JTM ASSOCIATES, LLC
environmental consulting

October 30, 2017

John Strang, P.E.
NYSDEC
Region Four Headquarters
1130 North Westcott Road
Schenectady, NY 12306-2014

Re: NYSDEC Site # 37177
Amphenol – Boiler Room Area Site
Membrane Interface Probe Survey

Dear Mr. Strang:

The recently updated Conceptual Site Model (CSM) for the referenced site presented during our September 7, 2017 meeting indicates that an intermediate depth (50 to 70 feet below ground surface) CVOC plume may be present down-gradient of the site. As we discussed, Amphenol intends to take voluntary action to assess the fate and transport of this plume to support the site-wide Statement of Basis proposed by the Department for the old plant area.

We feel a reasonable first step of the fate and transport assessment is the screening of the groundwater chemistry in the down-gradient direction as informed by data previously collected on-site as part of Amphenol's remediation enhancement program. This will be accomplished by completing a number of membrane interface probes (MIPs) which have been successfully utilized to assess CVOC distribution in groundwater along the north side of the facility.

The attached figure depicts the anticipated locations for the MIPs. Based on the regional hydrogeology, the intermediate groundwater flow direction is most likely to the north-northwest. Therefore, the proposed survey area represents the areas hydraulically down-gradient of where the greatest concentrations have been observed along the north side of the former manufacturing facility.

The specific scope of the investigation will include:

- Install ten (10) MIPs throughout the study area
- Update the CSM with the new MIP data
- Prepare a technical memorandum summarizing the MIP survey activities and its results

The probes will be advanced using a direct push type drilling rig. The probe will be equipped with hydraulic profiling (HPT) and VOC detection tools. The HPT will measure dynamic pore pressure and soil permeability to facilitate an interpretation of the variability of hydraulic conductivity. VOC detection will be accomplished using a photoionization detector (PID), flame ionization detector (FID) and halogen specific detector (XSD) similar to that utilized during the

2015 investigation inside the old plant. The attachment provides standard operating procedures (SOPs) for the MIP system including QA/QC considerations.

During the survey, the MIP data from each respective probe will be reviewed such that the anticipated locations of probes may be adjusted as appropriate.

We plan on beginning the proposed MIP survey on November 6, 2017 and anticipate completing it in 2 weeks. The technical memorandum summarizing the results of the survey is expected to be available by the end of February 2018.

Should questions arise, please do not hesitate to contact us.

Very truly yours,
JTM Associates, LLC
James T. Mickam
James T. Mickam, PG
President

Cc: J. Bianchi – Amphenol
S. Wright – Amec Foster Wheeler

Legend

● Proposed MIP Locations

0 150 300 Feet

amec foster wheeler

JTM ASSOCIATES, LLC

Figure 1
Proposed MIP Locations

Amphenol Facility Sites
Sidney, New York

Prepared/Date: RRR 10/23/17	Checked/Date: SEW 10/23/17

Geoprobe® Membrane Interface Probe (MIP)

Standard Operating Procedure

Technical Bulletin No. MK3010
PREPARED: May, 2003
REVISED: January, 2015

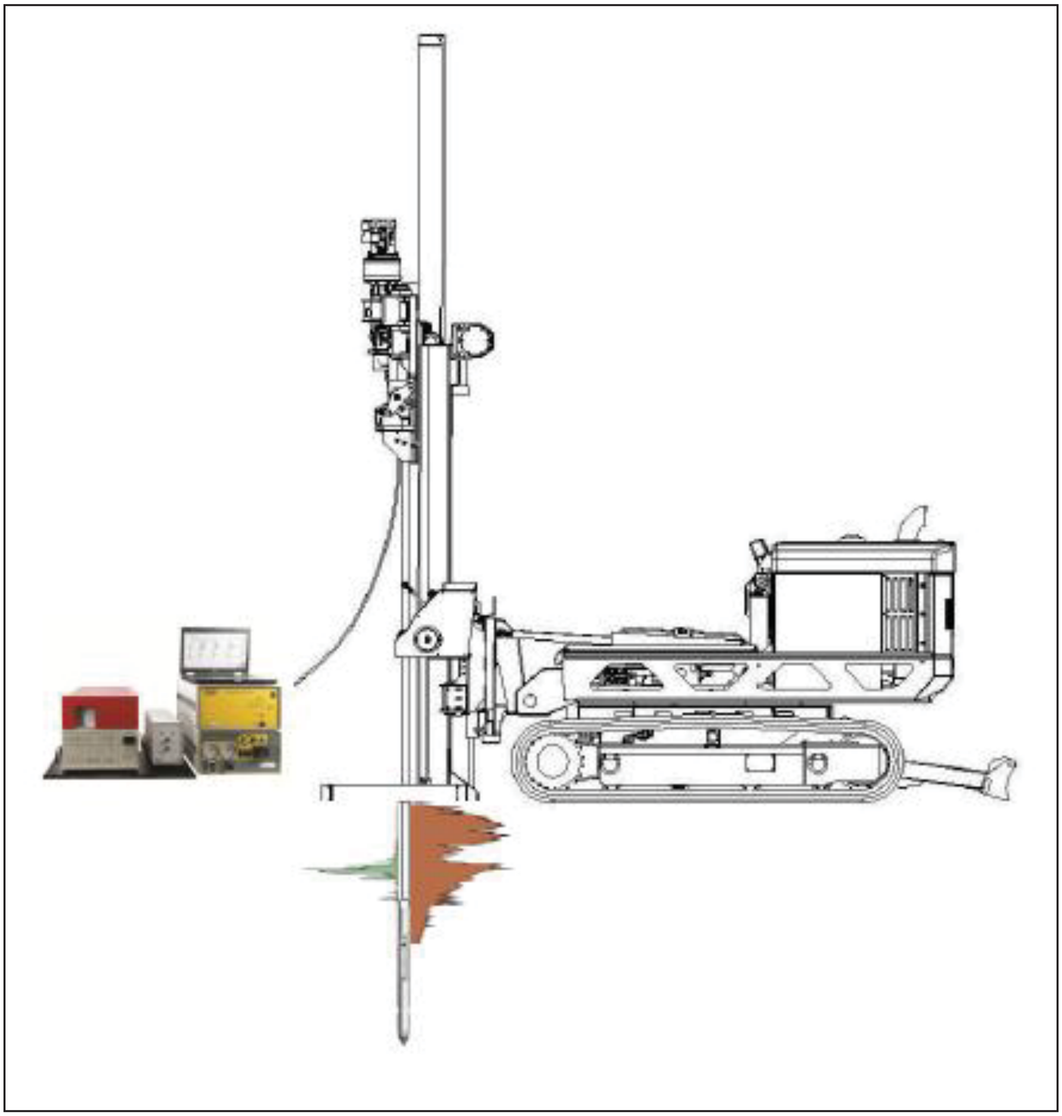


Table of Contents:

1.0 Objective

This document serves as the standard operating procedure for use of the Geoprobe Systems® Membrane Interface Probe (MIP) used to detect volatile organic compounds (VOCs) at depth in the subsurface.

2.0 Background

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and testing, soil conductivity and contaminant logging, grouting, and materials injection.
**Geoprobe® is a registered trademark of Kejr, Inc., Salina, Kansas.*

Membrane Interface Probe (MIP): A system manufactured by Geoprobe Systems® for the detection and measurement of volatile organic compounds (VOCs) in the subsurface. A heated probe carrying a permeable membrane is advanced to depth in the soil. VOCs in the subsurface cross the membrane, enter into a carrier gas stream, and are swept to gas phase detectors at ground surface for measurement.

2.2 Discussion

The MIP is an interface between contaminates in the soil and the detectors at ground surface. It is a mapping tool used to find the depth at which the contamination is located, but is not used to determine concentration of the compound. Two advantages of using the MIP are that it detects contamination in situ and can be used in all types of soil conditions.

The MIP is a logging tool used to make continuous measurements of VOCs in soil. Volatile compounds outside the probe diffuse across a membrane and are swept from the probe to a gas phase detector at ground surface. A log is made of detector response versus probe depth. In order to speed diffusion, the probe membrane is heated to approximately 121°C. (Refer to Figure 2.1).

Along with the detection of VOCs in the soil, the MIP also measures the electrical conductivity of the soil to give a probable lithology of the subsurface. This is accomplished by using a dipole measurement arrangement at the end of the MIP probe so that both conductivity and detector readings may be taken simultaneously. A simultaneous log of soil electrical conductivity is recorded with the detector response.

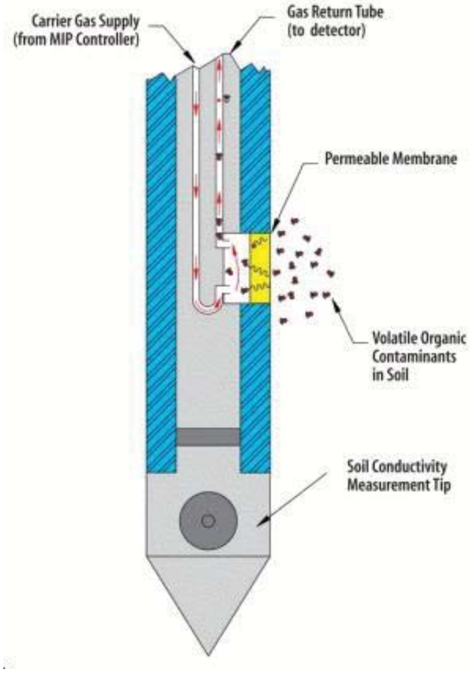


Figure 2.1: Diffusion across the membrane

Interpretation of electrical conductivity (EC) logs comes with field experience. It is very important that soil core samples are taken to confirm lithologic changes as each EC log is unique per site. As a generalization, a high conductivity reading indicates a smaller grain size and a low conductivity reading indicates a larger grain size (See Fig. 2.2).

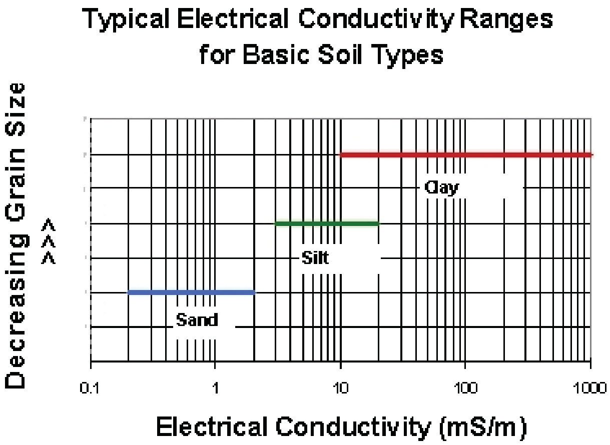


Figure 2.2: Generalized Electrical Conductivity Readings

3.0 MIP/EC Interferences

3.1 Detector saturation may require a short period of time for the detector to return to baseline after a log has been performed in higher concentrations. The MIP system can be used in free product environments with the operator monitoring and making the necessary adjustments to the detector and software gain/attenuation settings to account for the higher voltage readouts.

3.2 The MIP system can be operated in a wide range of contaminant concentrations from low dissolved phase to free phase materials. During a log and the removal of the tool string, contaminants can absorb onto the surface of the membrane and trunkline material causing elevated detector baseline signals. It is very important that the probe and trunkline system is clean enough to see the low concentrations typically used in the chemical response test. Not adequately decontaminating the probe prior to performing a response test can elevate the concentration of the standard causing an inaccurate high response to the specific concentration of standard that was prepared for the test.

3.3 Electrical conductivity can provide false positives or higher than expected readings when the soil is impacted by ionic plumes (chloride, nitrate) originating from, but not limited to: agriculture practices, seawater, salt storage, mining practices. Encountering metallic objects in the subsurface can also result in high EC readings.

3.4 Some silt and clay soils will not have the typical ionic composition that an operator may be used to for similar soils. This can result in lower than expected readings and perhaps cause misidentification of the associated soil zone based on typical response of a courser grain material. This can occasionally be found in clays that have had the minerals leached out or in intermixed silt-sand zones.

4.0 Tools and Equipment

The following equipment is needed to perform and record MIP logs. Basic MIP system components are listed in section 4.1 and shown in Figure 4.1. Additional equipment needed to run MiHPT logs is listed in section 4.2 with optional equipment listed in section 4.3. Refer to Appendix V for a detailed illustration of the GC1000 setup configuration. Appendix VI shows the common MIP probe tool string diagrams. There may be more required tools as determined by your specific model of Geoprobe® direct push machine.

