

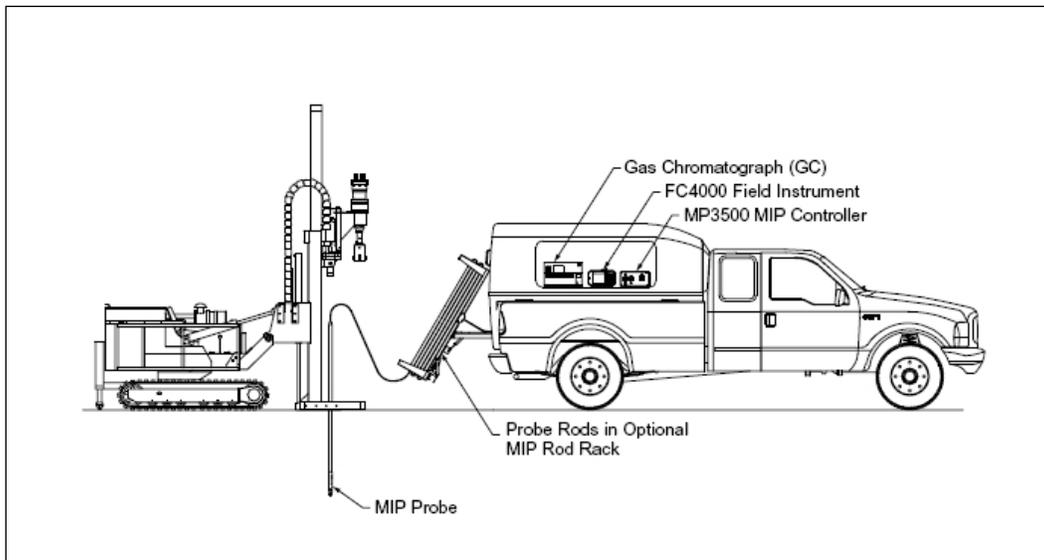
GEOPROBE® MEMBRANE INTERFACE PROBE (MIP)

Standard Operating Procedure

Technical Bulletin No. MK3010

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**THE MIP SYSTEM MAY BE DEDICATED TO A SINGLE CARRIER VEHICLE
FOR USE IN TANDEM WITH MULTIPLE GEOPROBE® MACHINE MODELS**



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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 contaminants 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.

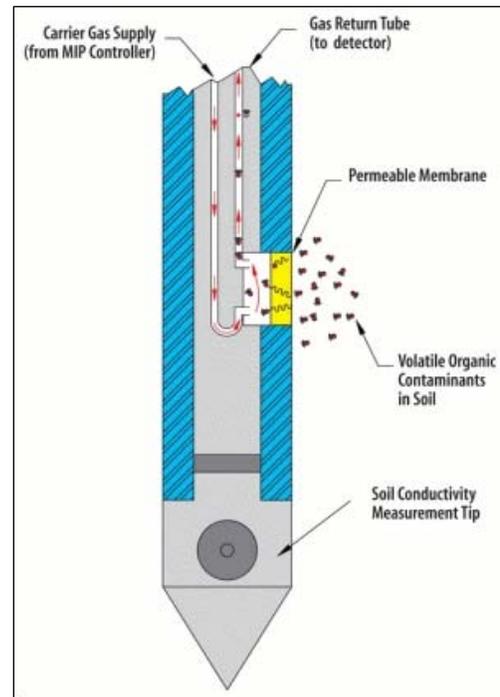


Figure 2.1: Diffusion across the membrane.

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).

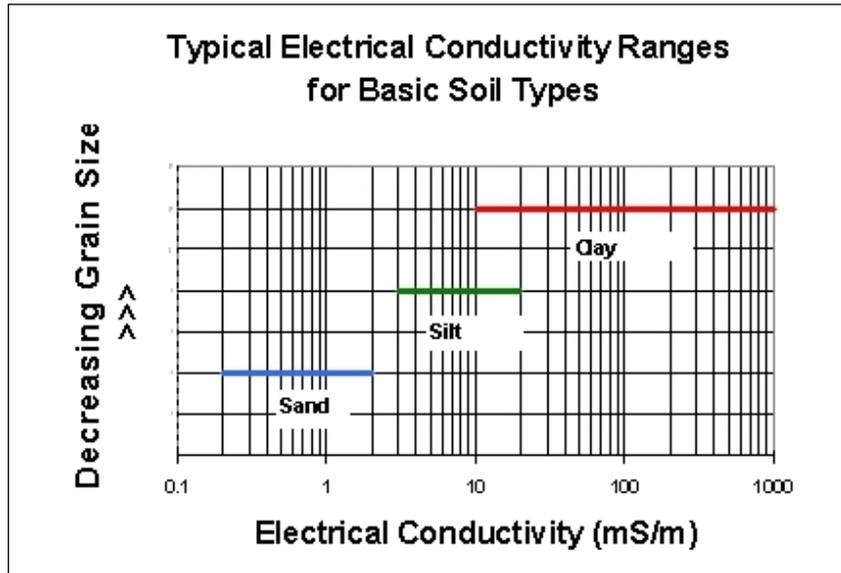


Figure 2.2: Generalized Electrical Conductivity Readings.

