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The overall objective of this effort was to evaluate a series of collapsible fabric tanks (CFT) under simulated operational conditions. Long-standing field experience has witnessed the propensity of some tanks to fail catastrophically due to material or construction flaws. The proposed CFT test articles under investigation were a mix of unused tanks currently in the USMC inventory and new candidate tanks. The existing tanks vary by manufacturer, material, and age. For tanks currently in the USMC inventory, the goal was to determine if long-term dry-storage impacts the operational life of the tank. A total of nine candidate 20,000 gallon capacity CFTs were evaluated under this test program at the SwRI CFT Facility in San Antonio, TX. Three of these CFTs failed to advance past the 30-day static soak fuel storage phase of the testing, as they developed significant fuel leaks. All six of the remaining CFTs that entered the second phase of the testing completed it successfully in December 2021 without significant fuel loss.

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LONG-TERM STORAGE AND EVALUATION OF USMC COLLAPSIBLE FABRIC TANKS

FINAL TECHNICAL REPORT
No. 500

By
Kevin Shannon

GVSC Fuels and Lubricants Research Facility
Southwest Research Institute® (SwRI®)
San Antonio, TX

For
Eric Sattler

Force Projection Technology
Warren, Michigan

Contract No. W56HZV-15-C-0030 (WD 033)

January 25, 2022

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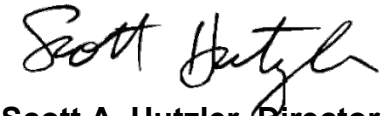

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EXECUTIVE SUMMARY

The overall objective of this effort was to evaluate a series of collapsible fabric tanks (CFT) under simulated operational conditions. Long-standing field experience has witnessed the propensity of some tanks to fail catastrophically due to material or construction flaws. The CFT test articles under investigation were a mix of unused tanks currently in the USMC inventory and new candidate tanks. The existing tanks varied by manufacturer, material, and age. For tanks currently in the USMC inventory, the goal was to determine if long-term dry-storage impacts the operational life of the tank. A total of nine candidate 20,000 gallon capacity CFTs were evaluated under this test program at the SwRI CFT Facility in San Antonio, TX.

Three of these CFTs failed to advance past the 30-day static soak fuel storage phase of the testing, as they developed fuel leaks concerning enough to warrant their removal from the program in order to prevent a massive fuel spill. These tanks were manufactured as far back as 2007, and as recently as the year 2014. Two were of nitrile construction and one had a polyurethane fabric exterior.

The remaining 6 CFTs, having both nitrile and polyurethane exterior compositions and ranging in age from 10 years to fresh off the assembly line, were placed on a 10-month fuel cycling schedule after successfully completing their static soak, whereby a nominal 20,000 gallon fuel volume was transferred into and then drained from the tank every 2 weeks. This “exercising” of the CFTs as they alternately expanded and collapsed from fuel transfer placed load stress on the CFT materials, seams, and design. All of the CFTs that entered the second phase of the testing completed it successfully in December 2021 without significant fuel loss.

FOREWORD/ACKNOWLEDGMENTS

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The authors would like to acknowledge the contribution of the GFLRF technical and administrative support staff.

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ACRONYMS AND ABBREVIATIONS

AEF	Avon Engineered Fabrications (Picayune, MS)
BLSS	Bulk Liquid Storage Systems (Mansfield, TX - now known as NAFT)
°C	degrees Celsius
CFT	Collapsible Fabric Tank
DoD	Department of Defense
GTA	GTA Containers Inc. (South Bend, IN)
GVSC	U.S. Army Ground Vehicle Systems Center
max	maximum
MCLB	Marine Corps Logistics Base
mg	milligrams
MIL-PRF-32233C	DoD CFT Performance Specification
min	minimum
mL	milliliters
MPC	MPC Containment Systems (Chicago, IL)
NAFT	North American Fuel Tank (Mansfield, TX)
N/A	Not Applicable
SEI	SEI Industries Ltd. (Delta, British Columbia, Canada)
SwRI	Southwest Research Institute
TIR	Test Incident Report
USMC	United States Marine Corps

1.0 BACKGROUND & INTRODUCTION

The overall objective of this effort was to evaluate a series of collapsible fabric tanks (CFT) under simulated operational conditions. Long-standing field experience has witnessed the propensity of some tanks to fail catastrophically due to material or construction flaws. The CFT test articles under investigation were a mix of unused tanks currently in the USMC inventory and new candidate tanks. The existing tanks varied by manufacturer, material, and age. For tanks currently in the USMC inventory, the goal was to determine if long-term dry-storage impacts the operational life of the tank. A total of 9 candidate CFTs were evaluated under this test program at the SwRI CFT Facility in San Antonio, TX. They are described in greater detail in the paragraphs below and in Table 1.

SwRI's CFT Facility is an open, outdoor, 22,000 square-foot concrete-lined revetment replete with stainless steel fuel distribution lines, valves, electric-motorized pumps, calibrated flow meters, and hoses to service fuel bladder tanks up to 50,000 gallons in capacity. For the purposes of this work directive, 100,000 gallons of Jet A fuel was inventoried at the site for transfer to the CFTs for static storage and periodic fill/drain cycling events according to a weekly schedule over the course of the project. All CFTs were unprotected from the elements of sun, rain, and even ice and snow. The nearly year-long deployment of the tanks in a harsh natural environment revealed any underlying shortcomings or vulnerabilities in the design, materials and workmanship of the CFTs. San Antonio, Texas has a typical semi-arid to subtropical climate, with extremely warm summers and mild winters. The area historically experiences approximately 30 inches of rainfall per year, with most of the total coming during the transition seasons of spring and fall. These transition seasons are more temperate and pleasant, with occasional drastic temperature swings and high winds caused by advancing weather frontal systems. Due to the proximity to the Texas coast, relative humidity can range up to stifling levels for long stretches of days and weeks. Tropical storms originating in the nearby Gulf of Mexico are infrequent but when they do occur, produce extremely heavy rainfall, high winds, and flash flooding. Hard freezes occur rarely and are generally short in duration—with the exception of Winter Storm Uri in mid-February 2021 (see Figure 1 below), which saw local temperatures in the South Texas region plunge to single digits and low teens degrees Fahrenheit and remain there for several days. Fuel cycling activity between CFTs was suspended during this period due to hazards in accessing the site.

Figure 1. SwRI CFT Facility on February 15, 2021 During Winter Storm Uri

Since the effect of weather on the CFTs was expected to be significant, a calibrated weather monitoring station was installed atop the control shed at the SwRI CFT Facility. Instruments constantly measured the outside air temperature, barometric pressure, and relative humidity. This data was logged over a network and stored on a computer server. During fuel transfer events, fuel temperature was monitored using a calibrated in-line thermocouple mounted on the discharge side of the electric pump. The weather data is overlaid on the fuel cycling charts in the Appendices, with the fuel temperature noted for each cycling event.

Six candidate CFTs were shipped in crates to SwRI from a storage depot at the Marine Corps Logistics Base (MCLB) located in Albany, GA. These six CFTs were manufactured by different companies from the years 2007 through 2015 and had presumably been stored as new upon receipt by the United States Marine Corps (USMC). When the crates were opened and the CFTs removed and deployed at the SwRI CFT Facility in October 2020, they appeared unused. However, the CFT fabric showed varying degrees of aging and loss of flexibility from tank to tank.

Two candidate CFTs manufactured in 2019 by SEI Industries of Canada were shipped in crates to SwRI. One is designated for desert conditions and the other for jungle conditions, and are named and colored (tan and green, respectively) accordingly. During deployment, these tanks also appeared unused and due to their more recent date of production, possessed generally more flexible and new characteristics.

One tank was purchased as a prototype directly from the manufacturer, GTA. This tank was manufactured in 2020 and features a new spiral design, in contrast to the traditional geometry and construction of the other tanks in the study. Additionally, a 50,000 gallon reservoir CFT in SwRI's inventory was employed for extra fuel storage capacity at the site.

Descriptions of the nine 20,000 gallon CFTs and 50,000 gallon reservoir CFT evaluated in the test program are shown in the Table 1 below:

Table 1. Listing of CFTs in Test Program

CFT Identifier	NSN	Part No.	Mfr.	Date of Manufacture	Origin	Date Deployed	Date Filled with Fuel	Dry Footprint	Maximum Tank Height
BLSS/NAFT #1 (20K)	5430-01-387-3053	Not listed	BLSS (NAFT) Mansfield, TX	October 2014	MCLB Albany Depot Storage (Project Code R5F)	October 2, 2020	October 26, 2020	23'11" x 27'	55"
JGB #2 (20K)	5430-01-387-3053	Not listed	AEF/JGB	September 2010	MCLB Albany Depot Storage (Project Code R5F)	December 10, 2020	December 21, 2020	28' 6" x 24'	60"
AEF #3 (20K)	5430-01-126-7624	800048900A	AEF	September 2012	MCLB Albany Depot Storage (Project Code R5F)	October 1, 2020	October 29, 2020	26' x 25' 9"	72"
MILPAWS #4 (20K)	5430-01-058-6293	Not listed	AEF (via MILPAWS)	April 2015	MCLB Albany Depot Storage (Project Code R5F)	November 5, 2020	December 8, 2020	24' x 28'	66"
AEF #5 (20K)	5430-01-126-7623	8107000204	AEF	August 2007	MCLB Albany Depot Storage (Project Code R5F)	November 5, 2020	December 22, 2020	30' x 24'	60"
MPC #6 (20K)	5430-01-126-7623	MPC-E-20K AD	MPC	May 2010	MCLB Albany Depot Storage (Project Code R5F)	November 4, 2020	December 9, 2020	23' x 23'	66"
GTA Spiral #7 (20K)	None (prototype)	GTA-20KFS	GTA	November 2020	OEM	December 10, 2020	December 17, 2020	24' 7" x 30'	55"
SEI JK #8 (20K)	None (foreign)	011402 Jungle King	SEI	April 2019	OEM	October 1, 2020	November 3, 2020	26' x 30'	53"
SEI DK #9 (20K)	None (foreign)	011402 Desert King	SEI	April 2019	OEM	October 1, 2020	October 28, 2020	26' x 30'	53"
50K North	5430-01-487-0638	Lot: 63 SN: 11 of 24	MPC	June 2005	Unknown	October 2, 2020	October 19, 2020	65' x 24'	66"

2.0 TEST OBJECTIVE

SwRI developed a testing matrix that incorporated all nine candidate fuel tanks. This testing matrix included periods of 30 day, full capacity, static testing as well as intermittent cycling between fuel tanks over a 10 month period.

3.0 APPROACH

For the static storage requirement, each 20K gallon candidate tank was deployed onto a berm liner in the CFT Facility basin. It was then filled with Jet A fuel to its maximum tank height and left undisturbed for a period of 30 days in accordance with section 4.5.1.6 of MIL-PRF-32233C, which is the DoD performance specification document for CFTs. During this storage interval the tanks were inspected daily for signs of fuel leakage and surface wetness. Since the fuel supply at the site was capped at 100,000 gallons, the CFTs were filled with fuel over a staggered schedule; when one CFT reached its 30 day limit, the fuel drained from it was used to fill another newly deployed CFT. Three CFTs—BLSS #1, AEF #3, and AEF #5 Nitrile—did not pass this stage of the testing due to visible leakage from fabric seams or widespread fuel permeation from inside the tank through the exterior fabric surface. This was reported to the sponsor and after consultation, the decision was made to remove these CFTs from continuation in the test program due to risk of a sudden loss of structural integrity and massive uncontrolled fuel release. They were subsequently drained and folded to fit inside a crate. Minor leakage was observed from some of the other tanks but through discussion with the sponsor, the decision was made to allow these CFTs to continue in the program. They were closely monitored for any worsening of fuel leaks during the remainder of their deployment at the site.

Once the static storage testing was completed for all candidate CFTs, a weekly fuel cycling schedule was set up and followed for the next 10 months. The remaining 6 CFTs in the test program were grouped into pairs. Fuel was passed between them on a bi-weekly basis. For each pair, one tank would be drained to emptiness, and the other would be filled with Jet A fuel to its maximum tank height. In this way, the CFTs were “exercised” with alternating periods of fuel containment. This process would test the CFT’s ability to expand and contract as the materials and seams would be stressed by the weight of the fuel, then relaxed when the fuel was pumped

out. Even with delays caused by inclement weather, each tank underwent a minimum of 10 fill/drain cycles over the course of 10 months. These tank pairs were:

- CFT Pair #1: MPC #6 and SEI Desert King #9
- CFT Pair #2: GTA Spiral #7 and SEI Jungle King #8
- CFT Pair #3: JGB #2 and MILPAWS #4

The volume of fuel transferred for every cycling event was tracked continuously using one of two calibrated positive displacement-style flow meters owned by SwRI. A corresponding tank height was recorded at 1,000 gallon increments using an inch-ruled measuring stick, string, and line level to ensure consistent and accurate readings.

The fuel cycling schedule is shown in Table 2 on the following page.

Table 2. Fuel Cycling Schedule Between CFTs

	CFT Filled with Fuel During Week Indicated (Other CFT in Pair Drained)		
Week of	**CFT Pair #1**	**CFT Pair #2**	**CFT Pair #3**
2/22/2021	MPC #6	GTA Spiral #7	
3/1/2021			JGB #2
3/8/2021	SEI DK #9	SEI JK #8	
3/15/2021			MILPAWS #4
3/22/2021	MPC #6	GTA Spiral #7	
3/29/2021			JGB #2
4/5/2021	SEI DK #9	SEI JK #8	
4/12/2021			MILPAWS #4
4/19/2021	MPC #6	GTA Spiral #7	
4/26/2021			JGB #2
5/3/2021	SEI DK #9	SEI JK #8	
5/10/2021			MILPAWS #4
5/17/2021	MPC #6	GTA Spiral #7	
5/24/2021			JGB #2
5/31/2021	SEI DK #9	SEI JK #8	
6/7/2021			MILPAWS #4
6/14/2021	MPC #6	GTA Spiral #7	
6/21/2021			JGB #2
6/28/2021	SEI DK #9	SEI JK #8	
7/5/2021			MILPAWS #4
7/12/2021	MPC #6	GTA Spiral #7	
7/19/2021			JGB #2
7/26/2021	SEI DK #9	SEI JK #8	
8/2/2021			MILPAWS #4
8/9/2021	MPC #6	GTA Spiral #7	
8/16/2021			JGB #2
8/23/2021	SEI DK #9	SEI JK #8	
8/30/2021			MILPAWS #4
9/6/2021	MPC #6	GTA Spiral #7	
9/13/2021			JGB #2
9/20/2021	SEI DK #9	SEI JK #8	
9/27/2021			MILPAWS #4
10/4/2021	MPC #6	GTA Spiral #7	
10/11/2021			JGB #2
10/18/2021	SEI DK #9	SEI JK #8	
10/25/2021			MILPAWS #4
11/1/2021	MPC #6	GTA Spiral #7	
11/8/2021			JGB #2
11/15/2021	SEI DK #9	SEI JK #8	
11/22/2021			MILPAWS #4
11/29/2021	MPC #6	GTA Spiral #7	

4.0 RESULTS

The CFT information and associated data collected during testing is expressed in tables and figures found in the Appendices A through I at the end of this report.

5.0 CONCLUSIONS

The maximum tank height did not correspond well to the intended 20,000 gallon capacity of each CFT. Additionally, the fuel volume needed to reach the maximum tank height was not reproducible from one fuel transfer to the next. This is due to the fact that there is a considerable volume of residual fuel in the tank even after it is drained. The design of the tank requires a fabric stretching characteristic to allow the tank to expand upward and laterally. When fuel is drained and the tank collapses, folds and creases develop in the CFT, trapping pockets of fuel that cannot be pumped out. The fuel port hardware elbows thus make a suction seal on the floor of the CFT which eliminates removal of additional fuel in the CFT.

The newer CFTs expanded to their proper height initially but the older CFTs had presumably lost some of their elasticity in the horizontal direction when being filled with fuel, causing them to expand vertically and reaching the height limit prematurely. Over time, the CFTs seemed to grow more rigid after repeated fuel fill/drain cycles, likely due to environmental factors such as extreme heat and humidity and long periods of direct sunshine. The damaging impact of UV radiation from the sun in South Texas is significant, and it is unknown whether the tank fabrics possess UV-inhibitors to counteract it.

The tank manufacturing process seems to be mediocre and inconsistent at best. Storage life problems are difficult to separate from poor craftsmanship (such as seams coming apart or stripped flange bolts) and defects when the CFTs are unused.

Pinhole leaks through the CFT fabric were commonplace among the nitrile tanks, but also occurred in polyurethane tanks—including the newer ones. By the end of the test program under

a full year of weathering, all of the tanks showed signs of deterioration and degradation, with some leaking fuel to the point that they should be decommissioned from further use.

6.0 RECOMMENDATIONS

Fabric seams on the CFT exterior were usually the first indicators of fuel leakage. Future work should seek to identify manufacturing problems at the seams. Any testing program involving CFTs should leak check them prior to fuel contact by filling them with compressed air and examining the exterior seams and flange attachments for leaks with a liquid leak detector. The internal air pressure should also be monitored for an extended period to verify that the CFT does not have any slow leaks.

Laboratory testing (such as tensile strength, fuel permeability, and the effects of heat and UV aging) on CFT fabric and seam samples may help to predict CFT performance in the field. Fuel stored in the CFTs can be tested before CFT contact and at the end of the test program for changes in the fuel characteristics or the presence of any leachates, such as gums or plasticizers that may desorb over time from the CFT fabric into the fuel.

APPENDIX A
BLSS #1 (NAFT #1) CFT

The BLSS (NAFT #1) CFT was deployed at the SwRI CFT Facility on October 2, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on October 26, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with nitrile composition. The CFT reached its maximum rated fill tank height of 55" at a tank volume under 16,000 gallons, well below its expected fuel capacity of 20,000 gallons. Due to safety considerations, fuel transfer into the tank was halted after 16,770 gallons and a tank height of 60". The sponsor was notified of this product performance deficiency.

Fuel leakage became apparent at both seams and through the surface fabric of this CFT almost immediately. The leaks were manifested as pinholes through the fabric and staining along the lateral seams of the tank. This was reported to the sponsor. These issues continued to worsen, becoming more widespread and acute. A joint decision was reached between the sponsor and SwRI to remove the CFT from the test program and drain it of all fuel to avoid the risk of a sudden loss of containment and possibly extensive fuel spill. The CFT was summarily folded up and placed in a crate for temporary storage in consideration of possible future laboratory testing on fabric samples taken from areas of interest. As such, the BLSS (NAFT #1) CFT did not undergo the intermittent fuel cycling stage of the work directive.

A description of the CFT can be found in Table A-1. Images of the CFT are shown in Figure A-1 through Figure A-9. The strapping chart for the CFT is shown in Figure A-10. It was created from the initial fuel fill data shown in Table A-2. The daily tank height record is shown in Table A-3. The chart of daily CFT heights is shown in Figure A-11.

Table A-1. Description of BLSS (NAFT #1) CFT

CFT DETAILS	
NSN	5430-01-387-3053
PN	Not listed
MFR	BLSS MANSFIELD TEXAS (NAFT)
MFR DATES	Sep 2014 to Dec 2014
Shipped From	MCLB Albany Depot Storage (Project Code R5F)
Deployed	10/2/2020
Filled	10/26/2020
Dry Footprint	23'11" x 27'
Max Fill Height	55"
Date drained	11/17/2020 (Removed from test program due to leaks)

