Chiron K9, LLC

Success Through Innovation

Trials of Training Aid Delivery Device for Underwater Oil Detection Canine Training

(Updated – 14 May 2021)

14 May 2021

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Acknowledgments

I would like to thank the following people for their contribution to the Trials of Training Aid Delivery Device for Oil Detection Canine Training and preparation of this report:

Michele Maughan – SciK9
Chiron's Nika – Chiron K9
Dr. Ed Owens – Owens Coastal Consultants

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Acronyms

ODC	Oil Detection Canine
TADD	Training Aid Delivery Device

Executive Summary

Background

A Training Aid Delivery Device (TADD) is a (relatively) new device with multiple canine training applications. This trial aimed specifically to assess the use of TADDs when deployed in a sub-water environment for oil detection canine training. A baseline assessment was conducted utilizing a trained, certified, and fielded experienced Oil Detection Canine (ODC) and this provided a pathway to study trials, further examining the methods of deployment and utilization.

Methodology

A series of study trials were conducted to determine the most efficient and effective methods of TADD utilization within the Oil Detection Canine field. A trained and certified Oil Detection Canine, experienced in detecting oil underwater, was utilized throughout the study. The study trials were both field and lab-based and used a consistent oil target.

Key Findings

- The various studies reported here show that TADDs can be used to train ODCs without exposing the water source to contamination by the target oil sample.
- Odor molecules, which a trained ODC can identify, pass through the TADD membrane into water or air medium.
- For effective utilization of the TADD, in-field training, the ODC should be imprinted and trained on the device containing the target, underwater.
- On one occasion of prolonged exposure for five days in static water, oil in a TADD led to the presence of a silver sheen on the water surface.

Key Recommendations

- Field trials need to be conducted in static water
- Field trials need to be undertaken in running water
- Future trials need to investigate the longevity of available headspace molecules from the TADD containing oil.

1 Introduction

1.1 Background

A Training Aid Delivery Device (TADD) is a (relatively) new device with multiple canine training applications. This trial aimed specifically to assess the use of TADDs when deployed in a sub-water environment for oil detection canine training. A baseline assessment was conducted utilizing a trained, certified, and fielded experienced Oil Detection Canine (ODC) and this provided a pathway to further trials examining the methods of deployment and utilization.

1.2 Objectives

The objectives of these trials of the Training Aid Delivery Device are to:

- Determine the effectiveness of a TADD for the training of Oil Detection Canines in underwater search.

2 Methodology

2.1 Research Questions

The research questions to be answered by this trial are:

1. Can a trained Oil Detection Canine detect the oil contained in a TADD underwater?
2. What training protocols are needed to ensure canines can detect oil in a TADD underwater?
3. Does a canine detect an empty TADD underwater?

2.2 Research Design

The trial will use laboratory and field-based methods to answer the research questions.

2.3 Instruments

2.3.1 Canine

Chiron's Nika is a black female Labrador. Date of Birth: July 24, 2016. She is certified as an Oil Detection Canine through the International Canine Spill & Leak Detection Association. She has been utilized in Oil Detection Canine research trials and demonstrated the capability to detect targets below one part-per-million (API, 2020). She also has been deployed and has field experience, including a proven ability to located hydrocarbons within spill environments.

2.3.2 Training Aid Delivery Device

A Training Aid Delivery Device (TADD) is a small 4oz (other sizes available) glass jar sample containment system. Comprising of a gas-tight chemical-resistant gasket, a hydrophobic and oleophobic membrane, and a custom polypropylene membrane holder with a safety grid to prevent membrane puncture and a gas-tight chemical resistant polypropylene lid – adapted from the Scientific Canine Solutions (SciK9) web site (*Training Aid Delivery Device: SciK9 LLC*).

For these trials, SciK9 supplied two 4oz TADDs.

2.3.3 Preparation

Standard Chiron K9 protocols were utilized in the preparation of training aids:

2.3.3.1 TADD – The TADD's were unpacked, and standard Chiron K9 handling protocols were followed as detailed in the Handling and Storage of Canine Training Aids webinar (Bunker, 2020).

