.8. Test Tube Setup for Distilled Water and Soap Testing

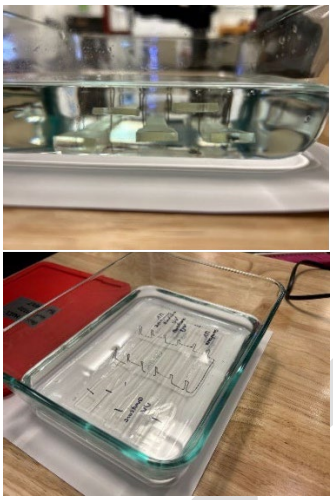

Figure 0.9. Setup For Potentially Corrosive Chemical Testing with Nichrome Wire Test Stand

Figure 0.10. Corrosive Chemical Testing Setup in Fume Hood

Appendix B: Raw Data for Each Individual Control Coupon

This section contains all of the raw data gotten from the coupons including weight and thicknesses before any immersion testing was done.

Table 0.1. Chemical 1 – Distilled Water

Sample Name	Sample Nu	Material	Chemical	Identifier	Weight (g)	Thickness	Thickness	Thickness
1-DI-5-UVMH-1	1	5-UVMH	1-DI	No Notches	10.1607	3.15	3.62	3.84
1-DI-5-UVMH-2	2	5-UVMH	1-DI	One Notch on top	9.9574	3.29	3.31	3.17
1-DI-5-UVMH-3	3	5-UVMH	1-DI	Two notches on top	10.1658	3.23	3.33	3.34
1-DI-5-UVMH-4	4	5-UVMH	1-DI	One Notch on top, one Notch on Bottom	10.0613	3.04	3.62	3.57
1-DI-5-UVMH-5	5	5-UVMH	1-DI	Two Notches on top, one Notch on bottom	9.8578	3.6	3.17	3.07
1-DI-3-UVL200-1	1	3-UVL200	1-DI	No Notches	9.8981	3.17	3.07	3.42
1-DI-3-UVL200-2	2	3-UVL200	1-DI	One Notch on top	10.041	3.56	3.16	3.01
1-DI-3-UVL200-3	3	3-UVL200	1-DI	Two notches on top	9.9254	3.21	3.26	3.17
1-DI-3-UVL200-4	4	3-UVL200	1-DI	One Notch on top, one Notch on Bottom	9.8694	3.34	3.19	3.18
1-DI-3-UVL200-5	5	3-UVL200	1-DI	Two Notches on top, one Notch on bottom	9.9893	3.45	3.17	3.15
1-DI-1-QCUV-1	1	1-QCUV	1-DI	No Notches	10.029	3.66	3.31	3.23
1-DI-1-QCUV-2	2	1-QCUV	1-DI	One Notch on top	10.0924	4.18	3.19	2.99
1-DI-1-QCUV-3	3	1-QCUV	1-DI	Two notches on top	10.0371	3.15	3.29	3.87
1-DI-1-QCUV-4	4	1-QCUV	1-DI	One Notch on top, one Notch on Bottom	10.1247	3.82	3.47	3.03
1-DI-1-QCUV-5	5	1-QCUV	1-DI	Two Notches on top, one Notch on bottom	10.1556	3.61	3.41	3.43

Table 0.2. Chemical 2 – Gasoline

2-GAS-5-UVMH-1	1	5-UVMH	2-GAS	No Notches	9.8203	3.23	3.24	3.1
2-GAS-5-UVMH-2	2	5-UVMH	2-GAS	One Notch on top	9.7698	3.05	3.24	3.36
2-GAS-5-UVMH-3	3	5-UVMH	2-GAS	Two notches on top	9.9986	3.06	3.47	3.64
2-GAS-5-UVMH-4	4	5-UVMH	2-GAS	One Notch on top, one Notch on Bottom	9.7721	3.33	3.42	3.14
2-GAS-5-UVMH-5	5	5-UVMH	2-GAS	Two Notches on top, one Notch on bottom	9.6	3.25	3.19	3.21
2-GAS-3-UVL200-1	1	3-UVL200	2-GAS	No Notches	10.1336	3.41	3.21	3.3
2-GAS-3-UVL200-2	2	3-UVL200	2-GAS	One Notch on top	9.9291	3.37	3.26	3.08
2-GAS-3-UVL200-3	3	3-UVL200	2-GAS	Two notches on top	9.9039	3.35	3.21	3.08
2-GAS-3-UVL200-4	4	3-UVL200	2-GAS	One Notch on top, one Notch on Bottom	10.121	3.58	3.24	3.14
2-GAS-3-UVL200-5	5	3-UVL200	2-GAS	Two Notches on top, one Notch on bottom	10.0406	3.26	3.3	3.21
2-GAS-1-QCUV-1	1	1-QCUV	2-GAS	No Notches	11.0229	4.52	3.65	3.3
2-GAS-1-QCUV-2	2	1-QCUV	2-GAS	One Notch on top	10.8026	3.47	4.5	3.78
2-GAS-1-QCUV-3	3	1-QCUV	2-GAS	Two notches on top	11.0114	3.75	3.61	3.89
2-GAS-1-QCUV-4	4	1-QCUV	2-GAS	One Notch on top, one Notch on Bottom	10.6234	4.18	3.5	2.96
2-GAS-1-QCUV-5	5	1-QCUV	2-GAS	Two Notches on top, one Notch on bottom	10.8075	4.29	3.51	3.08

Table 0.3. Chemical 3 – Gas Condensate

3-GCON-5-UVMH-1	1	5-UVMH	3-GCON	No Notches	9.7537	3.16	3.28	3.26
3-GCON-5-UVMH-2	2	5-UVMH	3-GCON	One Notch on top	9.7205	3.06	3.61	3.52
3-GCON-5-UVMH-3	3	5-UVMH	3-GCON	Two notches on top	9.9129	3.57	3.45	2.96
3-GCON-5-UVMH-4	4	5-UVMH	3-GCON	One Notch on top, one Notch on Bottom	9.7861	3.16	3.21	3.14
3-GCON-5-UVMH-5	5	5-UVMH	3-GCON	Two Notches on top, one Notch on bottom	10.0882	3.49	3.36	3.61
3-GCON-3-UVL200-1	1	3-UVL200	3-GCON	No Notches	9.7996	3.28	3.16	3.15
3-GCON-3-UVL200-2	2	3-UVL200	3-GCON	One Notch on top	9.6874	3.05	3.2	3.04
3-GCON-3-UVL200-3	3	3-UVL200	3-GCON	Two notches on top	9.869	3.33	3.2	3.07
3-GCON-3-UVL200-4	4	3-UVL200	3-GCON	One Notch on top, one Notch on Bottom	10.0342	3.41	3.5	3.09
3-GCON-3-UVL200-5	5	3-UVL200	3-GCON	Two Notches on top, one Notch on bottom	9.799	3.65	3.11	2.97
3-GCON-1-QCUV-1	1	1-QCUV	3-GCON	No Notches	11.1374	3.67	3.64	4.18
3-GCON-1-QCUV-2	2	1-QCUV	3-GCON	One Notch on top	11.1627	4.14	3.76	3.77
3-GCON-1-QCUV-3	3	1-QCUV	3-GCON	Two notches on top	10.9172	3.8	3.83	3.62
3-GCON-1-QCUV-4	4	1-QCUV	3-GCON	One Notch on top, one Notch on Bottom	11.1697	3.66	3.76	4.02
3-GCON-1-QCUV-5	5	1-QCUV	3-GCON	Two Notches on top, one Notch on bottom	11.1041	3.77	3.83	3.82