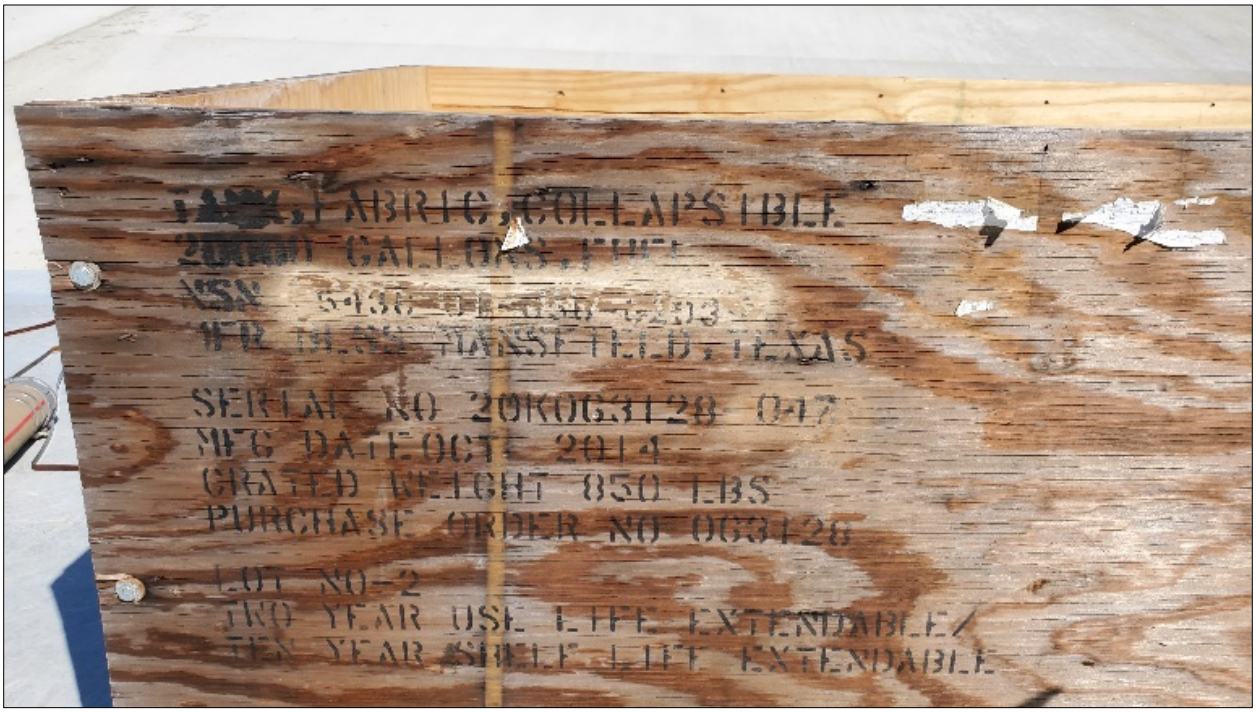

Figure A-1. BLSS #1 (NAFT #1) Shipping Crate with CFT Information

Figure A-2. BLSS #1 (NAFT #1) Filled with Fuel; Evidence of Leaks Through Fabric

Figure A-3. BLSS #1 (NAFT #1) CFT with Fuel Leak Through Fabric

Figure A-4. BLSS #1 (NAFT #1) CFT with Fuel Leaks Through Fabric

Figure A-5. BLSS #1 (NAFT #1) CFT with Fuel Leaks Below Seam

Figure A-6. BLSS #1 (NAFT #1) CFT with Widespread Fuel Leaks and Spotting

Figure A-7. BLSS #1 (NAFT #1) CFT Fuel Leaks and Drips

Figure A-8. BLSS #1 (NAFT #1) CFT Spread of Fuel Drips Along Entire Seam

Figure A-9. BLSS #1 (NAFT #1) Fuel Leak from Surface Crack and Pooled Along Edge

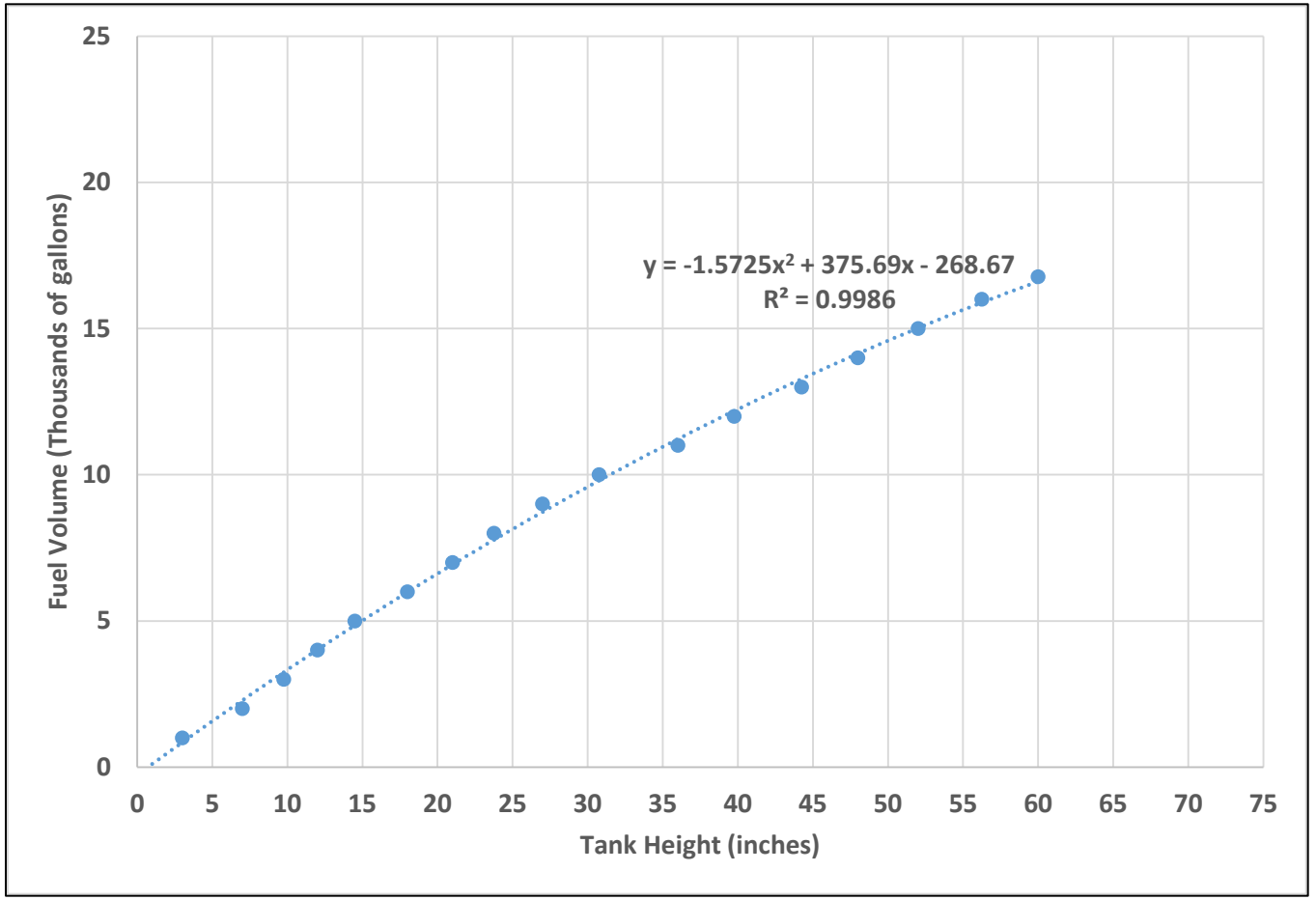

Figure A-10. BLSS #1 (NAFT #1) CFT Strapping Chart

Table A-2. BLSS #1 (NAFT #1) CFT Strapping Chart Data

Initial Fill: BLSS (NAFT #1) CFT Date: October 26, 2020		
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	3.00
1000	2000	7.00
1000	3000	9.75
1000	4000	12.00
1000	5000	14.50
1000	6000	18.00
1000	7000	21.00
1000	8000	23.75
1000	9000	27.00
1000	10000	30.75
1000	11000	36.00
1000	12000	39.75
1000	13000	44.25
1000	14000	48.00
1000	15000	52.00
1000	16000	56.25
770	16770	60.00

Table A-3. BLSS #1 (NAFT #1) CFT Daily Height Measurements

Date	String Height (inches)
11/3/2020	55.75
11/4/2020	56.00
11/5/2020	56.50
11/6/2020	57.00
11/9/2020	56.00
11/10/2020	56.50
11/11/2020	56.75
11/12/2020	56.25
11/13/2020	57.00
11/17/2020	56.50
Monthly avg.	**56.43**

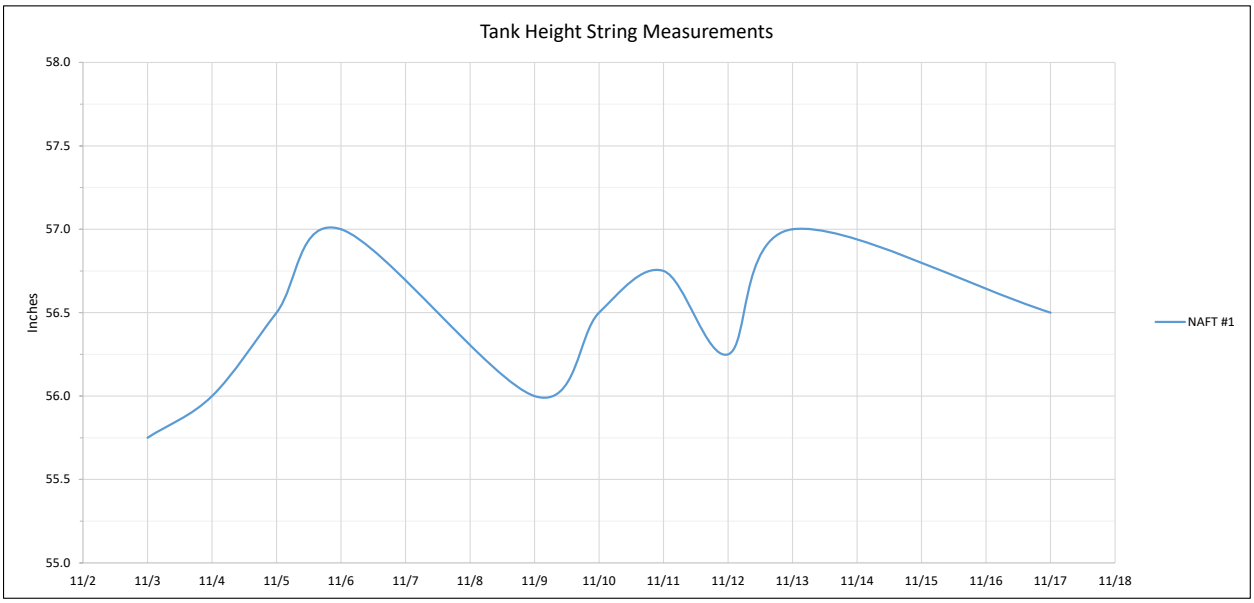

Figure A-11. BLSS #1 (NAFT #1) CFT Daily Height Chart

APPENDIX B
JGB #2 NITRILE

The JGB #2 NITRILE CFT was deployed at the SwRI CFT Facility on December 10, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on December 21, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with nitrile composition. The CFT reached its maximum rated fill tank height of 60" at a tank volume under 19,000 gallons, well below its expected fuel capacity of 20,000 gallons. Due to safety considerations, fuel transfer into the tank was halted after 19,704 gallons and a tank height of 64.25". The sponsor was notified of this product performance deficiency.

Fuel leakage at some of the tank corners became apparent after a couple of weeks. This was reported to the sponsor. Since the leakage was minimal and seemed to stabilize, a joint decision was reached between the sponsor and SwRI to allow the CFT to continue in the test program. The JGB #2 NITRILE CFT survived intermittent fuel cycling from February 2021 through the end of the program in December 2021.

A description of the CFT can be found in Table B-1. Images of the CFT are shown in Figure B-1 through Figure B-7. The strapping chart for the CFT is shown in Figure B-8. It was created from the initial fuel fill data shown in Table B-2. The daily tank height records are shown in Table B-3 through Table B-5. The charts of daily CFT heights are shown in Figure B-9 through Figure B-11.

Table B-1. Description of JGB #2 NITRILE CFT

CFT DETAILS	
NSN	5430-01-387-3053
PN	Not listed
MFR	AVON ENGINEERED FABRICATIONS INC
MFR DATES	September 2010
Shipped From	MCLB Albany Depot Storage (Project Code R5F)
Deployed	12/10/2020
Filled	12/21/2020
Dry Footprint	28' 6" x 24'
Max Fill Height	60"
Date drained	At end of program

Figure B-1. JGB #2 NITRILE CFT Unfolded and Deployed (Looking South)

Figure B-2. JGB #2 NITRILE CFT Stencil on Tank Surface

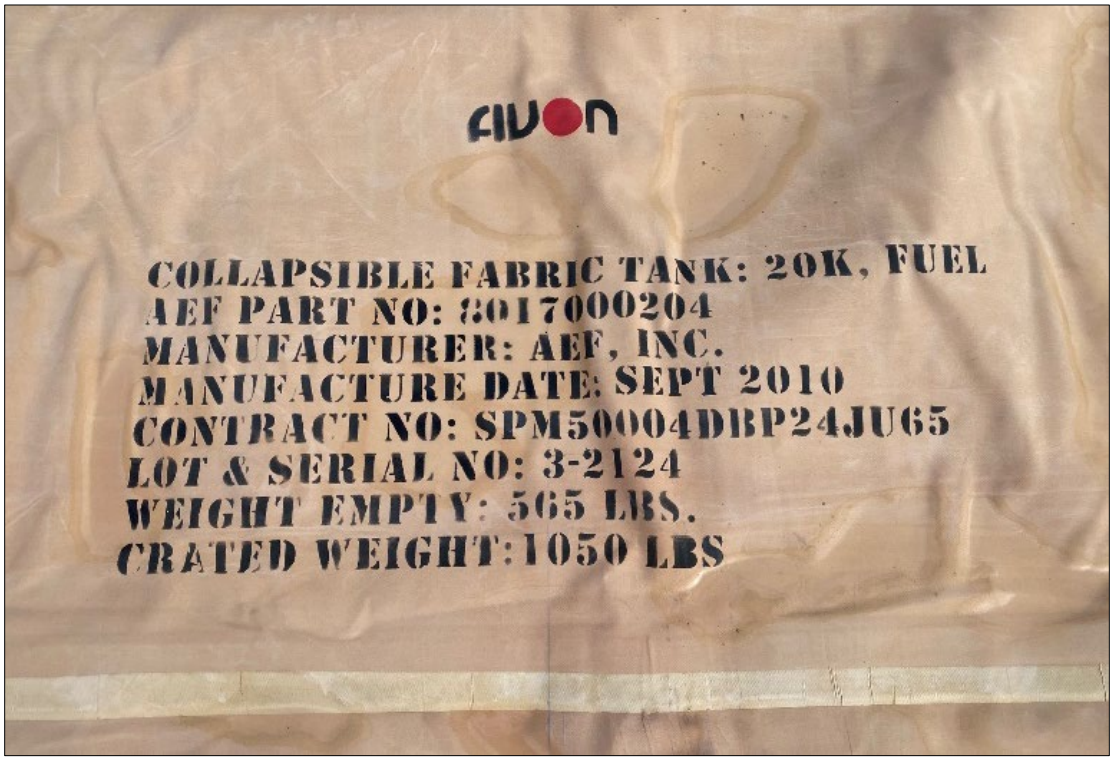

Figure B-3. JGB #2 NITRILE CFT Stencil on Tank Surface

Figure B-4. JGB #2 NITRILE CFT Unfolded and Deployed (Looking North)

Figure B-5. Location of JGB #2 NITRILE CFT at SwRI CFT Facility

Figure B-6. JGB #2 NITRILE CFT Corner Fuel Wetting
(Puddles are from Recent Rains, not Fuel)

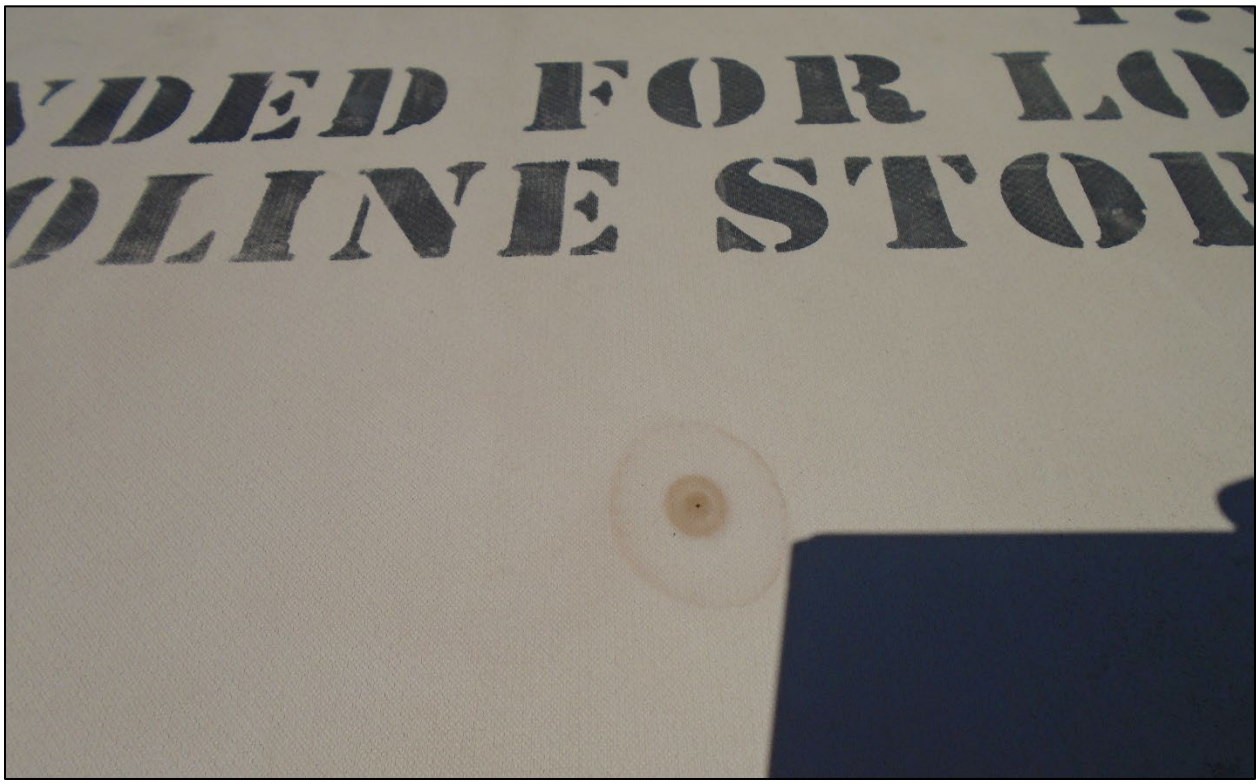

Figure B-7. JGB #2 NITRILE CFT Pinhole Leak Through Fabric

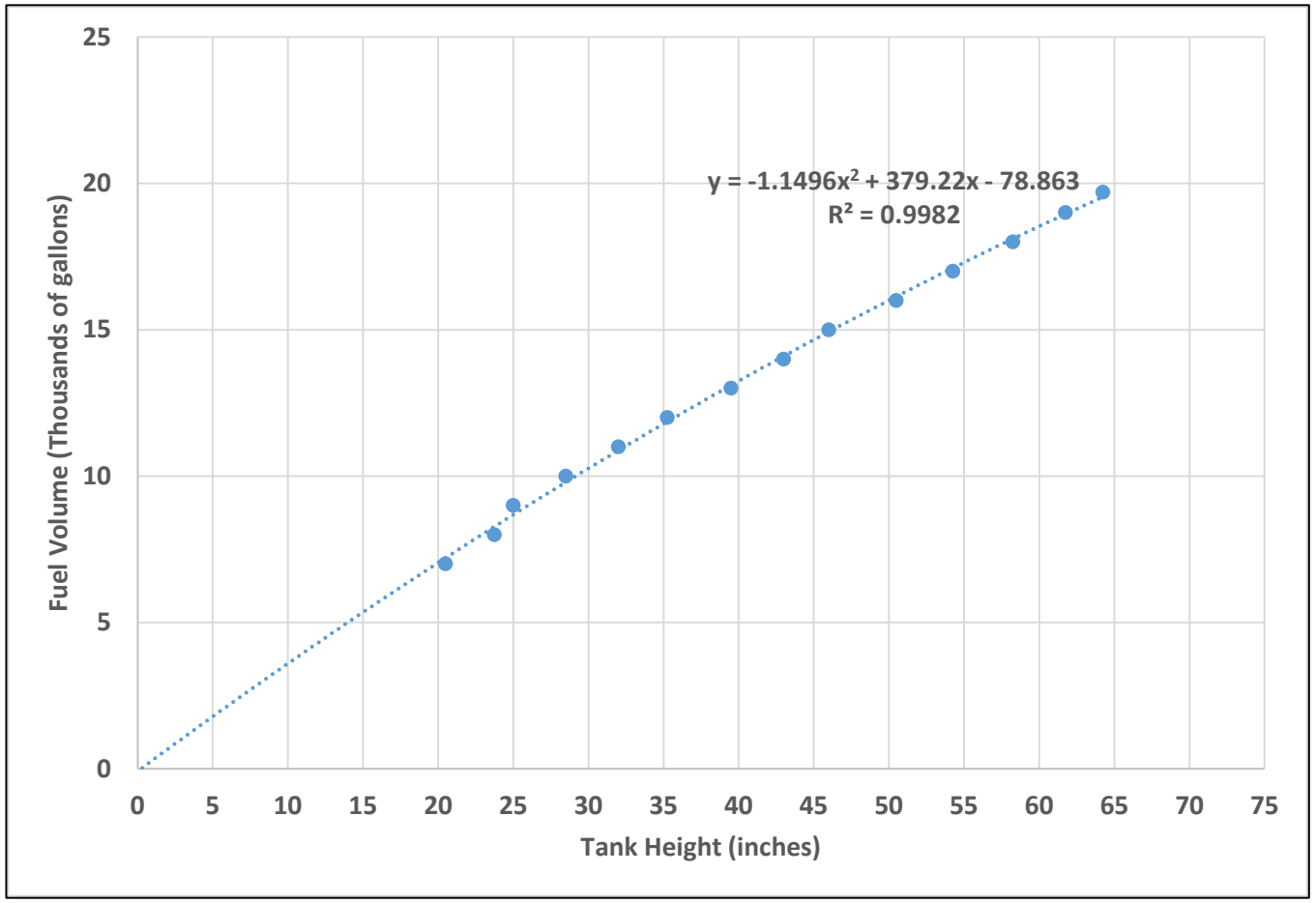

Figure B-8. JGB #2 NITRILE CFT Strapping Chart

Table B-2. JGB #2 NITRILE CFT Strapping Chart Data

Initial Fill: JGB #2 NITRILE CFT Date: December 21, 2020		
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	Not Measurable
1000	2000	Not Measurable
1000	3000	Not Measurable
1000	4000	Not Measurable
1000	5000	Not Measurable
1000	6000	Not Measurable
1000	7000	20.50
1000	8000	23.75
1000	9000	25.00
1000	10000	28.50
1000	11000	32.00
1000	12000	35.25
1000	13000	39.50
1000	14000	43.00
1000	15000	46.00
1000	16000	50.50
1000	17000	54.25
1000	18000	58.25
1000	19000	61.75
704	19704	64.25