2.3.3.2 Mason jars - The mason jars were prepared utilizing standard Chiron K9 handling protocols as detailed in the Handling and Storage of Canine Training Aids webinar (Bunker, 2020).

Figure 1: Mason jar containing TADD in water with oil and washer

2.3.3.3 Washers – Metal washers were utilized to aid the weighting of the TADD's to submerge underwater. The TADD would float if not weighted. The washers were procured new from a commercial hardware store and cleaned with acetone, then direct sunlight dried. They were stored in a cleaned mason jar before preparation into sample jars. Each washer was handled with cleaned surgical tweezers after cleaning.

2.3.3.4 Water – Standard drinking water was utilized, and all purchased from the same source.

2.3.4 The following tables provide an outline of the prepared samples used throughout the trials:

Training Aid	Size	TADD	Water	Oil	Washer	Mason Jar
TADD	4oz			X	X	
TADD	4oz				X	
Training Aid	**Size**	**TADD**	**Water**	**Oil**	**Washer**	
Mason Jar	16oz	X	X	X	X	
Mason Jar	16oz	X	X		X	
Mason Jar	16oz		X		X	
Mason Jar	16oz		X			
Mason Jar	32oz		X	X		
Mason Jar	32oz	Removed	X	X	X	
Mason Jar	32oz	X	X	X	X	
Training Aid	**Size**	**TADD**	**Water**	**Oil**	**Washer**	**Mason Jar**
Bucket	2-Gallon	X	X	X	X	X
Bucket	2-Gallon	X	X		X	X
Bucket	2-Gallon		X		X	X
Bucket	2-Gallon		X			X

Table 1: Training aid setup

2.4 Sample

A West Texas Crude oil was selected as the target. The oil was sourced from Texas Raw Crude, https://www.texasrawcrude.com/. The Safety Data Sheet and Hydrogen Sulfide analysis report is attached.

2.5 Data Collection

Paul Bunker recorded the data during each trial event. Data was manually recorded, and the results are detailed within this report.

2.6 Limitations

The number of canines was small (one), and replication in the future would ensure repeatability of the results.

3 Results

3.1 Study # 1- Establishing the Baseline - Will, a trained Oil Detection Canine, detect an empty TADD or TADD with oil underwater?

An initial field trial (Study # 1) was conducted on August 01, 2020, in the Kreutzberg Canyon natural area (https://www.co.kendall.tx.us/page/Parks.Department) to provide a baseline for future assessments.

The objective of this baseline assessment was to:

- Determine if there was any response on an empty TADD within a searchable area
- Determine if there was any response on a TADD containing target within a searchable area
- Confirm detection of the target within a searchable area

Both TADD's had washers placed in them as described above. One TADD was prepared with 20ml of West Texas Intermediate crude oil. The TADDs were located 1" below the water surface at a distance of 1' from the shoreline.

A mason jar containing 20ml of West Texas Intermediate crude was also used as a confirmation find. This sample was not placed underwater due to the possible risk of a release to the river.

The TADDs and Mason jar were 10meters (30') apart along a running river within the park. The order of placement was:

- TADD – Empty
- TADD – with oil
- Mason jar – with oil

Figure 2: Baseline setup

The training aids were left to naturalize for 1-hour before being worked.

The canine was worked along the shoreline of the river off-leash in a Wide Area Search pattern.

Environmental Data: August 01, 2020	
Temperature - Dry Bulb	86°F
Feels Like	77.72°F
Humidity	57%
Dew Point	69°F
Pressure	29.15"

Table 2: Study #1 Environmental Data

3.1.1 Study # 1- Field Trial Results

Nika demonstrated no change of behavior or any interest in the blank TADD.

Nika did not detect or respond to the TADD with the target. Observations were made that she showed a change of behaviors downwind and downstream of the TADD with the target. Both observed changes in behavior were:

- 5 meters from source downstream
- 10 meters from source downwind

In both cases, she quickly lost the plume and did not locate the source.