4.1 Basic MIP System Components

Description	Quantity	Material Number
Field Instrument, 120V (Model FI6000)	-1-	213940
Field Instrument, 220V (Model FI6003)	*	213941
MIP Acquisition Software	-1-	214128
MIP Controller, 120V (Model MP6505)	-1-	214137
MIP Controller, 220V (Model MP6507)	*	214139
Gas Chromatograph, 120V with PID, FID and XSD	-1-	213946
Gas Chromatograph, 220V with PID, FID and XSD	*	213947
MIP Probe, 1.75 inch	-2-	214143
MIP/HPT Connection Tube	-2-	220912
MIP/HPT Drive Head 1.5in. rods	-2-	203794
Slotted 1.5” Drive Cap, Threadless	-2-	206609
MIP Probe, 2.25 inch	**	214152
2.25 Connection Tube	**	219455
2.25 Inch Water Seal Drive Head	**	212089
2.75 Inch Water Seal Drive Head	**	209796
Slotted 2.25” Drive Cap	**	211798
MIP Trunkline 100 ft.	(optional)	204077
MIP Trunkline 150 ft.	-2-	202570
MIP Trunkline 200 ft.	(optional)	204655
Agilent ADM 1000 Digital Flow Meter	-1-	600227
Hydrogen Gas Regulator	-1-	600137
Nitrogen Gas Regulator	-1-	600175
Vertical Gas Bottle Rack	-1-	214121
MIP Service Kit	-1-	214142
EC Bypass Cable	-1-	204025
Stringpot, 100-inch	-1-	214227
Stringpot Ground Plate	-1-	220775
Stringpot Cordset, 65-feet (19.8 m)	-1-	202884
Stringpot Mounting Bracket (6600/7700)	(optional)	202947
Stringpot Mounting Bracket (78 Series)	-1-	209511

Stringpot Foot Bracket (6600/7700)	(optional)	201816
Stringpot Foot Bracket (78 Series)	-1-	209533
Stringpot Piston Weight	-1-	214225
Drive Cushion (GH60)	-1-	204278
Rod Wiper, 1.25/1.5” Rods	-1-	600341
Rod Wiper Weldment	-1-	204387

4.2 Additional MiHPT System Components

Description	Quantity	Material Number
HPT Flow Module, 120V (Model K6300)	-1-	214091
HPT Flow Module, 220V (Model K6303)	*	214093
HPT Reference Tube 1.75 in HPT Probe	-1-	212689
HPT Reference Tube 2.25 in HPT Probe	**	211762
MiHPT Probe, 1.75 inch	-2-	219228
MiHPT Probe, 2.25 inch	**	214117
MiHPT Connection Tube	-2-	219594
MiHPT Drive Head for 1.5” rods	-2-	220545
MiHPT Trunkline 100 ft.	(optional)	214113
MiHPT Trunkline 150 ft.	-2-	214114
MiHPT Trunkline 200 ft.	(optional)	214115
Coupling 1/8 to 1/8 Tube	-5-	107963
Coupling 0.135 to 0.150 Tube	-5-	220978
Oetiker Band Clamp 4.7mm x 5.7mm	-10-	220977
Oetiker Band Clamp #7	-10-	220976
HPT Sensor Module	-2-	210091
Heated Trunkline Seal Asm.	-4-	211768
HPT Test Load	-1-	206552
HPT Service Kit	-1-	205599

4.3 Optional Accessories

Description	Quantity	Material Number
Heated Trunkline Controller, 120V (Model MP7000)	-1-	214147
Heated Trunkline Controller, 220V (Model MP7003)	*	214148
MIP Heated Trunkline 100 ft.	(optional)	214150
MIP Heated Trunkline 150 ft.	-1-	214151
MIP Heated Transfer Line 8 ft.	-1-	214149
MIP Breakout Connection Panel.	-1-	211100
Roll-out Rod Rack (30-1.5in rods)	-1-	213627
Water Transport System.	-1-	203450

*Use in place of 120V components if desired.

**Use in place of 1.75 inch probe and components if desired.

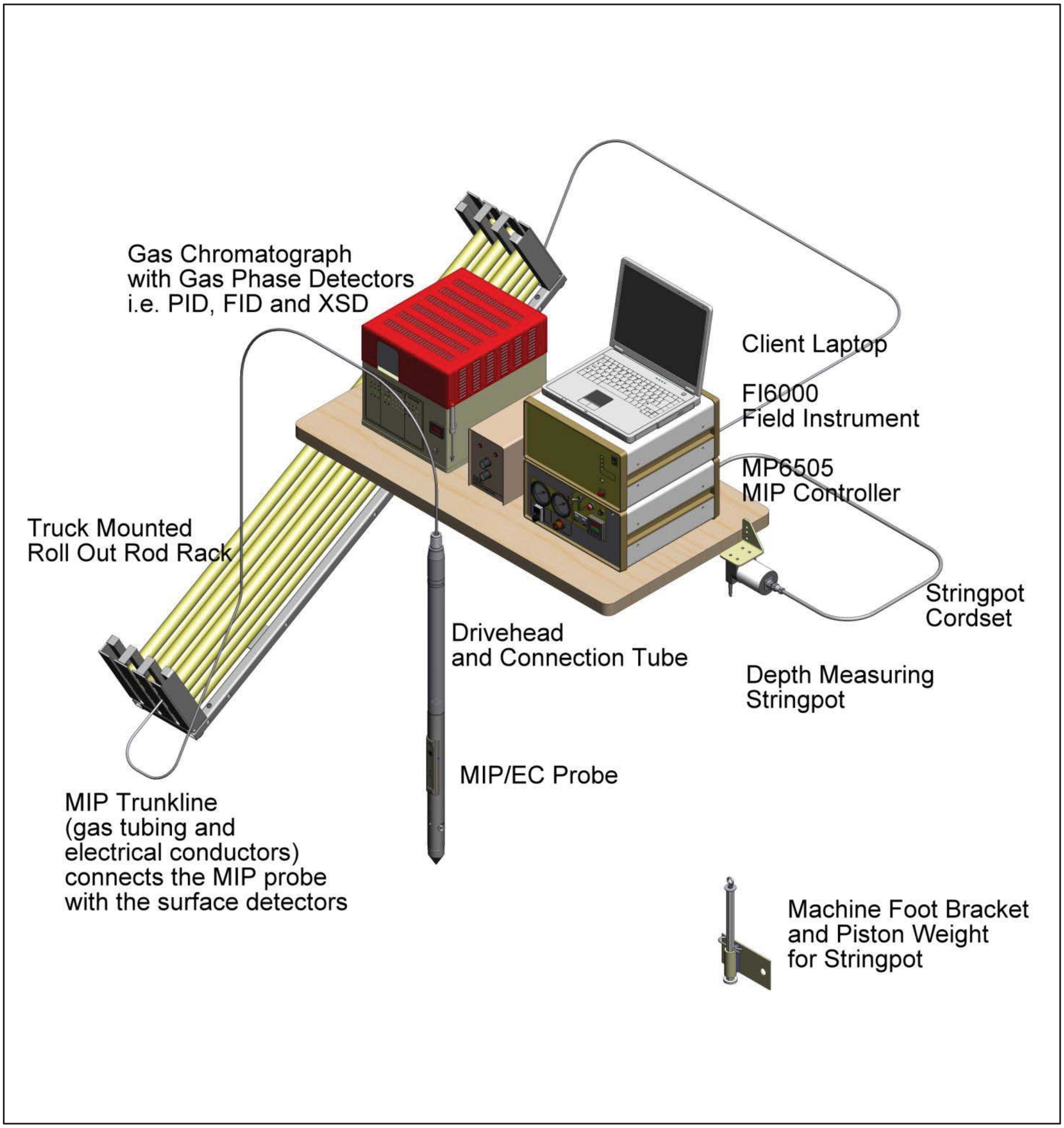


Figure 4.1: MIP System Components

5.0 Quality Assurance/Quality Control

Quality assurance (QA) testing of each of the sensors on the probe is too be performed before and after each log to validate that the equipment is capable of generating good data. The MIP tool includes chemical response tests (Section 5.1.3) which are performed to ensure that the probe membrane, trunkline and detectors are capable to providing ample signal over baseline noise to a known site contaminant at a given concentration. The electrical conductivity (EC) sensor is tested using an EC dipole test (Section 5.2) with low and high readings typical to EC values of the soil. The HPT sensor is included on the MiHPT probe and is tested using the HPT reference test (Section 5.3) which confirms the sensors ability to accurately measure a 6” column of water and provides an accurate measurement of atmospheric pressure.

Quality control (QC) is performed during and after each log is generated. Log QC will answer the following questions to ensure that the data is good and makes sense:

1. Does the log look correct? Does the elctrical conductivity appear to be in an acceptable range? Is there anything seen in the log that would make you suspect that the system wasn’t working correctly, ie. a loss of temperature or gas pressure of the system.
2. Response consistency? As more logs are completed do they show general consistency of EC and contaminant response? Review a cross section of logs in the DI-Viewer (Appendix IV).
3. Repeatablity? Replicate logs may be run every 10 to 20 locations to verify repeatability.
4. Are my lithogy changes consistant with physical soil cores? Take continuous or discreet confirmation soil samples to confirm your lithogy changes in EC.
5. Do the MIP detector responses make sense for contaminant concentration. This must be verified by the collection of water or soil samples for lab analysis to confirm contaminants and their concentrations.

5.1 MIP Chemical Response Test:

Chemical response testing is an important quality assurance measure used to validate each log by proving that the integrity of the detector system is intact. With the chemical response test the operator introduces a working standard (known site contaminant of concern) at a known concentration to the membrane for a set time of 45 seconds which should match the residence or holding time at each sampling interval. Two acceptable methods of introducing the standard to the membrane are shown in Figures 5.4 and 5.5.

Typical site contaminant of concerns which are used in MIP chemical response tests include but are not limited to Benzene, Toluene, Trichloroethylene or Perchloroethylene. The stock standard should be made up from one of these or an appropriate mix of chemicals.

5.1.1 Preparation of the Stock Standard

Preparation of the stock standard is critical to the final outcome of the concentration to be placed into the testing cylinder. The following items are required for preparing the stock standard:

- Neat sample of the analyte of interest (i.e.: Benzene, Toluene, TCE, PCE, etc.) purchased from a chemical vendor
- Microliter syringes (recommended to have: 25μL, 100μL and a 500μL or 1,000μL syringes).
- 25-mL or 50-mL Graduated cylinder
- Several 40-mL VOC vials with labels
- 25mL Methanol

1. The total volume of methanol and the compound added should equal 25mL.
2. Pour methanol into graduated cylinder to the 23.5-24mL mark, the volume depends upon the compound density (Table 5.1).
3. Pour the methanol from the graduated cylinder into a 40mL VOC vial.
4. Add the appropriate volume of desired neat analyte into 40mL VOC vial containing methanol. The required volume of neat analyte for seven common compounds is listed in Column 3 of Table 5.2. The equation in table 5.1 shows how to calculate the appropriate neat analyte volume for other compounds of interest given the appropriate density.
5. Label the vial with the name of the stock standard (i.e. Benzene, Toluene, TCE, PCE), concentration (50mg/mL), date created, and created by (your name or initials).
6. Stock standards need to be kept cold in a refrigerator or freezer to ensure they can last up to one month otherwise they should be made up more frequently as often as every 3 days if there is not cooling during the summer months. The more volatile the compound the quicker it will lose its concentration.

Stock Standard Calculations

25mL (methanol) x 50mg/mL = 1250mg
1250mg x 1/density of analyte = amount of neat material to be placed with methanol to make up 25mL total volume

Example: Preparation of 50mg/mL Benzene standard.

1250mg x 1/0.8765mg/μL = 1426μL
Use 1426μL of neat Benzene in 23.5mL of Methanol to get a 50mg/mL stock standard.

Table 5.1: Stock Standard Preparation Calculations

Compound	**Density (mg/μL)**	**Volume (μL) of Neat Standard Required to prepare Working Standard (0.5 L)**
Benzene	0.876	1426
Toluene	0.867	1442
Xylenes	0.860	1453
Methylene Chloride	1.335	936
Carbon Tetrachloride	1.594	784
Chloroform	1.480	845
Trichloroethylene	1.464	854
Perchloroethylene	1.623	770

Table 5.2: Density and required volumes of neat (pure ~100%) compounds used to make a 50mg/mL stock standard into 25 ml of methanol

5.1.2 Preparation of Working Standards

The following items are required to perform response testing:

- Microliter syringes (recommended to have: 10, 25, 100 & 500µL syringes).
- Freshly made 50ml/ml Stock standard
- Testing cylinder made from a nominal 2-in. PVC pipe with a length of 24 in. or 40ml vial
- 0.5 L plastic beaker or pitcher
- Supply of fresh water, 500mL needed per test
- Stopwatch

Volume of 50mg/ml Stock Standard (µL)		Final Concentration mg/L = ppm
10		1.0
100		10
1000		100

Table 5.3: Volumes of stock standard and final concentrations

Figure 5.1: Working standard

5.1.3 Performing the Chemical Response Test

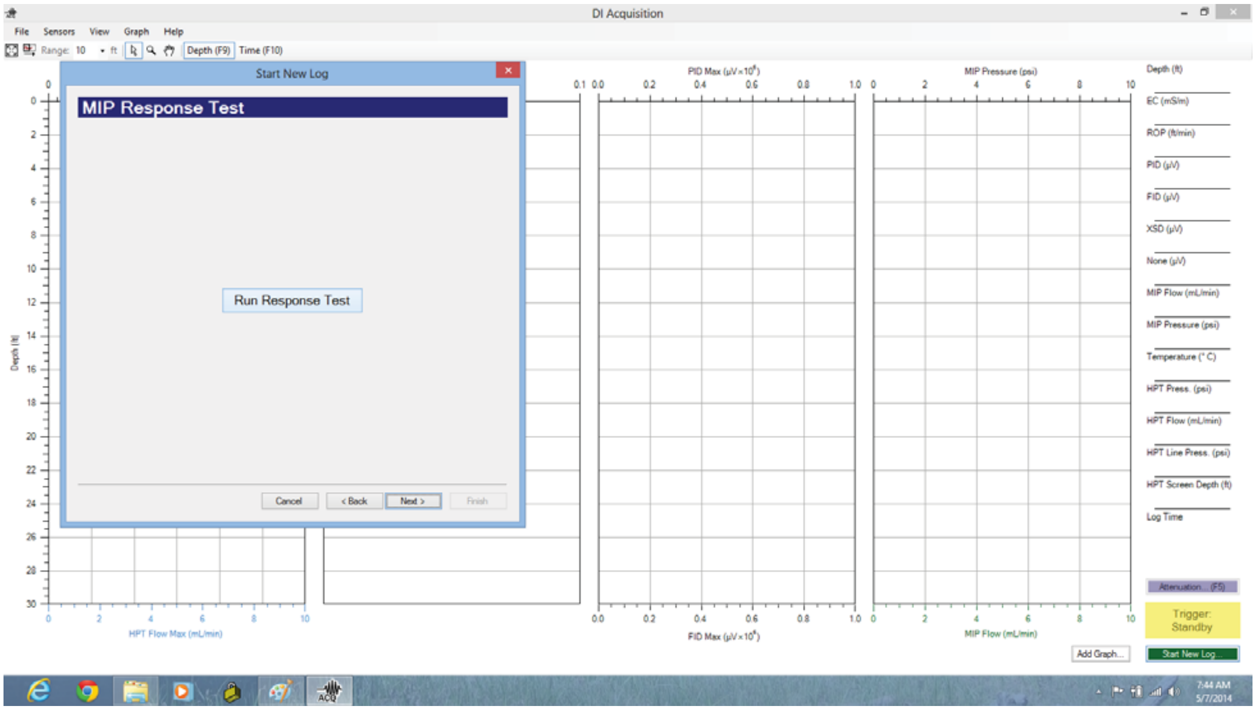
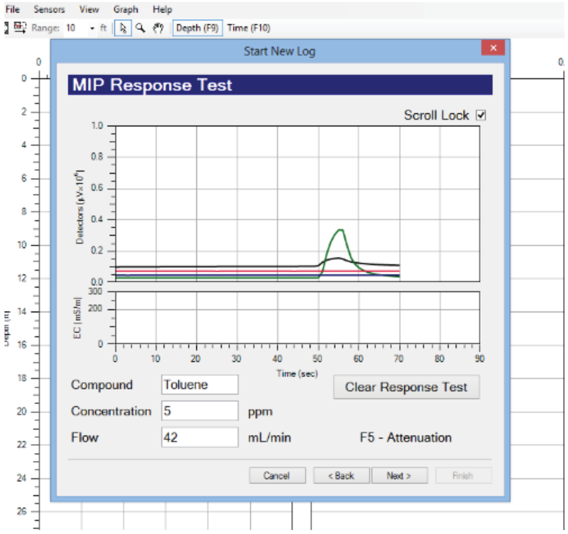


Figure 5.2: DI Acquisition Response Test Screen

1. Begin a new log in the DI-Acquisition software and proceed to the response test screen. The detector signals should be stable before proceeding with the test.
2. Measure out 500mL of tap or distilled water in a graduated beaker.
3. Using Table 5.3, determine the desired volume of stock standard to place into the 500ml measured volume of water to make up the working standard.
4. If the detector baselines have been monitored while the standard was being prepared select “Clear Response Test”.
5. When ready with the working standard prepare to run the response test by exposing the membrane to the working standard. Two acceptable methods are to pour the standard into a nominal 2-inch x 24-inch PVC pipe and insert the probe into the tube (Fig. 5.4) and the other method is to pour the working standard into a 40ml/vial and invert onto the membrane (Fig. 5.5).
6. Start the response test by clicking on the “Run Response Test” button (Fig. 5.2) and immediately expose the MIP membrane to the test solution (Figures 5.4 or 5.5).



