STANDARD OPERATING PROCEDURE

UVOST®

Ultraviolet Optical Screening Tool

Version 2.0, updated January 2024

TABLE OF CONTENTS

1.0   UVOST® OVERVIEW

The Ultraviolet Optical Screening Tool (UVOST®) is a laser-induced fluorescence (LIF) screening tool specifically designed to detect non-aqueous phase liquid (NAPL) in the subsurface. It responds to a wide variety of NAPLs including gasoline, diesel, jet fuel, and hydraulic fluids. It does this by sensing the fluorescence or glow of polycyclic aromatic hydrocarbons (PAHs) found in these NAPLs. Dakota developed the UVOST® in the early 1990's with U.S. Air Force funding. The UVOST® platform is a mature technology that has been applied at hundreds of petroleum, oil, and lubricant (POL) contaminated sites in the U.S., Europe, and Japan since 1994. This document provides the standard operating procedure for safe and efficient use of the UVOST® system.

2.0   SYSTEM

To power up the UVOST® system, flip the power switch on the front of the unit's e-deck. All peripheral devices are powered through the unit, minimizing tangles and trip hazards. The laser takes several minutes to warm up. LED lights on the excimer laser will indicate when the system is ready. Push the ON button to activate lasing.

> *Note:* If powering up in cold conditions (overnight, etc.), allow the laser to run for 10-15 minutes prior to attempting your first Reference Emitter (RE) calibration (Section 5.0). Some of the older model PSX lasers may be outfitted with a heater for cold conditions.   This heater should not be left on for more than 15min.

High (above 85⁰ F) or low (below 32⁰ F) temperatures negatively affect laser power. If operating in such conditions, one should house the UVOST® system in a warmer/cooler environment to assure proper operation. There are no hard and fast rules for this, as the conditions (wind speed, intensity of sunlight, ventilation of unit, etc.) will dictate the necessary steps.

To power down the UVOST®, flip the power switch to the "off" position.

2.1   SYSTEM INFORMATION FOR OPTIONAL UVOST COMPONENTS

A. ELECTRICAL CONDUCTIVITY SYSTEM

The EC module is a peripheral device located within the UVOST® rack. The EC module sits between the laser shelf containing the excimer laser/vacuum pump and the emission module. To power up the EC system, simply make sure that the 3-pin black power/data cable connecting it to the electronic (e-deck) is plugged in

prior to powering up the UVOST® system. With the 3-pin power/data cable connecting the EC module to the e-deck, the EC module can be controlled with the OST software. The EC module connects to the downhole fiber/EC probe via the front connection panel mounted on the left side of the UVOST® rack above the laser shelf. The EC module will power down when the UVOST system is powered off.

B. HYDRAULIC PROFILING SYSTEM

To power up the HP system, turn on the power switch on the top of the system. Check that serial cable is connecting the HP control box to the UVOST® field computer. Place the intake line into a supply of clean water and turn the pump on and turn the flow valve on the HP control box to "to probe". Allow water to fully prime the line and probe so no air bubbles remain. This usually takes 10 -15 minutes. When the flow is turned off, the flow valve should also be closed.

> *Note:* Always keep the HP control box, trunklines, and probes winterized with RV antifreeze between projects. This will prevent internal damage due to freezing conditions, lubricate internal seals, and prevent the growth of bacteria and mold in the pump, trunkline, and the water lines.

If, during an investigation, temperatures fall below freezing it is advisable to heat the supply water with a bucket heater to provide warm water through the trunkline and probe. Try to house the system in a warm environment such a heated space in a vehicle. A secondary option is to use RV antifreeze in place of water; however, this option must be addressed with both the client and local regulators before exercising. Many states will not allow the injection of anything besides clean water into the subsurface. Additionally, with the substitution of antifreeze for water, uncertainty is increased by up to 10%, as the density of antifreeze is not the same as water.

To power down the HP system, flip the power switch to the "of" position on the HP (pump) control box.

3.0   SOFTWARE

Ensure UVOST® system is turned on and the LAN connections between system and PC are intact. Power on PC and start the OST software. Indicators in the software will assist in alerting you to problematic connections and the general status of the components (Hardware tab). See software manual for specifics on OST software functions and operation.