Nika detected the mason jar and oil sample from 30' away and directly followed the source's plume with a final response.

In my opinion, Nika did detect pockets of target odor from the TADD but was unable to follow a plume to the source. I believe she was detecting airborne molecules, which were pockets of scent, and there was no plume to follow. Additionally, no odor was emitted immediately from the source location to the surface based on her behavior. This would make sense as the river was flowing.

Based on the observations, I believed there was odor transfer from the TADD into the environment through the water. I made the following assumptions:

1. Molecules leave the TADD and dissolve within the river water, and are carried downstream.
2. Molecules leave the TADD and dissolve within the river water, and as they are carried downstream, they rise to the surface.
3. Molecules leave the TADD and dissolve within the river water, and as they are carried downstream and rise to the surface, they then evaporate on exposure to the air.
4. Molecules leave the TADD and do not dissolve but instead are transported through the water before reaching the surface.
5. A combination of all of the above.

Based on the baseline results, I decided to take the TADDs into the Chiron K9 Research Facility and experiment in a more controlled manner.

3.2 Study # 2 - Can a trained Oil Detection Canine detect the oil contained in a TADD underwater?

3.2.1 Experimental Design

This assessment (Study # 2) aimed to determine the Oil Detection Canine ability to detect a TADD containing oil from under 1" of water in a 16oz Mason jar. Three inferant jars were placed to confirm no response on non-target components.

A 12-arm carousel was utilized for the assessment. Eight carousel arm pots were concealed with perforated lids but did not contain any inferents or targets. The remaining four pots were used without lids so that the mason jars could be accommodated.

The assumption was that the molecules would be easier to reach the surface and, therefore, detectable by the canine due to the water being both contained and static.

Using clean water meant that no masking odor or bacteria in river water could influence the molecules. The climatic conditions within the lab would not facilitate the evaporation of the water from the mason jar.

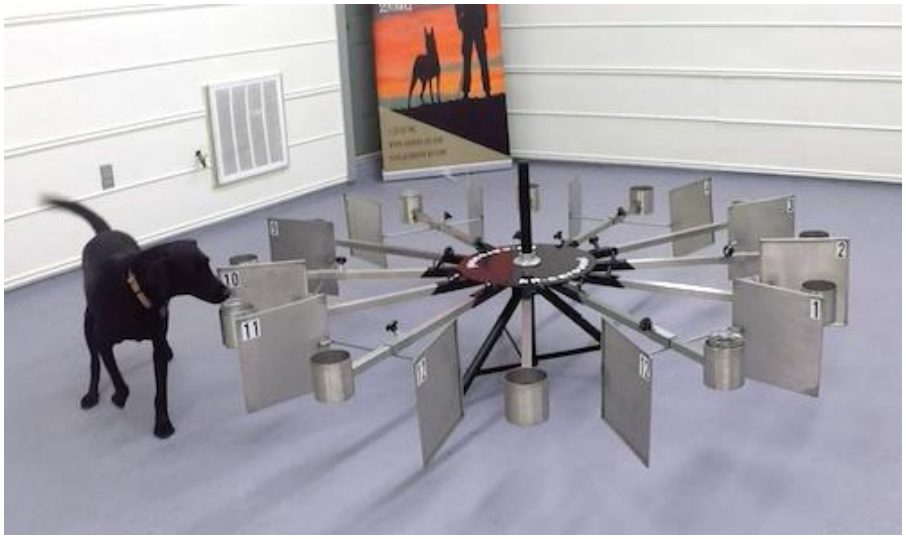

Figure 3: Carousel being searched by Chiron's Nika

Environmental Data: August 14, 2020			
Temperature - Dry Bulb	77.72°F	Temperature - Wet Bulb	61.88°F
Feels Like	77.72°F	Air Density	0.00538973lb/ft^3
Humidity	43%	Pressure	29.2086"
Dew Point	30.2°F		

Table 3: Study #2 Environmental Data

Five mason jars were prepared at the time of the assessment:

	Water	Washer	TADD	Oil
Mason jar	X			
Mason jar	X	X		
Mason jar	X	X	X	
Mason jar	X	X	X	X
Mason jar	X			X

Table 4: Study #2.1 Setup

3.2.2 Test Sequence:

Trial 1: determine if any contamination or false positives present in the experimental equipment.