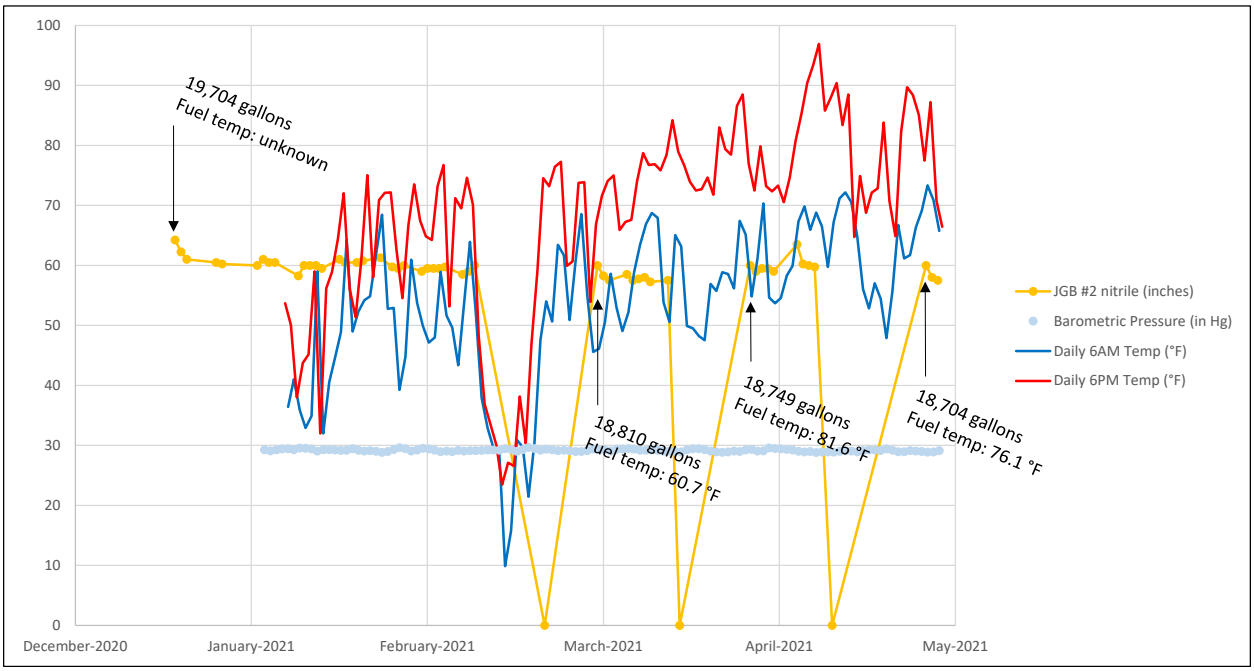

Figure B-9. JGB #2 NITRILE CFT Fuel Cycling Log

Table B-3. JGB #2 NITRILE CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
12/21	64.25	2/1	59.00
12/22	62.25	2/2	59.50
12/23	61.00	2/3	59.50
12/28	60.50	2/4	59.50
12/29	60.25	2/5	59.75
Monthly avg.	**61.65**	2/8	58.50
1/4	60.00	2/9	59.00
1/5	61.00	2/10	60.00
1/6	60.50	**Monthly avg.**	**59.34**
1/7	60.50	3/3	60.00
1/11	58.25	3/4	58.25
1/12	60.00	3/5	57.50
1/13	60.00	3/8	58.50
1/14	60.00	3/9	57.50
1/15	59.50	3/10	57.75
1/18	61.00	3/11	58.00
1/19	60.50	3/12	57.25
1/21	60.50	3/15	57.50
1/22	60.75	3/29	60.00
1/25	61.25	3/30	59.00
1/27	59.75	3/31	59.50
1/28	59.50	**Monthly avg.**	**58.40**
1/29	60.00		
Monthly avg.	**60.18**		

Table B-3. JGB #2 NITRILE CFT Daily Height Measurements (Continued)

Date	CFT Height (inches)
4/1	59.50
4/2	59.00
4/6	63.50
4/7	60.25
4/8	60.00
4/9	59.75
4/28	60.00
4/29	58.00
4/30	57.50
Monthly avg.	**59.72**

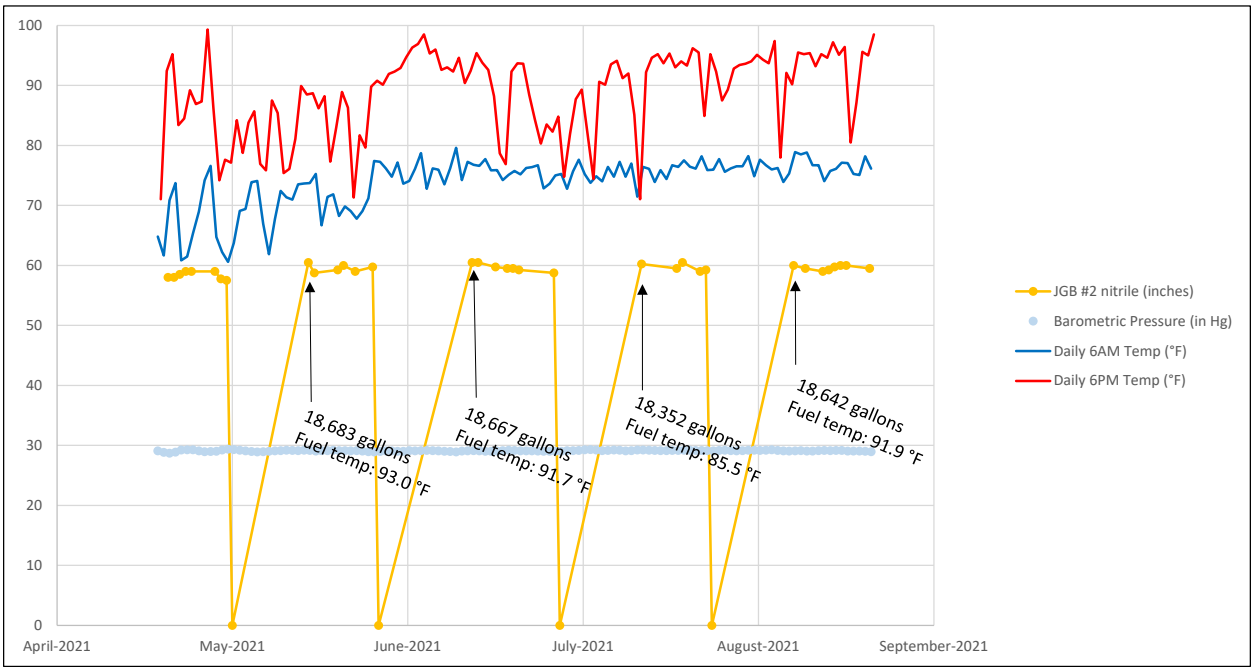

Figure B-10. JGB #2 NITRILE CFT Fuel Cycling Log

Table B-4. JGB #2 NITRILE CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
5/3	58.00	7/1	59.50
5/4	58.00	7/2	59.25
5/5	58.50	7/8	58.75
5/6	59.00	7/23	60.25
5/7	59.00	7/29	59.50
5/11	59.00	7/30	60.50
5/12	57.75	**Monthly avg.**	**59.63**
5/13	57.50	8/2	59.00
5/27	60.50	8/3	59.25
5/28	58.75	8/18	60.00
Monthly avg.	**58.60**	8/20	59.50
6/1	59.25	8/23	59.00
6/2	60.00	8/24	59.25
6/4	59.00	8/25	59.75
6/7	59.75	8/26	60.00
6/24	60.50	8/27	60.00
6/25	60.50	8/31	59.50
6/28	59.75	**Monthly avg.**	**59.53**
6/30	59.50		
Monthly avg.	**59.78**		

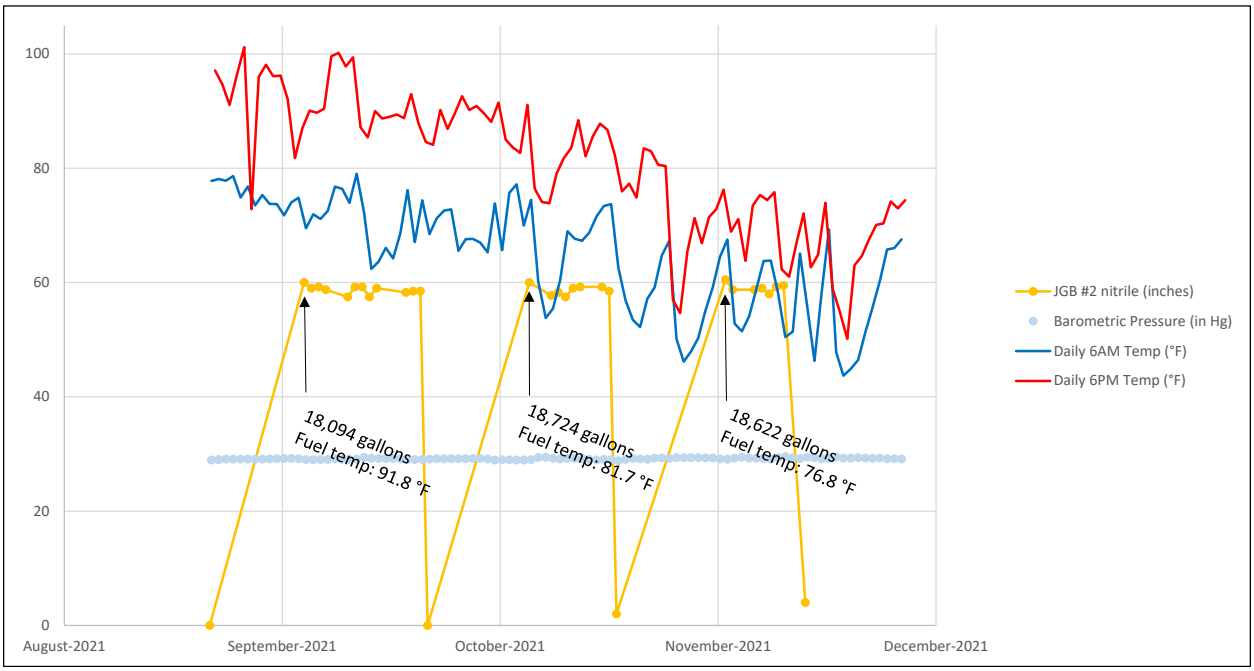

Figure B-11. JGB #2 NITRILE CFT Fuel Cycling Log

Table B-5. JGB #2 NITRILE CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
9/14	60.00	11/11	60.50
9/15	59.00	11/12	58.75
9/16	59.25	11/15	58.75
9/17	58.75	11/16	59.00
9/20	57.50	11/17	58.00
9/21	59.25	11/18	59.25
9/22	59.25	11/19	59.50
9/23	57.50	**Monthly avg.**	**59.11**
9/24	59.00		
9/28	58.25		
9/29	58.50		
9/30	58.50		
Monthly avg.	**58.73**		
10/15	60.00		
10/18	57.75		
10/19	58.25		
10/20	57.50		
10/21	59.00		
10/22	59.25		
10/25	59.25		
10/26	58.50		
Monthly avg.	**58.69**		

APPENDIX C
AEF #3 CFT

The AEF #3 CFT was deployed at the SwRI CFT Facility on October 1, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on October 29, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with polyurethane composition. The CFT reached its maximum rated fill tank height of 72" at a tank volume roughly matching its expected fuel capacity of 20,000 gallons.

Fuel leakage became apparent at a tank seam near one of the CFT corners. This was reported to the sponsor. A joint decision was reached between the sponsor and SwRI to remove the CFT from the test program and drain it of all fuel to avoid the risk of a sudden loss of containment and possibly extensive fuel spill. The CFT was summarily folded up and placed in a crate for temporary storage in consideration of possible future laboratory testing on fabric samples taken from areas of interest. As such, the AEF #3 CFT did not undergo the intermittent fuel cycling stage of the work directive.

A description of the CFT can be found in Table C-1. Images of the CFT are shown in Figure C-1 through Figure C-5. The strapping chart for the CFT is shown in Figure C-6. It was created from the initial fuel fill data shown in Table C-2. The daily tank height record is shown in Table C-3. The chart of daily CFT heights is shown in Figure C-7.

Table C-1. Description of AEF #3 CFT

CFT DETAILS	
NSN	5430-01-126-7624
PN	800048900A
MFR	AVON ENGINEERED FABRICATIONS INC
MFR DATES	September 2012
Shipped From	MCLB Albany Depot Storage (Project Code R5F)
Deployed	10/1/2020
Filled	10/29/2020
Dry Footprint	26 x 25' 9"
Max Fill Height	72"
Date drained	11/17/2020 (Removed from test program due to leaks)

Figure C-1. AEF #3 CFT Removed from Crate

Figure C-2. AEF #3 CFT Unfolded and Deployed
(Mfr. Applied Talcum Powder to Prevent Fabric from Sticking to Itself)

Figure C-3. AEF #3 CFT Filled with Fuel

Figure C-4. AEF #3 CFT Filled with Fuel

Figure C-5. AEF #3 CFT Developing Fuel Leak at Seam

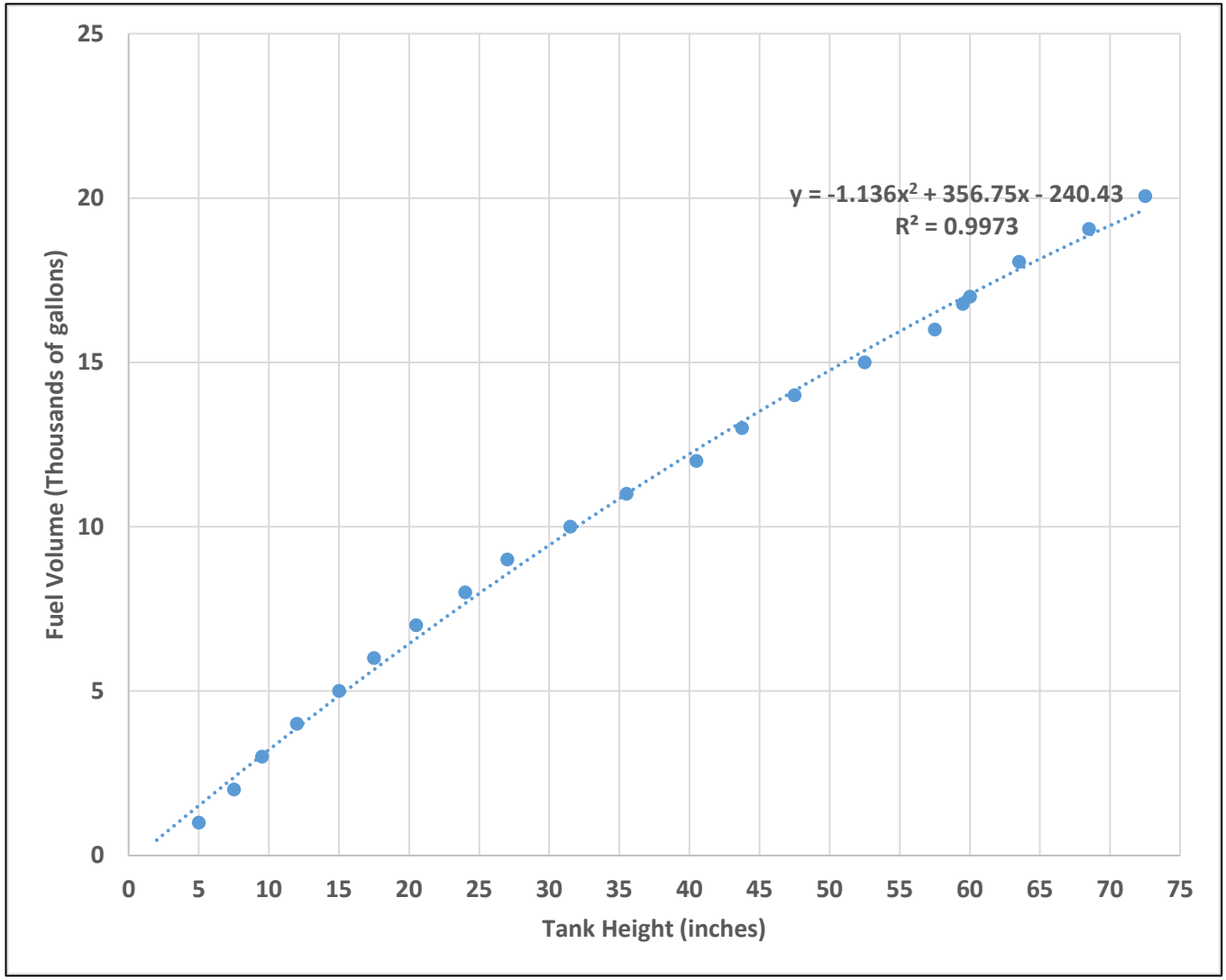

Figure C-6. AEF #3 CFT Strapping Chart

Table C-2. AEF #3 CFT Strapping Chart Data

Initial Fill: AEF #3 CFT Date: October 29, 2020		
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	5.00
1000	2000	7.50
1000	3000	9.50
1000	4000	12.00
1000	5000	15.00
1000	6000	17.50
1000	7000	20.50
1000	8000	24.00
1000	9000	27.00
1000	10000	31.50
1000	11000	35.50
1000	12000	40.50
1000	13000	43.75
1000	14000	47.50
1000	15000	52.50
1000	16000	57.50
782	16782	59.50
219	17002	60.00
1056	18058	63.50
1000	19058	68.50
1000	20057	72.50

Table C-3. AEF #3 CFT Daily Height Measurements

Date	String Height (inches)
11/3	72.50
11/4	71.50
11/5	72.50
11/6	72.50
11/9	72.00
11/10	72.25
11/11	72.75
11/12	72.50
11/13	72.50
11/17	72.50
Monthly avg.	72.35

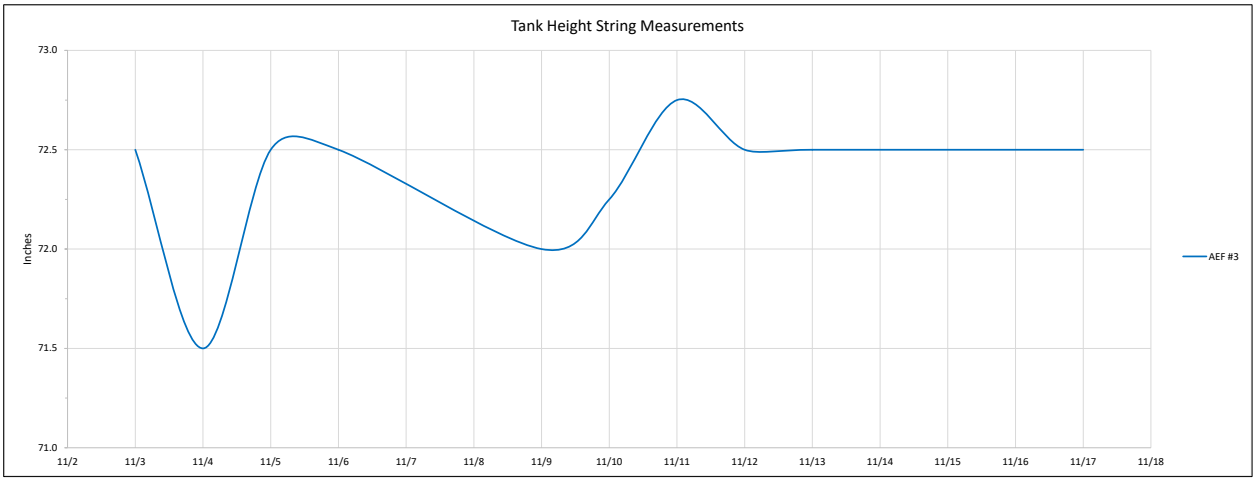

Figure C-7. AEF #3 CFT Daily Height Chart

APPENDIX D
MILPAWS #4 CFT

The MILPAWS #4 CFT was deployed at the SwRI CFT Facility on November 5, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on December 8, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with polyurethane composition. The CFT reached its maximum rated fill tank height of 66" at a tank volume between 18,000 and 19,000 gallons, well below its expected fuel capacity of 20,000 gallons. Due to safety considerations, fuel transfer into the tank was halted after 19,123 gallons and a tank height of 70.25". The sponsor was notified of this product performance deficiency.

Fuel leakage at some of the seams became apparent within a couple of weeks. This was reported to the sponsor. Since the leakage was minimal and seemed to stabilize, a joint decision was reached between the sponsor and SwRI to allow the CFT to continue in the test program. The MILPAWS #4 CFT survived intermittent fuel cycling from February 2021 through the end of the program in December 2021.

A description of the CFT can be found in Table D-1. Images of the CFT are shown in Figure D-1 through Figure D-11. The strapping chart for the CFT is shown in Figure D-12. It was created from the initial fuel fill data shown in Table D-2. The daily tank height records are shown in Table D-3 through Table D-5. The charts of daily CFT heights are shown in Figure D-13 through Figure D-15.

Table D-1. Description of MILPAWS #4 CFT

CFT DETAILS	
NSN	5430-01-058-6293
PN	8000016704
MFR	AVON (MILPAWS supplied)
MFR DATES	April 2015
Shipped From	MCLB Albany Depot Storage (Project Code R5F)
Deployed	11/5/2020
Filled	12/8/2020
Dry Footprint	24' x 28'
Max Fill Height	66"
Date drained	At end of program