Compound Toluene

Concentration 5 ppm

Flow 42 mL/min

Figure 5.3: Running the Chemical Response Test

7. Leave the membrane exposed to the test solution for 45 seconds. This time is to be equal to the resonance time at each depth interval during probe advancement.
8. Starting the response test time file as the membrane is exposed to the test solution allows the trip time (Section 5.1.4) to be easily calculated by when response begins to climb which is approximately 50seconds in Fig. 5.3.
9. Fresh working standards need to be made for each test, they cannot be reused.
10. After the response has come through the detectors and adequate detector response is seen the operator may select “next” to move to the EC QA test.

Acceptable methods for performing the MIP Chemical Response Test

Figure 5.4 Probe immersed in steel or PVC pipe containing working standard

Figure 5.5: 40ml vial of working standard inverted onto membrane

5.1.4 Determination of Contaminant Trip Time:

Response testing also enables the operator to measure the chemical trip time which needs to be entered into the MIP software to accurately plot the contaminants depth position. The trip time is the time it takes for the contaminant to travel through the trunkline from the membrane to the detectors. The contaminant trip time is influenced primarily by trunkline length and carrier gas flow rates as well as the contaminant makeup specifically boiling point. The chemical response trip time can be determined from the results on the Pre-Log Response Test. Using Fig. 5.6 the Benzene trip time (TT) would be approximately 55 seconds. This response test would need to have been started right when the chemical used in the response test was exposed to the membrane. Additional typical response test graphs are located in Appendix I.

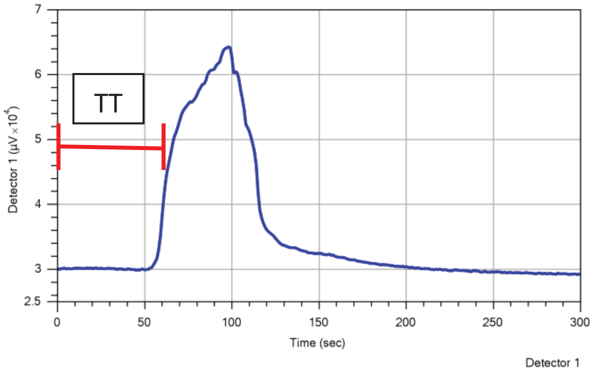


Figure 5.6: 5ppm Benzene on PID

5.1.5 Appropriate Chemical Response Test Concentrations and Response

The compound used in a chemical response test should be the site contaminant of concern or similar which will give you the most accurate response magnitude for that chemical as well as an accurate trip time. If the site objective is to delineate the extent of a dry cleaner plume then the operator should use PCE for the response tests at the lowest possible concentrations ~1ppm or less. If the site objective is to delineate the extent of the petroleum plume from a gas station then the operator should use one of the BTEX compounds or a gasoline mixture at or near the detection limit. If the site objective is to map out a plume source and high contaminant concentrations are expected then the response tests should be run at higher concentrations such as 10ppm-50ppm. This should reduce the possibility of trunkline/membrane carryover masking the chemical response tests.

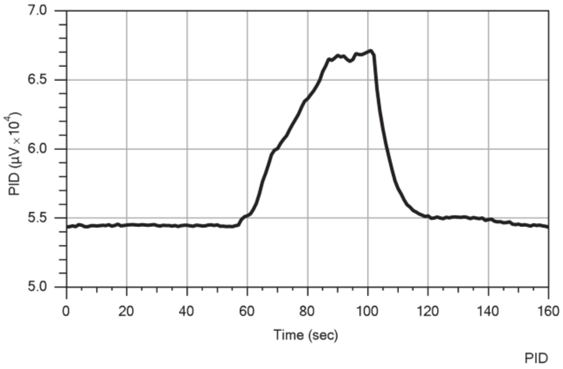


Figure 5.7: 2.5ppm Benzene on the PID

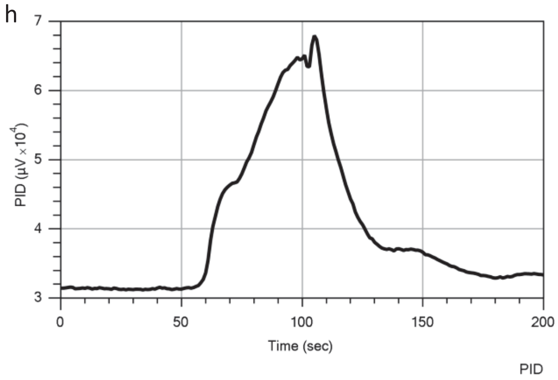


Figure 5.8: 5ppm TCE on the XSD

Figure 5.7 shows a benzene response over baseline on the PID of approximately 12,500μV on a 2.5ppm standard for a 5,000μV/1ppm. Figure 5.8 shows TCE responses over baseline on the XSD of 33,000μV on a 5ppm standard for approximately a 6,500μV/1ppm response.

5.1.6 Minimum Acceptable MIP Response Test Levels and Maintenance Tips

Geoprobe Systems specifies the following guidelines as minimum MIP response test values for performing MIP logging.

Detector systems can vary in the level of response for a given chemical concentration depending on detector age, model, and maintenance performed. However, it should be expected that the detector system would be able to provide at least a 5:1 signal to noise ratio (see Appendix I) for 1ppm of Benzene or TCE. Other compounds or concentration may be performed at the client requests however they may have different response magnitudes and signal to noise ratios at 1ppm. These specifications are required with operation of the PID and XSD (ECD or DELCD as well as alternative halogen detectors). The FID is a less sensitive detector typically used as a confirmation detector and one used for mapping natural gas components.

If the minimum response test levels are not achievable or throughout the day or project the detector sensitivity falls below these levels, the operator must stop and perform maintenance on the system to enhance the sensitivity of the detectors. Corrective actions could include:

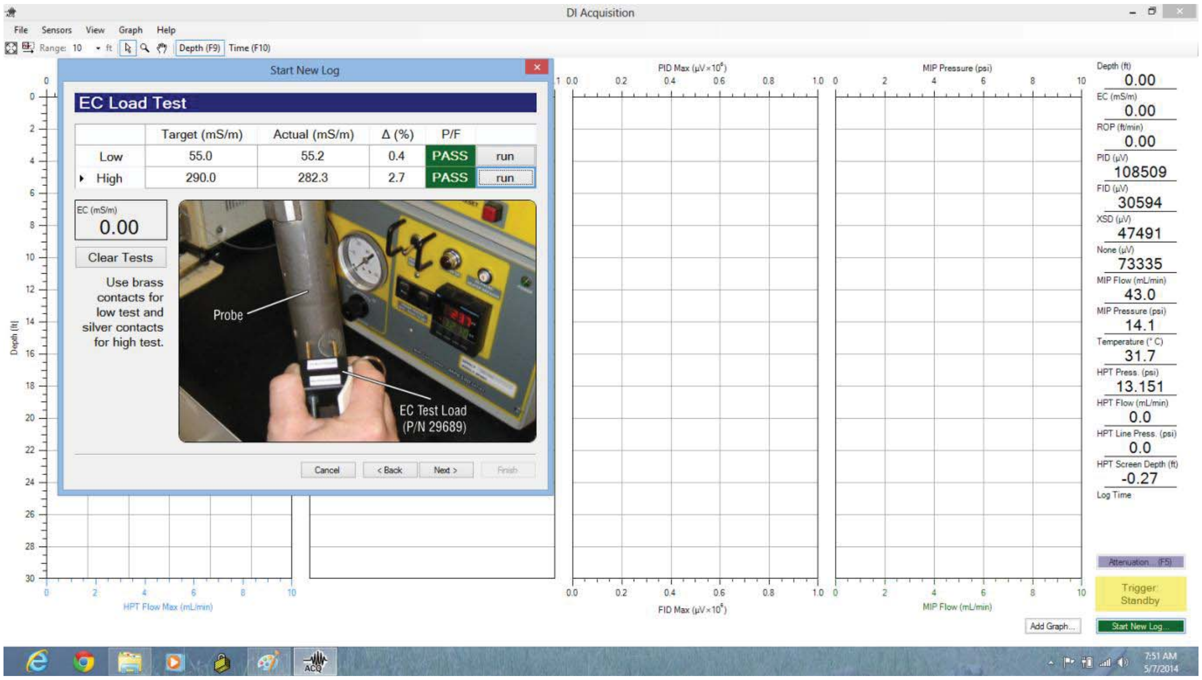
- Changing MIP membrane (see section 9.0)
- Making a fresh chemical stock standard (see section 5.1.1). It does not take long for a volatile chemical standard to lose the original concentration.
- Decreasing trunkline carrier gas flow from 40ml/min to 30 or 20ml/min. This will lower the pressure in the trunkline and at the membrane which will increase system sensitivity. If this is corrective action is taken the operator must update the system trip time which has changed.
- Performing detector maintenance
    - Cleaning or replacing the PID bulb
    - Replacing the XSD probe assembly or reactor core
- Checking and adjusting detector gas flows - especially in the FID.
- Replacing the trunkline (an old trunkline can be a source of contaminant phase buildup. This will reduce detector sensitivity by causing contaminant dispersion in the trunkline which results in reduced response levels as well as delayed trip times).

It is wise for the MIP operator to monitor the detector response heights from the chemical response tests to evaluate membrane performance. With increased membrane footage, detector response will fall off indicating that it is time to change the membrane (see Appendix III). It may be possible to rejuvenate a MIP membrane by scrubbing with a wire brush.

5.2 EC Dipole Test

On the FI6000 and the DI-Acquisition software the EC dipole test screen (Fig. 5.10) will open up after the chemical response test is completed. When ready place the low (brass) side of the EC Dipole test jig (Fig. 5.9) between the EC dipole and body of the probe and start the low level test, hold for 5 sec until the system captures the data (Fig. 5.10). Repeat for the high (stainless steel) EC test. These tests should result in readings of 55mS/m and 290mS/m + 10%.

Figure 5.9: EC Dipole Test Jig



EC Load Test

	Target (mS/m)	Actual (mS/m)	Δ (%)	P/F	
Low	55.0	55.2	0.4	PASS	run
High	290.0	282.3	2.7	PASS	run

EC (mS/m) 0.00

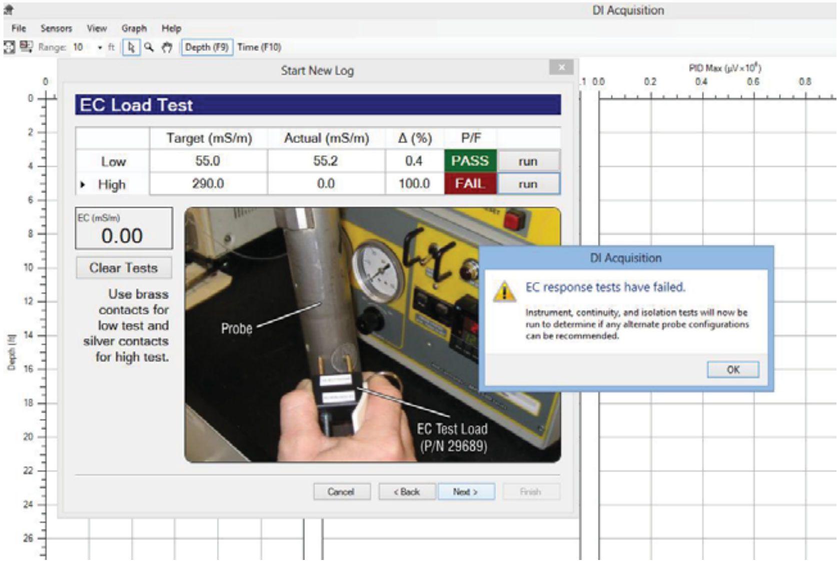
Clear Tests

Use brass contacts for low test and silver contacts for high test.