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 coarser 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 this section in section 4.1 with optional equipment listed in section 4.2. 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	Part Number
Field Instrument	(1)	FC5000 / FI6000
MIP Controller	(1)	MP6500 / MP6505
Gas Chromatograph with PID, FID and XSD	(1)	GC1000
DI Acquisition Software	(1)	MP3517
MIP Probe	(3)	MP6520/MP8520
MIP PEEK Trunkline, 150-ft (45 m) length	(2)	14929
MIP Connection Tube	(3)	31641
MIP Adapter and Drive Head	(3)	20712
Agilent ADM 1000 Digital Flow Meter	(1)	17463
Hydrogen Gas Regulator	(1)	10344
Nitrogen Gas Regulator	(1)	13940
Vertical Gas Bottle Rack	(1)	ML2500
Stringpot (linear position transducer)	(1)	SC160-100
Stringpot Cordset	(1)	SC161
Stringpot Mounting Bracket (6600/7700)	(1)	16791
Stringpot Foot Bracket (6600/7700)	(1)	11751
Stringpot Piston Weight	(1)	SC112
Slotted 1.5" Drive Cap	(2)	13722
MIP Service Kit	(1)	MP6515
Drive Cushion (GH60)*	(1)	23321
Rod Wiper, 1.25/1.5" Rods	(1)	23852
Rod Wiper Weldment	(1)	23633

4.2 Optional Accessories

Description	Quantity	Part Number
Heated Trunkline Control Box	(1)	MP7000
Heated Trunkline, 100-ft (30m) length	(1)	MP7100
Heated Trunkline, 150-ft (46m) length	(1)	MP7150
Heated Transfer Line, 8-ft (2.4m) length	(1)	MP7010
Roll-out Rod Rack (30-1.5in rods)	(1)	20400-30
Rod Grip Pull Handle, for GH40 hammer	(1)	GH1255
Rod Grip Pull Handle, for GH60 hammer	(1)	9641
Stringpot Mounting Bracket (7822)	(1)	41932
Stringpot Foot Bracket (7822)	(1)	41993
Water Transport System	(1)	19011

*For Geoprobe® 66- and 78-Series Direct Push Machines only.