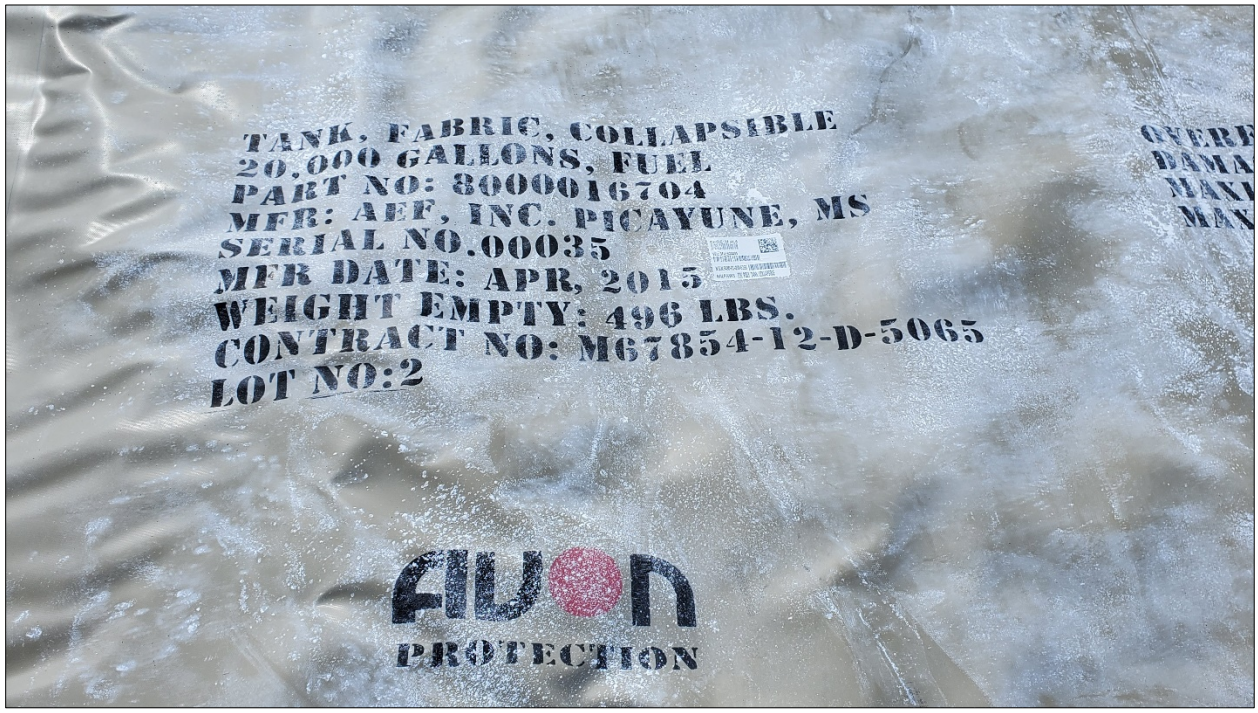

Figure D-1. MILPAWS #4 CFT Stencil on Tank Surface

Figure D-2. MILPAWS #4 CFT Filled with Fuel

Figure D-3. MILPAWS #4 CFT Fuel Moistening at Seam

Figure D-4. MILPAWS #4 CFT Fuel Seeping from Seam

Figure D-5. MILPAWS #4 CFT Surface Blistering

Figure D-6. MILPAWS #4 CFT Fuel Seeping from Seam

Figure D-7. MILPAWS #4 CFT Fuel Seeping from Seam

Figure D-8. MILPAWS #4 CFT at End of Test Program

Figure D-9. MILPAWS #4 CFT at End of Test Program Showing Seam Leaks

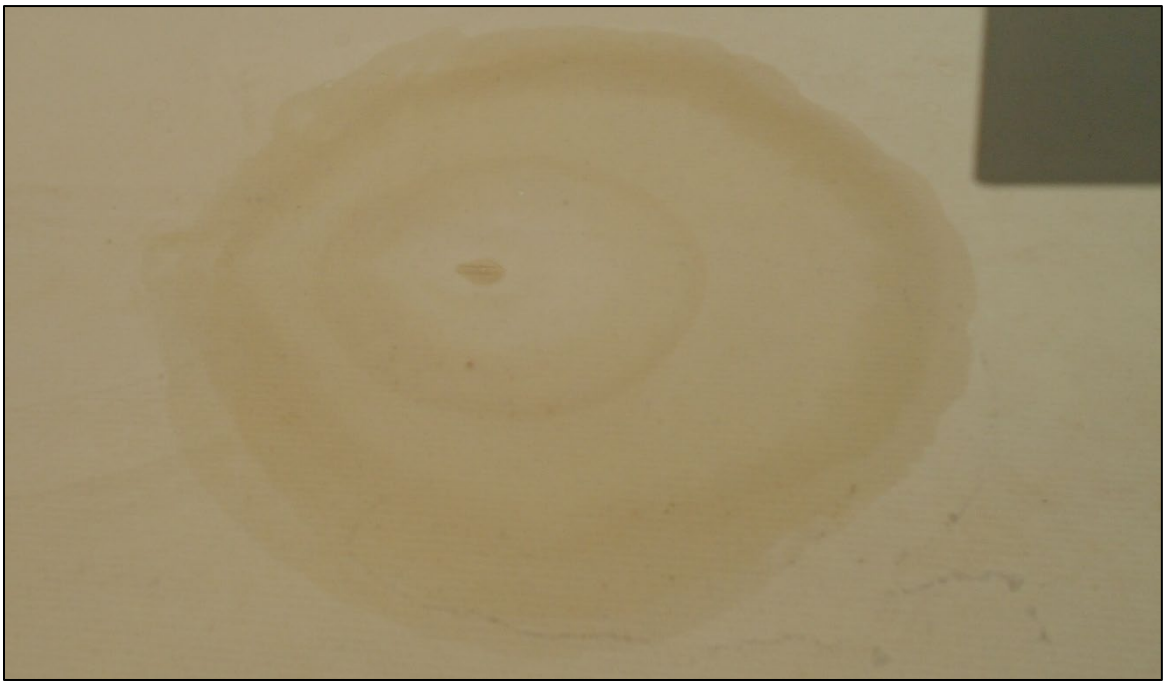

Figure D-10. MILPAWS #4 CFT Pinhole Leak Through Fabric

Figure D-11. MILPAWS #4 CFT at End of Test Program Showing Seam Leak

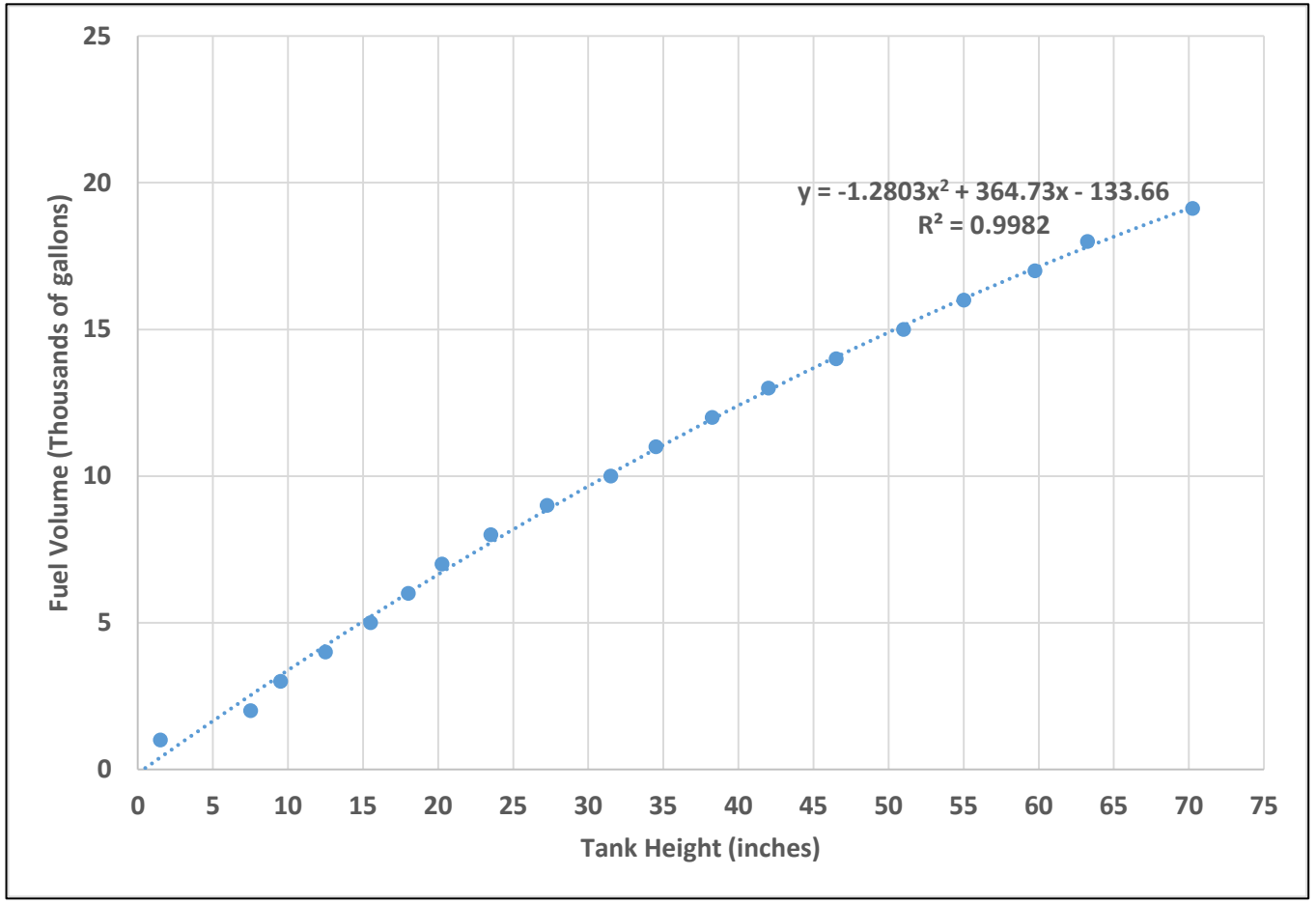

Figure D-12. MILPAWS #4 CFT Strapping Chart

Table D-2. MILPAWS #4 CFT Strapping Chart Data

Initial Fill: MILPAWS #4 Date: December 8, 2020		
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	1.50
1000	2000	7.50
1000	3000	9.50
1000	4000	12.50
1000	5000	15.50
1000	6000	18.00
1000	7000	20.25
1000	8000	23.50
1000	9000	27.25
1000	10000	31.50
1000	11000	34.50
1000	12000	38.25
1000	13000	42.00
1000	14000	46.50
1000	15000	51.00
1000	16000	55.00
1000	17000	59.75
1000	18000	63.25
1123	19123	70.25

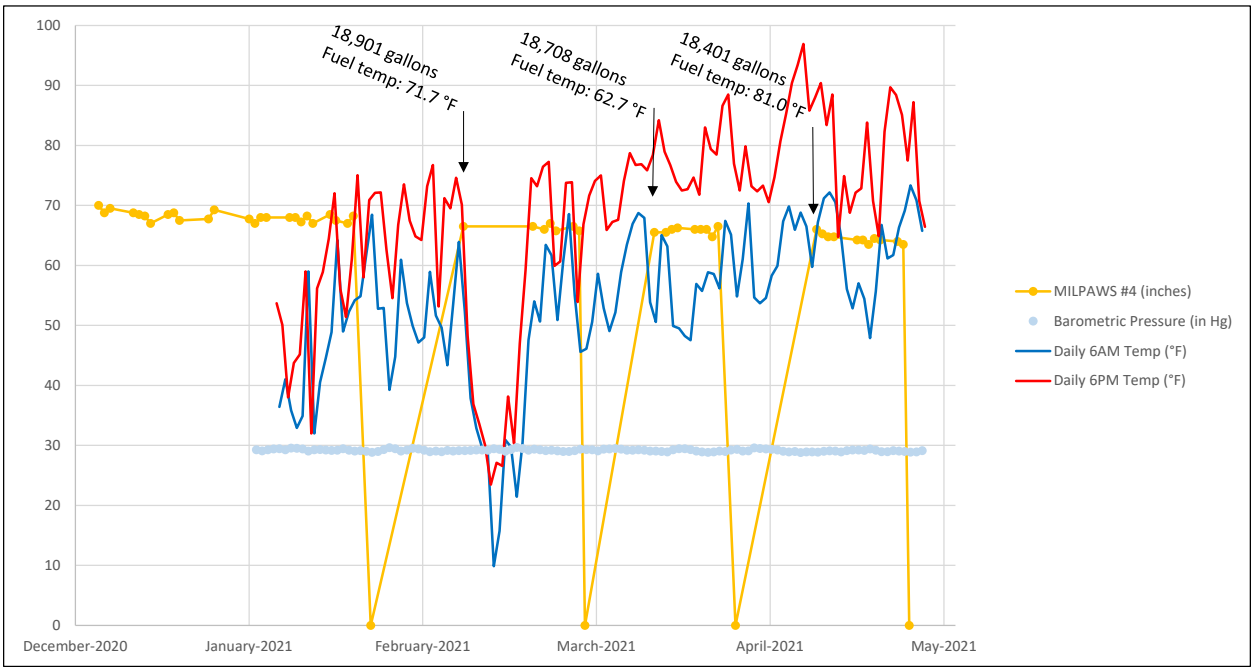

Figure D-13. MILPAWS #4 CFT Fuel Cycling Log

Table D-3. MILPAWS #4 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
12/9	70.00	1/18	68.50
12/10	68.75	1/19	67.50
12/11	69.50	1/21	67.00
12/15	68.75	1/22	68.25
12/16	68.50	**Monthly avg.**	**67.73**
12/17	68.25	2/10	66.50
12/18	67.00	2/22	66.50
12/21	68.50	2/24	66.00
12/22	68.75	2/25	67.00
12/23	67.50	2/26	65.75
12/28	67.75	**Monthly avg.**	**66.35**
12/29	69.25	3/1	66.50
12/9	70.00	3/2	65.75
12/10	68.75	3/15	65.50
12/11	69.50	3/17	65.50
12/15	68.75	3/18	66.00
12/16	68.50	3/19	66.25
12/17	68.25	3/22	66.00
12/18	67.00	3/23	66.00
Monthly avg.	**68.54**	3/24	66.00
1/11	68.00	3/25	64.75
1/12	68.00	3/26	66.50
1/13	67.25	3/29	0.00
1/14	68.25	**Monthly avg.**	**65.89**

Table D-3. MILPAWS #4 CFT Daily Height Measurements (Continued)

Date	CFT Height (inches)
4/12	66.00
4/13	65.25
4/14	64.75
4/15	64.75
4/19	64.25
4/20	64.25
4/21	63.50
4/22	64.50
4/23	64.25
4/26	64.00
4/27	63.50
Monthly avg.	**64.45**

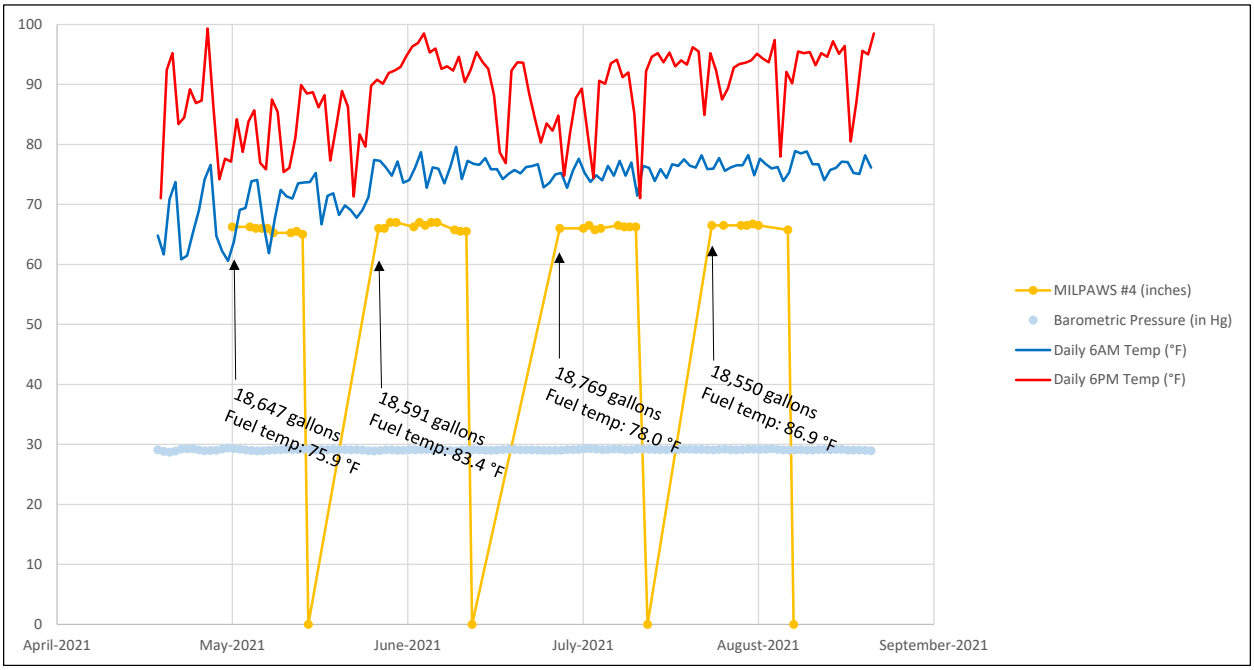

Figure D-14. MILPAWS #4 CFT Fuel Cycling Log

Table D-4. MILPAWS #4 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
5/14	66.25	7/9	66.00
5/17	66.25	7/13	66.00
5/18	66.00	7/14	66.50
5/19	66.00	7/15	65.75
5/20	66.00	7/16	66.00
5/21	65.25	7/19	66.50
5/24	65.25	7/20	66.25
5/25	65.50	7/21	66.25
5/26	65.00	7/22	66.25
Monthly avg.	**65.72**	**Monthly avg.**	**66.17**
6/8	66.00	8/4	66.50
6/9	66.00	8/6	66.50
6/10	67.00	8/9	66.50
6/11	67.00	8/10	66.50
6/14	66.25	8/11	66.75
6/15	67.00	8/12	66.50
6/16	66.50	8/17	65.75
6/17	67.00	**Monthly avg.**	**66.43**
6/18	67.00		
6/21	65.75		
6/22	65.50		
6/23	65.50		
Monthly avg.	**66.38**		

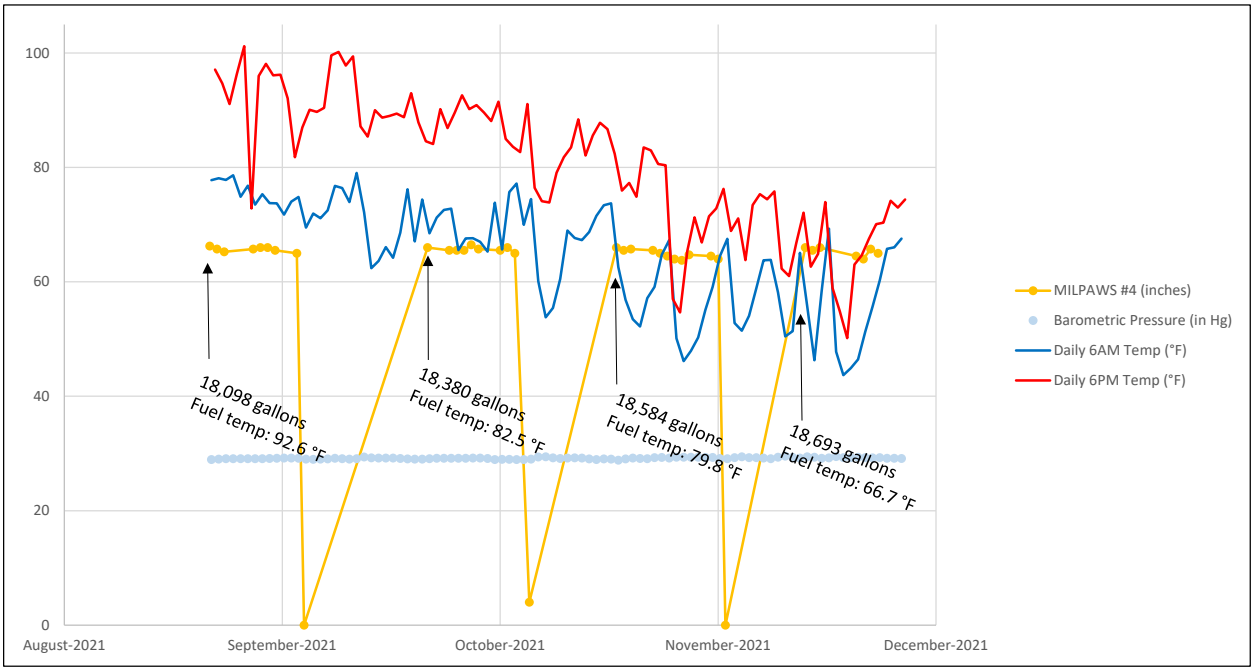

Figure D-15. MILPAWS #4 CFT Fuel Cycling Log

Table D-5. MILPAWS #4 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
9/1	66.25	11/1	65.50
9/2	65.75	11/2	65.00
9/3	65.25	11/3	64.50
9/7	65.75	11/4	64.00
9/8	66.00	11/5	63.75
9/9	66.00	11/6	64.75
9/10	65.50	11/9	64.50
9/13	65.00	11/10	64.00
Monthly avg.	**65.69**	11/22	66.00
10/1	66.00	11/23	65.50
10/4	65.50	11/24	66.00
10/5	65.50	11/29	64.50
10/6	65.50	11/30	64.00
10/7	66.50	12/1	65.75
10/8	65.75	12/2	65.00
10/11	65.50	**Monthly avg.**	**64.85**
10/12	66.00		
10/13	65.00		
10/27	66.00		
10/28	65.50		
10/29	65.75		
Monthly avg.	**65.71**		

APPENDIX E
AEF #5 CFT

The AEF #5 CFT was deployed at the SwRI CFT Facility on November 5, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on December 22, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with nitrile composition. The CFT reached its maximum rated fill tank height of 60" at a tank volume between 19,000 and 20,000 gallons. A final tank volume of 20,000 gallons was achieved at a tank height of 62".

Fuel leakage became immediately apparent at one of the CFT corners and from a stripped bolt on one of the fuel port flanges. This was reported to the sponsor. A joint decision was reached between the sponsor and SwRI to remove the CFT from the test program and drain it of all fuel to avoid the risk of a sudden loss of containment and possibly extensive fuel spill. The CFT was summarily folded up and stored in a crate. As such, the AEF #5 CFT did not undergo the intermittent fuel cycling stage of the work directive.

A description of the CFT can be found in Table E-1. Images of the CFT are shown in Figure E-2 through Figure E-6. The strapping chart for the CFT is shown in Figure E-7. It was created from the initial fuel fill data shown in Table E-2. The daily tank height record is shown in Table E-3. The chart of daily CFT heights is shown in Figure E-8.