With the software running, check the depth encoding, remote display, scope, and other peripheral functions if applicable. Green lights will display next to properly functioning peripherals in the status box of the

DAKOTA TECHNOLOGIES

Hardware tab. Depth encoding may also be checked by actuating the probe or hand advancing the string pot cable, which should alter the Current Depth reading in the Depth tab of the OST software. Similarly, check the Remote Display for established communication. Software must be in UVOST® mode. Confirm this on the hardware tab and with the display of "UVOST®" in bold green font between the Depth and Signal windows in the Primary Commands area of the software.

The optional UVOST® components are controlled from within the UVOST® software. In the Accessories tab, check boxes next to the optional components to toggle them on or off. Within this tab the EC constants (calibration values) may also be set for each individual UVOST® system.

4.0   HARDWARE

A properly setup and maintained SPOC with result in the best and most accurate data collected in the field. The following should be conducted prior to the first hole of the day, and after each hole is completed:

Step 1.   Examine the SPOC window for:

A. Fogging (moisture intrusion)

B. window chips or cracks

C. scratches

D. mirror damage

The window and mirror must be very clean for proper logging. Damaged windows can be replaced without adjusting the SPOC setup if the damage did not foul the optics or allow water or other contamination into the SPOC. Damaged mirrors must be replaced and not simply cleaned.

Step 2.   Ensure tight fitting between the:

A. SPOC tip – This is especially important when using the optional EC equipment to reduce the wearing of EC wires.

B. SPOC adapter

C. window

D. *optional:* hydraulic profiling housing

> **Step 3.**   If using the optional Hydraulic Profiling tool examine the screen for**:**
>
> A.   plugged ports
>
> B.   damaged mesh
>
> C.   tightness

Note: Once a SPOC is set up it should not need to be adjusted unless a major problem occurs such as a leakage of water/contaminant into the optical chamber, rotation of the mirror or fiber, fiber optic damage/breakage, or loss of SPOC down hole. If such a situation arises, refer to the SPOC setup document for new installation.

5.0   CALIBRATION

Reference Emitter (RE) calibration should occur before each UVOST® logging event; however, a push should begin within two minutes of RE acquisition. Do *not* calibrate with RE, then spend time prepping the push rig, etc. In difficult pushing conditions, or where asphalt or concrete is present at the surface, it is recommended to pre-probe up to four feet with a dummy tip to start a plumb probe hole. Keep in mind that UVOST® data in this interval is not reliable, which should be noted.

Once the probe is ready, place the magnetic RE holder with RE cuvette on the window of the probe. Immediately acquire RE with the "Acq RE" command via the software. Extended exposure to laser light can cause photo-degradation, or a morph in waveform shape and intensity.

If you change the length of your optical cable, the software may correct the time delay to achieve proper position on the oscilloscope. If not, the RE waveform needs to be manually moved into approximate position by adjusting the horizontal position dial on the oscilloscope. Make sure the RE signal level exceeds the 7,000 pVs minimum but is less than the 20,000 pVs. The optimum range is 10,000-12,000 but should be run with the RE as close to 11,000 pVs as possible. This will ensure consistency between projects and operators.

The OST software will alert you if the RE signal level is less than 7,000 pVs. The amount of signal can be increased by adjusting the amount of light launched into the fiber using the launch adjust knob on the fiber I/O block. Aim for a consistent RE signal for all logs on the same project/site. Next, confirm that the RE waveform shape resembles the reference waveform stored on the oscilloscope. An example of a good RE waveform is shown in Figure 1. Extremely noisy (jagged) or misshapen waveforms and missing or low channel contributions indicate a damaged or loose fiber optic cable, filter, or detector.