Table 0.4. Chemical 4 – Methanol

4-MNOL-5-UVMH-1	1	5-UVMH	4-MNOL	No Notches	9.9373	3.09	3.25	3.57
4-MNOL-5-UVMH-2	2	5-UVMH	4-MNOL	One Notch on top	9.8083	3.12	3.13	3.48
4-MNOL-5-UVMH-3	3	5-UVMH	4-MNOL	Two notches on top	9.7917	3.3	3.31	3.16
4-MNOL-5-UVMH-4	4	5-UVMH	4-MNOL	One Notch on top, one Notch on Bottom	9.9201	3.25	3.29	3.27
4-MNOL-5-UVMH-5	5	5-UVMH	4-MNOL	Two Notches on top, one Notch on bottom	9.6664	3.23	3.21	3.12
4-MNOL-3-UVL200-1	1	3-UVL200	4-MNOL	No Notches	9.8522	3.26	3.27	3.2
4-MNOL-3-UVL200-2	2	3-UVL200	4-MNOL	One Notch on top	9.8784	3.3	3.17	3.11
4-MNOL-3-UVL200-3	3	3-UVL200	4-MNOL	Two notches on top	9.8642	3.1	3.12	3.41
4-MNOL-3-UVL200-4	4	3-UVL200	4-MNOL	One Notch on top, one Notch on Bottom	9.9395	3.46	3.16	3.1
4-MNOL-3-UVL200-5	5	3-UVL200	4-MNOL	Two Notches on top, one Notch on bottom	9.9684	3.9	3.04	2.97
4-MNOL-1-QCUV-1	1	1-QCUV	4-MNOL	No Notches	10.0211	3.16	3.32	3.75
4-MNOL-1-QCUV-2	2	1-QCUV	4-MNOL	One Notch on top	10.147	3.63	3.31	3.6
4-MNOL-1-QCUV-3	3	1-QCUV	4-MNOL	Two notches on top	10.1242	4.18	3.18	3.18
4-MNOL-1-QCUV-4	4	1-QCUV	4-MNOL	One Notch on top, one Notch on Bottom	10.014	3.2	3.14	3.99
4-MNOL-1-QCUV-5	5	1-QCUV	4-MNOL	Two Notches on top, one Notch on bottom	10.0981	3.48	3.52	3.46

Table 0.5. Chemical 5 – Triethylene Glycol

5-TGLY-5-UVMH-1	1	5-UVMH	5-TGLY	No Notches	9.6778	3.2	3.24	3.14
5-TGLY-5-UVMH-2	2	5-UVMH	5-TGLY	One Notch on top	9.9828	3.63	3.21	2.96
5-TGLY-5-UVMH-3	3	5-UVMH	5-TGLY	Two notches on top	10.1591	3.07	3.38	3.5
5-TGLY-5-UVMH-4	4	5-UVMH	5-TGLY	One Notch on top, one Notch on Bottom	10.3667	3.63	3.68	3.17
5-TGLY-5-UVMH-5	5	5-UVMH	5-TGLY	Two Notches on top, one Notch on bottom	9.7878	3.11	3.34	3.58
5-TGLY-3-UVL200-1	1	3-UVL200	5-TGLY	No Notches	9.8148	3.18	3.15	3.18
5-TGLY-3-UVL200-2	2	3-UVL200	5-TGLY	One Notch on top	9.9458	3.16	3.22	3.29
5-TGLY-3-UVL200-3	3	3-UVL200	5-TGLY	Two notches on top	9.9137	3.2	3.23	3.16
5-TGLY-3-UVL200-4	4	3-UVL200	5-TGLY	One Notch on top, one Notch on Bottom	9.8008	3.66	3.09	2.99
5-TGLY-3-UVL200-5	5	3-UVL200	5-TGLY	Two Notches on top, one Notch on bottom	9.8492	3.28	3.2	2.23
5-TGLY-1-QCUV-1	1	1-QCUV	5-TGLY	No Notches	9.9995	3.95	3.18	3.26
5-TGLY-1-QCUV-2	2	1-QCUV	5-TGLY	One Notch on top	9.9329	3.32	3.21	3.77
5-TGLY-1-QCUV-3	3	1-QCUV	5-TGLY	Two notches on top	9.9647	3.32	3.31	3.47
5-TGLY-1-QCUV-4	4	1-QCUV	5-TGLY	One Notch on top, one Notch on Bottom	10.1135	3.28	3.23	3.91
5-TGLY-1-QCUV-5	5	1-QCUV	5-TGLY	Two Notches on top, one Notch on bottom	9.9271	3.41	3.25	3.47

Table 0.6. Chemical 6 – Brine Solution

6-SALT-5-UVMH-1	1	5-UVMH	6-SALT	No Notches	10.0358	3.03	3.57	3.47
6-SALT-5-UVMH-2	2	5-UVMH	6-SALT	One Notch on top	9.9561	3.55	3.2	3.11
6-SALT-5-UVMH-3	3	5-UVMH	6-SALT	Two notches on top	10.2034	3.18	3.43	3.42
6-SALT-5-UVMH-4	4	5-UVMH	6-SALT	One Notch on top, one Notch on Bottom	9.8377	3.24	3.25	3.16
6-SALT-5-UVMH-5	5	5-UVMH	6-SALT	Two Notches on top, one Notch on bottom	9.6133	3.19	3.26	3.32
6-SALT-3-UVL200-1	1	3-UVL200	6-SALT	No Notches	9.9536	3.78	3.3	3.28
6-SALT-3-UVL200-2	2	3-UVL200	6-SALT	One Notch on top	9.9792	3.06	3.2	3.42
6-SALT-3-UVL200-3	3	3-UVL200	6-SALT	Two notches on top	9.8052	3.18	3.18	3.17
6-SALT-3-UVL200-4	4	3-UVL200	6-SALT	One Notch on top, one Notch on Bottom	9.8526	3.15	3.18	3.2
6-SALT-3-UVL200-5	5	3-UVL200	6-SALT	Two Notches on top, one Notch on bottom	9.825	3.18	3.19	3.14
6-SALT-1-QCUV-1	1	1-QCUV	6-SALT	No Notches	10.0282	3.67	3.41	3.31
6-SALT-1-QCUV-2	2	1-QCUV	6-SALT	One Notch on top	10.1907	4.27	3.42	3.08
6-SALT-1-QCUV-3	3	1-QCUV	6-SALT	Two notches on top	9.9367	3.58	3.28	3.26
6-SALT-1-QCUV-4	4	1-QCUV	6-SALT	One Notch on top, one Notch on Bottom	9.9458	3.61	3.2	3.22
6-SALT-1-QCUV-5	5	1-QCUV	6-SALT	Two Notches on top, one Notch on bottom	9.1385	3.23	3.17	3.42