Depth (ft) 0.00
EC (mS/m) 0.00
ROP (ft/min) 0.00
PID (µV) 108509
FID (µV) 30594
XSD (µV) 47491
None (µV) 73335
MIP Flow (mL/min) 43.0
MIP Pressure (psi) 14.1
Temperature (° C) 31.7
HPT Press. (psi) 13.151
HPT Flow (mL/min) 0.0
HPT Line Press. (psi) 0.0
HPT Screen Depth (ft) -0.27
Log Time

Figure 5.10: EC Dipole Test QA Screen

If the EC readings do not pass, the DI Acquisition (FI6000) software will prompt the user to proceed through a series of troubleshooting tests (Fig. 5.11). These tests will check the EC calibration (Fig. 5.12) to determine if the reason EC Test loads have failed was an issue internal to the FI6000 or if it is external in the trunkline-probe circuit. From here the operator should have an idea where to focus their attention to fix the problem.



EC Load Test

	Target (mS/m)	Actual (mS/m)	Δ (%)	P/F	
Low	55.0	55.2	0.4	PASS	run
High	290.0	0.0	100.0	FAIL	run

EC (mS/m) 0.00

Clear Tests

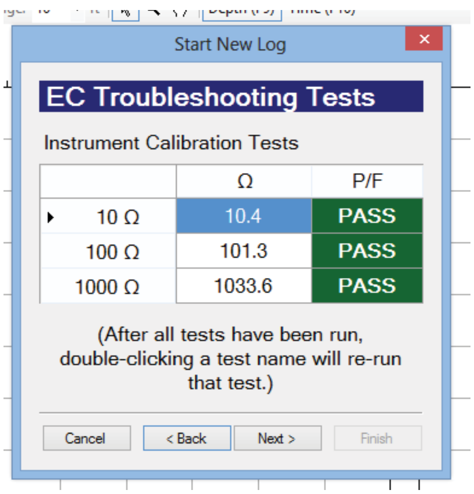
Use brass contacts for low test and silver contacts for high test.

DI Acquisition

EC response tests have failed.

Instrument, continuity, and isolation tests will now be run to determine if any alternate probe configurations can be recommended.

Figure 5.11: Failed EC Dipole Test Error Screen



EC Troubleshooting Tests

Instrument Calibration Tests

	Ω	P/F
10 Ω	10.4	PASS
100 Ω	101.3	PASS
1000 Ω	1033.6	PASS

(After all tests have been run, double-clicking a test name will re-run that test.)

Figure 5.12: EC Calibration Check

5.3 HPT Reference Test – (MiHPT)

Reference testing is done to ensure that the HPT pressure sensor is in working order and to evaluate the condition of the HPT injection screen. The HPT reference test calculates atmospheric pressure which is required to obtain static water level readings and to determine the estimated K values for the log in our post log processing software the DI Viewer.

Reference Test Procedure

1. Connect a clean water source to the HPT controller and turn on the pump.
2. Allow water to flow through the system long enough so that no air remains in the trunkline or probe (air in the system can cause inaccurate flow and pressure measurements).
3. Insert the probe into the HPT reference tube and allow the water to flow out the valve adjusting the flow rate to between 200-300ml/min (Fig. 5.13). Ensure that the reference tube is close to vertical.
4. With a stable pressure reading and the water flowing out of the valve select "capture" - bottom with flow (Fig. 5.14)

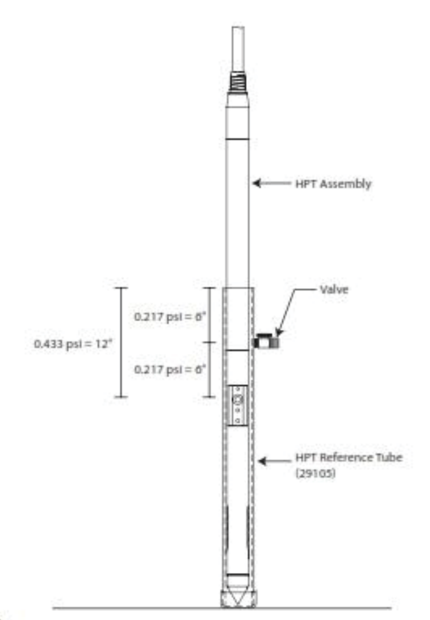
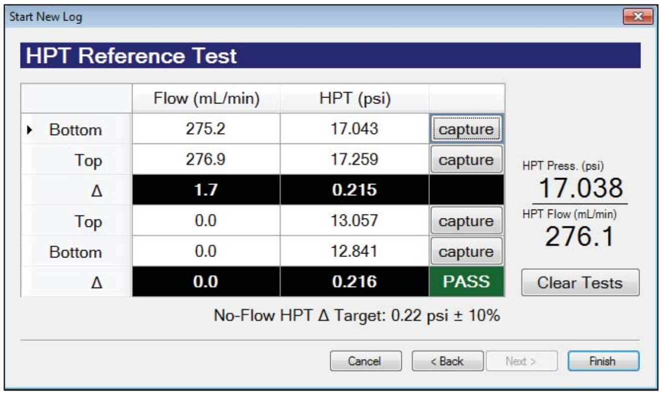


Figure 5.13: HPT Reference Test Setup

5. Close the valve and allow the water to overflow the top of the tube. When the pressure stabilizes select “capture” - top with flow.
6. Shut off the water flow. When the pressure stabilizes select “capture” - top flow = 0.
7. Open the valve and allow the water to drain out. When the pressure stabilizes select “capture” - bottom flow = 0.



	Flow (mL/min)	HPT (psi)	
Bottom	275.2	17.043	capture
Top	276.9	17.259	capture
Δ	1.7	0.215	
Top	0.0	13.057	capture
Bottom	0.0	12.841	capture
Δ	0.0	0.216	PASS

HPT Press. (psi) 17.038

HPT Flow (mL/min) 276.1

No-Flow HPT Δ Target: 0.22 psi ± 10%

Figure 5.14: HPT Reference Test Screen

The HPT reference test reading flow = 0 is the true test of the condition of the pressure sensor and is the only sensor test to have a pass/fail reading on it. Ideally, the pressure difference between the top and bottom values will be 0.22 psi (1.52kPa). Typical pressure readings of the sensor will be in the 12PSI-15PSI (83kPa-104kPa) range.

6.0 Equipment Preparation for Site Work

The biggest issues to the performance of any specific MIP system is inadequate project preparation and system review, too heavy of a workload which reduces the ability to perform needed maintenance and inexperienced operators how do not fully understand the steps of troubleshooting.

When a MIP system is stored for a period of time between projects, operators must review the equipment and give it a full system checkup which includes checking detector gas flow rates, running response chemical response tests with known chemicals at concentrations at or near required site detection limits. This needs to be performed 1-2 weeks in advance of project work so there is time to obtain required supplies that might be needed for proper operation. A final checkout needs to be performed within 7 days of the project. If the MIP site contaminant of concern is an obscure chemical not normally tested for the operator should run some of that chemical for response tests to confirm it can be detected and to determine reasonable detection limits. The operator should be able to supply the consultant with pre-project performance data of all sensor information to be performed at the site which might include EC, MIP chemical response tests, and HPT reference test information.

If a MIP system is scheduled on a long job or has a number of jobs strung together it is in the best interest of the MIP service company to schedule a maintenance day at least every 3 weeks to allow the operator time to go through system and service the components that need attention. This will help to be able to keep to system performing well for the company and their clients. Pre project performance must still be able to be produced.

New operators will always be needed as the MIP community continues to grow, however it is imperative that operators who are running the MIP systems on their own have been properly trained by experts from their own company or at Geoprobe Systems® headquarters. An inadequately trained operator who faced difficulties onsite and does not understand the system and how to troubleshoot it will quickly bring frustration upon themselves, their company and clients. It is important that each operator is properly trained, is able to spend consistent time with the equipment and the software, and whenever possible operate of the equipment under the guidance of a mentor "MIP specialist."

7.0 MIP Field Operation

1. Power on the generator.
2. Open the gas cylinders that will be used for the MIP system (i.e. nitrogen, hydrogen, air, etc.).
3. Power on the GC and detectors and allow them to warm up (min. 20 minutes) to set temperature.
4. Power on the MIP controller, field instrument and laptop computer.
5. Check the trunkline supply and return flows of the system and MIP pressure. Compare these numbers to previous work.
6. Start the Acquisition software and start a new log.
7. Perform the chemical response test (Section 5.1.2) and record the height of the peak response and the trip time into a field notebook. Refer to Figure 5.4 and Appendix I and III.
8. Complete the EC dipole test (Section 5.3) and finish setting up the log.
9. Record the system parameters in a field notebook at this time (i.e. flow, pressure, trip time, detector baseline voltages).
10. Connect the stringpot cable to the stringpot and the stringpot wire to the weight located on the probe foot and pull keeper pin so the weight will drop to the ground.

NOTE: Do not allow the stringpot cable to snap back into the stringpot housing at a high rate of speed. This will ultimately damage the stringpot transducer.

11. Place the drive cushion onto the probing machine head.
12. Place a slotted drive cap to the MIP drive head.
13. Place the rod wiper on the ground and insert the point of the MIP probe into rod wiper opening.
14. Start the HPT water flow if running MiHPT.

    Note: It is important that there is always water flowing when the probe is moving to avoid soil particles from moving through and plugging up the screen.
15. Align the probe exactly straight and advance the probe to the starting depth: MIP membrane even with the ground surface.
16. Click the trigger button in the lower right hand corner of computer screen. (The Trigger label will flash and the background will change from yellow to green).
17. Standard advancement the probe is at a rate of 1ft/min meaning: advance 1 ft (30 cm) in 15 seconds and then hold at depth for 45 seconds, then advance to the next depth interval (1 foot) over 15 seconds and wait for 45 seconds. Do this until the predetermined log depth or until refusal is attained.

Advancement the MIP probe can be performed using a continuous push method with no stopping intervals which may be desirable in source level contamination. Data collected by this method will result in higher detection limits and is not directly comparable to data collected by the standard advancement method previously discussed.

NOTE: If the there is a loss in MIP pressure or temperature during the logging process, stop and evaluate the problem using the troubleshooting guide located in Appendix II.

NOTE: Refusal is attained when it takes longer than 1 minutes of continuous hammering to advance the probe one foot. This is the maximum time to reach one foot of probe travel.

18. Perform an HPT dissipation test (Section 7.1) in a zone of higher permeability indicated by lower HPT pressure if you are operating the MiHPT probe.
19. When the MIP log is complete, turn the trigger off and slowly return the stringpot cable into the stringpot housing.
20. Turn off the heater switch to the probe during tool string retraction so no as few contaminants as possible are diffused through the membrane and into the trunkline during retraction.
21. Raise the probe foot of the direct push machines foot assembly and place the rod wiper weldment under the foot assembly to keep it in place during rod retraction.
22. Pull the probe rod string using either the Geoprobe® rod grip pull system or a slotted pull cap.
23. When the MIP probe reaches the surface, clean the probe and membrane well with a detergent/water mix and rinse off well.
24. Now turn the probe heat back on to back off the membrane. Make sure the probe membrane and trunkline are clean of contaminants and the detector baselines are stable prior to running a post log response test. View the detector activity in the response test screen.
25. When the baselines are stable run a post log response test. These response test results should be written down in the field notes and compared to the initial test. This system check ensures the data for that log is valid.
26. When using the FI6000, the data will be saved into your designated folder on your laptop in a compact .zip file. Data from the MIP log can now be graphed and printed using the DI-Viewer software (Appendix IV).

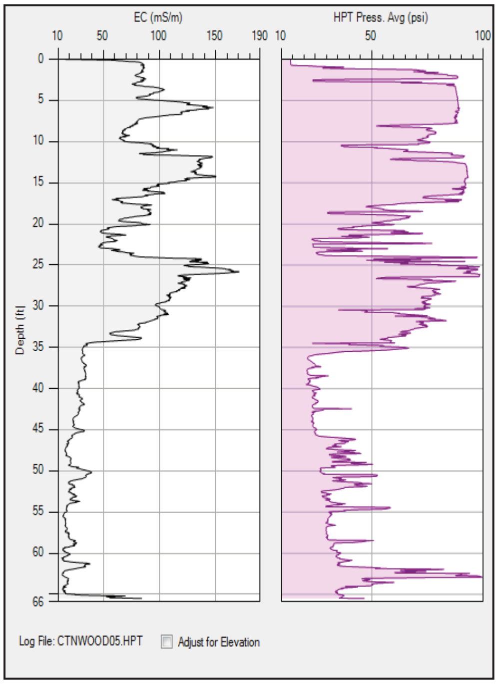
7.1 Performing an HPT Dissipation Test

At least one dissipation test must be performed in order to calculate the static water level and estimated K readings from the HPT log. Dissipation tests need to be performed below the water table and are best in zones of high permeability where the injection pressure can dissipate off quickly once the flow is shut off. The following are the steps for running an HPT Dissipation test.

1. Stop in a zone of higher permeability which is indicated by lower HPT inject pressure.
2. Switch the DI Acquisition display view from the depth screen to the time screen by pressing the F10 key (F9 and F10 toggle between the depth and time screen of the acquisition software).

3. The screen will be grayed out which means that the data up to that point has not been saved. Select “Start Dissipation Test” which will turn the screen from gray to a white background indicating that you are now saving the time data.
   Now shut the pump switch off and when the line pressure reaches zero, turn the flow valve off.
4. The HPT Pressure will begin to drop (dissipate the hydrostatic increase) and allow it to stabilize so very little visible drop in pressure is seen. When the pressure has fully dissipated turn the flow valve and the pump switch back on. When the flow and pressure are reestablished select “End Dissipation test.”
5. Select F9 to return to the depth screen and advancing the tool into the ground.

Note: Performing a dissipation test in zones of higher permeability may only take 60 seconds or so but if the HPT pressure was higher to start with it may take a long time up to several hours to dissipate off to equilibrium. This is why targeting the most permeable zone to perform the dissipation tests is most desirable.