RE in Target Range
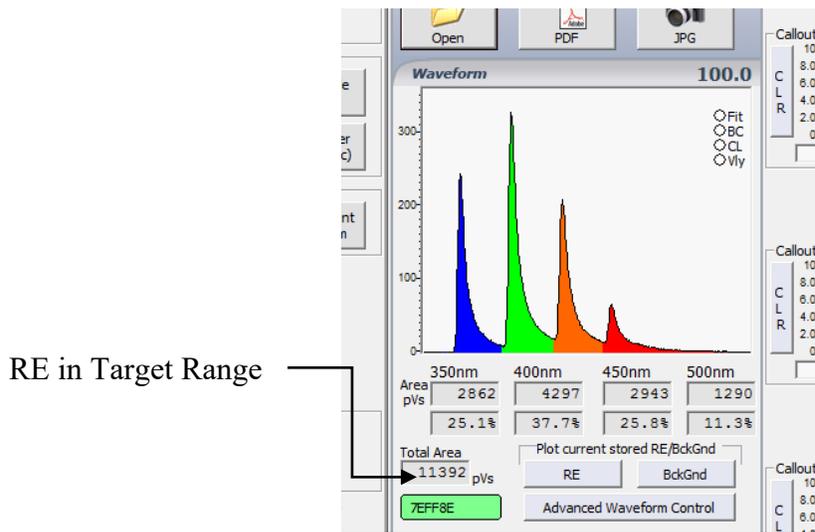
Figure 1. Target RE waveform

Note: A deviation from the waveform stored on the oscilloscope may indicate problems with internal optics or filters and will need to be inspected and fixed. Quick adjustments/cleaning to the internal optics or filters cannot easily be done in the field.

After collecting an acceptable RE reading, remove the magnetic RE holder, and acquire a Background (blank) waveform with the "Acq BckG" command. Make sure the outside of the window is clean prior to these tests.

Note: The SPOC window should *not* be exposed to direct sunlight during background acquisition as this may negatively affect the reading.

A perfect system would yield no background waveform in the last 3 channels - strictly white noise. Thus, the lowest background area possible is desired, but anything under 100 pVs can be used. Background signals higher than 100 pVs (or climbing towards) indicate potential problems such as a poor setup (mirror or fiber misalignment), interference in the optical chamber (e.g., lint, dust, or moisture), or damaged fiber lines. The cause needs to be investigated and remedied *before* collecting data.

5.1   CALIBRATION OF OPTIONAL UVOST COMPONENTS

Note: <u>ALL</u> calibration of optional UVOST® components should be completed before acquiring RE/Background so that data acquisition starts soon after the calibration. Significant time delays will cause technical issues.

A.   ELECTRICAL CONDUCTIVITY

Electrical Conductivity (EC) calibration should occur before each UVOST® logging event. If the EC constants have been previously determined, calibration may be done without any additional steps. Once the probe is ready, place the EC block on the probe with one prong against the probe body and one prong on the dipole. Within the accessories tab of the OST software, the EC output should be displayed in mS/m. The system can be used to record the EC calibration, or the values can be recorded within the field notes. At least two different values on the EC block should be tested to ensure proper function. Minimally, use the 25 mS/m and 266 mS/m values as they fall within the typical range of natural EC values you will find.

Note: It is important to record the EC calibration values. Deviations in the calibration values can be an indication of potential EC problems. Sometimes it is possible to identify problems (and fix them) before they lead to a full-blown EC failure. Tracking the EC background is useful for monitoring moisture intrusion which can cause the EC background to creep up throughout the day.

The EC constants required by the OST software differ from EC module to EC module. If you are using a new UVOST® unit, a different UVOST® unit than you normally do, or a different laptop than you normally do, then EC constants will need to be calculated prior to being able to calibrate.

Determining EC Constants

1. Click on the Accessories tab within the OST software.
2.   Make sure that the Electrical Conductivity option is selected.
3. Notice the four macros style buttons that read: Store 0, Store 25, Store 266, Store 560.
4. With a clean EC probe, click the "Store 0" button to store an EC baseline (zero) reading.
5. Take the EC block provided and place the 25 mS/m side on the probe, making sure one prong of the block is on the body of the probe while the other is on the dipole. Click the "Store 25" button.
6. Repeat this for the 266 mS/M and 560 mS/m sides of the EC block.
7. Once all four readings have been saved, the OST software will calculate the EC constants specific to that individual EC module.
8. Once EC constants are saved, normal calibration procedures can be followed until a different EC module is used with that laptop.