Table E-1. Description of AEF #5 CFT

CFT DETAILS	
NSN	5430-01-126-7623
PN	8107000200
MFR	AVON ENGINEERED FABRICATIONS INC (CAGE CODE 66618)
MFR DATES	August 2007
Shipped From	MCLB Albany Depot Storage (Project Code R5F)
Deployed	11/5/2020
Filled	12/22/2020
Dry Footprint	30' x 24'
Max Fill Height	60"
Date drained	1/7/2021 (Removed from test program due to leaks)

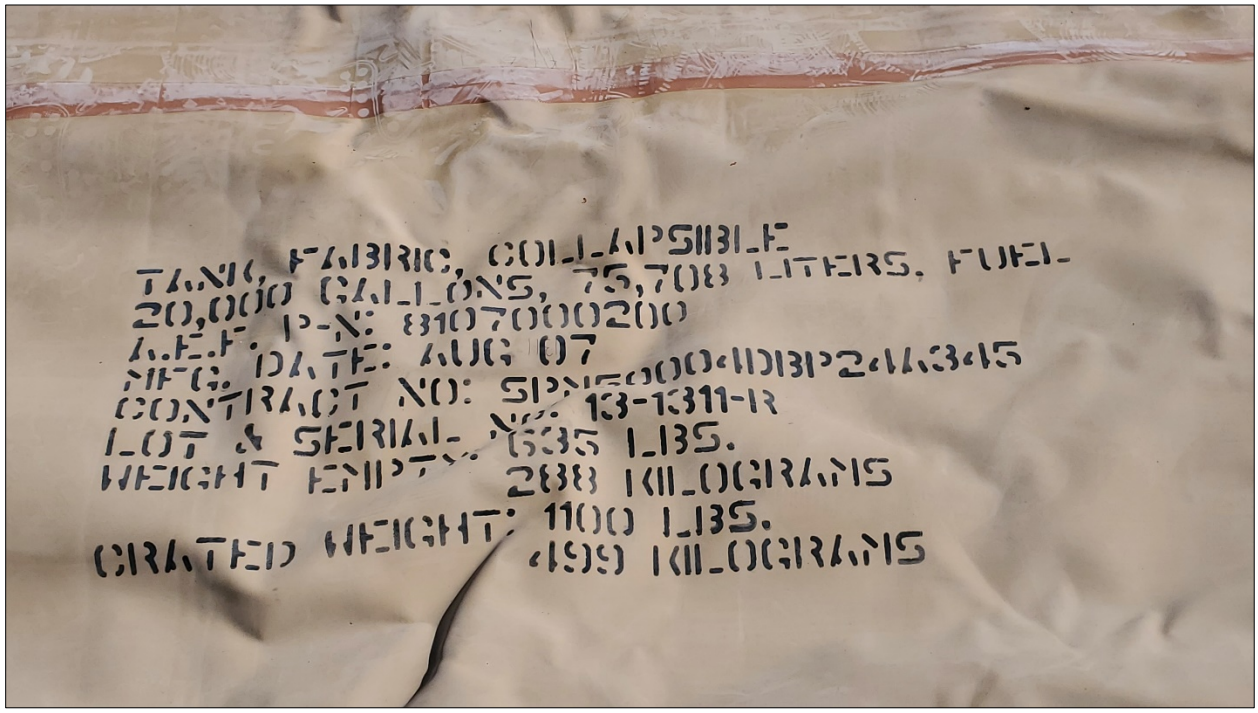

Figure E-1. AEF #5 CFT Stencil on Tank Surface

Figure E-2. AEF #5 CFT Unfolded and Deployed

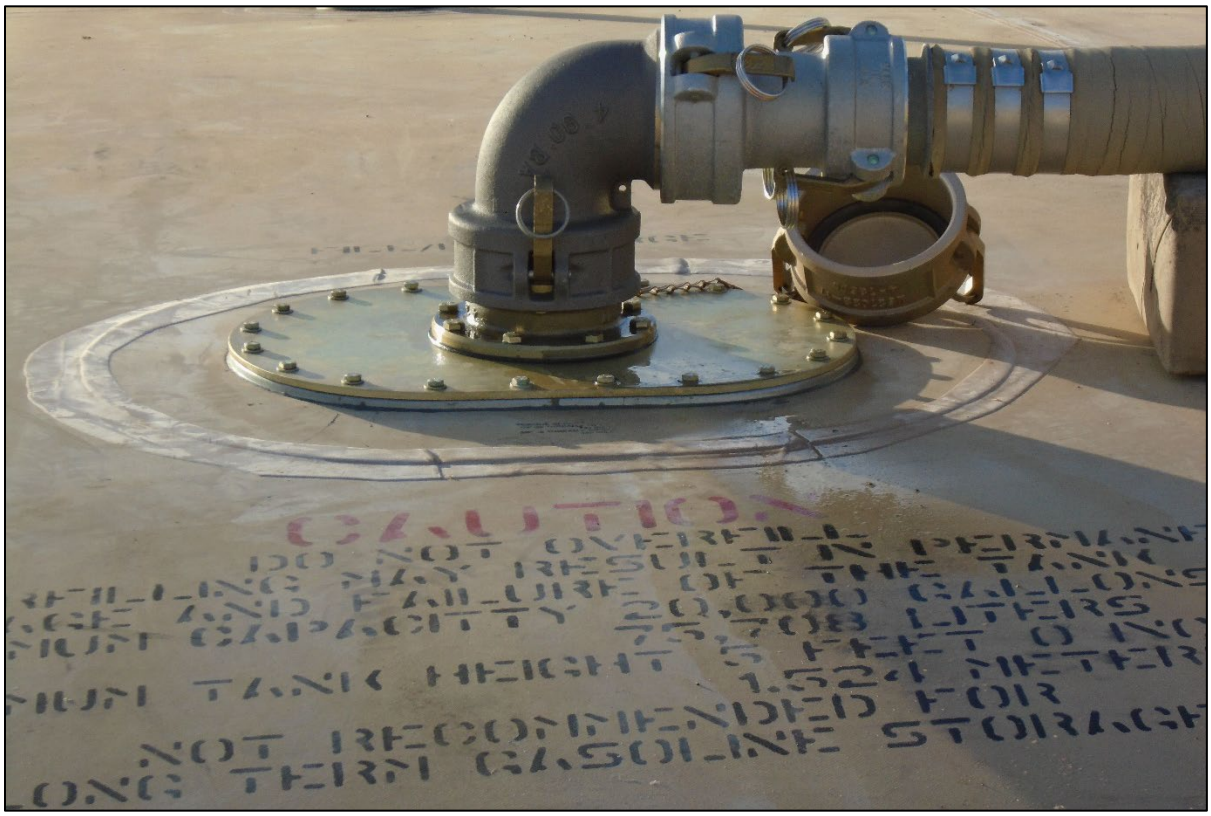

Figure E-3. AEF #5 CFT Fuel Leak from Stripped Bolt at Port Flange

Figure E-4. AEF #5 CFT Fuel Leak from Stripped Bolt at Port Flange

Figure E-5. AEF #5 CFT Fuel Drip from Corner Collected in Bucket

Figure E-6. AEF #5 CFT Fuel Drip Forming at Corner

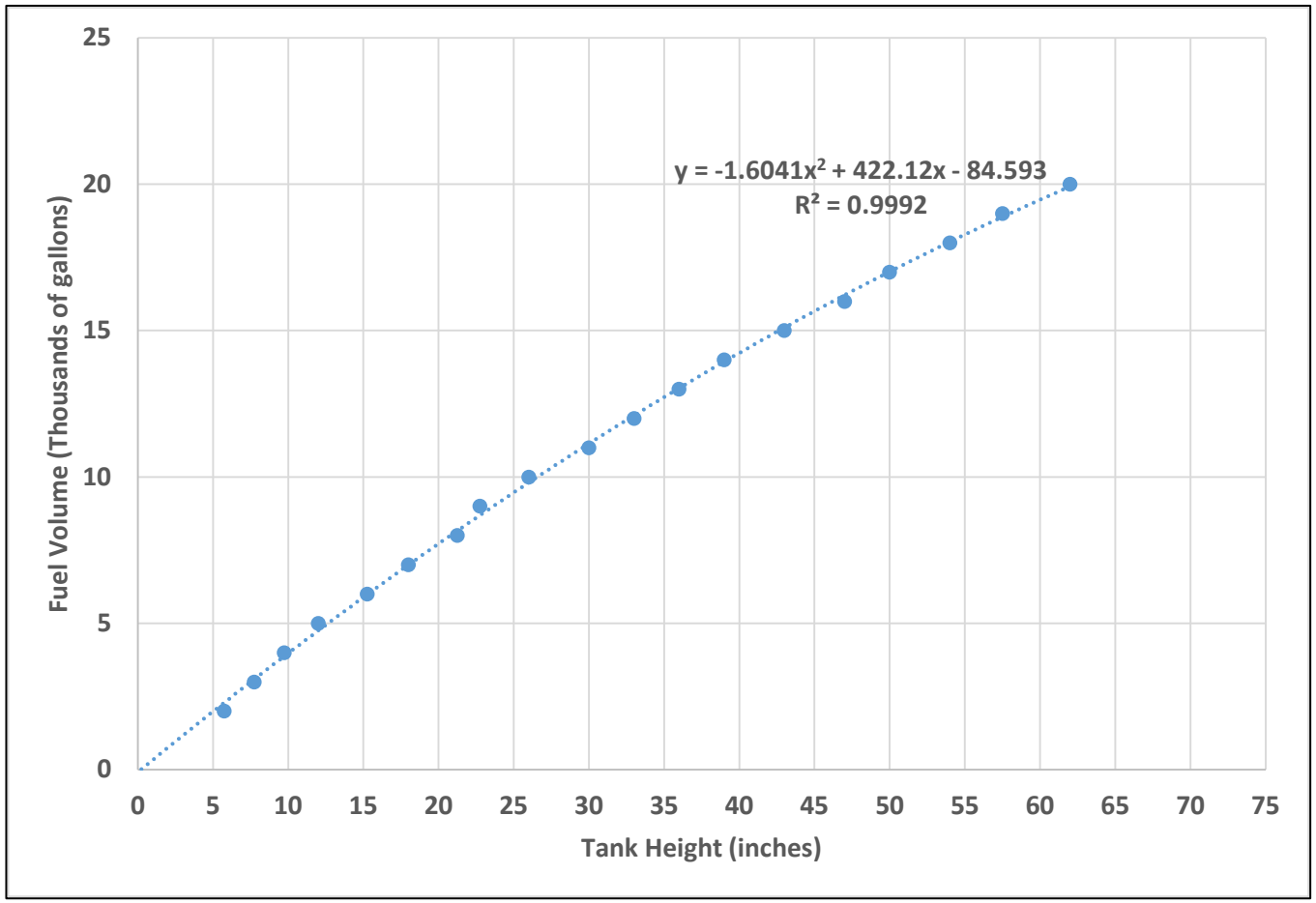

Figure E-7. AEF #5 CFT Strapping Chart

Table E-2. AEF #5 CFT Strapping Chart Data

Initial Fill: AEF #5	Date: December 22, 2020	
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	Not measurable
1000	2000	5.75
1000	3000	7.75
1000	4000	9.75
1000	5000	12.00
1000	6000	15.25
1000	7000	18.00
1000	8000	21.25
1000	9000	22.75
1000	10000	26.00
1000	11000	30.00
1000	12000	33.00
1000	13000	36.00
1000	14000	39.00
1000	15000	43.00
1000	16000	47.00
1000	17000	50.00
1000	18000	54.00
1000	19000	57.50
1000	20000	62.00

Table E-3. AEF #5 CFT Daily Height Measurements

Date	String Height (inches)
12/22	62.00
12/23	58.25
12/28	58.50
12/29	58.75
1/4	58.75
1/5	58.50
1/6	59.00
Monthly avg.	**59.14**

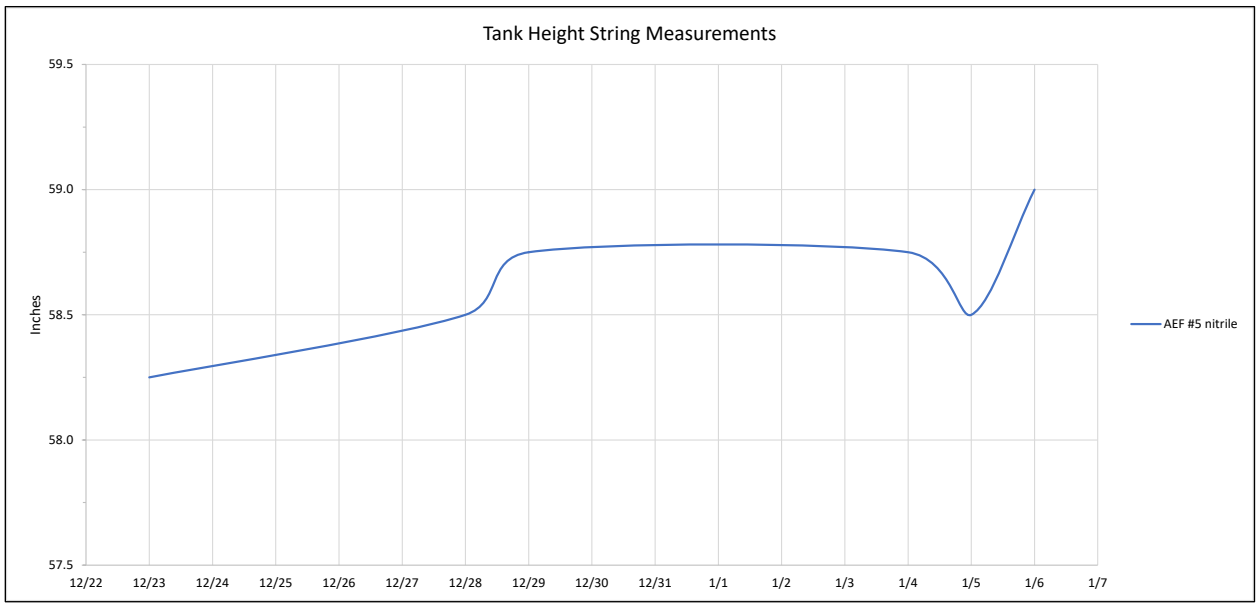

Figure E-8. AEF #5 CFT Daily Height Chart

APPENDIX F
MPC #6 CFT

The MPC #6 CFT was deployed at the SwRI CFT Facility on November 4, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on December 9, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with polyurethane composition. The CFT reached its maximum rated fill tank height of 66" at a tank volume between 19,000 and 20,000 gallons. A final tank volume of 20,000 gallons was achieved at a tank height of 67".

The MPC #6 CFT exhibited leak-free performance during the course of intermittent fuel cycling from February 2021 through the end of the program in December 2021. Some minor fuel staining was observed on the CFT exterior toward the end of the test program.

A description of the CFT can be found in Table F-1. Images of the CFT are shown in Figure F-1 through Figure F-5. The strapping chart for the CFT is shown in Figure F-6. It was created from the initial fuel fill data shown in Table F-2. The daily tank height records are shown in Table F-3 through Table F-5. The charts of daily CFT heights are shown in Figure F-7 through Figure F-9.

Table F-1. Description of MPC #6 CFT

CFT DETAILS	
NSN	5430-01-567-8840
PN	MPC-E-20K AD
MFR	MPC CONTAINMENT SYSTEMS LLC
MFR DATES	May 2010
Shipped From	MCLB Albany Depot Storage (Project Code R5F)
Deployed	11/4/2020
Filled	12/9/2020
Dry Footprint	23' x 23'
Max Fill Height	66"
Date drained	At end of program

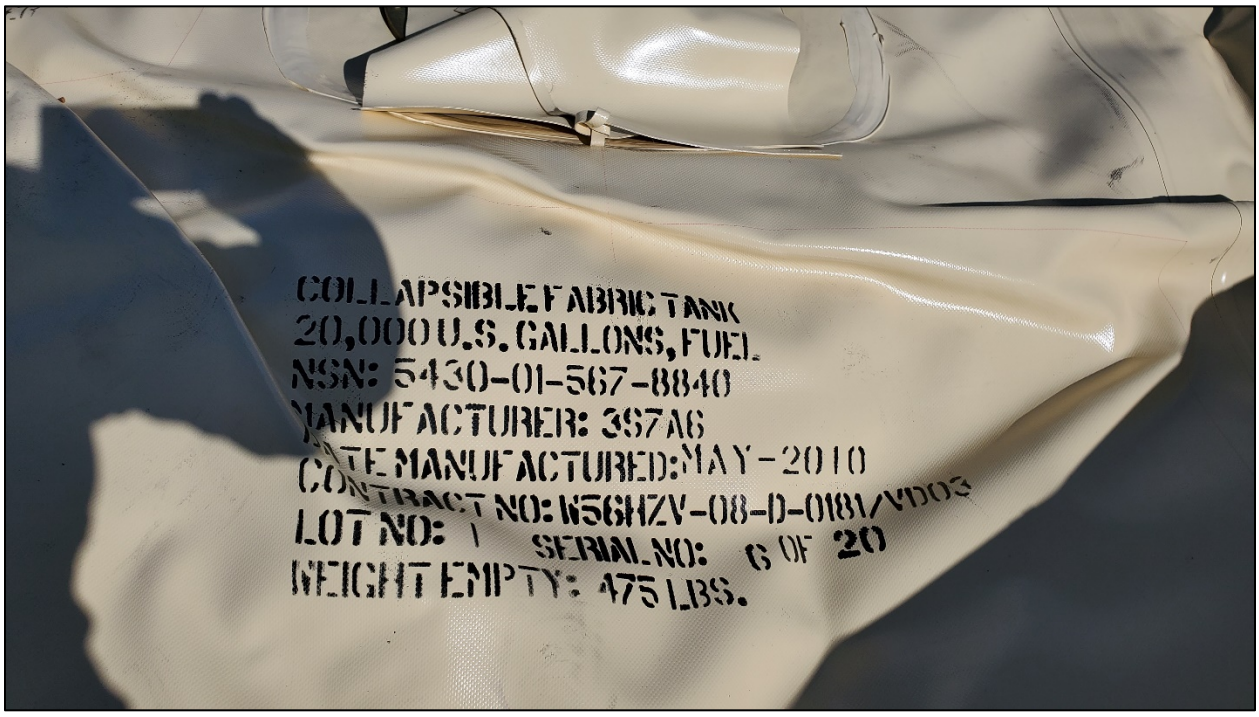

Figure F-1. MPC #6 CFT Stencil on Tank Surface

Figure F-2. MPC #6 CFT Unfolded and Deployed

Figure F-3. Location of MPC #6 CFT Filled with Fuel at SwRI CFT Facility, Viewed from NW (Top Photo) and SW (Bottom Photo)

Figure F-4. MPC #6 CFT Showing Surface Fuel Staining

Figure F-5. MPC #6 CFT at End of Test Program, Showing Some Fuel Staining at Corner

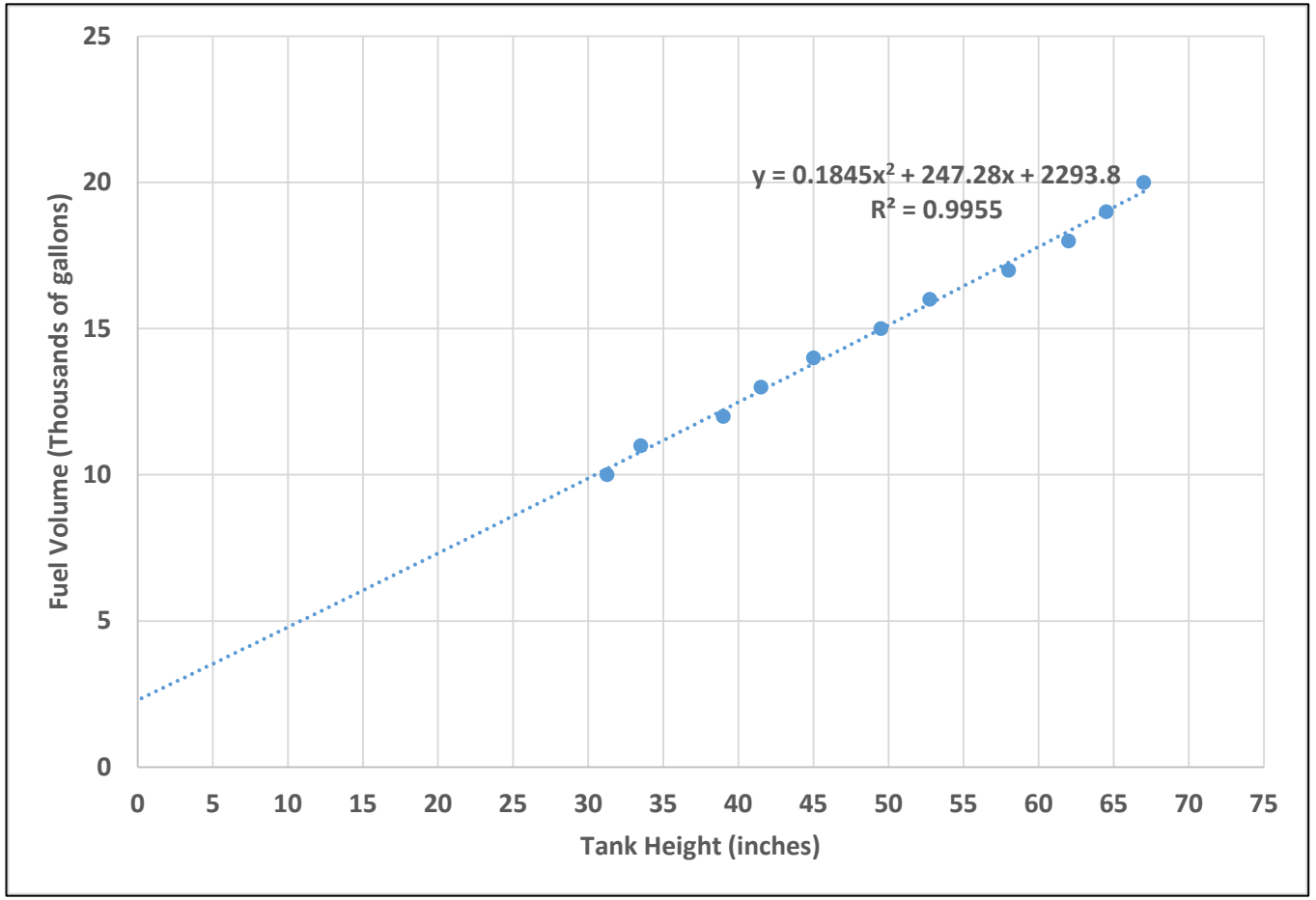

Figure F-6. MPC #6 CFT Strapping Chart

Table F-2. MPC #6 CFT Strapping Chart Data

Initial Fill: MPC #6 CFT Date: December 9, 2020		
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	Not Measurable
1000	2000	Not Measurable
1000	3000	Not Measurable
1000	4000	Not Measurable
1000	5000	Not Measurable
1000	6000	Not Measurable
1000	7000	Not Measurable
1000	8000	Not Measurable
1000	9000	Not Measurable
1000	10000	31.25
1000	11000	33.50
1000	12000	39.00
1000	13000	41.50
1000	14000	45.00
1000	15000	49.50
1000	16000	52.75
1000	17000	58.00
1000	18000	62.00
1000	19000	64.50
1001	20001	67.00