Log File: CTNWOOD05.HPT ☐ Adjust for Elevation

Figure 7.1: EC and HPT Pressure Graphs

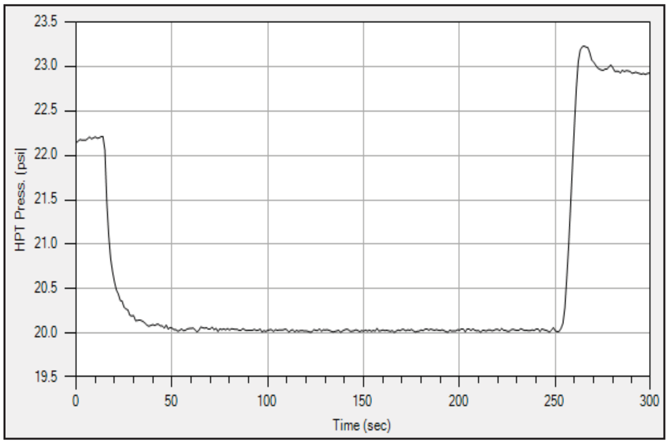


Figure 7.2: HPT Dissipation Test Screen.

The dissipation test shown in Figure 7.2 was performed in the lower pressure zones located at 39.5’ of the log shown in Figure 7.1. With HPT sands and gravels are indicated by lower injection pressure which is primarily seen below 35’ in the above log. The dissipation test in Figure 7.2 shows a higher pressure at the start of the test which falls off which is a result of shutting off the water flow. A good dissipation test will run for a period of time approximately 30-60seconds at a stabilized pressure and then turn the water flow back on during the saved log.

7.2 Detector Gain/Software Attenuation Changes

While mapping volatile contaminants with the MIP system operators commonly encounter highly contaminated/free product zones that can result in the detector signal climbing to the point of saturation or “flat lining.“ This occurs because the GC or detector system has a limited signal output range. What that range is varies depending upon the GC model or detector controller. Typical signal out limits for are 0-5VDC for SRI and Shimadzu GC models and 0-1VDC for HP/Agilent GCs and the OI XSD. The attenuation settings (software multipliers) for SRI and Shimadzu GCs and the XSD are based on a 10^x multiplication factor. The attenuation settings for detectors operated through an HP GC are based on a 2^x multiplication scale x = HP GC Range with the sum being the corresponding attenuation for the MIP software (Table 7.1).

As the probe is being advanced into higher concentration petroleum hydrocarbon soils the operator, if using an SRI GC, will want/need to adjust the GC gain on the PID and probably the FID from a gain setting of high to medium which takes those detector signals and divides them by a factor of 10 (Table 7.1). This reduction in the signal can be seen in the software both in the digital display as well as on the time graph. After the signal has been reduced the operator will need to select the attenuation tab/F5 in the DI Acquisition software and input a 10x multiplier in for the PID and the FID if both gain switches were changes to the medium setting.

If the operator chooses to go back to the highest sensitivity on those detectors after passing through the high contamination zone they need to first remove the multiplier in the software (F5) and then change the gain setting from medium to high on the GC – removing the signal divider. If either of these is performed in reverse fashion the log will see a very larger false positive peak because the signal is multiplied up without having a signal divider in place. The operator always wants to add the signal divider in first as they go into higher reading soils and remove it last as they come out of them.

Gain/Attenuation Settings on the GC detectors and the DI Acquisition software

HP GC* Range	DI Acq. Attenuation	SRI GC Gain	XSD Gain	DI Acq. Attenuation
0	1	High	High	1
1	2	Medium	Medium	10
2	4	Low	Low	100
3	8			

Table 7.1: GC gain/range settings and associated software multipliers.

*- The detectors on the HP GC can have attenuation settings up to a range of 7 on the GC corresponding to an acquisition software multiplication value of 128.

8.0 Replacing a Membrane on the MIP Probe

A probe membrane is considered in good working condition as long as two requirements are met:

1. Adequate signal response is achieved during the chemical response tests to see the required detection limits.
2. The difference between the supply and return flow has not increased by more than 3mL/min from the original settings. (A digital or bubble flow meter should be kept with the system at all times).

If either one of these requirements are not met, a new membrane must be installed as follows.

1. Turn the heater off and allow the block to cool to less than 50° C on the control panel readout.
2. Clean the entire heating block with water and a clean rag to remove any debris.
3. Dry the block completely before proceeding.
4. Remove the membrane using the membrane wrench (Fig. 8.1). Keep the wrench parallel to the probe while removing the membrane to ensure proper engagement with socket head cap screw.

NOTE: Do not leave the membrane cavity open for extended periods. Debris can become lodged in the gas openings in the plug.

5. Remove and discard the copper washer as shown in Figure 8.2. Each new membrane is accompanied by a new copper washer. **Do not reuse the copper washer**.
6. Clean the inside of the membrane socket with a q-tip and methanol removing dirt and debris that will be present.
7. Insert the new copper washer around the brass plug making sure that it sits flat on the surface of the block.
8. Install the new membrane by threading it into the socket. Thread the membrane into the socket by hand, do not use the membrane wrench until the membrane is nearly all the way threaded. Use the membrane wrench to tighten the membrane to a snug fit. Do not over-tighten.
9. Turn the carrier gas on and leave the heater off. Apply soapy water to the membrane and surrounding area to check for leaks. If bubbles form in the water around the edges of the membrane or in the wrench holes use the membrane wrench to further tighten the membrane.
10. Use a flow meter to check carrier flow. The difference between the supply flow from the MP6505 and the return flow from the trunkline should be less than 3ml/min. Record the values in a field notebook.

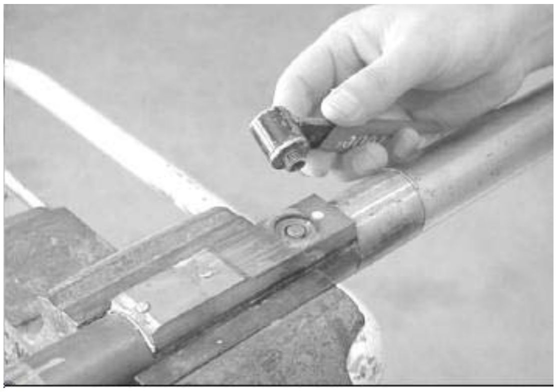
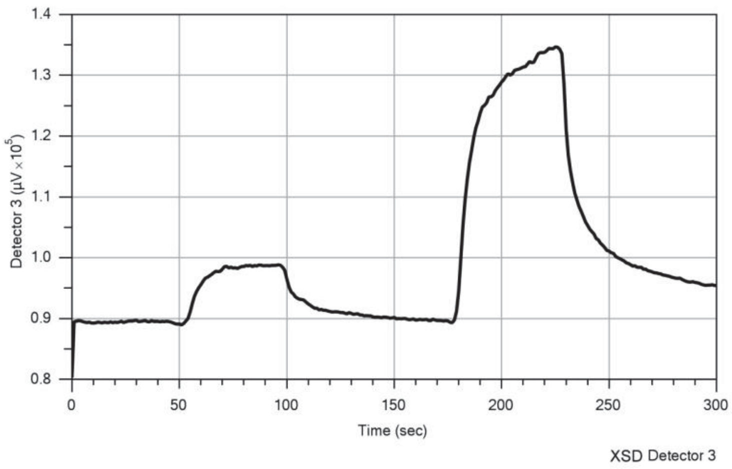


Figure 8.1: Unthread the membrane from the probe block.

Figure 8.2: Remove and discard the copper washer.

APPENDIX I

Typical Response Test Data

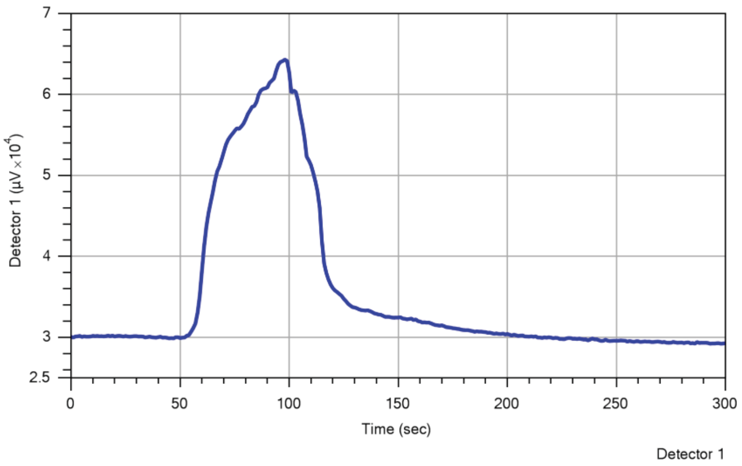


System Parameters:

MP6520 Probe with 121°C setpoint
150’ PEEK Trunkline
40ml/min of Nitrogen Carrier Gas
XSD Temperature of 1,100°C

System Response:
1ppm – 9,000μV
5ppm- 45,000μV

Figure 1: Chemical Response Test: TCE 1 & 5ppm on XSD



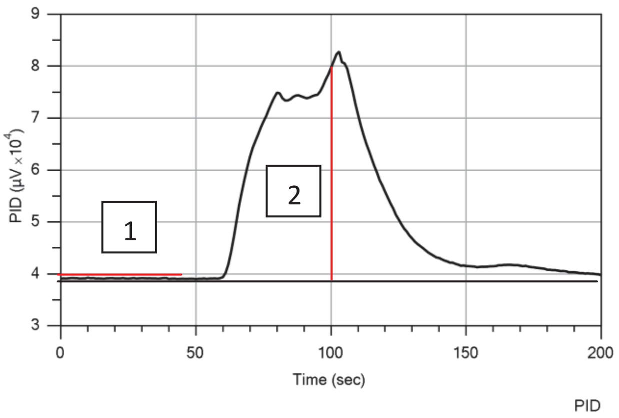
System Parameters:

MP6520 Probe with 121°C setpoint
150’ PEEK Trunkline
40ml/min of Nitrogen Carrier Gas
PID Lamp intensity

System Response: 5ppm- 35,000μV

7,000μV/1ppm

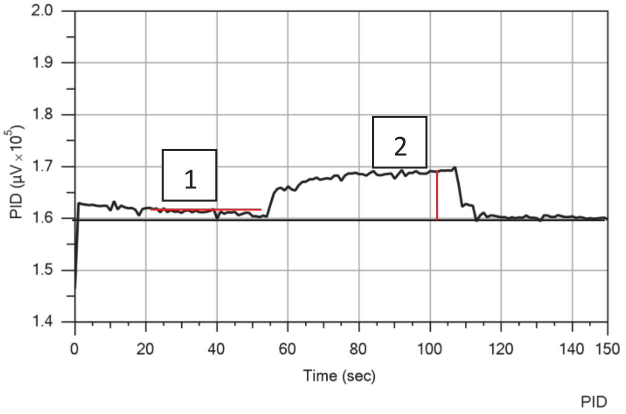
Figure 2: Chemical Response Test: Benzene 5ppm on PID



Response test - PID	5ppm Benzene
Response magnitude (2)	~40,000µV
Response/1ppm	~8,000µV
Baseline noise (1)	<500µV

Parameters: 150’TL/40ml/min flow/12PSI

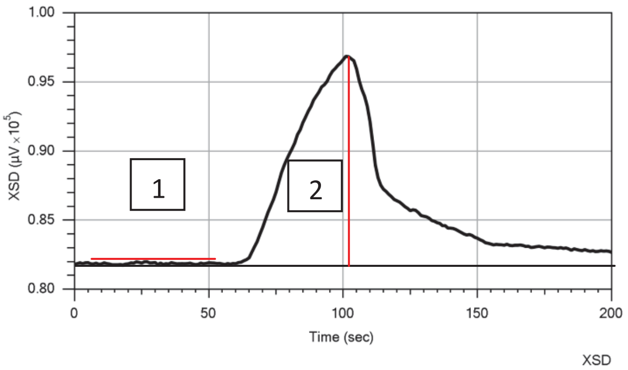
Acceptable response test. Response to baseline noise ratio is >5:1 at 1ppm



Response test - PID	1ppm Benzene
Response magnitude (2)	~8,000µV
Baseline noise (1)	~2,000µV

Parameters: 150’TL/39ml/min flow/12PSI

Not Acceptable response test
Response to baseline noise ratio is <5:1 for 1ppm Benzene
Quick Fix: Lowering carrier flow rate to 25-30ml/min will improve signal response 50% or more.



Response test - XSD	2.5ppm TCE
Response magnitude	15,000µV
Response/1ppm	6,000µV
Baseline noise	<300µV

Parameters: 150’TL/40ml/min flow/11.4PSI
Acceptable response test, Response to baseline noise ratio >5:1 for 1ppm TCE

1. Baseline noise is the amount of variation in baseline signal over a given time.
2. Signal response is the amount of rise in baseline over the stable baseline level.

APPENDIX II

Troubleshooting Guide

Loss of Pressure 1-2 PSI

- If the pressure loss has been gradual, and your MIP controller has a flow sensor check to see if the MIP supply flow has gradually dropped over the course of the log. This can happen due to the control box warming up and will be indicated by a gradual drop of both MIP pressure and flow. To resolve this increase the mass flow controller to bring the supply flow back to its original set point.
- Punctured membrane: Are there any obvious holes in the membrane with bubbles streaming out of them? Replace membrane.
- Membrane leaking out of the face – heavy frothing of bubbles on membrane face but no obvious punctures in membrane. **With the heat off**, place your thumb over the membrane**,** if the pressure goes back up to the gas pressure prior to the boring the pressure and flow loss is due to a leak in at the membrane face. Replace the membrane.
- Swagelok fitting connecting one of the trunkline gas lines to stainless steel gas line of the probe is loose. Check with soapy water, if bubbles build, fix by slowly tighten the gas line 1/16" nut to the probe.
- Examine for cuts, kinks & cracks in the length of the observable gas line. Expect to see bubbling when MEOH or soapy water is placed on it. Cut gas line prior to this and replace nut and ferrule and reconnect onto the probes steel gas line connection.
- Broken gas line somewhere else up the trunkline. Confirmed when trunkline connections are removed from the probe and close coupled. The carrier gas supply and return should be within 2ml/min, if it is >5ml/min first check with soapy water at the connecting nuts and exposed gas line then look for cuts in throughout the trunkline and see if they will show bubbles with soapy water placed on them. If this is seen you will likely need to change the trunkline.