B. HYDRAULIC PROFILING

Prior to starting a boring, HP components shall be tested for accuracy. This quality assurance protocol will ensure the acquisition of accurate, reproducible data.

Transducer reference test

1. Ensure clean water flows freely through the screen.

2. Place probe into the HPT reference tube.

3. Allow water to flow through the system until water spills over the top of the reference tube.

4. Turn off flow to the probe and allow the flow and pressure to stabilize. These values can be seen on the HP accessory window.

5. Press the "Store 1 FT" button on the accessory window.

6. Remove the probe from the reference tube and allow the pressure to stabilize outside of the tube.

7. Press the "Store 0 FT" button on the accessory window to save the final QA/QC value.

   The test must receive a "Pass" designation before continuing operations.

6.0   LOGGING

With proper RE and background acquired following the calibration of any UVOST add-ons, follow these steps to acquire a UVOST® log:

Step 1.   Open the Info tab and input job information for storage with each LIF log.

Step 2.   Activate the "Record" command.

Step 3.   Choose a directory and name for your log.

Note: UVOST® auto-suggests the name sequentially to reduce typing.

DAKOTA
TECHNOLOGIES

Step 4. Advance the probe until the window is just below ground surface and choose to "Zero" the depth by clicking "Yes" on the on-screen prompt. When using the HP add-on, you will be prompted to start flow to the probe prior to zeroing the depth and beginning a log.

Step 5. Determine whether to view plots of push rate, conductivity, pressure uphole, pressure downhole, flow rate, or estimated K value alongside the main plot. To view simultaneously, collapse the secondary command pane using the arrow in the upper left of the OST software interface. Click the arrow in the upper right corner of the default push rate plot area and select the plot you would like to view from the drop-down selections.

> *Note:* The conductivity option will not be available from the drop-down box if hydraulic profiling is in use. Conversely, the hydraulic profiling options won't be available from the drop-down box if the EC tool is in use.

Step 6. Ensure the system operates properly by observing the oscilloscope and OST display for unusual events such as:

  A. Consistently high or low rate of probe advancement (0.8 inch/sec is desired).

  B. Abnormal background drifts indicating fogging or damage of the SPOC window.

  C. Inconsistent depth logging.

  D. Lack of waveform updates despite depth advancement.

Step 7. End the log with the "End" command in either situation:

  A. Refusal of probe advancement.

  B. Target depth is reached .

Step 8. Conduct SPOC field check after the probe has been removed from the ground (**4.0 Hardware**).

7.0   OUTPUT AND DATA MANAGEMENT

After the UVOST® push is complete, view the log to select callout waveforms.

Consider the following:

- Bracket large zones of homogenous NAPL. Do not span (group together) different products

DAKOTA
TECHNOLOGIES

- Highlight unusual signatures – perhaps to suggest sampling or "flag" things the client needs to investigate or discount.

- Highlight an occasional background to remind viewer what "clean" soil looks like.

- Highlight any potential false positives such as mineral, plant, urban background, or highly degraded NAPL. These different waveforms should help clients understand that these areas are not of concern.

- Use caution when highlighting single waveforms from the rising edge of NAPL hits. The waveforms in these areas are usually saturated because the oscilloscope scaling was not able to fully respond. These waveforms are morphed and could otherwise cause unnecessary confusion and alarm.

- Choose the callout box nearest the zone of interest for neater appearance rather than starting with the top callout and working down.

- Avoid crossing the depths of multiple callouts as this can look messy and confusing.

- Annotate callouts in the text box under each waveform. This is especially pertinent if the findings are unusual or significant.

- Discuss with the client the log depth, RE scales, depths of interest, etc.

- Data is automatically uploaded to a secure, cloud-based storage/backup and data sharing system. Clients will receive a data viewing link from Dakota via email prior to (or the day of) project start. Additionally, data may be shared with clients via field printouts, USB drive, email, or other methods that may have been agreed upon.

DAKOTA
TECHNOLOGIES