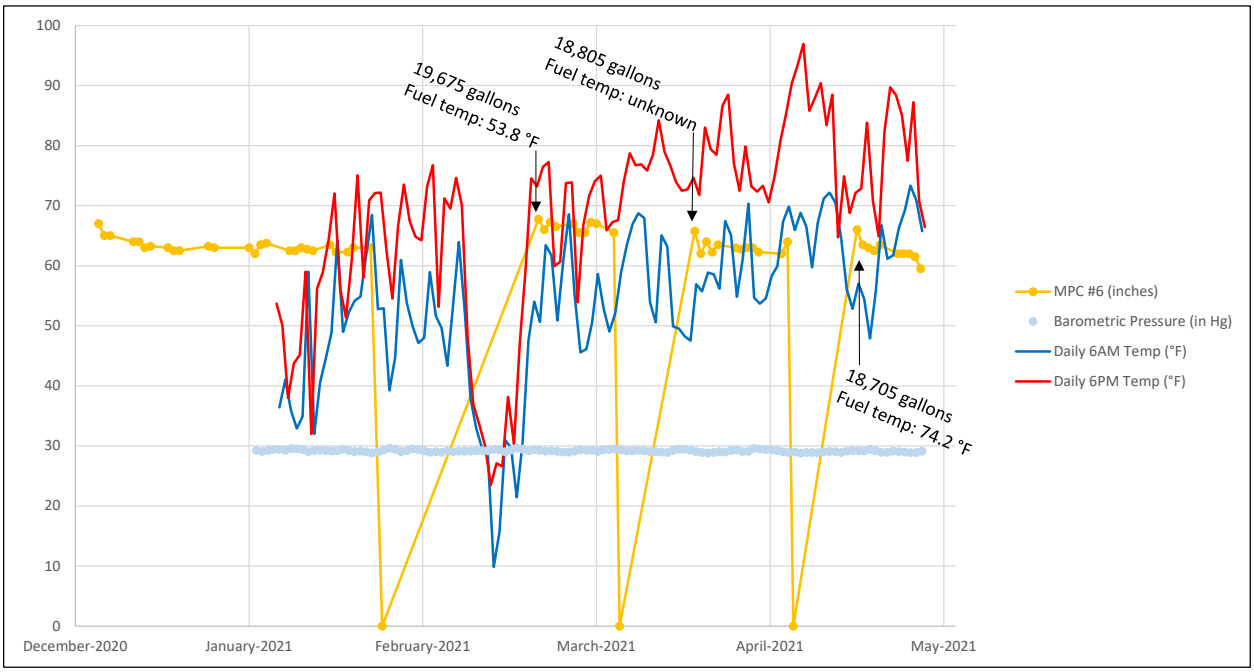

Figure F-7. MPC #6 CFT Fuel Cycling Log

Table F-3. MPC #6 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
12/9	67.00	1/22	63.00
12/10	65.00	1/25	63.00
12/11	65.00	**Monthly avg.**	**62.82**
12/15	64.00	2/23	67.75
12/16	64.00	2/24	66.00
12/17	63.00	2/25	67.25
12/18	63.25	2/26	66.50
12/21	63.00	**Monthly avg.**	**66.88**
12/22	62.50	3/1	67.00
12/23	62.50	3/2	65.50
12/28	63.25	3/3	65.50
12/29	63.00	3/4	67.25
Monthly avg.	**63.79**	3/5	67.00
1/4	63.00	3/8	65.50
1/5	62.00	3/22	65.75
1/6	63.50	3/23	62.00
1/7	63.75	3/24	64.00
1/11	62.50	3/25	62.25
1/12	62.50	3/26	63.50
1/13	63.00	3/29	63.00
1/14	62.75	3/30	62.75
1/15	62.50	3/31	63.00
1/18	63.50	**Monthly avg.**	**64.57**
1/19	62.25		
1/21	62.25		

Table F-3. MPC #6 CFT Daily Height Measurements (Continued)

Date	CFT Height (inches)
4/1	63.00
4/2	62.25
4/6	62.00
4/7	64.00
4/19	66.00
4/20	63.50
4/21	63.00
4/22	62.50
4/23	63.50
4/26	62.00
4/27	62.00
4/28	62.00
4/29	61.50
4/30	59.50
Monthly avg.	**62.63**

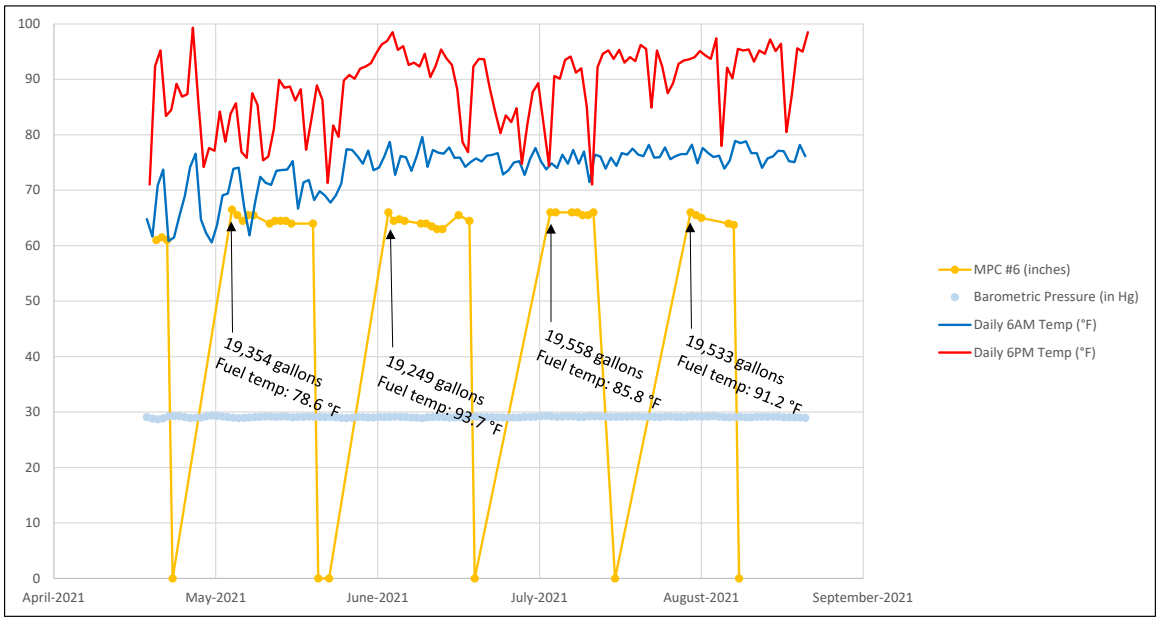

Figure F-8. MPC #6 CFT Fuel Cycling Log

Table F-4. MPC #6 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
5/3	61.00	7/15	66.00
5/4	61.50	7/16	66.00
5/5	61.00	7/19	66.00
5/17	66.50	7/20	66.00
5/18	65.50	7/21	65.50
5/19	64.50	7/22	65.50
5/20	65.50	7/23	66.00
5/21	65.50	**Monthly avg.**	**65.86**
5/24	64.00	8/10	66.00
5/25	64.50	8/11	65.50
5/26	64.50	8/12	65.00
5/27	64.50	8/17	64.00
5/28	64.00	8/18	63.75
Monthly avg.	**64.04**	**Monthly avg.**	**64.85**
6/1	64.00		
6/15	66.00		
6/16	64.50		
6/17	64.75		
6/18	64.50		
6/21	64.00		
6/22	64.00		
6/23	63.50		
6/24	63.00		
6/25	63.00		
6/28	65.50		
6/30	64.50		
Monthly avg.	**64.27**		

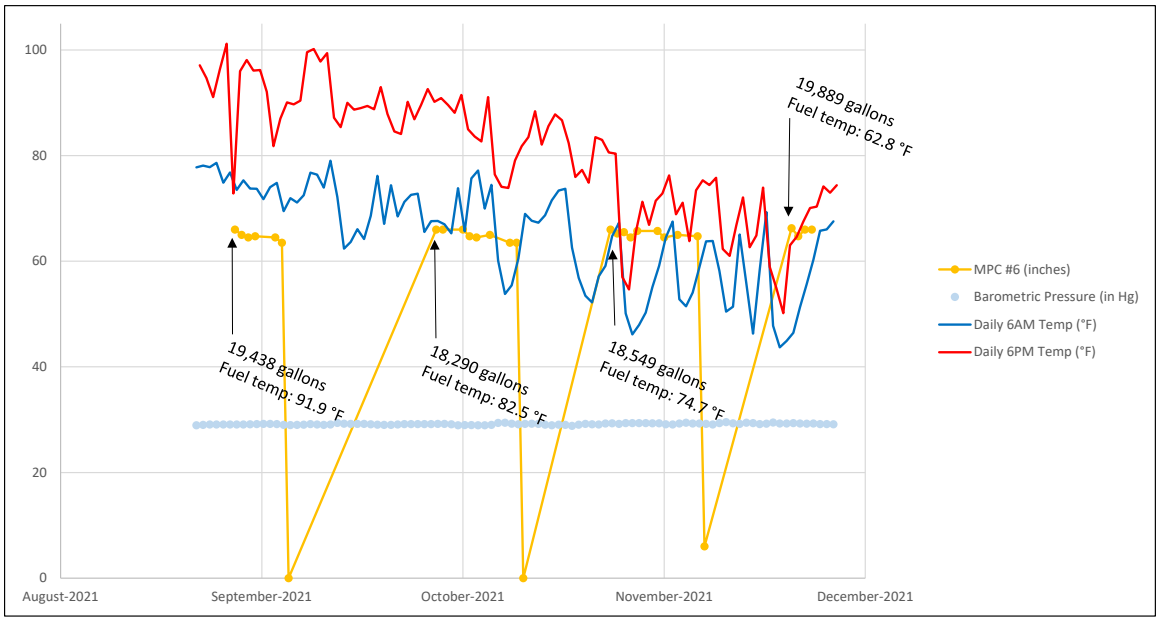

Figure F-9. MPC #6 CFT Fuel Cycling Log

Table F-5. MPC #6 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
9/7	66.00	11/2	66.00
9/8	65.00	11/3	65.25
9/9	64.50	11/4	65.50
9/10	64.75	11/5	64.50
9/13	64.50	11/6	65.75
9/14	63.50	11/9	65.75
Monthly avg.	**64.71**	11/10	64.50
10/7	66.00	11/12	65.00
10/8	66.00	11/15	64.75
10/11	66.00	11/29	66.25
10/12	64.75	11/30	64.75
10/13	64.50	12/1	66.00
10/15	65.00	12/2	66.00
10/18	63.50	**Monthly avg.**	**65.38**
10/19	63.50		
Monthly avg.	**64.91**		

APPENDIX G
GTA Spiral #7 CFT

The GTA Spiral #7 CFT was deployed at the SwRI CFT Facility on December 10, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on December 18, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with polyurethane composition. The CFT reached its maximum rated fill tank height of 55" at a tank volume between 19,000 and 20,000 gallons. A final tank volume of 20,000 gallons was achieved at a tank height of 58.5".

The GTA Spiral #7 CFT exhibited leak-free performance during the course of intermittent fuel cycling from February 2021 through the end of the program in December 2021. Some fuel seepage and staining did occur along the spiral seams in the final months of the testing.

A description of the CFT can be found in Table G-1. Images of the CFT are shown in Figure G-1 through Figure G-5. The strapping chart for the CFT is shown in Figure G-6. It was created from the initial fuel fill data shown in Table G-2. The daily tank height records are shown in Table G-3 through Table G-5. The charts of daily CFT heights are shown in Figure G-7 through Figure G-9.

Table G-1. Description of GTA Spiral #7 CFT

CFT DETAILS	
NSN	None (prototype)
PN	GTA-20KF-32233B-AC
MFR	GTA Containers Inc.
MFR DATES	November 2020
Shipped From	OEM
Deployed	12/10/2020
Filled	12/18/2020
Dry Footprint	30' x 24.5'
Max Fill Height	55
Date drained	At end of program

Figure G-1. GTA Spiral #7 CFT Unfolded and Deployed

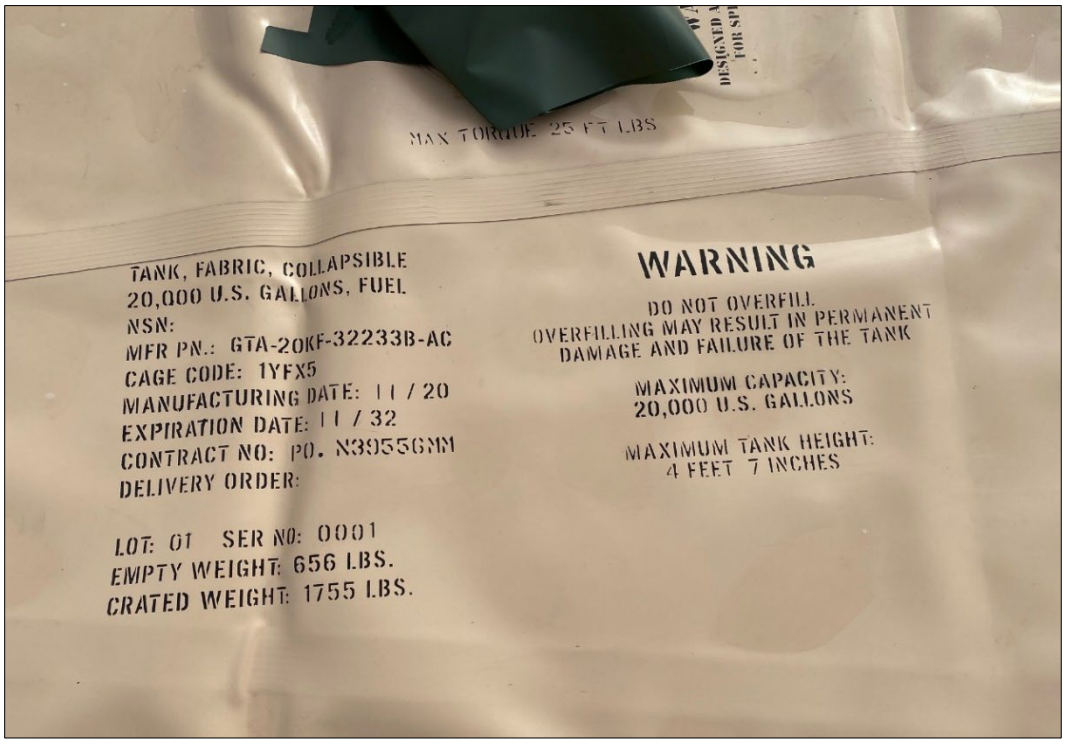

Figure G-2. GTA Spiral #7 CFT Stencil on Tank Surface

Figure G-3. Location of GTA Spiral #7 CFT at SwRI CFT Facility

Figure G-4. GTA Spiral #7 CFT Fuel Leaks Along Spiral Seams

Figure G-5. GTA Spiral #7 CFT at End of Test Program

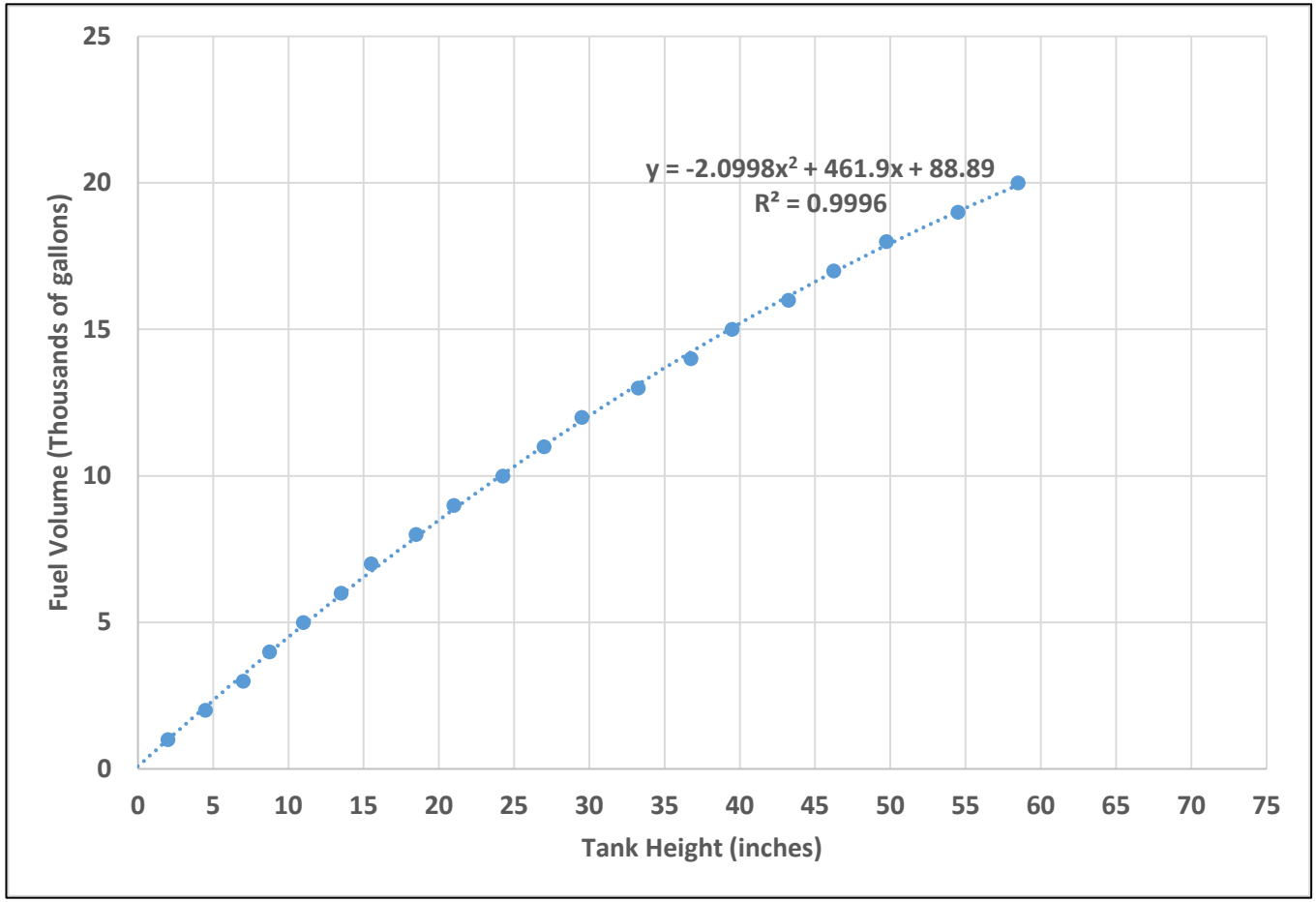

Figure G-6. GTA Spiral #7 CFT Strapping Chart

Table G-2. GTA Spiral #7 CFT Strapping Chart Data

Initial Fill: GTA Spiral #7 CFT Date: December 18, 2020		
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	2.00
1000	2000	4.50
1000	3000	7.00
1000	4000	8.75
1000	5000	11.00
1000	6000	13.50
1000	7000	15.50
1000	8000	18.50
1000	9000	21.00
1000	10000	24.25
1000	11000	27.00
1000	12000	29.50
1000	13000	33.25
1000	14000	36.75
1000	15000	39.50
1000	16000	43.25
1000	17000	46.25
1000	18000	49.75
1000	19000	54.50
1001	20001	58.50

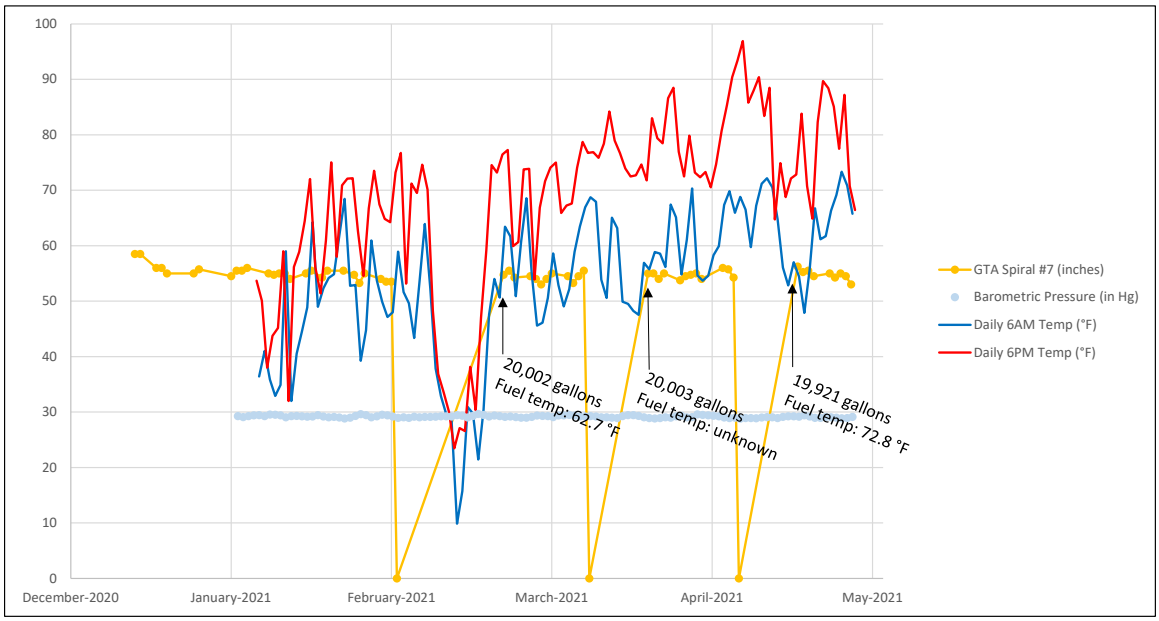

Figure G-7. GTA Spiral #7 CFT Fuel Cycling Log

Table G-3. GTA Spiral #7 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)	Date	CFT Height (inches)
12/17	58.50	2/24	54.75	4/27	54.25
12/18	58.50	2/25	55.50	4/28	55.00
12/21	56.00	2/26	54.25	4/29	54.50
12/22	56.00	**Monthly avg.**	**54.25**	4/30	53.00
12/23	55.00	3/5	55.00	**Monthly avg.**	**54.88**
12/28	55.00	3/8	54.50		
12/29	55.75	3/9	53.25		
Monthly avg.	**56.39**	3/10	54.50		
1/6	55.50	3/11	55.50		
1/7	56.00	3/23	55.00		
1/11	55.00	3/24	55.00		
1/12	54.75	3/25	54.00		
1/13	55.00	3/26	55.00		
1/14	55.00	3/29	53.75		
1/15	54.00	3/30	54.50		
1/18	55.00	3/31	54.75		
1/19	55.50	**Monthly avg.**	**54.39**		
1/21	54.25	4/1	55.00		
1/22	55.50	4/2	54.00		
1/25	55.50	4/6	56.00		
1/27	54.75	4/7	55.75		
1/28	53.25	4/8	54.25		
1/29	55.00	4/20	56.25		
Monthly avg.	**54.94**	4/21	55.25		
2/1	54.00	4/22	55.50		
2/2	53.50	4/23	54.50		
2/3	53.50	4/26	55.00		