Trial 2: test the ability of the canine to detect the target in the experimental setup

Trial 3: test the ability of the canine to detect the target placed within a TADD in the experimental setup

3.2.3 Study 2.1

This study aimed to confirm no contamination or false positives within the carousel setup.

Three 16oz Mason jars were located within the carousel:

1. Mason jar and water
2. Mason jar with water and washers
3. Mason jar with TADD and washers

3.2.4 Study 2.1 Results

Study 2.1	Positive Response	No Response
Run 1		X
Run 2		X
Run 3		X

Table 5: Study #2.1 Results

This confirmed no contamination and no false positives on the assessment items. Also, the K9 did not respond to the water, washers, or TADD.

3.2.5 Study 2.2

This session aimed to confirm the ability of the canine to detect the target within the carousel setup.

Four 16oz Mason jars were prepared as follows:

Study 2.2	Water	Washer	TADD	Oil
Mason jar	X			
Mason jar	X	X		
Mason jar	X	X	X	
Mason jar	X	X		X

Table 6: Study #2 .2 Setup

20ml of West Texas crude was added to water in one of the Mason jars.

3.2.6 Study 2.2 Results

Study 2.2	Positive Response	No Response
Run 1	X	
Run 2	X	
Run 3	X	

Table 7: Study #2.2 Results

The canine detected and responded to the West Texas Intermediate crude oil and gave no false positives.

3.2.7 Study 2.3

This session aimed to confirm the canine's ability to detect the target when placed within a TADD in the carousel setup.

Study 2.3	Water	Washer	TADD	Oil
Mason jar	X			
Mason jar	X	X		
Mason jar	X	X	X	
Mason jar	X	X	X	X

Table 8: Study #2.3 Setup

3.2.8 Study 2.3 Results

Study 2.3	Positive Response	No Response
Run 1	X	
Run 2	X	
Run 3	x	

Table 9: Study #2.3 Results

The canine detected and responded on the West Texas Intermediate crude oil within a TADD and gave no false positives.

Observations of note are:

1. For trials 2.2 and 2.3, the dog responded as soon as the target was encountered.
2. It was observed on each run-in trial 2.3 that the canine would lick the surface of the TADD/oil Mason jar before giving a final response.

Licking of water with sub-surface oil has been observed in real-life detection on rivers with Oil Detection Canines (it has also been observed with Human Remains Canines). It is believed that the vomeronasal organ has a role in waterborne molecule detection. In particular, as the canine did not lick any other jar containing water within the setup, nor the jar containing water and oil without a TADD (trial 2.2).

3.3 Study # 3 - Can a trained Oil Detection Canine detect the oil contained in a TADD underwater – deeper water depth?

August 17, 2020

It was hypothesized that the top of the TADD was so close to the surface of the water that the molecules which passed through the material could dissipate to the surface but that this process would be hampered by placing the TADD in deeper water so that the molecules would be diluted to the point that they would not be detected.

3.3.1 Experimental Design

The TADD was placed in a 32oz size tall Mason jar on 14 August 2020 and stored with a jar lid on. The TADD was 3" below the water's surface. Due to the target jar's size, the carousel could not be utilized; therefore, a line-up technique was used. The four jars were lined up in a row against a wall within the training lab.

1. Mason jar and water
2. Mason jar with water and washers
3. Mason jar with TADD and washers
4. Mason jar with TADD, washers, and oil

Nika was directed to search the line-up off-leash.