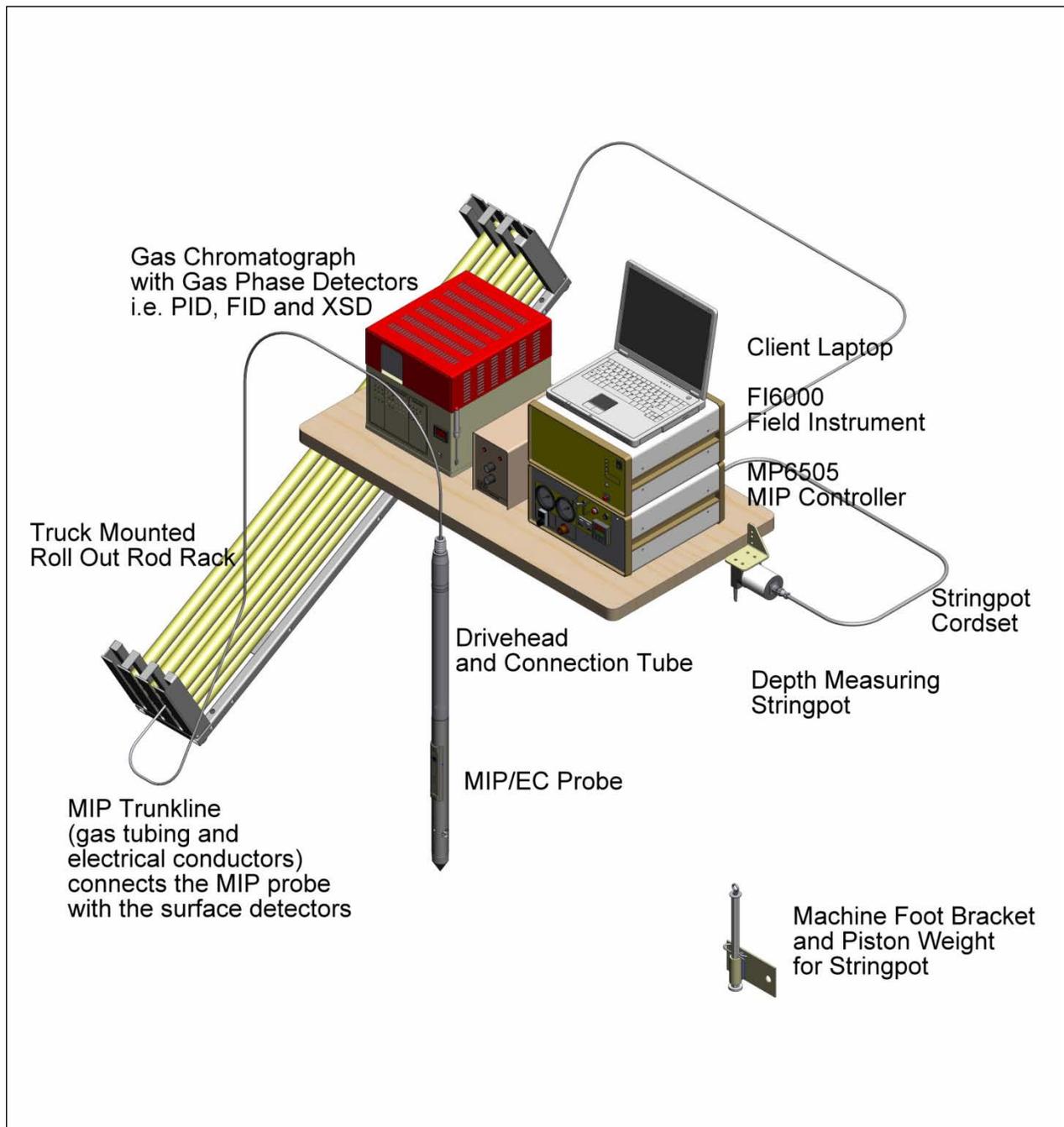


Figure 4.1: MIP System Components

5.0 Quality Assurance/Quality Control

Quality assurance (QA) is performed before and after each log to validate that the equipment being used is capable of generating good data. With MIP, chemical response tests (Fig. 5.1) must be performed to ensure that the probe, trunkline and series of detectors are working properly. The electrical conductivity (EC) portion of the MIP system is tested using an EC dipole test jig (Fig. 5.4)

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 electrical 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, i.e. 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 VI).
3. Repeatability? Replicate logs may be run every 10 to 20 locations to verify repeatability.
4. Are my lithogy changes consistent with physical soil cores? Take continuous or discrete confirmation soil samples to confirm your lithogy changes in EC.
5. Do my 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 Chemical Response Test:

Response testing is an important quality assurance measure used to validate each log by proving that the integrity of the detector system is intact. Without running a response test, the operator will have no idea if the detector system is operating consistently or potentially even at all. Detector response heights should be monitored and can be graphed 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). Response testing also enables the operator to measure the chemical trip time. This is the time it takes for the contaminant to travel through the trunkline from the probe to the detectors. This time needs to be entered into the MIP software to accurately plot the contaminants depth position.

5.1.1 Preparation of the Stock Standard

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: 500 and/or 1,000 μ L syringes).
- 25-mL or 50-mL Graduated cylinder
- Several 40-mL VOC vials with labels
- 25mL Methanol

Preparation of the stock standard is critical to the final outcome of the concentration to be placed into the testing cylinder.

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 40-mL VOC vial.
4. Add the appropriate volume of desired neat analyte into 40-mL VOC vial containing methanol. The required volume of neat analyte for seven common compounds is listed in Column 3 of Table 5.1. The equation at the bottom of this section shows how to calculate the appropriate neat analyte volume for other compounds of interest given the appropriate density.

- Label the vial with the name of the standard (i.e. Benzene, Toluene, TCE, PCE), concentration (50mg/mL), date created, and created by (your name). This is the Stock Standard.
- If stock standards are kept cold in a refrigerator 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.

Table 5.1
Density and required volumes of neat compounds used to make a 50mg/mL stock standard into 25 ml of methanol.

Compound	Density (mg/ μ L)	Volume 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

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 50 mg/mL Benzene standard.

$1250 \text{ mg} \times 1/0.8765 \text{ mg}/\mu\text{L} = 1426\mu\text{L}$

Use 1426 μ L of neat Benzene in 23.5mL of Methanol to get a 50 mg/mL stock standard.

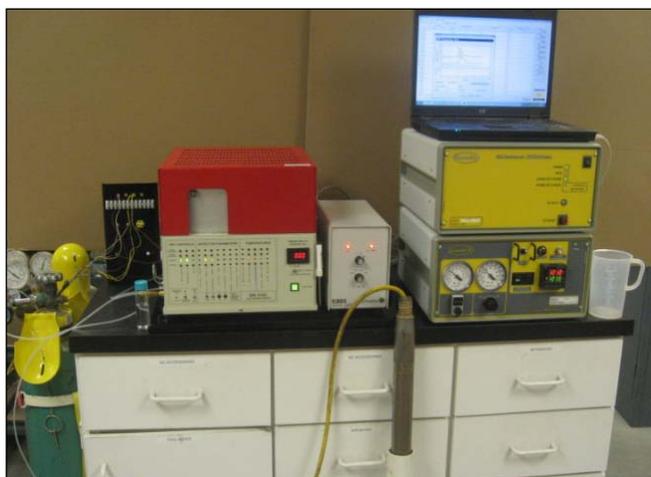


Figure 5.1: The MIP probe is placed into a steel or PVC pipe containing the standard solution.

