

QUANTITATIVE LEAK TESTING FOR SOIL GAS WELLS USING A COMMERCIALY AVAILABLE HELIUM TRACER SHROUD

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Abstract

In this paper we present design considerations, use, procedures and validation data for a commercially available Helium tracer soil gas sampling shroud that can be rented from an internationally accredited environmental testing laboratory with soil gas measurement capabilities. Soil Gas Sampling using the Helium shroud technique described in Appendix C, page 57, CA DTSC Soil Gas Advisory Document (March 2010) is employed to ensure valid soil gas samples are collected. Sampling soil gas wells under Helium enriched atmosphere provides a quantifiable way to ensure there has been no breakthrough of air down the probe/well or through leaks in the sampling train. Well and sample train integrity is confirmed by field and laboratory analysis of purge and sample streams for the Helium tracer.

Background

Helium tracer sampling and analysis is a data quality assurance procedure used to demonstrate that soil gas wells are properly constructed and that the sample train components do not leak. Sampling under Helium atmospheres is superior to the application of alternative liquid leak tracer compounds applied at the base of the probe and near all connections in the sampling train. While liquid leak check compounds such as propanol(s) or Freons applied on towels offer logistical simplicity, these tracers interfere with target compound measurements and their detection in the sample only confirms a low bias due to an unknowable amount of ambient air dilution. A small amount of the commonly employed liquid leak-test tracer Isopropanol interferes with target compound analysis, frequently requiring extensive sample dilution resulting in elevating reporting limits to levels that may no longer meet project DQO's.

Helium does not compromise target compound measurements and its detection in samples does not cause unnecessary sample dilutions. Helium tracer allows a quantitative determination of a leak dilution factor, allowing adjustment in determined values for ambient air dilution. Helium is relatively easy to measure quantitatively in the field and in the lab, and it is readily available. Despite the advantages, Helium was correctly considered to be more difficult to use than liquid leak detectors due to the lack of availability of appropriately constructed and tested sampling apparatus.

C&T designed and built its Helium leak tracer sampling shroud at the request of, and with assistance from, its consulting engineering customers. Environmental testing laboratories are ideally suited to provide this equipment as they possess the required assets to assemble, test, maintain, and service these devices. After each use, the shroud/train components must be disassembled, critically cleaned, reassembled,

performance tested and leak tested. The resources typically available at a fully equipped whole air testing laboratory are required to perform these functions.

Single shrouds are shipped from the laboratory with integral critically cleaned & leak tested sampling trains for each well to be sampled. After passing acceptance criteria for field use, the shroud/train is transported to the field under vacuum. Receipt of an evacuated shroud/train in the field assures samplers that the train does not leak on arrival. To use the sampling shroud, field personnel need make one leak tight connection from the well to the shroud/train. The use of dedicated integral shrouds and trains minimizes potential for cross contamination during sampling.

Design Considerations

The C&T Helium tracer shroud is based on published designs. Our shroud design differs primarily by size/volume and Helium measurement systems. We favored options leading to a small volume, lightweight, easily packaged and transported shroud. At less than 4 gallons, C&T's Helium tracer shroud volume is significantly smaller than published shroud designs (~ 50 gallons) that accommodated 6 liter sample canisters. The reduced shroud volume compels the use of 1.4 liter canisters thus opening questions regarding representative sample volumes. Smaller shroud volumes permit use of lightweight Helium supply sources and easier maintenance of higher concentrations of Helium in the shroud. C&T shroud/trains and support equipment can be transported to the field and operated by the most diminutive personnel.

C&T's palm sized battery powered Helium detectors provide accurate real time measurements of % Helium inside the shroud and % Helium in the well purge gas stream. This detection system provides efficient and effective use of field personnel, reducing costs and time required to sample soil gas wells with Helium tracer.

The measurement system uses two distinct Helium detectors; one diffusion cell type used to measure % Helium inside the shroud; the second is a flow through type detector for measuring % Helium in the well purge gas stream. The in-line Helium detector provides real time measurements and eliminates the lung box equipment shown in published shroud designs.

The shroud/train and Helium detectors enable field detection of Helium breakthrough from the surface through the probe or through leaks in the sampling train at the highest value point, when they can be corrected. Performing sample integrity checks in the field allows samplers to implement contingency plans to correct the problem(s) or relocate well(s) before taking a leak compromised sample. If the leak problem(s) cannot be corrected and/or the well cannot be relocated, the Helium shroud method allows valid values for soil gas samples diluted by ambient air.

C&T and its consulting engineering customers experimented with several configurations of Helium shrouds, some with interchangeable trains. Results indicated that shrouds with dedicated integral trains were more effective and most efficient to use in the field.

Use and Experience

C&T is preparing a detailed illustrated SOP for use of the Helium shroud in the field. This SOP will assist in training field personnel on appropriate procedure and practice necessary to obtain valid soil gas samples using this equipment. Experience with field use of this equipment indicates that orientation and practice operation of the shroud and associated equipment before application in the field contributes to success.