Environmental Data: August 17, 2020			
Temperature - Dry Bulb	76.1°F	Temperature - Wet Bulb	60.8°F
Feels Like	76.1°F		
Humidity	43%	Pressure	29.1814"
Dew Point	30.2°F	Air Density	0.00571745lb/ft^3

Table 10: Study #3 Environmental Data

3.3.2 Study 3.1 Results

Study 3.1	Positive Response	No Response
Run 1	X	
Run 2	X	
Run 3	x	

Table 11: Study #3.1 Results

3.4 Study # 4 - Are the headspace molecules of oil dissolving/suspending in the water?

August 18, 2020

It was hypothesized that the oil molecules move through the water to the surface but do not dissolve or are not suspended within the water. This means the molecules are not soluble, and therefore the target could not be detected by a canine from molecules at the surface of the water.

3.4.1 Experimental Design

The TADD was left in the 32oz size Mason jar from study 3.1 and stored with no lid on for 24hours. The aim was to see if headspace molecules dissipated from the jar, but no molecules remained in the water for detection. Due to the target jar's size, the carousel could not be utilized; therefore, a line-up technique was used. The jars were lined up in a row against a wall within the training lab.

1. Mason jar and water
2. Mason jar with water and washers
3. Mason jar with TADD and washers
4. Mason jar with TADD, washers, and oil

The test sequence is the same described above in Section 3.3.

Environmental Data: August 18, 2020			
Temperature - Dry Bulb	76.028°F	Temperature - Wet Bulb	60.752°F
Feels Like	76.028°F		
Humidity	43%	Pressure	29.1814"
Dew Point	30.2F	Air Density	0.00573217lb/ft^3

Table 12: Study #4 Environmental Data

3.4.2 Study 4.1

This session aimed to confirm no contamination or false positives within the setup.

Three mason jars were located along the lab wall in a line; each jar 4ft apart:

1. Mason jar and water
2. Mason jar with water and washers
3. Mason jar with TADD and washers

3.4.3 Study 4.1 Results

Study 4.1	**Positive Response**	**No Response**
Run 1		X
Run 2		X
Run 3		X

Table 13: Study #4.1 Results

This confirmed no contamination and no false positives on the assessment items. Also, the canine did not respond to the water, washers, or TADD.

3.4.4 Study 4.2

This session aimed to assess the canine's ability to detect any hydrocarbons contained in water, which previously had held oil within a TADD. The TADD that included the oil was removed from the jar, so only water remained. The canine was worked within 10 minutes of the TADD/oil's removal.

Study 4.2	**Water**	**Washer**	**TADD**	**Oil**
Mason jar	X			
Mason jar	X	X		
Mason jar	X	X	X	
Mason jar	X	X	Removed	X

Table 14: Study #4.2 Setup

3.4.5 Study 4.2 Results

Study 4.2	Positive Response	No Response
Run 1		X
Run 2		X
Run 3		X

Table 15: Study #4.2 Results

3.4.6 Study 4.3

The mason jar that contained a TADD/oil was taken outside the carousel room, and the lid was removed and left open to the natural environment for 2 hours before the trial was rerun. The aim was to assess if hydrocarbon molecules maintained their adhesion within the water or if the molecules evaporated/diffused out of the water. This assessment would give a more precise understanding if molecules from the headspace dissolved and remained within the water or if the molecules were slow at diffusing through the water.

Trial 4.3	Water	Washer	TADD	Oil
Mason jar	X			
Mason jar	X	X		
Mason jar	X	X	X	
Mason jar	X	X	Removed	X

Table 16: Study #4.3 Setup

3.4.7 Study 4.3 Results

Study 4.3	Positive Response	No Response
Run 1		X
Run 2		X
Run 3		X

Table 17: Study #4.3 Results

The results of this assessment provided a hypothesis that the headspace molecules did not completely evaporate under the environmental conditions and exposure time period of this experiment. Based on this, it is possible an ODC could detect the location of an oil within a TADD, particularly if the water was static.