5.1.2 Preparation of the Working Standard and Performing the Response Test

The following items are required to perform response testing:

- Microliter syringes (recommended to have: 10, 25, 100 & 500 μ L syringes).
 - Testing cylinder made from a nominal 2-in. PVC pipe with a length of 24 in.
 - 0.5 L plastic beaker or pitcher
 - Supply of fresh water, 0.5 L needed per test
 - Stopwatch
1. On the FI6000 and the DI-Acquisition software you will begin a new log and proceed to the response test screen. The detector signals should be stable before proceeding. On the FC4000 and FC5000 system, access the MIP Time software and view the detector vs. time data.
 2. Measure out 500mL of tap or distilled water and place into the testing cylinder.
 3. Using Table 5.2, determine the desired volume of stock standard to place into the 500ml measured volume of water. This is the Working Standard.
 4. Pour the working standard into a nominal 2-inch x 24-inch PVC pipe and immediately insert the MIP into the solution (Fig. 5.1). Leave the probe in the test solution for 45 seconds. At the end of 45 seconds, place the probe back in into a clean water source.
 5. The chemical response trip time can be determined from the results on the Pre-Log Response Test. Using Fig. 5.2 the trip time would be approximately 55 seconds. Additional typical response test graphs are located in Appendix I.
 6. A new, fresh working standard needs to be made for each test, it cannot be reused.

Table 5.2
Volume of stock standard and final concentration when making working standards.

Volume of Stock 50mg/mL Standard (μ L)	Final Concentration (mg/L or ppm) in 0.5L
10	1.0
100	10
1000	100

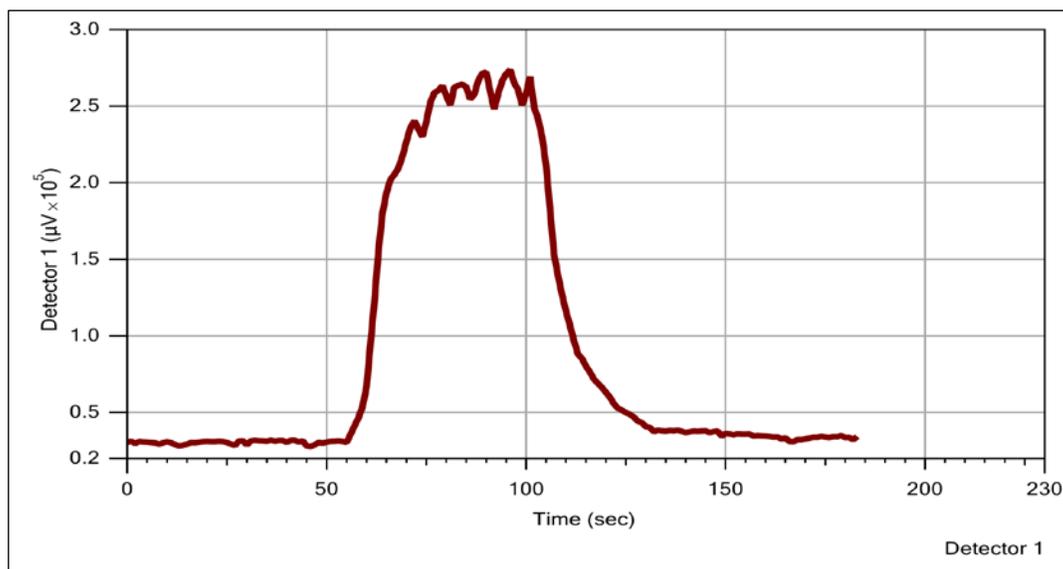


Figure 5.2: SRI PID Response Test - 10 ppm Benzene.

5.2 Operation of EC Dipole Test Jig

On the FI6000 and the DI-Acquisition software the EC dipole test screen will open up after the chemical response test is completed. When ready place the low (brass) side of the EC Dipole test jig (Fig 5.3) 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 5.4). Repeat for the high (stainless steel) EC test. These tests should result in readings of 55mS/m and 290mS/m \pm 10%.

In the FC4000 and FC5000 acquisition system these readings will need to be taken in the logging screen just prior to the beginning of the log.

If the EC readings do not pass, the DI Acquisition (FI6000) software will prompt the user to proceed through a series of troubleshooting tests (these tests used to be the standard test for EC in the FC4000 and FC5000 software). These tests will check the calibration of the EC board as well as the continuity and isolation of all of the wires in the system to determine the reason EC Tests loads have failed. This will give the operator an idea what needs to be done to fix the problem.



Figure 5.3: EC Dipole Test Jig.



Figure 5.4 Operation of the EC Dipole Test Jig.

6.0 Recommended Minimum MIP Response Test Levels and Maintenance Tips

Geoprobe Systems recommends 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 a detector system would be able to provide at least the following level of response in a chemical response test:

<u>Chemical & Concentration</u>	<u>Detector Response</u>	<u>Baseline Noise</u>
10ppm Benzene (see table 5.2)	PID-10,000 μ V	<3,000 μ V
10ppm Trichloroethylene (see table 5.2)	PID-5,000 μ V, XSD 10,000 μ V	<3,000 μ V

If these minimum response test levels are not achievable or throughout the day or project the detector sensitivity falls below these levels, the operator should 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.
- Cleaning the PID bulb
- Replacing the PID bulb
- Checking and adjusting detector gas flows - especially in the FID.
- Replacing the XSD probe assembly
- Replacing the XSD reactor core
- Decreasing trunkline carrier gas flow
- 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).