Table 0.7. Chemical 7 – Mineral Oil

7-MOIL-5-UVMH-1	1	5-UVMH	7-MOIL	No Notches	9.9193	3.01	3.33	3.73
7-MOIL-5-UVMH-2	2	5-UVMH	7-MOIL	One Notch on top	9.9562	3.17	3.37	3.44
7-MOIL-5-UVMH-3	3	5-UVMH	7-MOIL	Two notches on top	9.8392	3.52	3.44	3.14
7-MOIL-5-UVMH-4	4	5-UVMH	7-MOIL	One Notch on top, one Notch on Bottom	9.856	3.2	3.22	3.33
7-MOIL-5-UVMH-5	5	5-UVMH	7-MOIL	Two Notches on top, one Notch on bottom	0.9053	3.72	3.44	3.01
7-MOIL-3-UVL200-1	1	3-UVL200	7-MOIL	No Notches	9.7332	3.3	3.16	3.1
7-MOIL-3-UVL200-2	2	3-UVL200	7-MOIL	One Notch on top	9.8764	3.4	3.13	3.15
7-MOIL-3-UVL200-3	3	3-UVL200	7-MOIL	Two notches on top	9.8432	3.34	3.16	3.07
7-MOIL-3-UVL200-4	4	3-UVL200	7-MOIL	One Notch on top, one Notch on Bottom	10.0064	3.35	3.14	3.33
7-MOIL-3-UVL200-5	5	3-UVL200	7-MOIL	Two Notches on top, one Notch on bottom	10.0512	3.52	3.14	3.16
7-MOIL-1-QCUV-1	1	1-QCUV	7-MOIL	No Notches	9.8761	3.85	3.11	3.3
7-MOIL-1-QCUV-2	2	1-QCUV	7-MOIL	One Notch on top	10.0231	3.5	3.32	3.33
7-MOIL-1-QCUV-3	3	1-QCUV	7-MOIL	Two notches on top	9.8588	3.11	3.43	3.56
7-MOIL-1-QCUV-4	4	1-QCUV	7-MOIL	One Notch on top, one Notch on Bottom	10.025	3.13	3.2	3.85
7-MOIL-1-QCUV-5	5	1-QCUV	7-MOIL	Two Notches on top, one Notch on bottom	10.103	3.08	3.37	4.06

Table 0.8. Chemical 8 – Isopropanol

8-ISOP-5-UVMH-1	1	5-UVMH	8-ISOP	No Notches	10.1814	4.47	4.45	4.15
8-ISOP-5-UVMH-2	2	5-UVMH	8-ISOP	One Notch on top	9.8458	3.04	3.46	3.57
8-ISOP-5-UVMH-3	3	5-UVMH	8-ISOP	Two notches on top	9.8476	3.47	3.38	3.16
8-ISOP-5-UVMH-4	4	5-UVMH	8-ISOP	One Notch on top, one Notch on Bottom	10.1859	3.66	3.39	3.07
8-ISOP-5-UVMH-5	5	5-UVMH	8-ISOP	Two Notches on top, one Notch on bottom	9.8485	3.14	3.27	3.35
8-ISOP-3-UVL200-1	1	3-UVL200	8-ISOP	No Notches	10.0053	3.15	3.27	3.73
8-ISOP-3-UVL200-2	2	3-UVL200	8-ISOP	One Notch on top	9.8498	3.22	3.15	3.22
8-ISOP-3-UVL200-3	3	3-UVL200	8-ISOP	Two notches on top	9.816	3.38	3.14	3.18
8-ISOP-3-UVL200-4	4	3-UVL200	8-ISOP	One Notch on top, one Notch on Bottom	9.9685	3.15	3.14	3.35
8-ISOP-3-UVL200-5	5	3-UVL200	8-ISOP	Two Notches on top, one Notch on bottom	9.908	3.21	3.16	0.317
8-ISOP-1-QCUV-1	1	1-QCUV	8-ISOP	No Notches	10.0067	3.31	3.34	3.66
8-ISOP-1-QCUV-2	2	1-QCUV	8-ISOP	One Notch on top	9.9163	3.47	3.19	3.82
8-ISOP-1-QCUV-3	3	1-QCUV	8-ISOP	Two notches on top	9.8966	3.19	3.46	3.56
8-ISOP-1-QCUV-4	4	1-QCUV	8-ISOP	One Notch on top, one Notch on Bottom	10.0143	3.04	3.38	4.01
8-ISOP-1-QCUV-5	5	1-QCUV	8-ISOP	Two Notches on top, one Notch on bottom	9.9117	3.6	3.49	3.12

Table 0.9. Chemical 9 – Sulfuric Acid

9-SULF-5-UVMH-1	1	5-UVMH	9-SULF	No Notches	9.7525	3.38	3.3	3.13
9-SULF-5-UVMH-2	2	5-UVMH	9-SULF	One Notch on top	9.9651	3.06	3.25	3.43
9-SULF-5-UVMH-3	3	5-UVMH	9-SULF	Two notches on top	9.8903	3.24	3.33	3.09
9-SULF-5-UVMH-4	4	5-UVMH	9-SULF	One Notch on top, one Notch on Bottom	10.2538	4.04	3.38	3.03
9-SULF-5-UVMH-5	5	5-UVMH	9-SULF	Two Notches on top, one Notch on bottom	9.9022	3.26	3.21	3.11
9-SULF-3-UVL200-1	1	3-UVL200	9-SULF	No Notches	9.8032	3.32	3.32	3.2
9-SULF-3-UVL200-2	2	3-UVL200	9-SULF	One Notch on top	9.903	3.1	3.22	3.25
9-SULF-3-UVL200-3	3	3-UVL200	9-SULF	Two notches on top	9.8962	3.51	3.16	3.07
9-SULF-3-UVL200-4	4	3-UVL200	9-SULF	One Notch on top, one Notch on Bottom	9.8876	3.17	3.33	3.23
9-SULF-3-UVL200-5	5	3-UVL200	9-SULF	Two Notches on top, one Notch on bottom	9.7739	3.2	3.26	3.32
9-SULF-1-QCUV-1	1	1-QCUV	9-SULF	No Notches	9.8356	3.63	3.3	3.2
9-SULF-1-QCUV-2	2	1-QCUV	9-SULF	One Notch on top	9.8724	3.66	3.23	3.27
9-SULF-1-QCUV-3	3	1-QCUV	9-SULF	Two notches on top	9.8251	3.2	3.29	3.08
9-SULF-1-QCUV-4	4	1-QCUV	9-SULF	One Notch on top, one Notch on Bottom	9.9071	3.23	3.35	3.54
9-SULF-1-QCUV-5	5	1-QCUV	9-SULF	Two Notches on top, one Notch on bottom	9.8843	3.54	3.3	3.38