Loss of Pressure >5 PSI

- Large puncture in membrane. Either visible puncture or observable streaming bubble when soapy water or methanol placed on membrane. Replace membrane.
- Loosen the 1/16" Swagelok nut on gas line. Check and carefully tighten.
- Broken gas line in the probe. Compare the supply versus return flow values (should $\leq$ 2/ml/min) of trunkline connected with the probe and with a close coupled trunkline. If close coupled supply/return flow is good but connected to the probe shows a big leak, there is a break is in the probe. This may be seen with soapy water placed on the edges of the heater block or on the top of the probe where the connections come out. If this produces bubbles it confirms a broken internal line or connection point. Replace the probe.

DI Acquisition - Flash Warnings:

The DI acquisition system, operated with the FI6000 field instrument, will flash a large warning screen – MIP pressure out of Range - to the operator if the probe pressure (PSI) changes over 1 PSI from the initial starting MIP pressure of the log. This alerts the operator that something in the system has changed and the operator can take the necessary precautions for a punctured membrane, broken gasline or a plug in the system.

Increase in Pressure (clearing a blockage)

- After setting the mass flow, an increase of more than 3 PSI over the original set pressure indicates a potential blockage, especially if you can verify that the pressure first dropped a 2-5 PSI prior to rising toward 20PSI.
  - Shut off the Nitrogen carrier gas flow ASAP. Do this by turning off the black regulator knob on the MIP controller or removing the carrier gas supply line from the breakout panel or the back of the MIP controller.
  - Remove the tools from the ground.
  - Look for a hole in the membrane and water or dirt got into the up-hole gas line just behind the membrane.
  - Remove connection tube and membrane.
  - Remove the trunkline gas lines from the top of the probe. Take note of which one had the gas flow coming out because this is the line that will be plugged.
  - Look for any obvious particles in either holes behind the membrane or in the gas line at the top of the probe. If any are evident attempt to remove them.
  - Take the return gas line at the surface and connect it to the supply gas connection on the breakout panel or on the back of the MIP controller.
  - Place the probe end of this line into a jar of methanol to see if the line is clear which is evident by streaming bubbles. If there are no bubbles, increase the flow to try to expel the blockage. If this does not work you may need to cut back the trunkline.
  - To clear out the probe take a 5 ml plastic syringe (or a 3 foot section of Teflon/PEEK gas line will work) filled with methanol and attempt to inject through the plugged gas line at the top of the probe. If it clears it will shoot the methanol in an arcing stream out one of the ports in the plug that sits behind the membrane.
  - The probe must be dried of the methanol which can be accelerated by heating the probe. Don’t reconnect the trunkline to the detectors until you are sure the blockage is clear and the methanol is out of the system.
  - If the blockage cannot be cleared a new probe or trunkline will need to be connected.

Blinking Temperature Light

- If the temperature light on the MP6505 begins blinking in an unreadable number, it means that there is an open thermocouple in the system.
  - To complete the log in progress, replace the thermocouple for the trunkline with a thermocouple wire and twist-tie the wires together. This will fool the system to thinking there is continuity of the thermocouple wire and allow you to finish a log. The probe will continually heat set up this way and if left on when out of the ground it will overheat. When the log is complete remove the tricked thermocouple and remove tools from the ground.

- When you have the probe out of the ground, replace the thermocouple as follows.
  - Remove the connection tube from the probe.
  - Check the crimp connections of the thermocouple wires from the trunkline to the probe.
    - If one of the crimp connections has broken then strip back the wire on both sides of the thermocouple – probe and trunkline ends and reconnect in a new crimp connection and see if the probe temperature comes back.
    - If the thermocouple connection is good, the thermocouple wire in the probe has likely broken. Cut off the crimp connections of the thermocouple wires between the probe and the trunkline Check the resistance between the red and yellow thermocouple wires coming out of the probe. A resistance reading of approximately 40ohms indicates that the thermocouple is good reconnect. If they are open (O.L.) or mega ohms then the leads are broken on the thermocouple. Replace the thermocouple.
- To check the trunkline thermocouple wires, measure each wire from top to bottom. The resistances will be different between the two colored wires but should be somewhere approximately 50 ohms – 150ohms for the length of the trunkline. The resistances will also increase with an increase in trunkline length.
  - If they are open (no resistance) then there is a break in the trunkline. Replace the trunkline.

Blinking temperature readout or Spiking in the Pressure and/or Temperature Data

- If spikes show up in the temperature or pressure data especially when related to hammer strikes it is likely an intermittent break in the thermocouple connection. Spiking of the temperature may reach single point readings of 250^{o}C in the data but may not be visible when watching the temperature display on the MIP controller.
  - When you check the resistance between the two thermocouple wires they may check out at approximately 40 ohms, however there likely is an intermittent break in the wire.
  - Replacing the thermocouple should eliminate the pressure and temperature data spikes.

Probe Not Reaching Temperature

- If the heater light is on but the temperature seems low (<100^{o}C with a set point of 120^{o}C) a heater may have broken in the probe.
  - Check the resistance of the heater wires.
    - If a heater is broken the resistance will be over 40 ohms. The probe needs to be replaced.
    - Two good heaters will read approximately 22 ohms on the MP6520, MP8520 and MK6530.
      - Check to see if the thermocouple has pulled of few inches out of the probe.
        - If the thermocouple duct has broken and pulled back away from the probe, the probe will need to be replaced and rebuilt.
        - A thermocouple can unscrew and vibrated loose out of the thermocouple duct connection if it is not secured with shrink tubing or electrical tape. Reseated back into the leur-lock connection and secure. When the thermocouple pulls away from the probe it measures the probe temperature in the wrong location.

Flash Warning:

The DI acquisition system, operated with the FI6000 field instrument, will flash a large warning screen – Temperature out of Range - to the operator if the temperature goes outside of a set range from the setpoint temperature of 121^{o}C. This alerts the operator that something in the system has failed and the operator can take the necessary precautions for a broken probe heater or thermocouple problem.

System explanations and warnings

MIP Flow

MIP flow is the carrier gas flow set by the MIP controller. This flow is supplying carrier gas to the trunkline and probe and is typically set to approximately 42ml/min. This parameter may be monitored by the DI-Acquisition system if the operator has the necessary components in their MIP Controller. The return flow, or Flow-R, is the flow coming back to the GC up the return gas line. Flow-S and Flow-R should be within 3-4ml/min and are usually much closer.

MIP Pressure

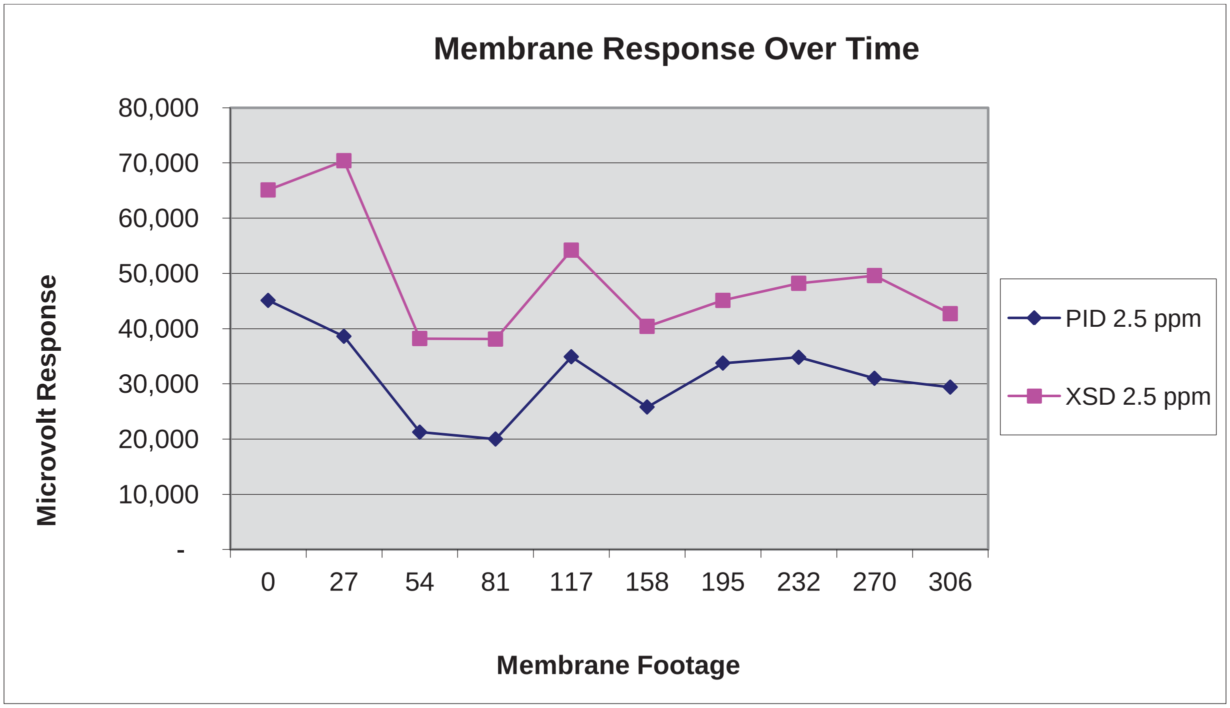
The MIP pressure is the back pressure of the carrier gas as it moves through the trunkline and probe. This is monitored digitally on the DI-Acquisition screen as well as by an analog pressure gauge on the front of the MIP controller. The MIP pressure is directly related to the MIP return flow (Flow-R) and the length of the trunkline. If the MIP pressure falls, the return flow has also dropped, if the MIP flow (Flow-S) has remained the same then there is likely a punctured membrane of problem with the gas lines.

APPENDIX III

Membrane Performance Control Charts

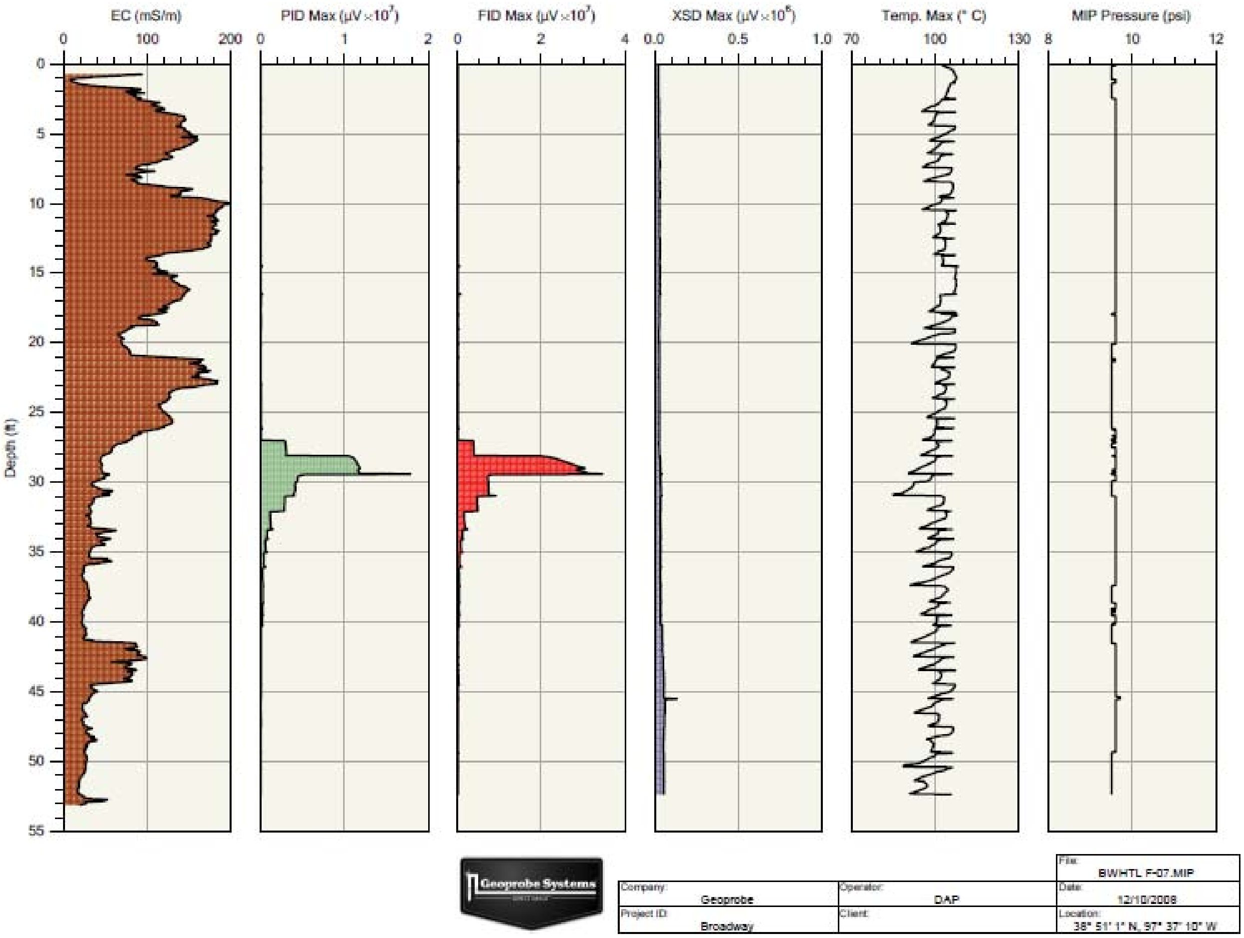
Response Tests using TCE

Pre/Post Log Response Test	Log ID:	PID Response 2.5ppm	XSD Response 2.5ppm	Log Footage	Membrane Footage
Pre-Log	MIP01	45,100	65,100	27	0
Pre-Log	MIP02	38,600	70,400	27	27
Pre-Log	MIP03	21,250	38,200	27	54
Pre-Log	MIP04	20,000	38,100	36	81
Pre-Log	MIP05	34,900	54,200	41	117
Pre-Log	MIP06	25,800	40,400	37	158
Pre-Log	MIP07	33.750	45,100	37	195
Pre-Log	MIP08	34,800	48,200	37	232
Pre-Log	MIP09	31,000	49,600	36	270
Post-Log	MIP09	29,400	42,700		306



APPENDIX IV

Sample Logs and Interpretation



File: BWHTL F-07.MIP
Company: Geoprobe
Operator: DAP
Date: 12/10/2008
Project ID: Broadway
Client:
Location: 38° 51' 1" N, 97° 37' 10" W

Here is a MIP log with the graphs left to right: electrical conductivity, detectors (PID, FID and XSD), probe temperature and trunkline carrier gas pressure.