7.0 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. Check the carrier flows of the system and psi on the mass flow controller. Compare these numbers to previous work.
5. Power on the MIP Controller, Field Computer or the Field Instrument and laptop computer.
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 5.2 and Appendix III.
8. Record the system parameters in a field notebook at this time (i.e. flow, pressure, trip time, detector baseline voltages).
9. Complete the EC Dipole test (Section 5.3) and finish setting up the log.
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 donut on the ground and insert the point of the MIP probe into rod wiper opening.
14. Align the probe exactly straight and advance the probe to the starting depth: MIP membrane even with the ground surface.
15. Place the trigger switch in the "ON" position.
16. Advance the probe 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.

NOTE: If 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.

17. When the MIP log is complete, turn the trigger off and slowly return the stringpot cable into the stringpot housing.
18. 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.
19. Raise the probe foot of the direct push machines foot assembly and place the rod wiper holder under it to keep it in place during rod retraction.
20. Pull the probe rod string using either the Geoprobe[®] rod grip pull system or a slotted pull cap.
21. When the MIP probe reaches the surface, clean the probe and membrane well with a detergent/water mix and rinse off well.
22. 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.
23. 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.
24. When using the FI6000, the data will be saved into your designated folder on your laptop in a compact .zip file. If you are using a FC5000 the data is saved on the field computer and the inserted flash card. When the log is complete the log files and response test files will need to be transferred to a field laptop for viewing on the DI Viewer.
25. Data from the MIP log can now be graphed and printed using the DI-Viewer software (Appendix IV).

8.0 GC Signal Adjustments

8.1 Dilution/Attenuation Changes

GC systems vary in signal output ranges such as 0-1V (typical for HP GCs) and 0-5V (typical for SRI & Shimadzu GCs) which means that when detector signals go beyond this voltage in the output, the acquisition software will display a flat line at the maximum voltage of 1 or 5Volts unless this signal output has been rescaled.

In highly contaminated soil regions (e.g. free product) detectors may flat line or reach a maximum signal output before they reach the observed signal of the contaminant in contact with the membrane. For example, on SRI GCs to be able to observe the actual response beyond the maximum output signal in these high response areas the PID gain switch should be adjusted from high to medium and the software attenuation set to 10. What this does is adjusts the detector output signal down by a factor of 10 which must then be readjust back up by the same factor of 10 in the acquisition software. To accurately map the grossly contaminated zones rescaling of the detectors must be done.

Detectors operated through a HP5890 GC have a 1V maximum signal output and the attenuation settings are based on a 2^x multiplication scale $x = \text{HP GC Range}$ and the corresponding attenuation in the MIP software. SRI and Shimadzu GCs have maximum signal outputs of 5V and the attenuation settings are based on a 10^x multiplication factor.

Table 8.1
Gain/Attenuation Settings on the GC detectors and the Acquisition software.

HP GC* Range	FI6000 Attenuation		SRI GC Gain	XSD Gain	FI6000 Attenuation
0	1		High	High	1
1	2		Medium	Medium	10
2	4		Low	Low	100
3	8				

*- 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.

9.0 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. Use the membrane wrench to tighten the membrane to a snug fit. Do not over-tighten.
9. Turn the gas on and leave the heater off. Apply water to the membrane and surrounding area to check for leaks. If a leak is detected (bubbles are formed in the water), 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

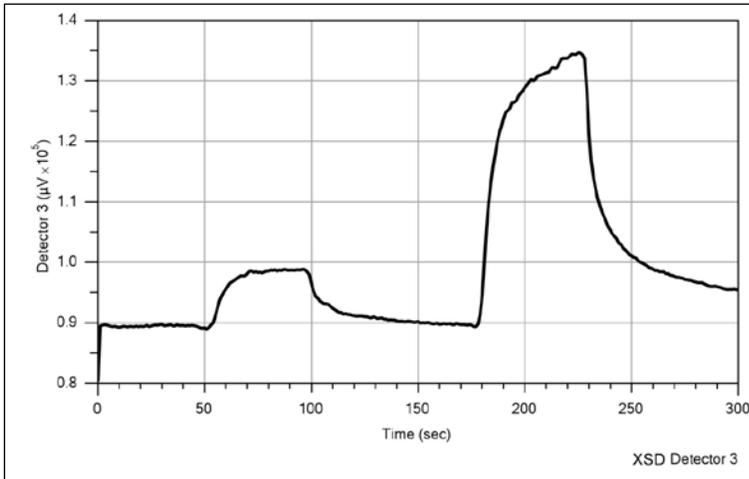


Figure 1: Chemical Response Test: TCE 1 & 5ppm on XSD.