Table 0.10. Chemical 10 – Surfactant

10-SOAP-5-UVMH-1	1	5-UVMH	10-SOAP	No Notches	9.9059	3.25	3.24	3.21
10-SOAP-5-UVMH-2	2	5-UVMH	10-SOAP	One Notch on top	10.3651	3.17	3.53	3.64
10-SOAP-5-UVMH-3	3	5-UVMH	10-SOAP	Two notches on top	9.8776	3.45	3.43	3.14
10-SOAP-5-UVMH-4	4	5-UVMH	10-SOAP	One Notch on top, one Notch on Bottom	10.0604	3.17	3.3	3.38
10-SOAP-5-UVMH-5	5	5-UVMH	10-SOAP	Two Notches on top, one Notch on bottom	10.058	3.48	3.43	3.14
10-SOAP-3-UVL200-1	1	3-UVL200	10-SOAP	No Notches	9.8675	3.15	3.2	3.2
10-SOAP-3-UVL200-2	2	3-UVL200	10-SOAP	One Notch on top	9.8787	3.15	3.16	3.24
10-SOAP-3-UVL200-3	3	3-UVL200	10-SOAP	Two notches on top	9.9647	3.17	3.26	3.45
10-SOAP-3-UVL200-4	4	3-UVL200	10-SOAP	One Notch on top, one Notch on Bottom	9.898	3.16	3.06	3.51
10-SOAP-3-UVL200-5	5	3-UVL200	10-SOAP	Two Notches on top, one Notch on bottom	10.0412	3.35	3.19	3.08
10-SOAP-1-QCUV-1	1	1-QCUV	10-SOAP	No Notches	10.0634	3.85	3.2	3.27
10-SOAP-1-QCUV-2	2	1-QCUV	10-SOAP	One Notch on top	9.9589	3.85	3.26	3.19
10-SOAP-1-QCUV-3	3	1-QCUV	10-SOAP	Two notches on top	10.0435	3.44	3.2	3.63
10-SOAP-1-QCUV-4	4	1-QCUV	10-SOAP	One Notch on top, one Notch on Bottom	9.9698	3.54	3.11	3.25
10-SOAP-1-QCUV-5	5	1-QCUV	10-SOAP	Two Notches on top, one Notch on bottom	10.1488	3.8	3.38	3.23

Appendix C: Additional Graphs

This section of the report contains supporting graphs to the data outside of the required contents. The graphs are weight change over time, percent change over time for each coupon, inspection area thickness change over time for each coupon, and average thickness change over time for each coupon.