The above log shows contamination from 27ft to 33ft bgs. The main detector response is on the PID and FID with minimal response on the XSD (Halogen Specific Detector). This indicates that the main contaminant would not contain halogenated (Cl-, Br-, Fl-) atoms, but would likely be hydrocarbon based. The contaminants are present in the lower electrical conductivity formations which typically indicate courser grained formations of higher permeability. The temperature deflections of the MIP block heater are indicative of the probe heat cycling and the trunkline carrier gas maintains a constant stable pressure which indicates no leak or plug issues occurred with the gas line or membrane during the log.

Detector Interpretation

Standard MIP systems are able to identify compound families and determine general compound classes. The identification of individual compounds is not possible. Standard MIP systems have a continuous carrier gas flow that is brought to the detectors from the down-hole probe. To be able to effectively speciate (determine specific contaminant chemicals) the operator would need a highly modified system in place. The carrier gas stream would need to be run through a mass spectrometer or trapped and run a secondary GC onsite.

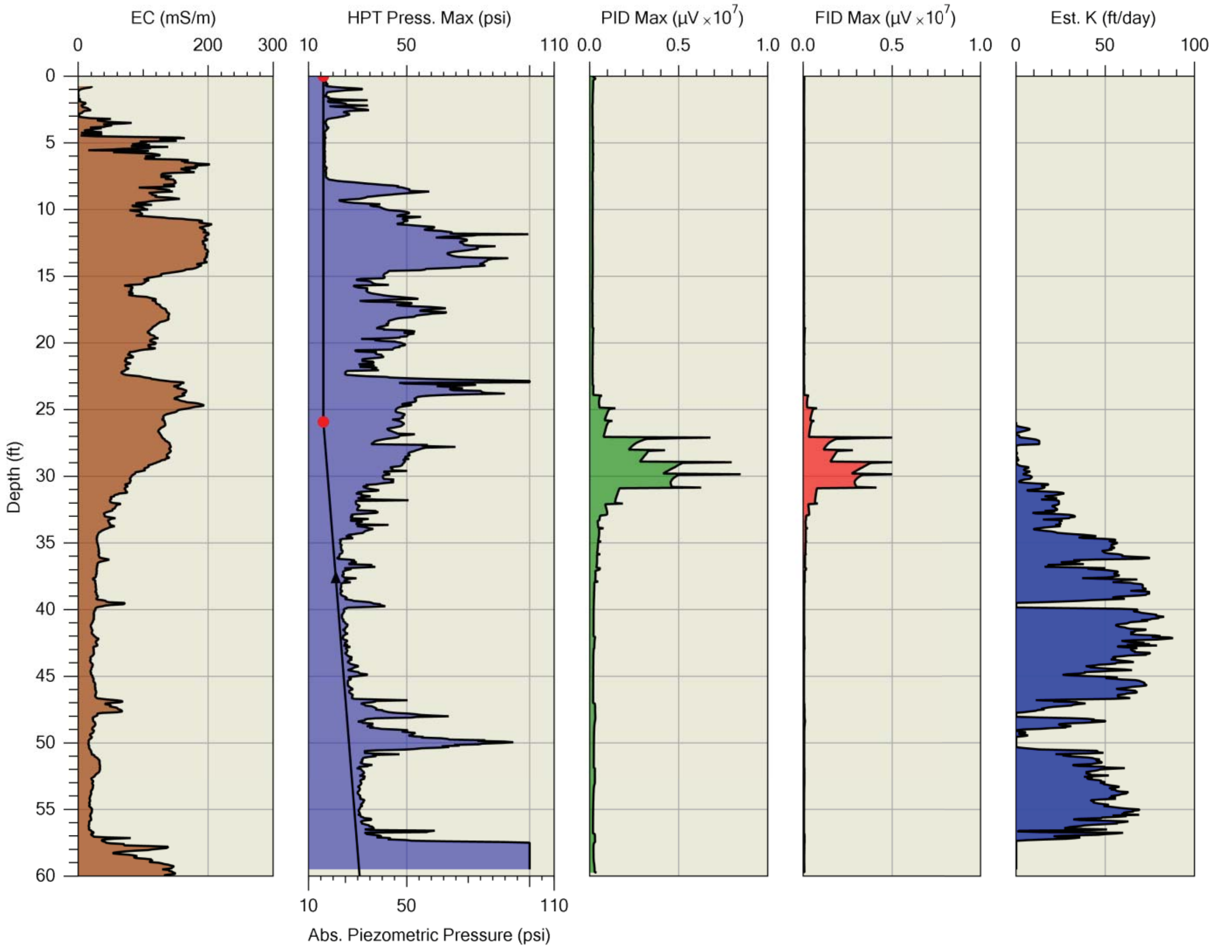
Typical standard MIP configurations use 3 gas phase detectors: a photo-ionization detector (PID), flame-ionization (FID) and a halogen specific detector (XSD). The PID responds to compounds which have an ionization potential $\leq$ electron voltage of the PID bulb. These compounds include both chlorinated and non-chlorinated hydrocarbons. A typical PID bulb has a 10.6eV lamp. The FID will respond when organic compounds (anything containing carbon) are present in the carrier gas stream in high enough concentration burn up in the flame which increases the flames ionization voltage. The XSD responds only to halogenated compounds which are made up of chlorinated (most typical halogen environmental contaminant), brominated and fluorinated compounds. Based upon which detector or detector series a contaminant responds on, we can determine if the contaminants are halogenated or petroleum based.

Petroleum hydrocarbons will respond on the PID and FID but not on the XSD. Fresh gasoline primarily contains aromatic hydrocarbons such as benzene, toluene, ethyl benzene and xylenes, which respond strongly on a photo-ionization detector (PID) and not so well on the FID. As gasoline breaks down or weathers the molecular structure changes from primarily aromatic to mainly straight chain hydrocarbons (single bonded hydrocarbons). Straight chain hydrocarbons typically do not show up on the PID do having a higher ionization potential but will respond on a flame ionization detector (FID). Weathered petroleum will still have a decent signal on the PID but may show a stronger FID signal.

Chlorinated compounds such as trichloroethylene and perchloroethylene are detected by the XSD and PID and respond in a similar profile. This is typical of the common double bonded chlorinated compounds seen in the subsurface which have an ionization potential that the PID can see. Chlorinated compounds without multiple bonds such as chloroform, methylene chloride and 1,1,1,-trichloroethane have an ionization potential higher than the PID electron voltage which results in a solid response on the XSD but will not show up on the PID.

The only sure way of determining contaminant concentration from MIP responses is to take confirmation soil and/or groundwater samples for laboratory analysis. After obtaining the results the actual concentrations can be compared to the MIP detector responses and concentrations may be estimated across the site.

MiHPT Log Example– Combined MIP & HPT



The addition of the HPT sensor to the MIP detectors and EC has provided valuable information to the subsurface lithogy encountered by the MIP operator. The above log shows graphs left to right: electrical conductivity, HPT injection pressure with the absolute piezometric pressure profile on the secondary axis, detectors (PID and FID) and estimated hydraulic conductivity (K).

The above log shows contamination from 24ft to 31ft bgs both on the PID & FID at similar magnitudes which is likely from petroleum hydrocarbons but without showing the XSD we cannot tell for sure that there are no halogenated (Cl-, Br-, Fl-) compounds present. The contaminants are present in the higher electrical conductivity and HPT pressure formations which indicate finer grained formations of lower permeability. The second graph with the Absolute Peizometric profile graph has a triangle on the increasing line at approximately 37 feet which indicates that an HPT dissipation test was performed at that depth. By taking the hydrostatic pressure at that interval and subtracting off the weight of water (0.445psi/ft) until the atmospheric pressure (calculated in the pre log HPT reference test) we can see the static water table is approximately 26 feet indicated by the red dot. Estimated hydraulic conductivity (K) is shown as the final graph which is a relationship between HPT injection pressure and HPT flow.

APPENDIX V

GC1000 Configuration and Operating Parameters

Figure 1: GC1000: SRI 310GC with XSD Controller

GC1000 Configuration

SRI310 GC with PID, FID & OI Analytical XSD
(all standalone detectors)

Flows:

TL Carrier (N_2): 40ml/min
Detector split 60:40 – 24ml/min-XSD
16ml/min-FID

Nafion Dryer (installed in GC Oven)
80ml/min (2x carrier flow rate)

A built in air compressor is split underneath the GC between the XSD & FID. The XSD & FID air supply is controlled through the GC air pressure screw control on front of GC and with different air line sizes and lengths to provide 250ml/min to the FID and 30 ml/min to the XSD.

Detectors front of GC to back: XSD, FID & PID

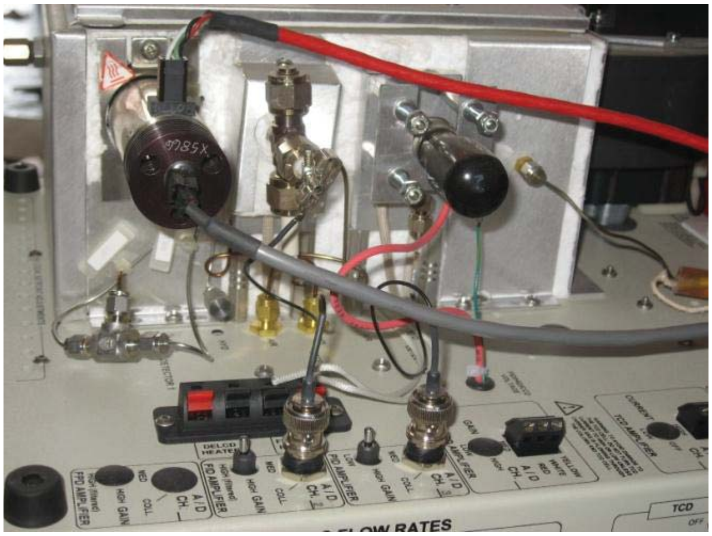


Figure 2: GC Detectors – left to right - XSD, FID, PID

SRI 310 GC Detector 1 position – XSD
(not controlled by GC)

SRI 310 GC Detector 2 position – FID

SRI 310 GC Detector 3 position – PID

Nafion dryer installed inside GC oven

GC Oven set to 85°C – 130°C max temp.

Flow comes into the GC oven via a 1/16" bulkhead fitting located in the 4th detector position furthest back (upper right inside oven) behind the PID detector. The trunkline will connect to this bulkhead and a 1/16" stainless steel line transports flow into the Nafion dryer. Silco steel takes this to the PID lamp which is inserted up to the lamp and backed off a 1/16" and tightened. A 1/16" stainless steel line brings it back into the GC oven where it is split between the FID and XSD and sent to them via a silco-steel line to the XSD and a stainless steel line to the FID.

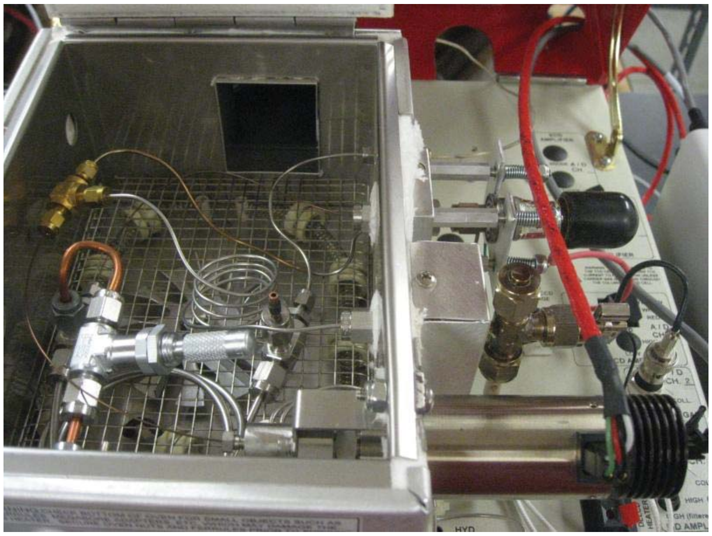


Figure 3: GC Oven Configuration

Detector Operating Parameters:

PID:

- MIP Carrier Flow (N_2) – 100% - 40ml/min
- Carrier return back into oven split between XSD & FID
- Detector Temperature setting – 150^{o}C
- PID current 70 (0.70ma)

FID:

- Carrier N_2 MIP effluent – 40% - 16ml/min
- Hydrogen – 25ml/min
- AIR – 250ml/min
- Detector Temperature setting – 250^{o}C
- FID igniter set at -600 (6.0V)