System Parameters:

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

System Response:

1ppm – 9,000µV
5ppm- 45,000µV

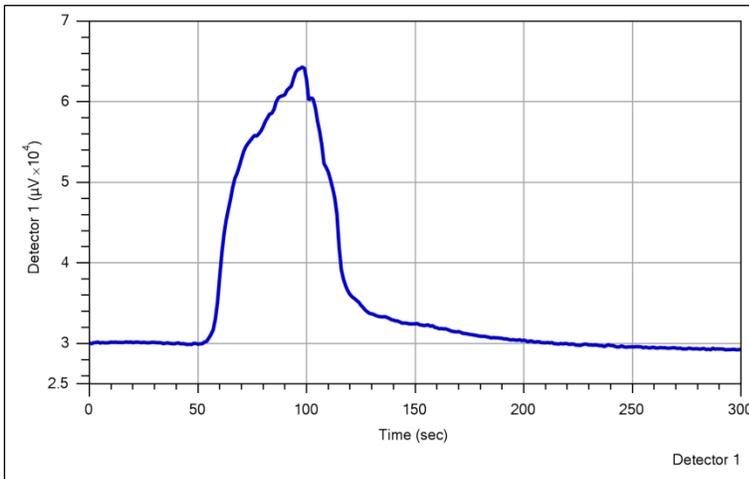


Figure 2: Chemical Response Test: Benzene 5ppm on PID.

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

APPENDIX II

Troubleshooting Guide

Loss of Pressure 1-2 PSI

- 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 1/8” Swagelok nut on gas line. Check and carefully tighten.
- Broken gas line in the probe. Compare the supply versus return flow values (should ≤ 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 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.

Flash Warning:

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 have 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.

Spiking 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°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°C with a set point of 120°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 a 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 vibrate loose out of the thermocouple duct connection if it is not secured with shrink tubing or electrical tape. Reseat 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°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**

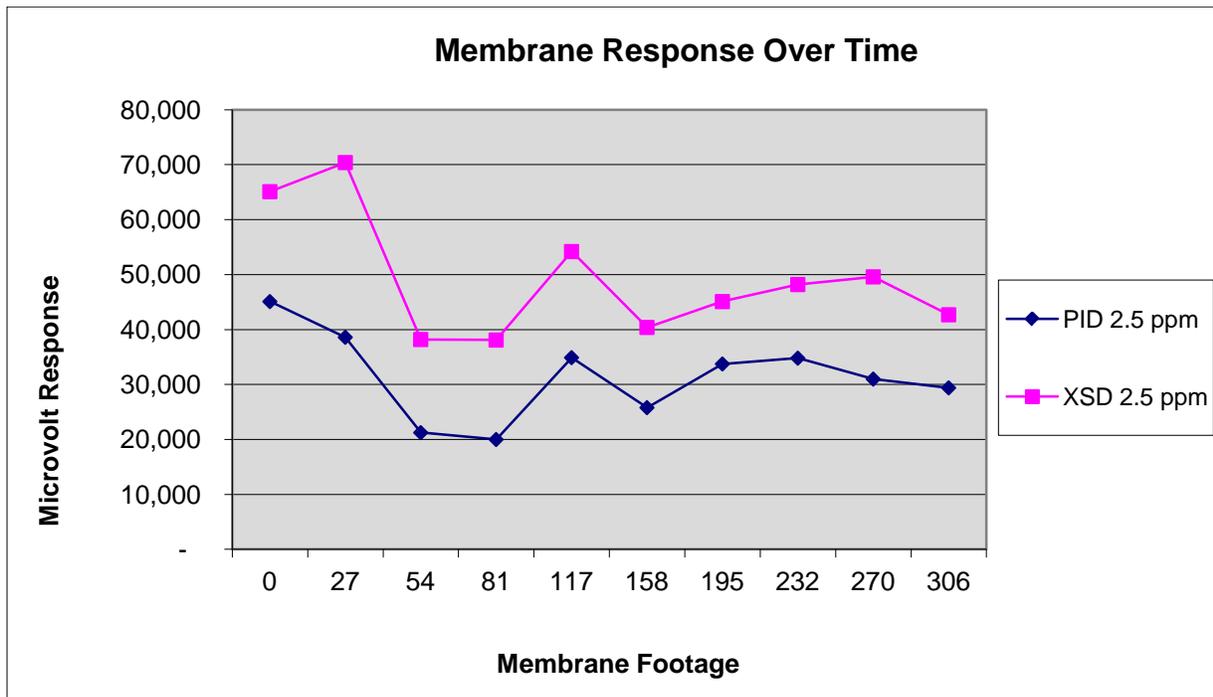
The MIP pressure is the back pressure of the carrier gas as it moves through the trunkline and probe. This is monitored digitally on the DI-Acquisition screen as well as by an analog pressure gauge on the front of the MIP controller. The MIP pressure is directly related to the MIP return flow (Flow-R). 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 or problem with the gas lines.