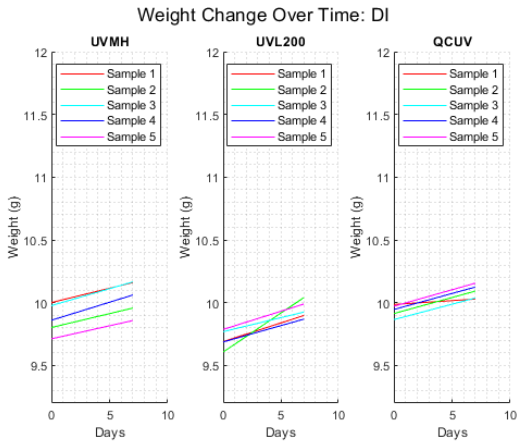

Figure 0.11. Chemical 1 – Distilled Water Weight Change Over Time

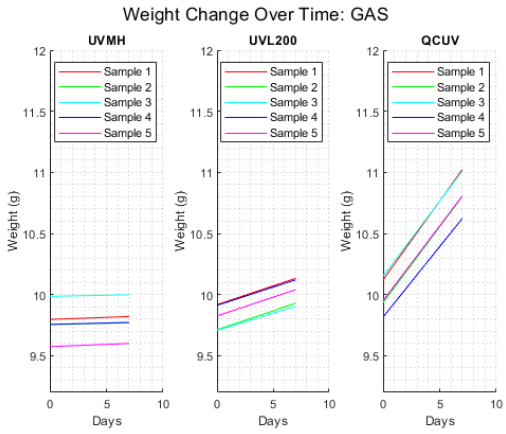

Figure 0.12. Chemical 2 – Gasoline Weight Change Over Time

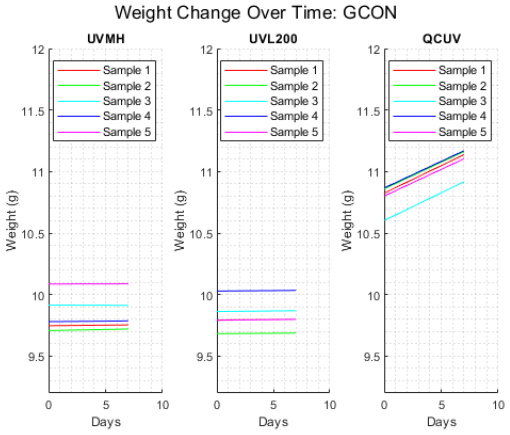

Figure 0.13. Chemical 3 – Gas Condensate Weight Change Over Time

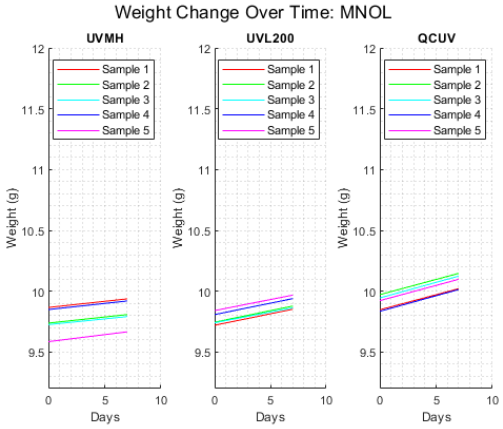

Figure 0.14. Chemical 4 – Methanol Weight Change Over Time

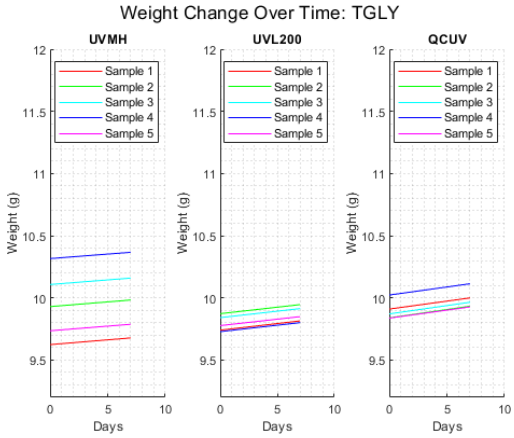

Figure 0.15. Chemical 5 – Triethylene Glycol Weight Change Over Time

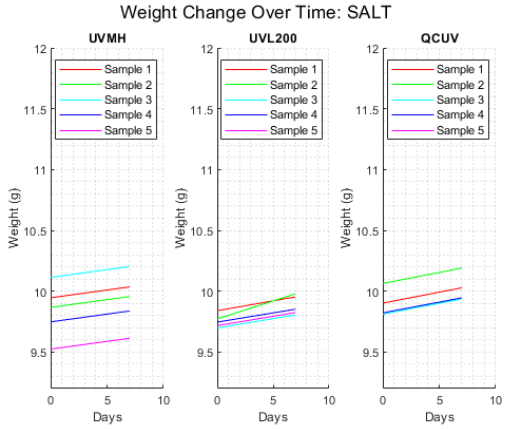

Figure 0.16. Chemical 6 – Salt Weight Change Over Time

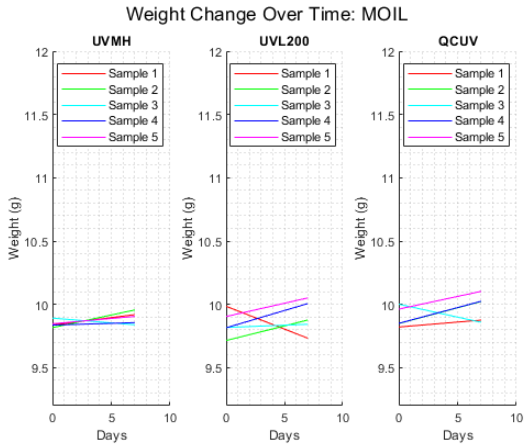

Figure 0.17. Chemical 7 – Mineral Oil Weight Change Over Time

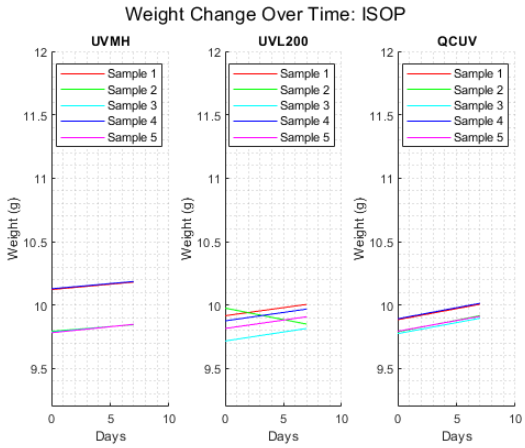

Figure 0.18. Chemical 8 – Isopropanol Weight Change Over Time

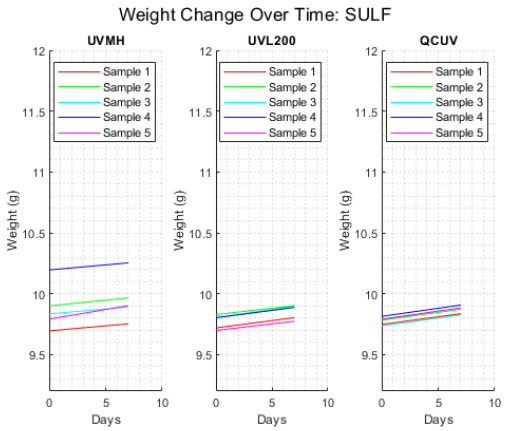

Figure 0.19. Chemical 9 – Sulfuric Acid Weight Change Over Time

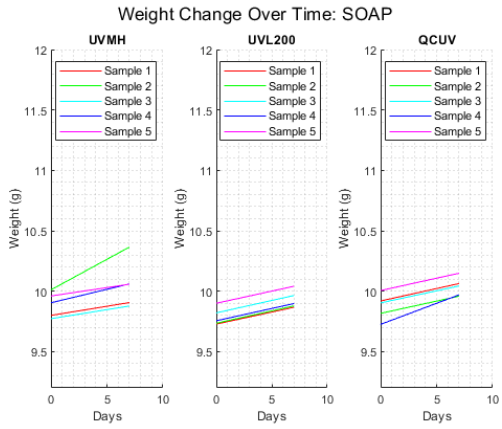

Figure 0.20. Chemical 10 – Surfactants Weight Change Over Time