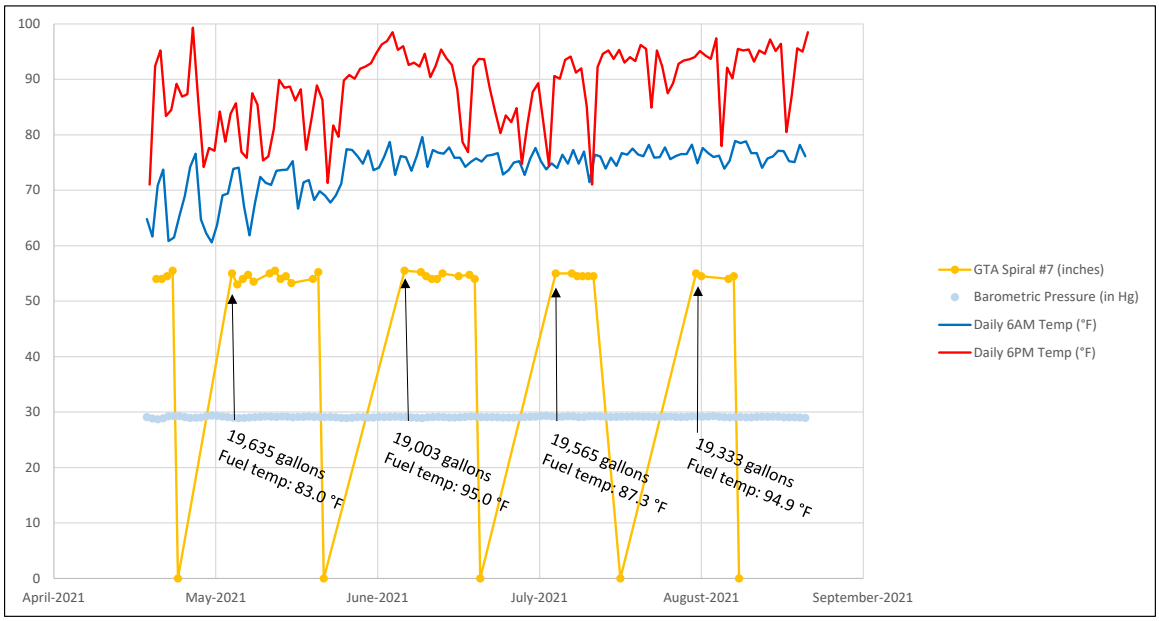

Figure G-8. GTA Spiral #7 CFT Fuel Cycling Log

Table G-4. GTA Spiral #7 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
5/3	54.00	7/1	54.00
5/4	54.00	7/16	55.00
5/5	54.50	7/19	55.00
5/6	55.50	7/20	54.50
5/17	55.00	7/21	54.50
5/18	53.00	7/22	54.50
5/19	54.00	7/23	54.50
5/20	54.75	**Monthly avg.**	**54.57**
5/21	53.50	8/11	55.00
5/24	55.00	8/12	54.50
5/25	55.50	8/17	54.00
5/26	54.00	8/18	54.50
5/27	54.50	**Monthly avg.**	**54.50**
5/28	53.25		
Monthly avg.	**54.32**		
6/1	54.00		
6/2	55.25		
6/18	55.50		
6/21	55.25		
6/22	54.50		
6/23	54.00		
6/24	54.00		
6/25	55.00		
6/28	54.50		
6/30	54.75		
Monthly avg.	**54.68**		

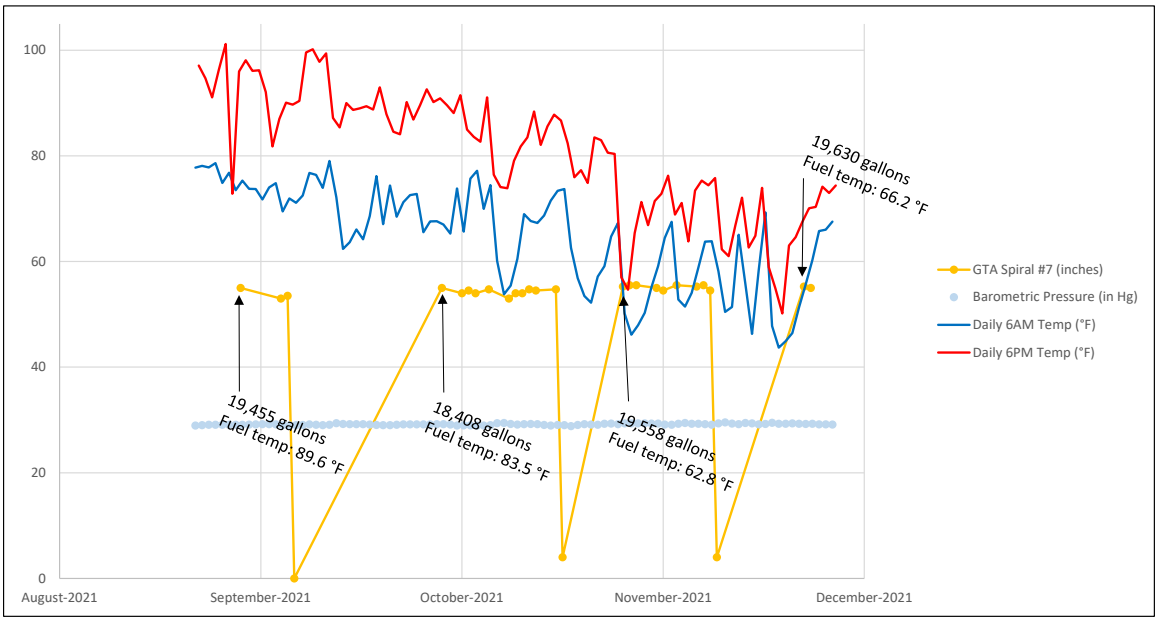

Figure G-9. GTA Spiral #7 CFT Fuel Cycling Log

Table G-5. GTA Spiral #7 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
9/8	55.00	11/4	55.25
9/14	53.00	11/5	55.50
9/15	53.50	11/6	55.50
Monthly avg.	**53.83**	11/9	55.00
10/8	55.00	11/10	54.50
10/11	54.00	11/12	55.50
10/12	54.50	11/15	55.25
10/13	54.00	11/16	55.50
10/15	54.75	11/17	54.50
10/18	53.00	12/1	55.25
10/19	54.00	12/2	55.00
10/20	54.00	**Monthly avg.**	**55.16**
10/21	54.75		
10/22	54.50		
10/25	54.75		
Monthly avg.	**54.30**		

APPENDIX H

SEI Jungle King (JK) #8 CFT

The SEI Jungle King (JK) #8 CFT was deployed at the SwRI CFT Facility on October 1, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on November 3, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with polyurethane composition. The CFT reached its maximum rated fill tank height of 53" at a tank volume between 19,000 and 20,000 gallons. A final tank volume of 20,039 gallons was achieved at a tank height of 54.25".

The SEI Jungle King (JK) #8 CFT exhibited leak-free performance during the course of intermittent fuel cycling from February 2021 through the end of the program in December 2021.

A Varec Tactical Fuel Gauge System was installed in the SEI JK #8 CFT on July 26, 2021. A residual minimum fuel volume of approximately 1,000 gallons is required in the tank to prevent damage to the sensitive Varec probe immersed in the fuel. The fuel volumes transferred to reach maximum tank height were therefore affected for all fuel transfers after this date. This is evident in the charts of the daily CFT heights below.

A description of the CFT can be found in Table H-1. Images of the CFT are shown in Figure H-1 through Figure H-5. The strapping chart for the CFT is shown in Figure H-6. It was created from the initial fuel fill data shown in Table H-2. The daily tank height records are shown in Table H-3 through Table H-5. The charts of daily CFT heights are shown in Figure H-7 through Figure H-9.

Table H-1. Description of SEI JK #8 CFT

CFT DETAILS	
NSN	None (foreign)
PN	011402 Jungle King
MFR	SEI Industries
MFR DATES	April 2019
Shipped From	OEM
Deployed	10/1/2020
Filled	11/3/2020
Dry Footprint	26' x 30'
Max Fill Height	53"
Date drained	At end of program

Figure H-1. SEI JK #8 CFT Unfolded and Deployed

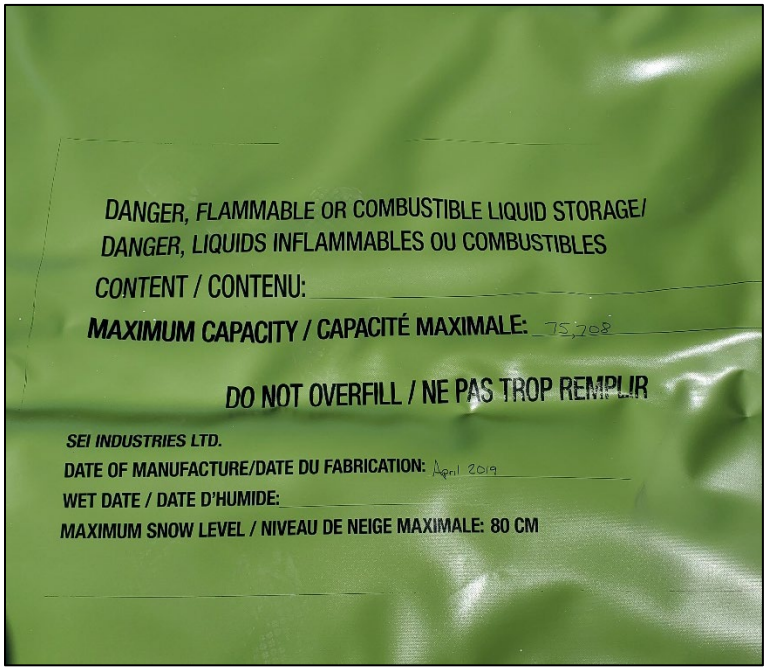

Figure H-2. SEI JK #8 CFT Stencil on Tank Surface

Figure H-3. SEI JK #8 CFT Stencil on Tank Surface

Figure H-4. SEI JK #8 CFT Filled with Fuel (Puddles are from Recent Rains, not Fuel)

Figure H-5. Location of SEI JK #8 CFT at SwRI CFT Facility

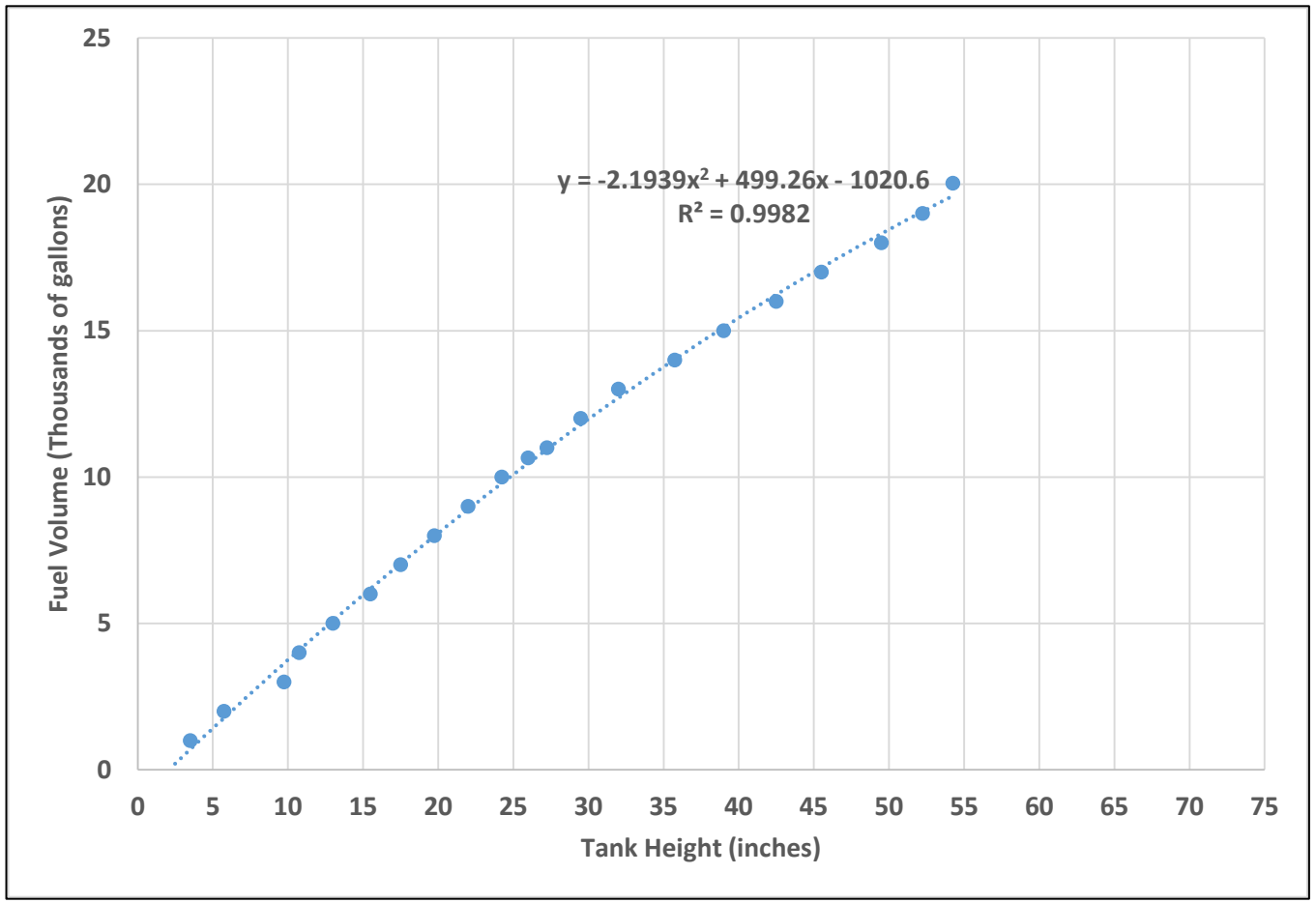

Figure H-6. SEI JK #8 CFT Strapping Chart

Table H-2. SEI JK #8 CFT Strapping Chart Data

Initial Fill: SEI JK #8 CFT Date: November 3, 2020		
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	3.50
1000	2000	5.75
1000	3000	9.75
1000	4000	10.75
1000	5000	13.00
1000	6000	15.50
1000	7000	17.50
1000	8000	19.75
1000	9000	22.00
1000	10000	24.25
655	10655	26.00
1000	11000	27.25
1000	12000	29.50
1000	13000	32.00
1000	14000	35.75
1000	15000	39.00
1000	16000	42.50
1000	17000	45.50
1000	18000	49.50
1000	19000	52.25
1039	20039	54.25

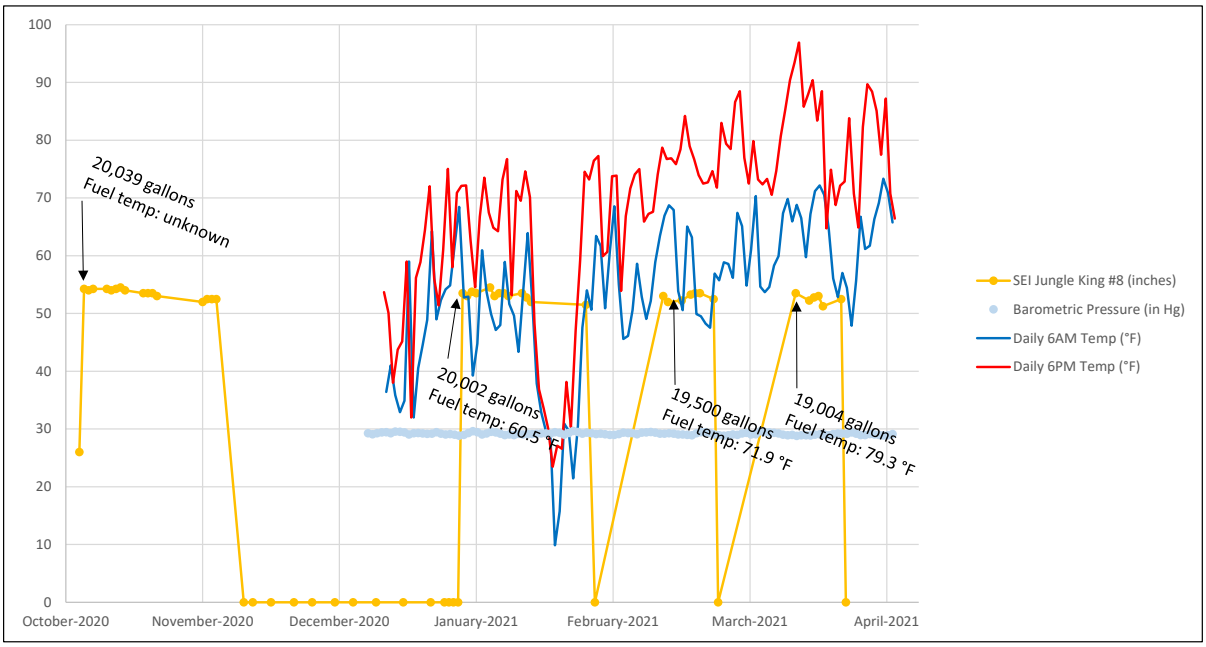

Figure H-7. SEI JK #8 CFT Fuel Cycling Log

Table H-3. SEI JK #8 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)	Date	CFT Height (inches)
11/3	26.00	2/1	54.50	4/9	53.50
11/4	54.25	2/2	53.00	4/12	52.25
11/5	54.00	2/3	53.50	4/13	52.75
11/6	54.25	2/4	53.50	4/14	53.00
11/9	54.25	2/5	53.00	4/15	51.25
11/10	54.00	2/8	53.50	4/19	52.50
11/11	54.25	2/9	52.75	**Monthly avg.**	**52.54**
11/12	54.50	2/10	52.00		
11/13	54.00	2/22	51.50		
11/17	53.50	**Monthly avg.**	**53.03**		
11/18	53.50	3/11	53.00		
11/19	53.50	3/12	52.00		
11/20	53.00	3/15	52.25		
11/30	52.00	3/17	53.25		
Monthly avg.	**53.77**	3/18	53.50		
12/1	52.50	3/19	53.50		
12/2	52.50	3/22	52.50		
12/3	52.50	**Monthly avg.**	**52.86**		
Monthly avg.	**52.50**				

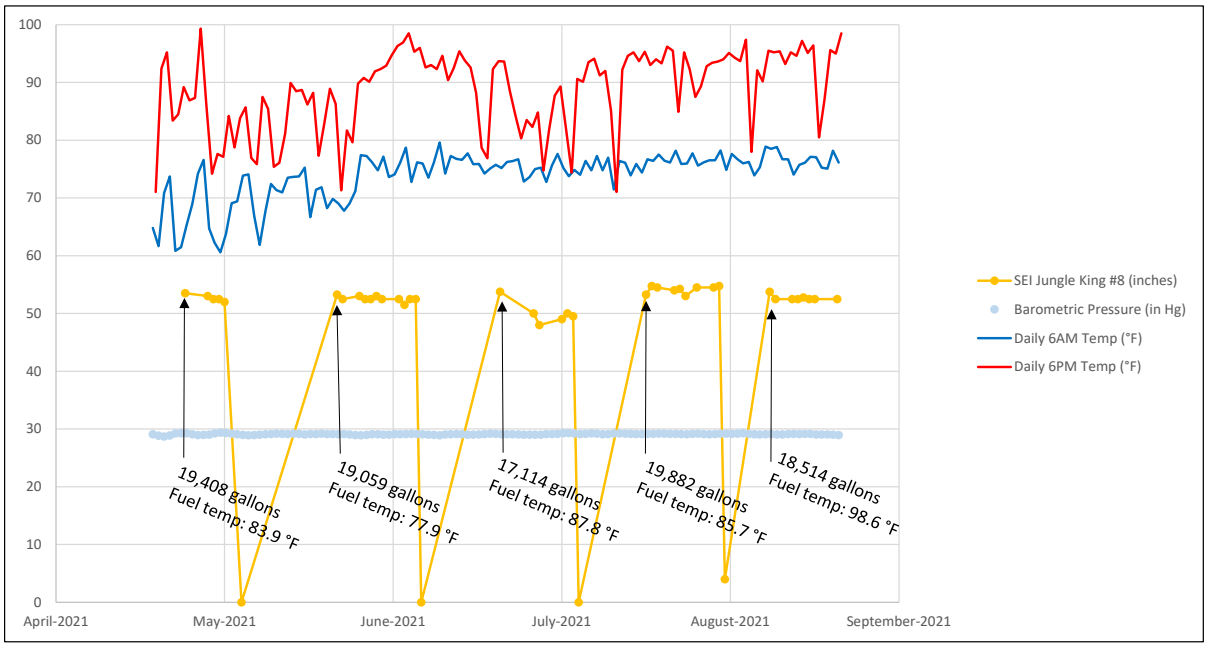

Figure H-8. SEI JK #8 CFT Fuel Cycling Log

Table H-4. SEI JK #8 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
5/7	53.50	7/2	53.75
5/11	53.00	7/8	50.00
5/12	52.50	7/9	48.00
5/13	52.50	7/13	49.00
5/14	52.00	7/14	50.00
Monthly avg.	**52.70**	7/15	49.50
6/3	53.25	7/28	53.25
6/4	52.50	7/29	54.75
6/7	53.00	7/30	54.50
6/8	52.50	**Monthly avg.**	**51.42**
6/9	52.50	8/2	54.00
6/10	53.00	8/3	54.25
6/11	52.50	8/4	53.00
6/14	52.50	8/6	54.50
6/15	51.50	8/9	54.50
6/16	52.50	8/10	54.75
6/17	52.50	8/19	53.75
Monthly avg.	**52.57**	8/20	52.50
		8/23	52.50
		8/24	52.50
		8/25	52.75
		8/26	52.50
		8/27	52.50
		8/31	52.50
		Monthly avg.	**53.32**

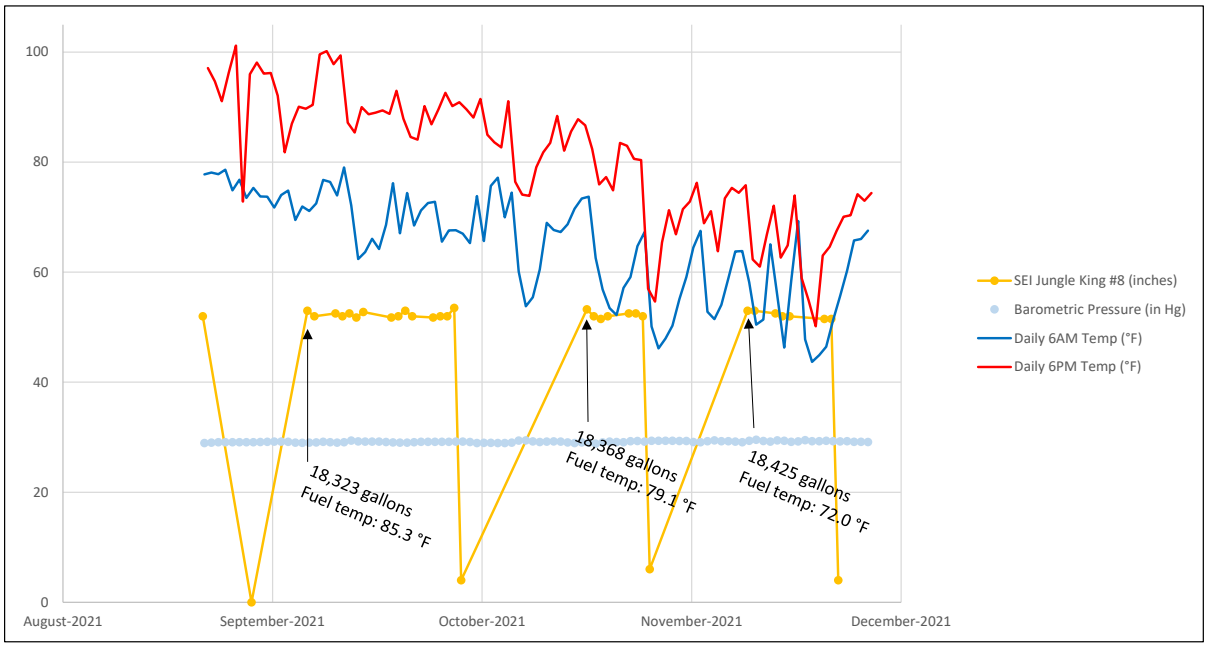

Figure H-9. SEI JK #8 CFT Fuel Cycling Log

Table H-5. SEI JK #8 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
9/1	52.00	11/1	52.50
9/16	53.00	11/2	52.50
9/17	52.00	11/3	52.00
9/20	52.50	11/18	53.00
9/21	52.00	11/19	53.00
9/22	52.50	11/22	52.50
9/23	51.75	11/23	52.00
9/24	52.75	11/24	52.00
9/28	51.75	11/29	51.50
9/29	52.00	11/30	51.50
9/30	53.00	**Monthly avg.**	**52.25**
Monthly avg.	**52.30**		
10/1	52.00		
10/4	51.75		
10/5	52.00		
10/6	52.00		
10/7	53.50		
10/26	53.25		
10/27	52.00		
10/28	51.50		
10/29	52.00		
Monthly avg.	**52.22**		

APPENDIX I

SEI Desert King (DK) #9 CFT

The SEI Desert King (DK) #9 CFT was deployed at the SwRI CFT Facility on October 1, 2020 and filled with Jet A fuel for a scheduled 30-day static soak at a flow rate of approximately 125 gallons/minute on October 28, 2020. This CFT's outer fabric possessed an appearance, texture, and weight consistent with polyurethane composition. The CFT reached its maximum rated fill tank height of 53" at a tank volume between 19,000 and 20,000 gallons. A final tank volume of 20,000 gallons was achieved at a tank height of 55.75".