3.5 Study # 5 - Is the oil headspace provided by a TADD sufficient to be detected by an Oil Detection Canine when placed in larger amounts of water?

August 19, 2020

Based on the above results, it was hypothesized that the concentration of available molecules from the TADD/oil headspace was sufficient to provide odor for a canine to detect but that a larger volume of water would not give the same level of detectable molecules due to dilution. This could affect future applications in a water body such as a pond or lake. The number of available molecules for detection could be below the canine's detection capability.

3.5.1 Experimental Design

This session aimed to confirm no contamination or false positives within the bucket line-up.

Figure 4: Bucket line-up

4x 2-gallon buckets were filled with tap water. The buckets were then loaded with the following:

1. Mason jar and water
2. Mason jar with water and washers
3. Mason jar with TADD and washers
4. Water alone

The buckets were prepared 24hours before the trial. The TADD was 6" below the water's surface.

Figure 5: TADD in a bucket

Environmental Data: August 19, 2020			
Temperature - Dry Bulb	77.036°F	Temperature - Wet Bulb	61.424°F
Feels Like	77.036°F		
Humidity	44%	Pressure	29.1785"
Dew Point	30.2°F	Air Density	0.00538226lb/ft^3

Table 18: Study #5 Environmental Data

3.5.2 Study 5.1

Study 5.1	Positive Response	No Response
Run 1		X
Run 2		X
Run 3		X

Table 19: Study #5.1 Results

This confirmed no contamination and no false positives on the assessment items. Also, the K9 did not respond to the water, washers, or TADD.

3.5.3 Study 5.2

A TADD containing oil was placed in one of the buckets with water. The other buckets were prepared the same way and had items listed below:

	Mason jar	Washer	TADD	Oil
Bucket	X			
Bucket	X	X		
Bucket	X	X	X	
Bucket		X	X	X

Table 20: Study #5.2 Setup

3.5.4 5.2 Results

Study 5.2	Positive Response	No Response
Run 1	X	
Run 2	X	
Run 3	X	

Table 21: Study #5.2 Results

The results demonstrated that oil in a TADD in 2-gallons of static water was detectable by an ODC.

Note: The TADD/oil was left in a bucket to conduct further training before moving to a lake and river field trial. After three days, a very light silver sheen (<0.3 µm thick) was observed on the water surface.

No water was observed inside the TADD. No water was within the Texas Crude inside the TADD.