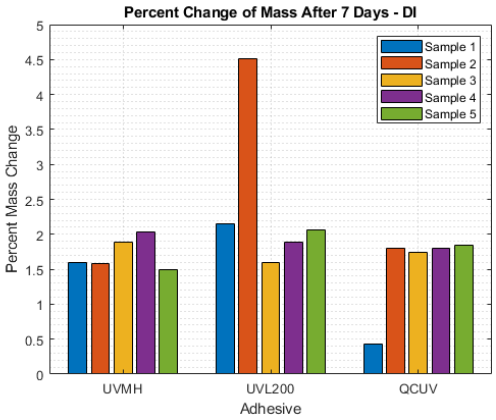

Figure 0.21. Chemical 1 – Distilled Water Percent Mass Change

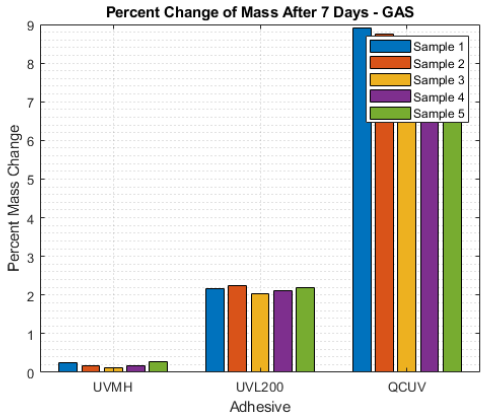

Figure 0.22. Chemical 2 – Gasoline Percent Mass Change

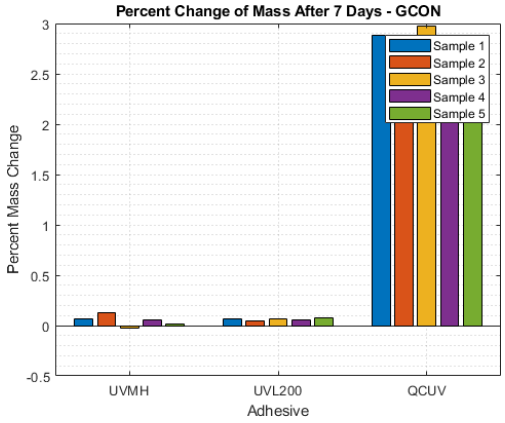

Figure 0.23. Chemical 3 – Gas Condensate Percent Mass Change

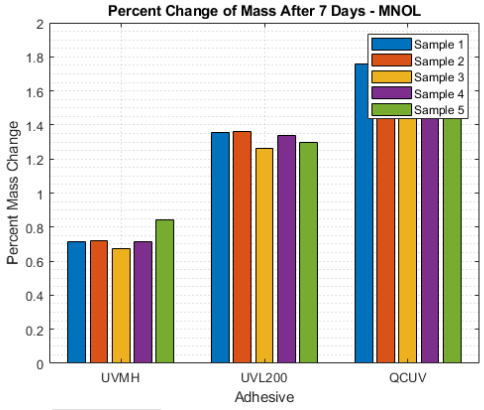

Figure 0.24. Chemical 4 – Methanol Percent Mass Change

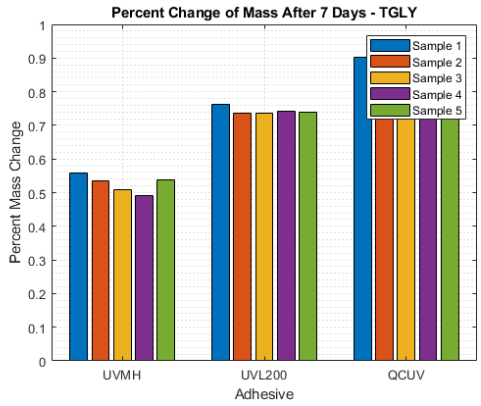

Figure 0.25. Chemical 5 – Triethylene Glycol Percent Mass Change

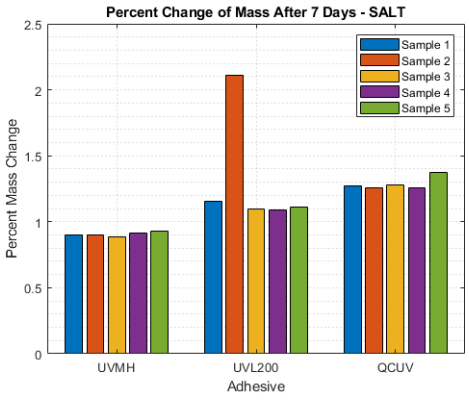

Figure 0.26. Chemical 6 – Salt Percent Mass Change

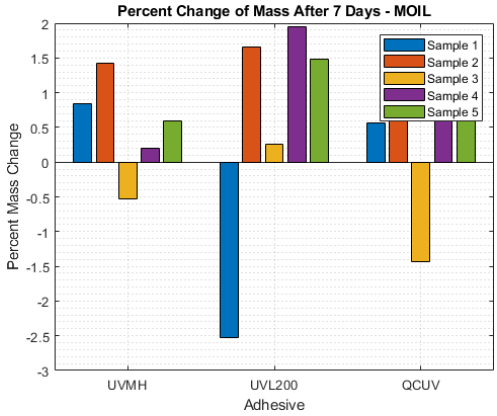

Figure 0.27. Chemical 7 – Mineral Oil Percent Mass Change

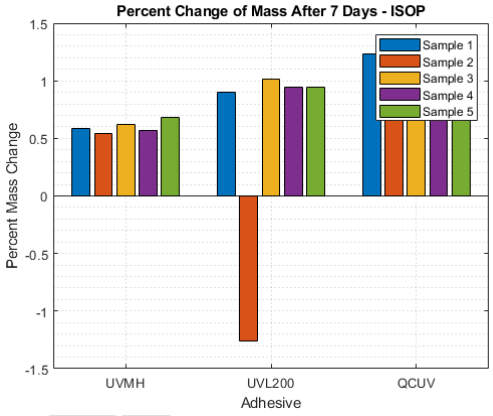

Figure 0.28. Chemical 8 – Isopropanol Percent Mass Change

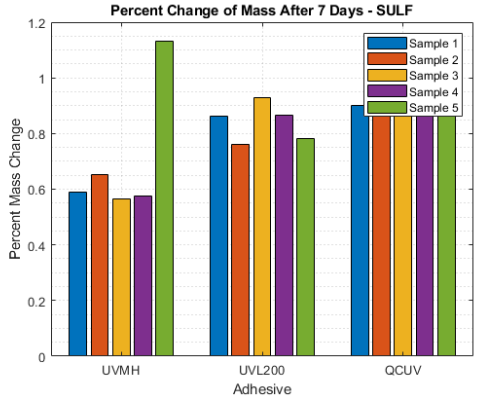

Figure 0.29. Chemical 9 – Sulfuric Acid Percent Mass Change

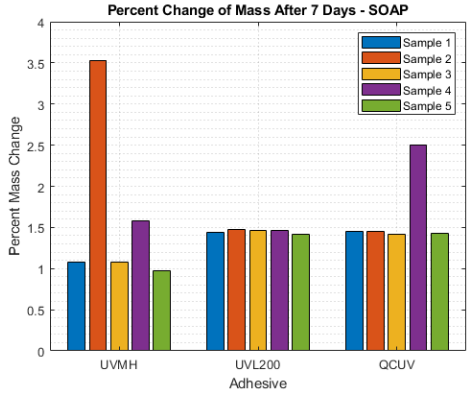

Figure 0.30. Chemical 10 – Surfactants Percent Mass Change

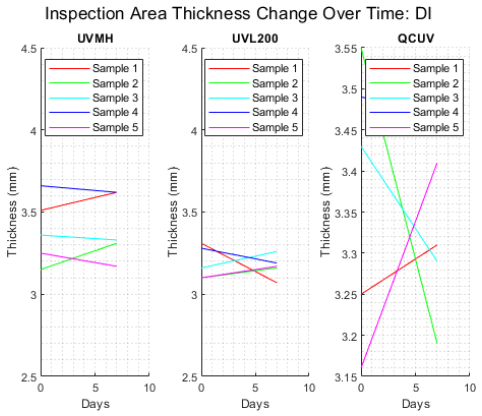