All components of the Helium shroud sampling system are available for rental; shroud with integral critically cleaned and leak tested sample train; Helium supply bottles with regulators and transfer lines; 1.4 liter summa canisters; and diffusion and flow through type Helium detectors. Rates are reasonable and are offered on daily and project/event basis. Today, C&T maintains 12 single shrouds with integral sample trains, three double shrouds with two independent integral sampling trains suitable for sampling a single well at two different depths or serially sampling two separate wells; and, one double shroud with train assembled for taking a simultaneous duplicate 1.4 liter samples.

EPA Method TO-15 specifies sample trains be tested by passing both spiked and clean dry air through the sampling trains to validate train performance characteristics. The C&T shroud/trains are appropriately validated. These validation tests are essential since the stainless steel components of the shroud train, while generally inert, are known to provide active sites that can catalyze the oxidation of target compounds, and trains must be adequately cleaned between uses to insure they do not contaminate samples.

Data for validation studies are presented in **Table 1** (not included)

Helium Tracer Sampling Procedure

A 20% Helium in air atmosphere is maintained around the sample train and above the well annulus by positioning the shroud/train with canister and Helium detector over the well. The single and double shroud boxes are 3.5 and 8 gallons respectively, food grade polycarbonate boxes that contain the sampling train integrated with a 3-way stainless steel valve for selecting flow and flow direction. The shroud is charged with Helium using a 1 liter Helium "lecture bottle" with regulator and transfer line. One lecture bottle of Helium can be used to sample 5 wells using a single train sampling shroud under low or no wind conditions.

Real time digital Helium measurements are provided inside the shroud by the diffusion cell Helium detector. A flow through Helium detector placed in the purge line measures % Helium content in the well purge gas stream. Both Helium detectors measure Helium in air to an accuracy and precision of 0.1% over the range of Helium concentrations in air between 0.5% and 95%.

DTSC guidance specifies the shroud Helium concentration be two orders of magnitude higher than the reporting limit of the laboratory Helium analysis or the field meter used to analyze the sample. The field Helium detectors display Helium content to 0.1%, so a

10% Helium atmosphere inside the shroud should be regarded as minimum concentration. We suggest samplers use a Helium concentration of 20% in the shroud as it is easier to maintain a steady state concentrations Helium at higher levels in the C&T shroud allowing easier correction of Helium concentration variations due to wind and off gassing. Under low or zero wind conditions, a relatively constant concentration of 20% Helium can be maintained over the ~10 minutes it takes to fill a 1.4 liter canister.

The Helium concentration in the shroud will decay over time after the initial helium dose depending on the uniformity of the ground surface, wind velocity, and other field conditions. By monitoring the Helium detector display in the shroud, additional Helium can be fed to the shroud in 10 psi increments to maintain the target Helium concentration. Field personnel should record the measured Helium concentration in the shroud at no less than 2 minute intervals during the sampling event.

The soil gas probe/well and train assembly can be field screened for leaks by drawing purge gas through the well and then through the in-line Helium detector while the shroud is in position and charged with a 20% Helium atmosphere. Detecting Helium in the purge gas under these conditions indicates either the well/probe or train is leaking. This field integrity determination allows the sampling crew to take corrective action to evaluate the well/probe and the train prior to collecting a sample for laboratory analysis.

To perform the purge leak detection procedure, place the in-line Helium detector between the purge pump, syringe, evacuated canister, or other suction device used to purge the well and the **Purge Port** on the shroud. You will need a male quick connect valve to connect the purge line to the C&T shroud. Charge the shroud to 20% Helium in air, initiate suction on the purge pathway and then turn the 3 way positioning valve on the shroud to **Purge**. Purge the well for the protocol specified purge volume, then move the valve selector to the **Off** position. If you have purged a volume of soil gas greater than the volume of the well and the train while maintaining a 20% Helium atmosphere surrounding the sampling train and above the wellhead without detecting Helium in the purge gas, one can assume the well and the train are leak free. Purge gas flow is depicted in **Figure 2**

The purge gas Helium detection step is recommended to save time and money. Detecting a significant leak in the well or train at the time of sampling provides information at a high value point in the process, when something can be done about it. If this step is bypassed and there is a significant leak, it will not be identified until after the sample has been collected and analyzed at the lab.

Leak Correction

Sample integrity is assured if Helium is not detected in samples obtained while using Helium shroud procedures. If Helium is detected in samples, the proportion of the sample attributable to ambient air leakage can be determined by the ratio of Helium concentration determined in the sample to the average Helium concentration recorded in the shroud during the sampling event. DTSC guidance specifies that leaks may be

acceptable, provided the magnitude of the leak is small compared to other unavoidable sources of bias and variability in soil gas sampling and analysis. DTSC soil gas guidance (March 2010) cites an opinion that leaks comprising less than 5% of the sample are relatively insignificant, while those greater than 5% require explanation regarding the validity of the measurement data.