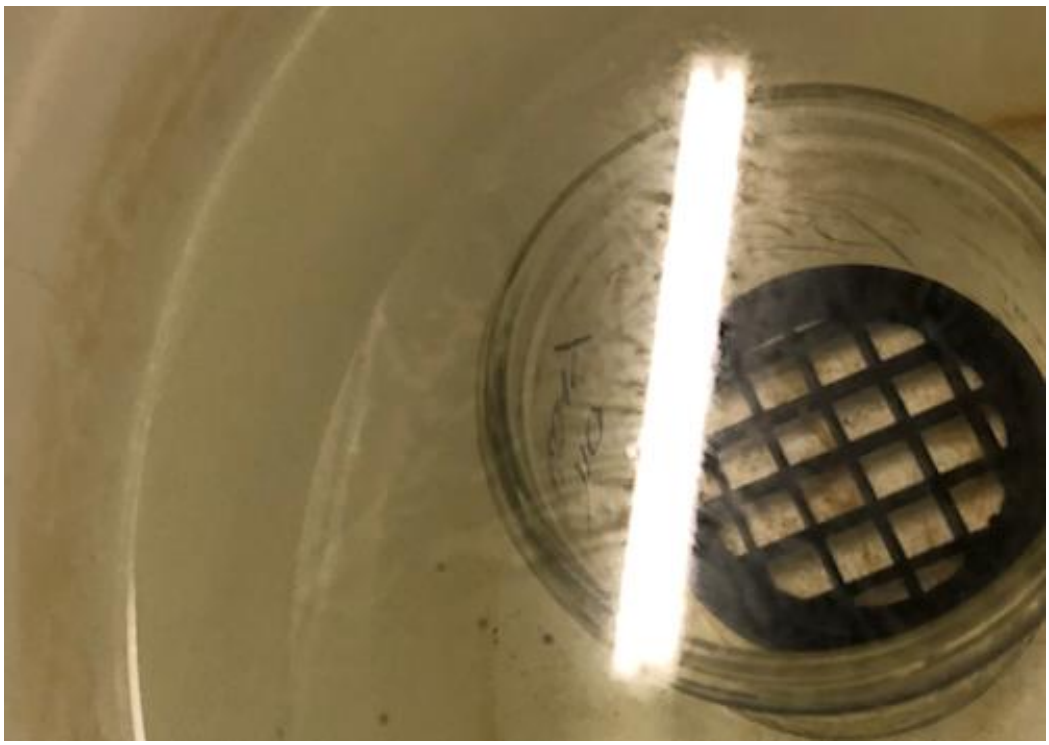

Figure 6: Silver sheen on the surface of bucket water (strip light is a reflection)

3.6 Study # 6 – Investigate the appearance of oil sheen on the surface of the bucket water?

20 April 2021

The appearance of sheen on the water surface within a bucket that contained a TADD with oil raised some questions. Initially, I assumed that the molecules from the headspace had collected on the surface and formed the sheen. However, consultation with a hydrocarbon chemical engineer provided information that oil vapor could not rebind and create a sheen. Therefore, follow-on trials were conducted to evaluate the appearance of sheen on the water surface.

3.6.1 Experimental Design

This trial aimed to confirm that a TADD containing oil underwater would produce a sheen or not.

Figure 7: Bucket line-up

3x 2-gallon buckets were filled with purified water. The buckets were then loaded with the following:

1. TADD with Texas Crude oil
2. TADD with Texas Crude oil
3. TADD with no oil

Each TADD contained a stainless-steel nut to allow the device to sit at the bucket base without floating.

Each TADD was under 2½ inches of water. The buckets were at a constant 70f and 40% humidity throughout the trial period.

3.6.2 Study 6.1 Results

Date	TADD	Observation	Odor
23 April 2021	1	No sheen observed	Odor of oil detectable by human
	2	No sheen observed	Odor of oil detectable by human
	3	No sheen observed	Odor of oil detectable by human
25 April 2021	1	No sheen observed	Odor of oil detectable by human
	2	No sheen observed	Odor of oil detectable by human
	3	No sheen observed	Odor of oil detectable by human
28 April 2021	1	No sheen observed	Odor of oil detectable by human
	2	No sheen observed	Odor of oil detectable by human
	3	No sheen observed	Odor of oil detectable by human
29 April 2021	1	No sheen observed	Odor of oil detectable by human
	2	No sheen observed	Odor of oil detectable by human
	3	No sheen observed	Odor of oil detectable by human

Table 22: Study #6.1 Results

The results demonstrated that a TADD containing oil underwater does not allow particles to escape sufficient to produce a sheen on the water's surface.

3.6.3 Study 6.2

To determine if there was environmental contamination of the studies using locally source water, two buckets were filled to replicate the ones used in study 6.1; however, no TADDs were added.

3.6.4 Experimental Design

Bucket one was filled with well water

Bucket two was filled with city water (from the faucet)

The buckets were left in the exact location as the previous studies and observed for two weeks.

3.6.5 Study 6.2 Results

No sheen was observed.

The results of Study #6 did not provide an answer as to why sheen appeared on the original TADD underwater, as observed during Study #5. There was no water inside the TADD in Study #5; it can be assumed there was no leak in the membrane. Also, the air space between the Texas Crude oil and the membrane was not compromised.

While there is no explanation of the observed sheen, it can be assumed some oil had contaminated the outside of the TADD during preparation. Or there was some external interference, which is very unlikely.