Figure 0.31. Chemical 1 – Distilled Water Inspection Area Thickness Change

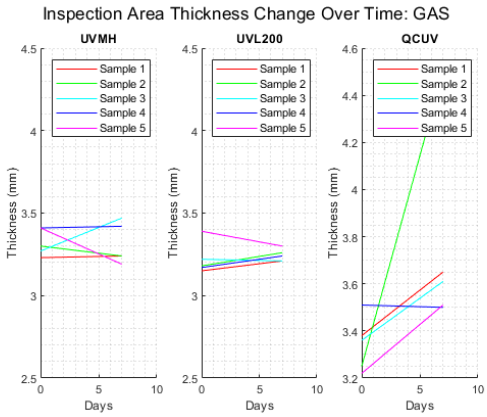

Figure 0.32. Chemical 2 - Gasoline Inspection Area Thickness Change

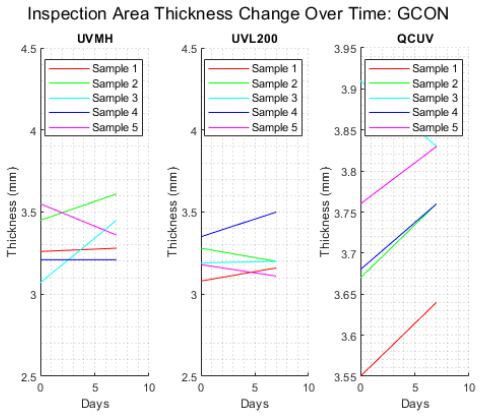

Figure 0.33. Chemical 3 – Gas Condensate Inspection Area Thickness Change

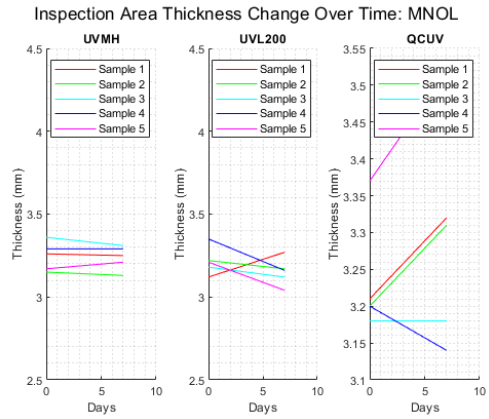

Figure 0.34. Chemical 4 - Methanol Inspection Area Thickness Change

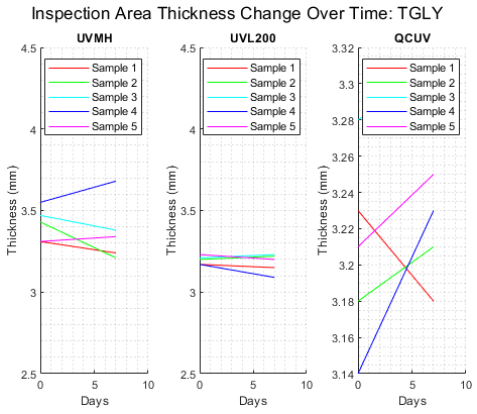

Figure 0.35. Chemical 5 – Triethylene Glycol Inspection Area Thickness Change

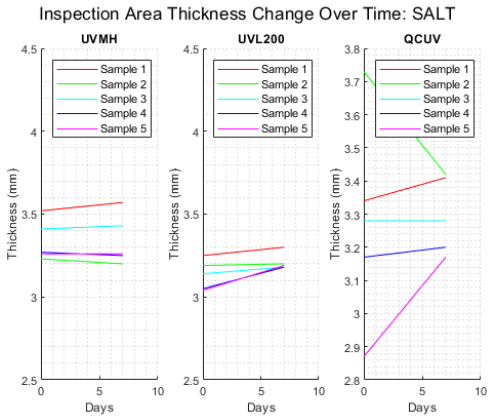

Figure 0.36. Chemical 6 – Salt Inspection Area Thickness Change

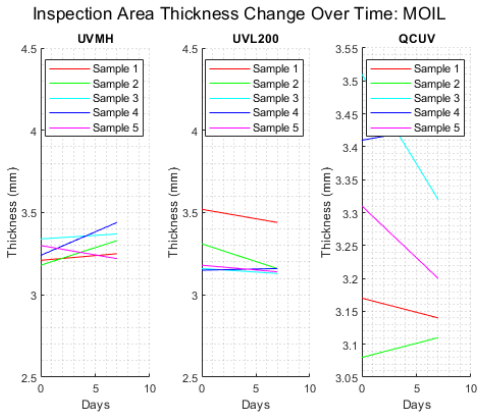

Figure 0.37. Chemical 7 – Mineral Oil Inspection Area Thickness Change

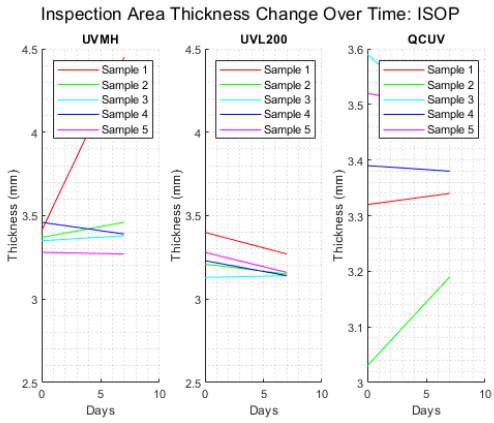

Figure 0.38. Chemical 8 - Isopropanol Inspection Area Thickness Change

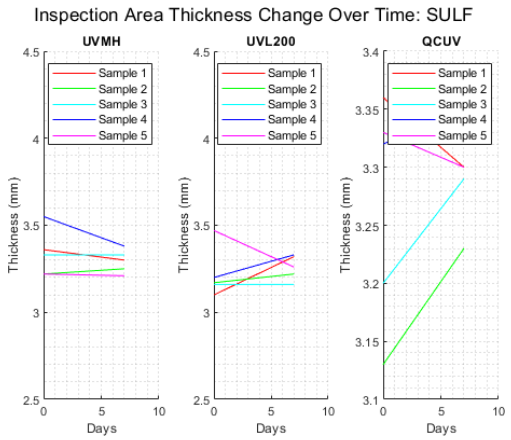

Figure 0.39. Chemical 9 – Sulfuric Acid Inspection Area Thickness Change

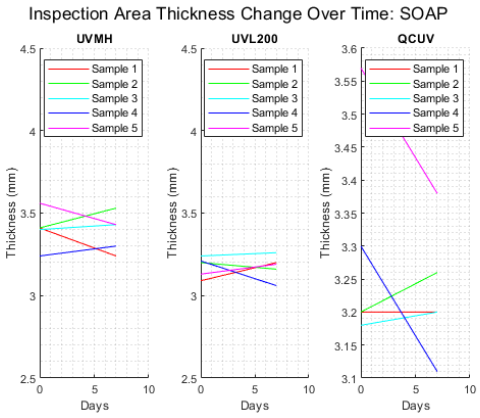

Figure 0.40. Chemical 10 – Surfactants Inspection Area Thickness Change