APPENDIX III

Membrane Performance Control Charts

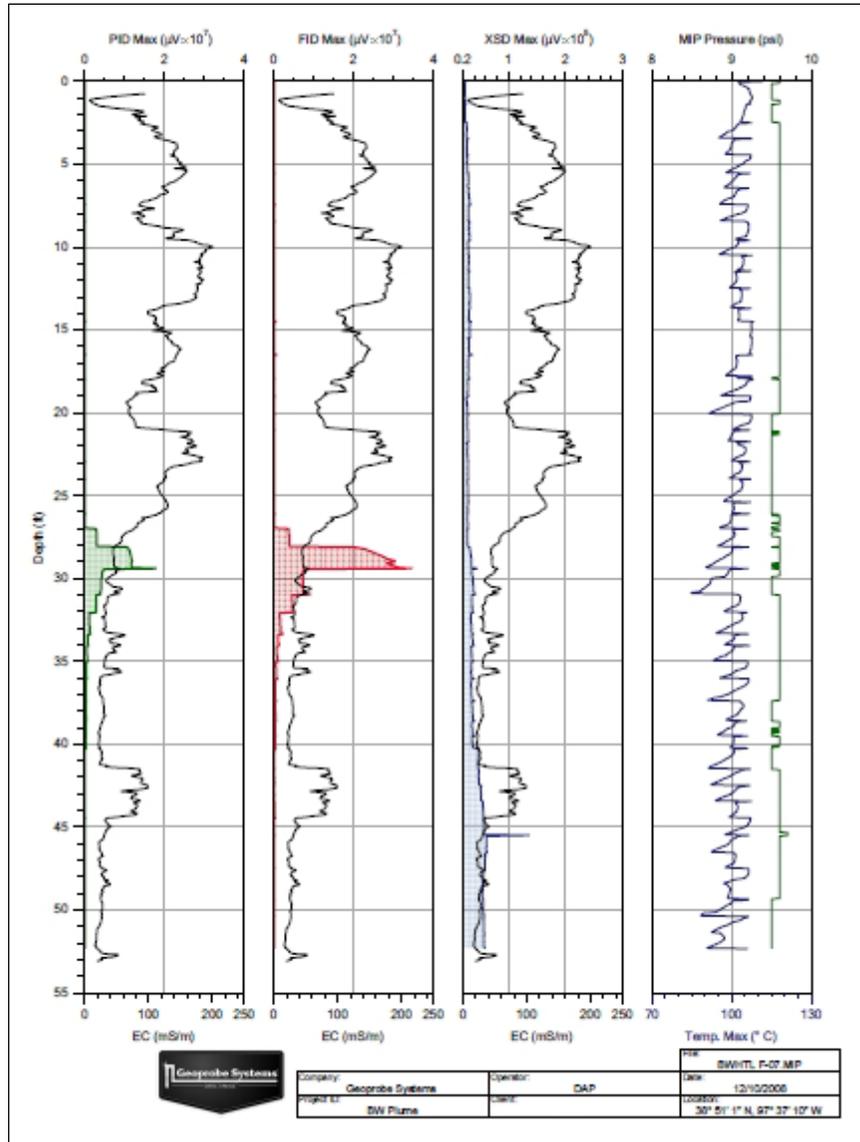
Response Tests using TCE

Pre or Post Log Response Test	Log ID:	PID Response 2.5 ppm	XSD Response 2.5 ppm	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



Here is a MIP log showing the detectors (PID, FID and XSD) over the electrical conductivity graph as well as a graph of probe temperature and gas pressure.

The above log shows contamination from 27 ft to 33 ft 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-, FI-) atoms, but would be likely be hydrocarbon based. The contaminants are present in the lower electrical conductivity formations which typically are courser grained, higher permeable formations. The increased temperature deflection of the MIP block heater around 25 ft provides an indication of where the water table may be in this log.

Detector Interpretation

Standard MIP systems are able to identify compound families and determine general compound classes. However 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 trapped and run through either a mass spectrometry or 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 (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.

APPENDIX V

GC1000 Configuration and Operating Parameters

GC1000 Configuration



Figure 1: GC1000: SRI 310GC with XSD Controller.

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

Flows:

TL Carrier (N₂): 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.

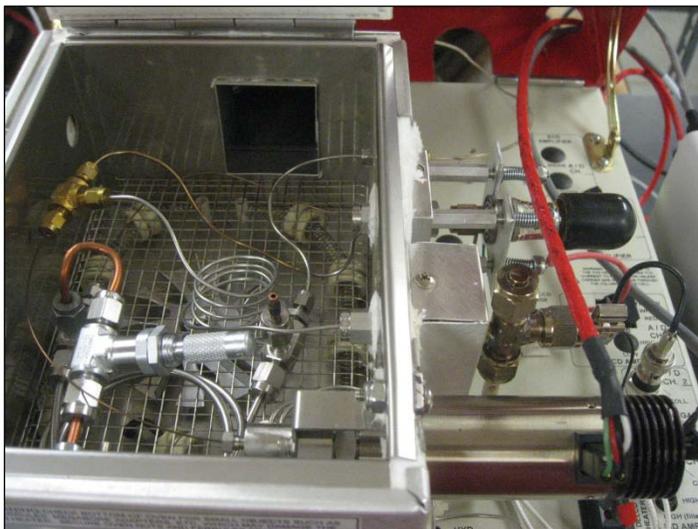


Figure 3: GC Oven Configuration.