The SEI Desert King (DK) #9 CFT exhibited leak-free performance during the course of intermittent fuel cycling from February 2021 through the end of the program in December 2021. Some minor fuel staining was observed on the CFT exterior toward the end of the test program.

A Varec Tactical Fuel Gauge System was installed in the SEI DK #9 CFT on July 26, 2021. A residual minimum fuel volume of approximately 1,000 gallons is required in the tank to prevent damage to the sensitive Varec probe immersed in the fuel. The fuel volumes transferred to reach maximum tank height were therefore affected for all fuel transfers after this date. This is evident in the charts of the daily CFT heights below.

A description of the CFT can be found in Table I-1. Images of the CFT are shown in Figure I-1 through Figure I-6. The strapping chart for the CFT is shown in Figure I-7. It was created from the initial fuel fill data shown in Table I-2. The daily tank height records are shown in Table I-3 through Table I-5. The charts of daily CFT heights are shown in Figure I-8 through Figure I-10.

Table I-1. Description of SEI DK #9 CFT

CFT DETAILS	
NSN	None (foreign)
PN	011402 Desert King
MFR	SEI Industries
MFR DATES	April 2019
Shipped From	OEM
Deployed	10/1/2020
Filled	10/28/2020
Dry Footprint	26' x 30'
Max Fill Height	53"
Date drained	At end of program

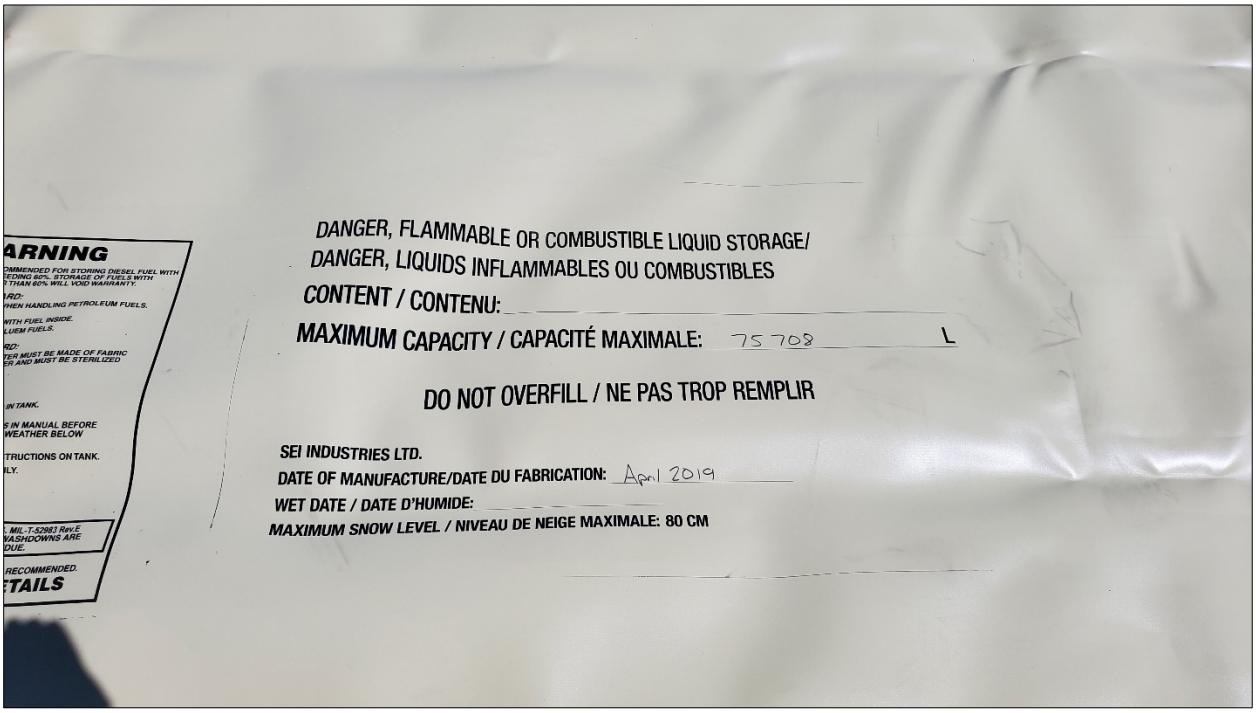

Figure I-1. SEI DK #9 CFT Stencil on Tank Surface

Figure I-2. SEI DK #9 CFT Stencil on Tank Surface

Figure I-3. SEI DK #9 CFT Unfolded and Deployed

Figure I-4. SEI DK #9 CFT Filled with Fuel

Figure I-5. Location of SEI DK #9 CFT at SwRI CFT Facility

Figure I-6. SEI DK #9 CFT Showing Fuel Staining Through Fabric, October 2021

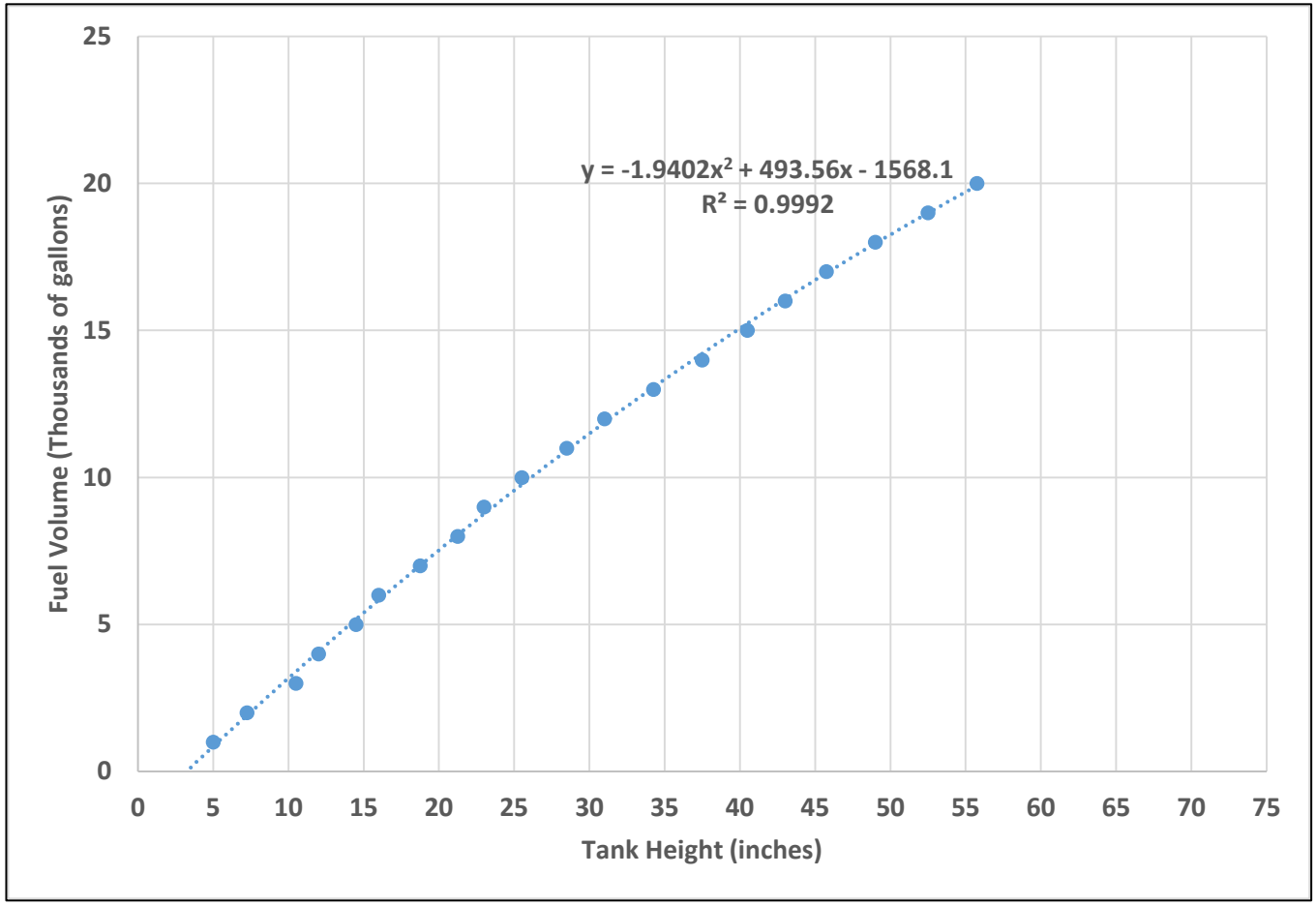

Figure I-7 SEI DK #9 CFT Strapping Chart

Table I-2. SEI DK #9 CFT Strapping Chart Data

Initial Fill: SEI DK #9 CFT Date: October 28, 2020		
Volume Increment (gallons)	**Running Balance (gallons)**	**Height (Inches)**
1000	1000	5.00
1000	2000	7.25
1000	3000	10.50
1000	4000	12.00
1000	5000	14.50
1000	6000	16.00
1000	7000	18.75
1000	8000	21.25
1000	9000	23.00
1000	10000	25.50
1000	11000	28.50
1000	12000	31.00
1000	13000	34.25
1000	14000	37.50
1000	15000	40.50
1000	16000	43.00
1000	17000	45.75
1000	18000	49.00
1000	19000	52.50
1000	20000	55.75

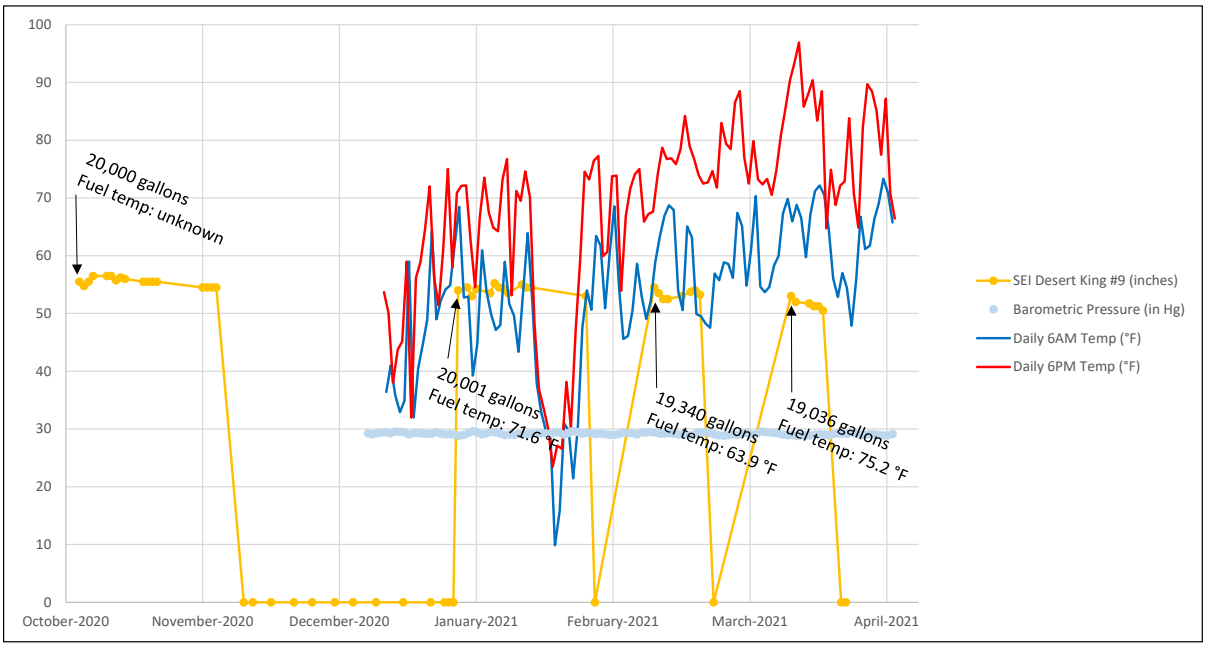

Figure I-8. SEI DK #9 CFT Fuel Cycling Log

Table I-3. SEI DK #9 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)	Date	CFT Height (inches)
11/6	56.50	1/25	54.00	3/9	54.50
11/9	56.50	1/27	54.50	3/10	53.50
11/10	56.50	1/28	53.00	3/11	52.50
11/11	55.75	1/29	54.25	3/12	52.50
11/12	56.25	**Monthly avg.**	**53.94**	3/15	53.00
11/13	56.00	2/1	53.50	3/17	53.75
11/17	55.50	2/2	55.25	3/18	54.00
11/18	55.50	2/3	54.50	3/19	53.25
11/19	55.50	2/4	54.25	**Monthly avg.**	**53.38**
11/20	55.50	2/5	53.50	4/8	53.00
11/30	54.50	2/8	55.00	4/9	52.00
Monthly avg.	**55.70**	2/9	54.50	4/12	51.75
12/1	54.50	2/10	54.50	4/13	51.25
12/2	54.50	2/22	53.00	4/14	51.25
12/3	54.50	**Monthly avg.**	**54.22**	4/15	50.50
Monthly avg.	**54.50**			**Monthly avg.**	**51.63**

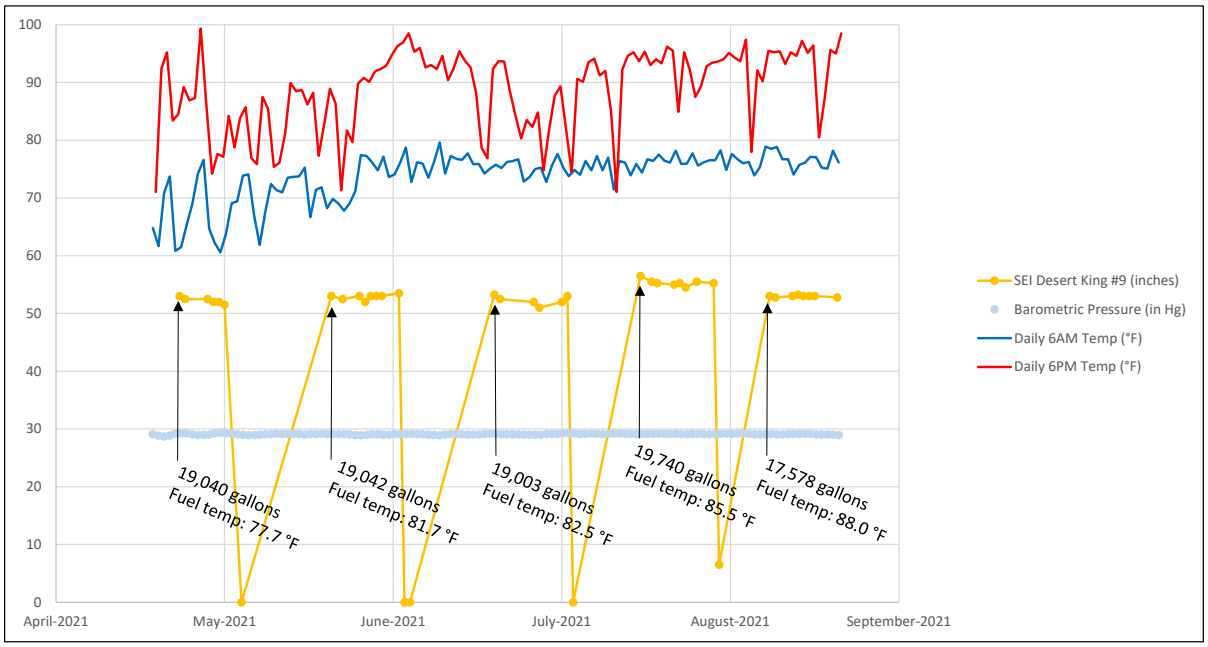

Figure I-9. SEI DK #9 CFT Fuel Cycling Log

Table I-4. SEI DK #9 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
5/6	53.00	7/1	53.25
5/7	52.50	7/2	52.50
5/11	52.50	7/8	52.00
5/12	52.00	7/9	51.00
5/13	52.00	7/13	52.00
5/14	51.50	7/14	53.00
Monthly avg.	**52.25**	7/27	56.50
6/7	53.00	7/29	55.50
6/8	52.00	7/30	55.25
6/9	53.00	**Monthly avg.**	**53.44**
6/10	53.00	8/2	55.00
6/11	53.00	8/3	55.25
6/14	53.50	8/4	54.50
Monthly avg.	**52.88**	8/6	55.50
		8/9	55.25
		8/19	53.00
		8/20	52.75
		8/23	53.00
		8/24	53.25
		8/25	53.00
		8/26	53.00
		8/27	53.00
		8/31	52.75
		Monthly avg.	**53.79**

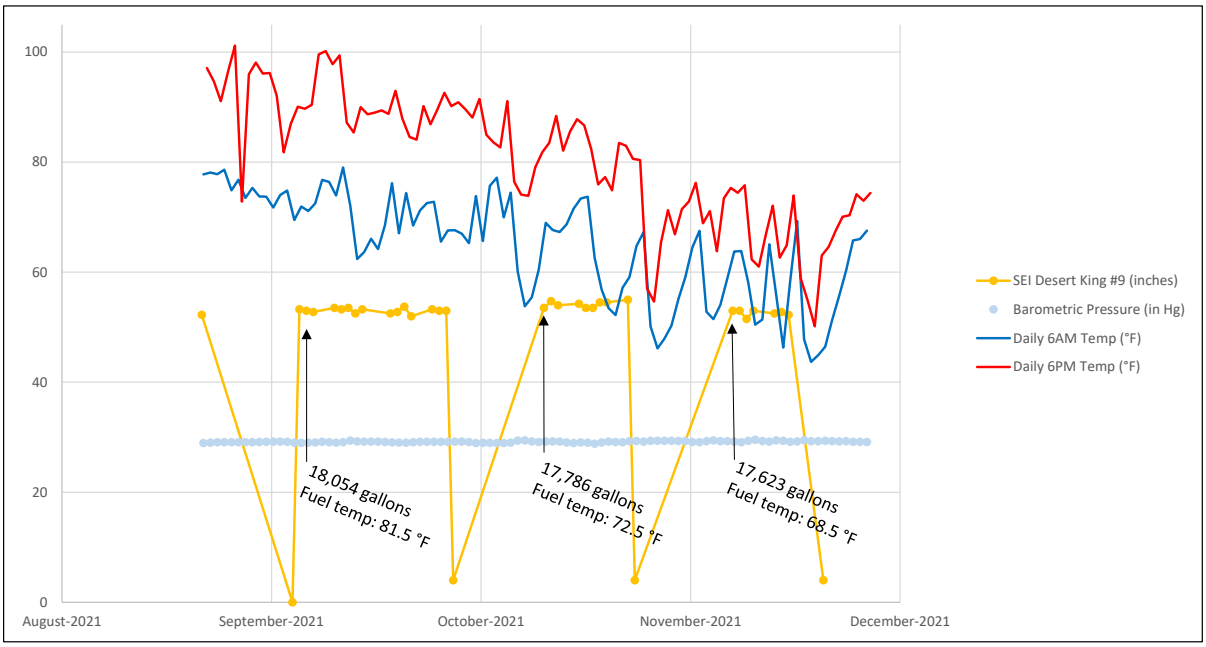

Figure I-10. SEI DK #9 CFT Fuel Cycling Log

Table I-5. SEI DK #9 CFT Daily Height Measurements

Date	CFT Height (inches)	Date	CFT Height (inches)
9/1	52.25	10/1	52.00
9/15	53.25	10/4	53.25
9/16	53.00	10/5	53.00
9/17	52.75	10/6	53.00
9/20	53.50	10/20	53.50
9/21	53.25	10/21	54.75
9/22	53.50	10/22	54.00
9/23	52.50	10/25	54.25
9/24	53.25	10/26	53.50
9/28	52.50	10/27	53.50
9/29	52.75	10/28	54.50
9/30	53.75	10/29	54.50
Monthly avg.	**53.02**	**Monthly avg.**	**53.65**
		11/1	55.00
		11/16	53.00
		11/17	53.00
		11/18	51.50
		11/19	53.00
		11/22	52.50
		11/23	52.75
		11/24	52.25
		Monthly avg.	**52.88**