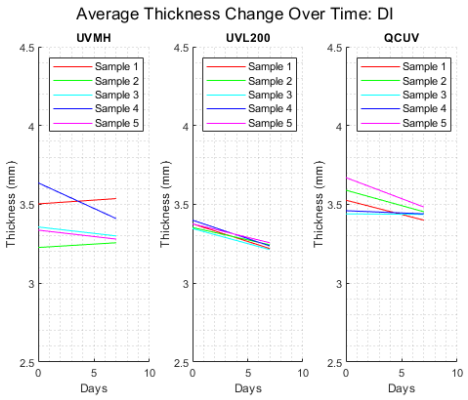

Figure 0.41. Chemical 1 – Distilled Water Average Thickness Change

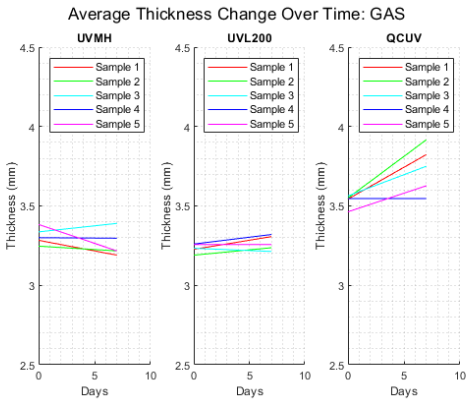

Figure 0.42. Chemical 2 – Gasoline Inspection Average Thickness Change

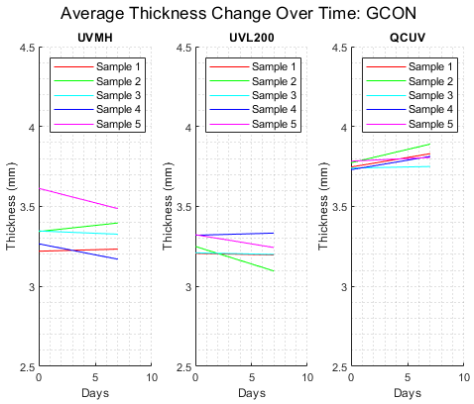

Figure 0.43. Chemical 3 – Gas Condensate Average Thickness Change

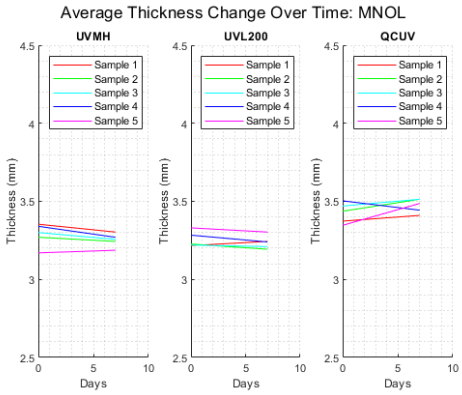

Figure 0.44. Chemical 4 – Methanol Average Thickness Change

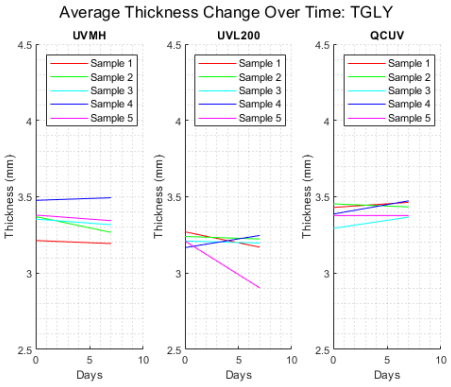

Figure 0.45. Chemical 5 – Triethylene Glycol Average Thickness Change

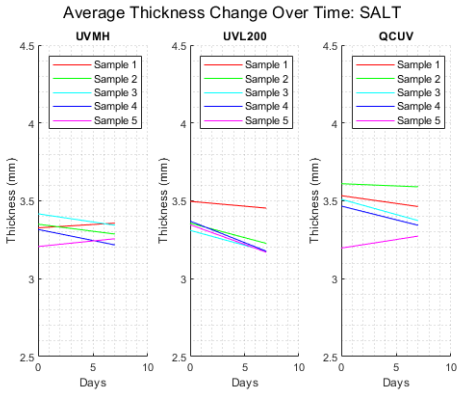

Figure 0.46. Chemical 6 – Salt Average Thickness Change

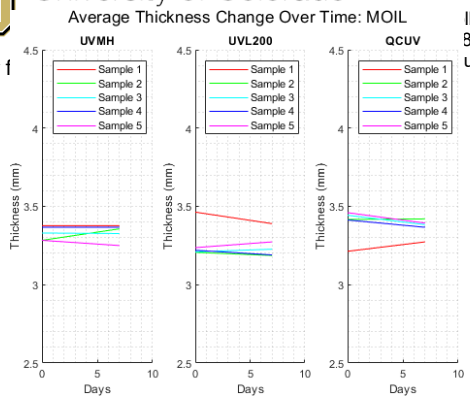

Figure 0.47. Chemical 7 – Mineral Oil Average Thickness Change

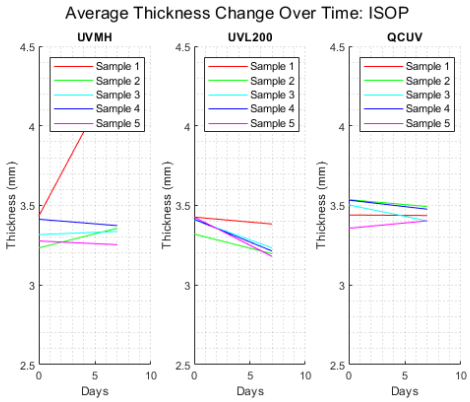

Figure 0.48. Chemical 8 – Isopropanol Average Thickness Change

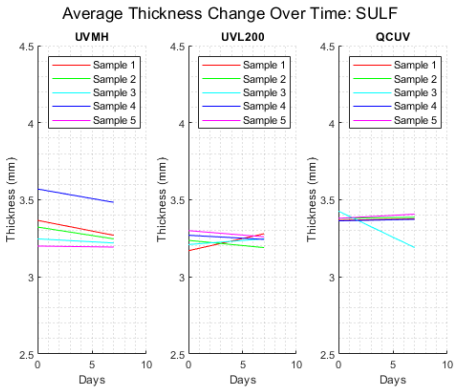

Figure 0.49. Chemical 9 – Sulfuric Acid Average Thickness Change

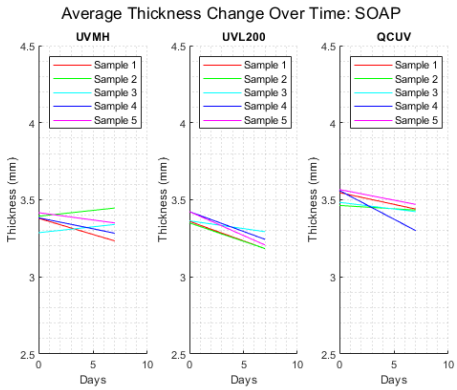

Figure 0.50. Chemical 10 – Surfactants Average Thickness Change