Detector Operating Parameters:

PID:

- MIP Carrier Flow (N₂) – 100% - 40ml/min
- Carrier return back into oven split between XSD & FID
- Detector Temperature setting – 150°C
- PID current 70 (0.70ma)

FID:

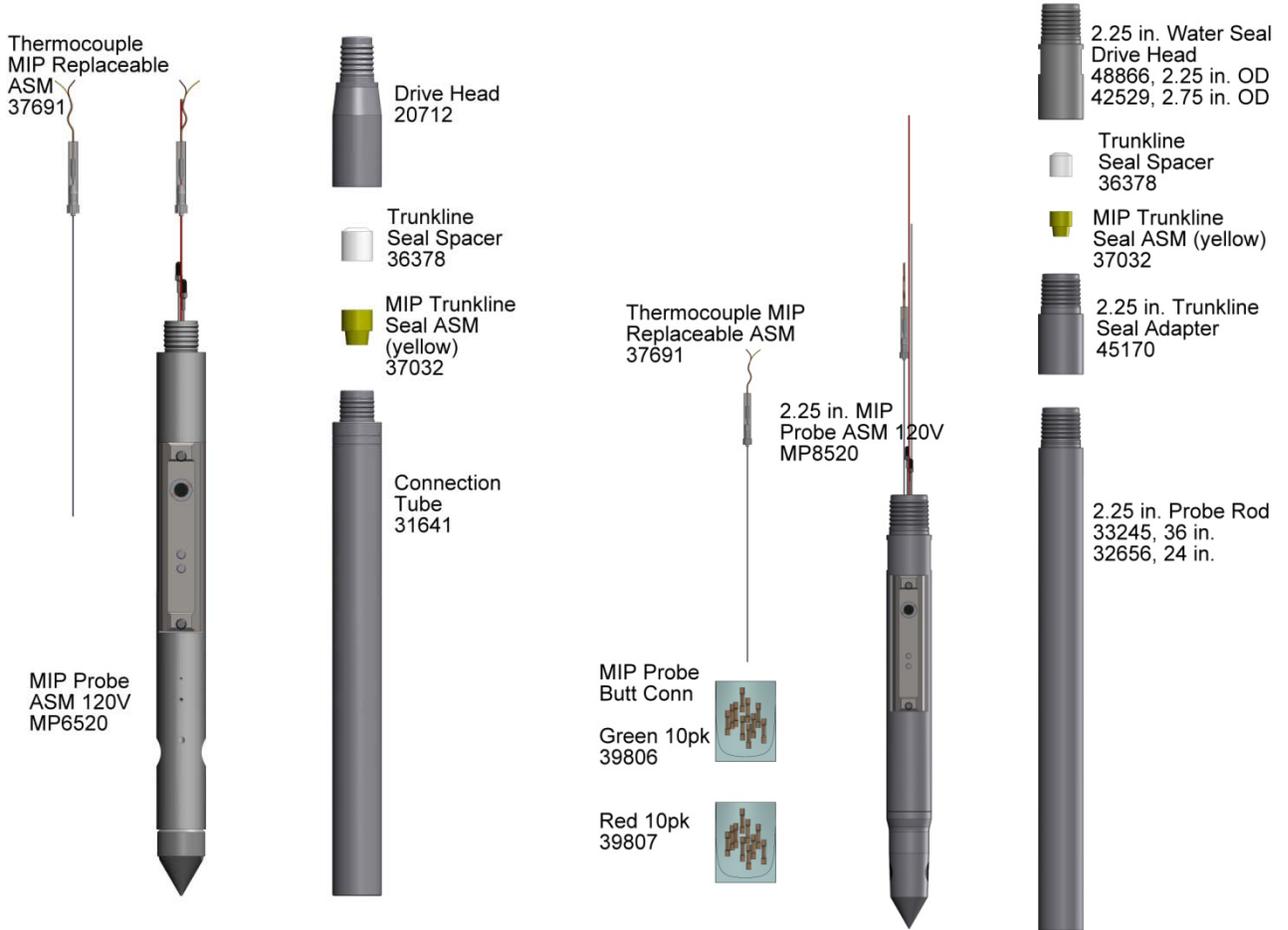
- Carrier N₂ MIP effluent – 40% - 16ml/min
- Hydrogen – 25ml/min
- AIR – 250ml/min
- Detector Temperature setting – 250°C
- FID igniter set at -600 (6.0V)

XSD:

- Carrier N₂ MIP effluent – 60% - 24ml/min
- Air – 30ml/min (split 50:50 wall & jet input of XSD)
- Detector Temperature setting – 1,100°C

APPENDIX VI

Tool Configurations



MIP - MP6520 Probe for 1.5 in. rods

MIP - MP8520 Probe for 2.25 in. rods

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this document are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.



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