4. Discussion and Conclusions

Discussion points:

- ODC's used in underwater target detection are trained to detect either the dissolved molecules of oil in water and/or the sheen on the surface. It was assumed that the headspace molecules were different from those the canine usually encounters either in training or in the field. As Nika is an experienced field canine with confirmed underwater finds, it was reasonable to assume she understood what target odors are present and detectable.
- The baseline assessment with static water demonstrated that she detected odors that she associated with the target but could not locate the plume or source in a flowing water situation. This was likely due to two reasons:
    - The river was fast-flowing, and the target did not provide sufficient concentration in one location to allow for source detection.
    - Nika was not calibrated to locate the headspace molecules in this type of situation and therefore was not specifically looking for them.
- The series of indoor trials conducted within the Chiron K9 Research facility provided an insight into TADD's ability, efficiency, and capability to provide target odor even when underwater. The TADD also protected the environment from the oil and therefore offered an option when training underwater target detection of environmentally hazardous materials.
- Therefore, it is assumed that to utilize a TADD in a natural water source correctly, the ODC needs to be trained/imprinted on the headspace molecules being given off at the surface.
- There are two limitations noted in this trial:
    - Only one ODC was utilized, and the system needs to be replicated with other trained ODCs. A second ODC will be trained in underwater TADD detection using a method developed based on these trials.
    - The TADD has not been assessed natural water sources yet. A water source has been identified, and field trials will be conducted once time/COVID restrictions permit.

5. Recommendations

Based on the results from the trials, the following recommendations are made:

- Field trials need to be conducted in static water
- Field trials need to be undertaken in running water
- Future trials need to investigate the longevity of available headspace molecules from the TADD containing oil.

6. References

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7. Appendices

7.3 West Texas Crude Data

West Texas Intermediate

		Data	Notes	Reference ID
Origin: Texas, USA				
The price of this crude, known as WTI, is used as a benchmark for pricing other U.S. crude oils. Data from OGJ 99 were originally published in 1994.				
API Gravity				
		36.4		ESD 92
		40.8		OGJ 99
Equation(s) for Predicting Evaporation				
%Ev = (2.77 + 0.045T)ln(t) Where %Ev = weight percent evaporated; T = surface temperature (°C); t = time (minutes)				ESD 97
Sulphur (weight %)				
Evaporation (volume %)				
0		0.48		ESD 93
		0.34		OGJ 99
14		0.49		ESD 93
29		0.57		ESD 93
Flash Point (°C)				
Evaporation (volume %)				
0		-17		ESD 92
14		32		ESD 92
29		87		ESD 92
Density (g/mL)				
Evaporation (volume %)	Temperature (°C)			
0	0	0.8538		ESD 92
	15	0.8420		ESD 92
		0.8212		OGJ 99
14	0	0.8786		ESD 92
	15	0.8674		ESD 92
29	0	0.8994		ESD 92
	15	0.8875		ESD 92
Pour Point (°C)				
Evaporation (volume %)				
0		-23		ESD 92
		-29		OGJ 99
14		-15		ESD 92
29		3		ESD 92

W-24 Properties of Crude Oils and Oil Products - 10/00

SPL

Certificate of Analysis
Number: 1030-17080949-001A

Houston Laboratories
8820 Interchange Drive
Houston, TX 77054
Phone 713-660-0901

Sep. 08, 2017

Hugh Barnes
Texas Raw Crude
PO Box 5611
Midland, TX 79704

Sample ID: 17080059
Station Name: Texas Raw Crude #2
Sample Conditions:

Sampled By:
Sample Of: Gas Spot
Sample Date: No sample date provided

Analytical Data

Test	Method	Result	Units	Detection Limit	Lab Tech.	Analysis Date
Hydrogen Sulfide	UOP-163	<5	ppmw		JSR	09/07/2017
Mercaptans	UOP-163	142	ppmw		JSR	09/07/2017

Hydrocarbon Laboratory Manager

Quality Assurance: The above analyses are performed in accordance with ASTM, UOP, GPA guidelines for quality assurance, unless otherwise stated.

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