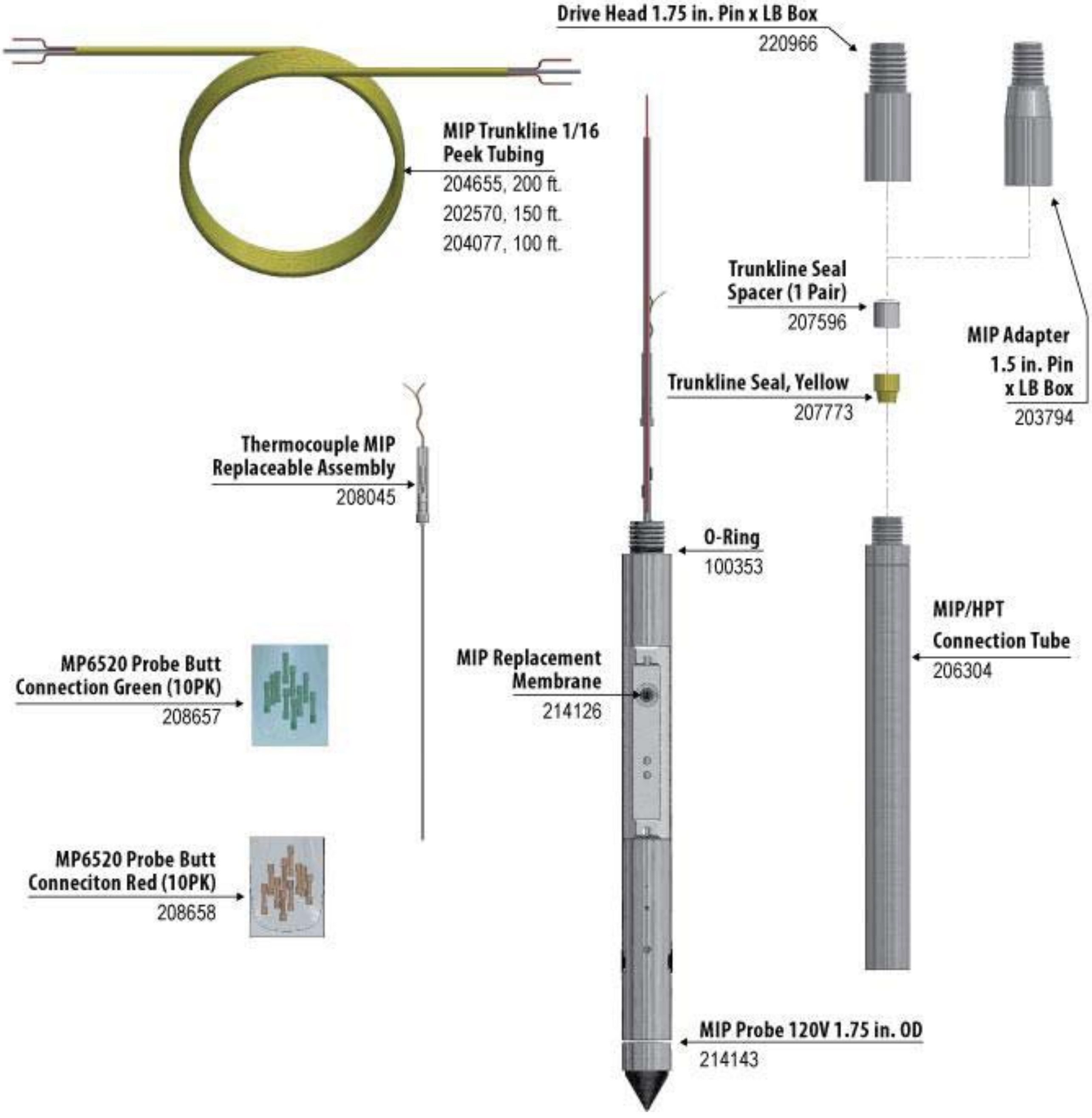
XSD:

- Carrier N_2 MIP effluent – 60% - 24ml/min
- Air – 30ml/min (split 50:50 wall & jet input of XSD)
- Detector Temperature setting – 1,100^{o}C

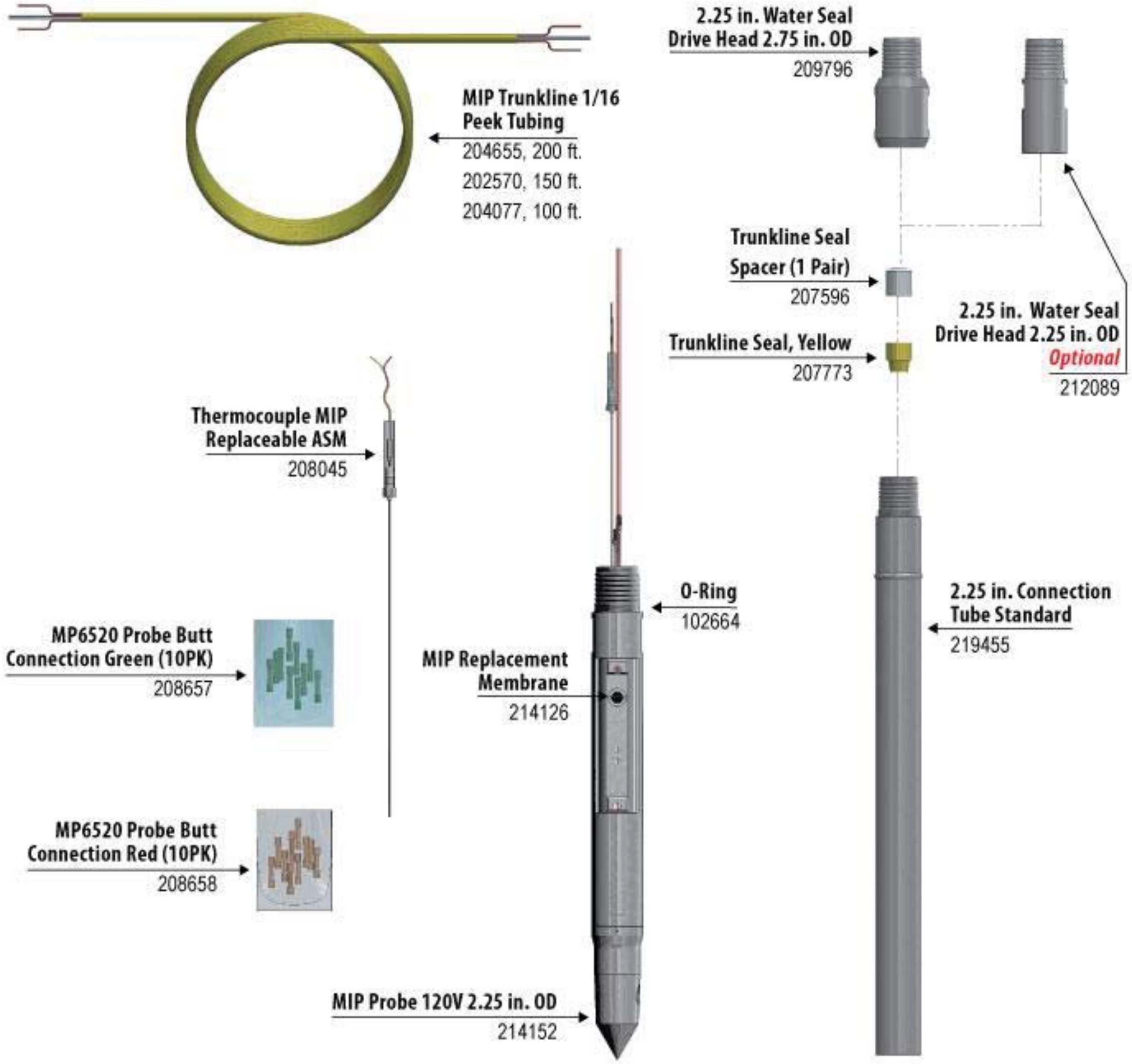
APPENDIX VI

MIP Tool Configurations

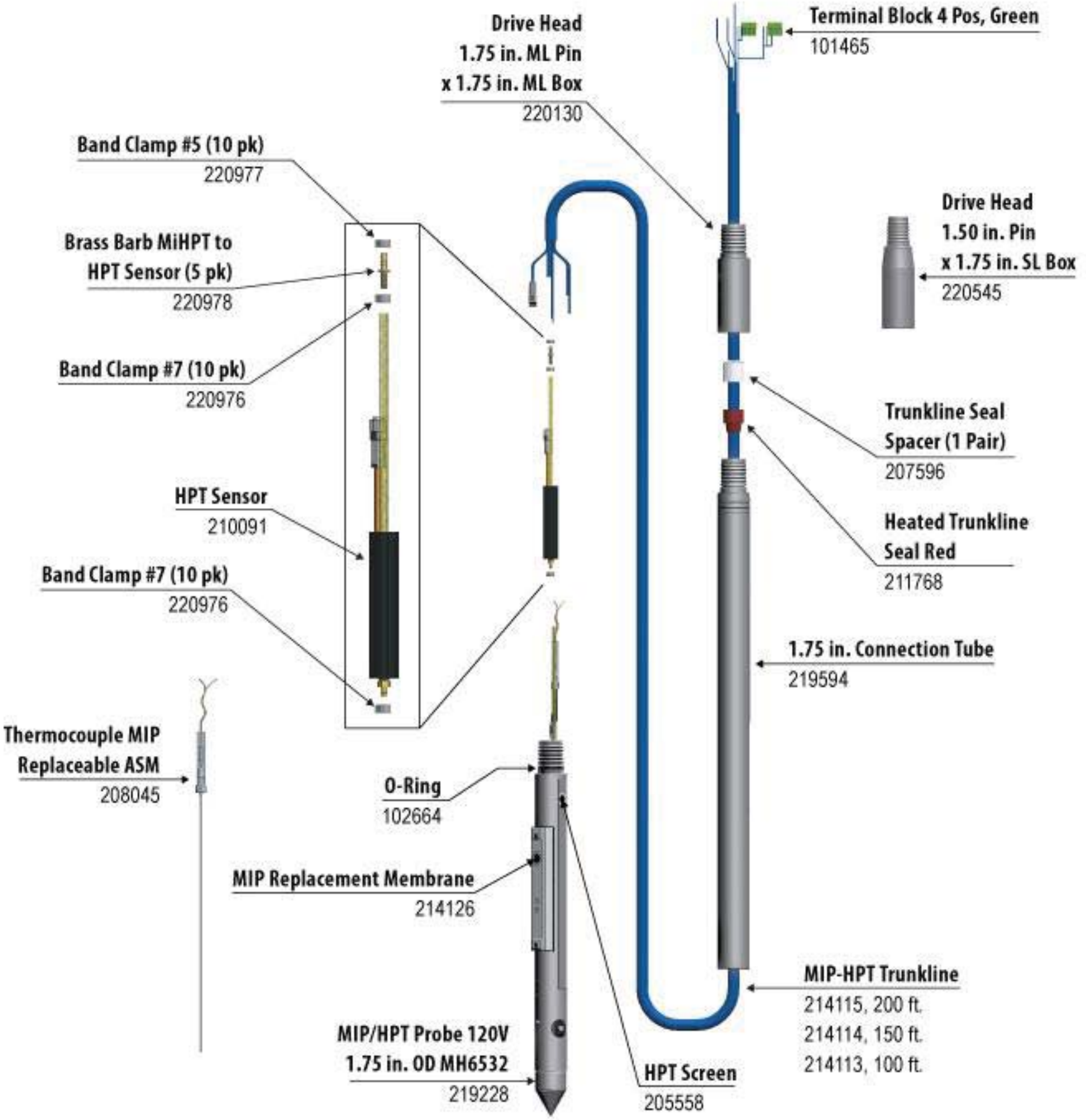
MIP - MP6520 (1.5 in. / 1.75 in. system)



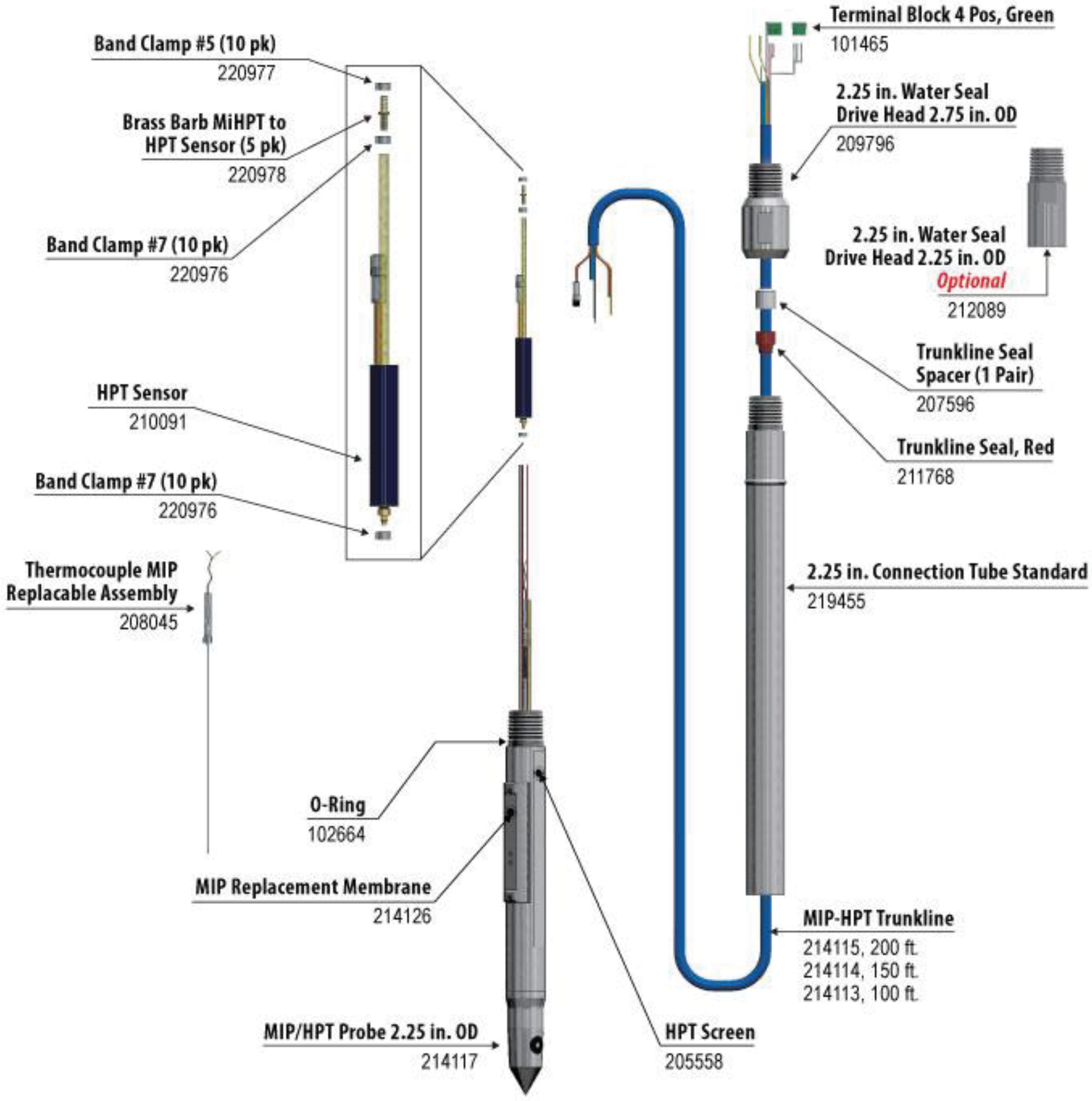
MIP – MP8520 (2.25 in. System)



MiHPT – MH6532 (1.5 in. / 1.75 in. system)



MiHPT – MH8530 (2.25 in. System)



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