The algebraic procedure for determining the “leak percent” is both simple and not published in regulatory guidance. In our view, “leak percentage” is probably best expressed by the term Dilution Factor (DF) which is algebraically expressed as follows:

$$DF = \% \text{ Helium in the sample} / \% \text{ Helium in the Shroud}$$

If a soil gas well was sampled under a 20% Helium atmosphere and laboratory analysis determined a Helium content of 1% in the sample, the dilution factor would be 1%/20% or 5%. In this example, a target analyte determined at 100 ppb could be corrected for the 5% dilution from ambient air leaking down the well or through the train by adding an additional 5% to the determined value returning a “leak corrected” value of 105ppb.

C&T’s Helium tracer sampling shroud is shown in **Figure1**.

In the laboratory, Helium concentration is measured in the sample canister by a modification of EPA Method TO-3. VOC target compounds in soil gas samples are analyzed by EPA Method TO-15.

Acknowledgements & Citations

The design of the C&T shroud is based on a similar Tedlar® bag/lung box setup described in SW 846 Method 0040 (USEPA, 1996). Another similar design and procedure appears on pages 57 and 58 of the CA DTSC soil gas advisory guideline document (March 2010) contributed by Geosyntec Consultants, Oakland, CA.

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Figure 1: The C&T Helium Leak Tracer Shroud

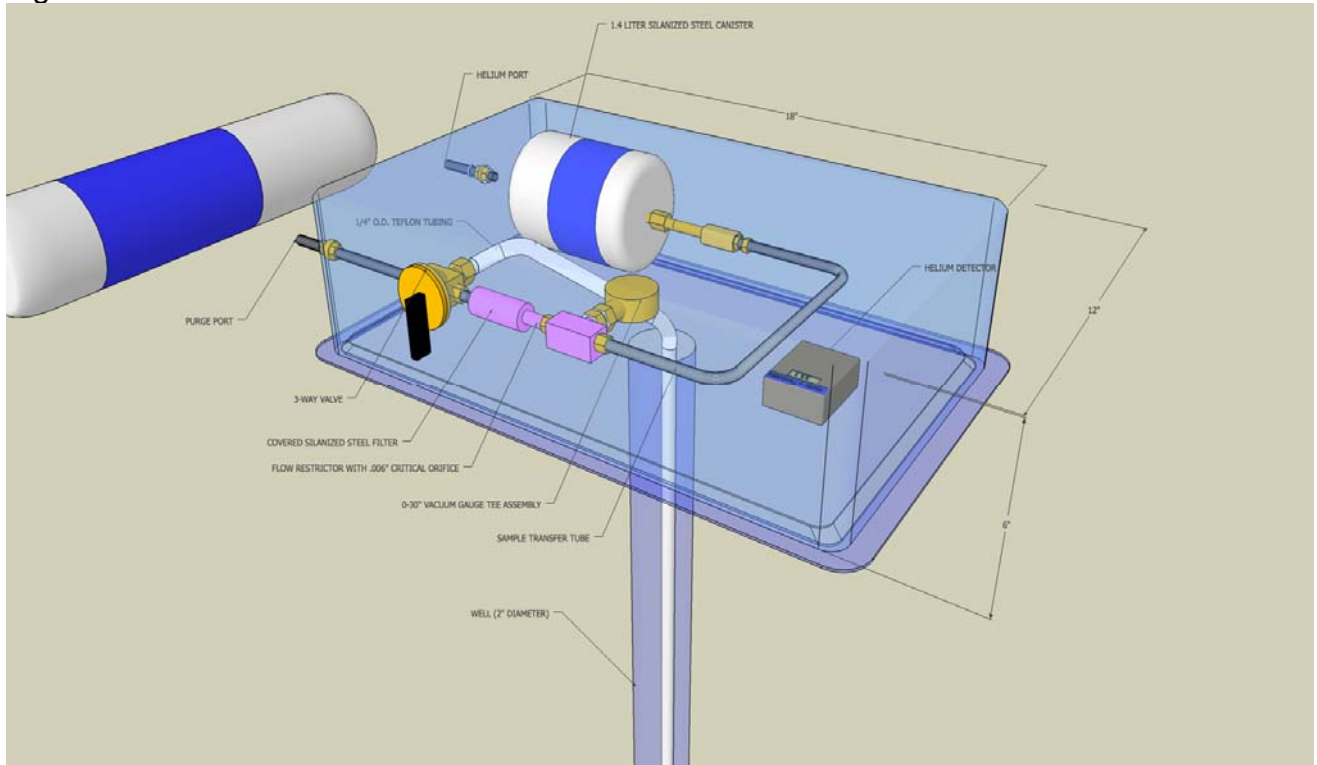


Figure 2: Purge Gas Flow

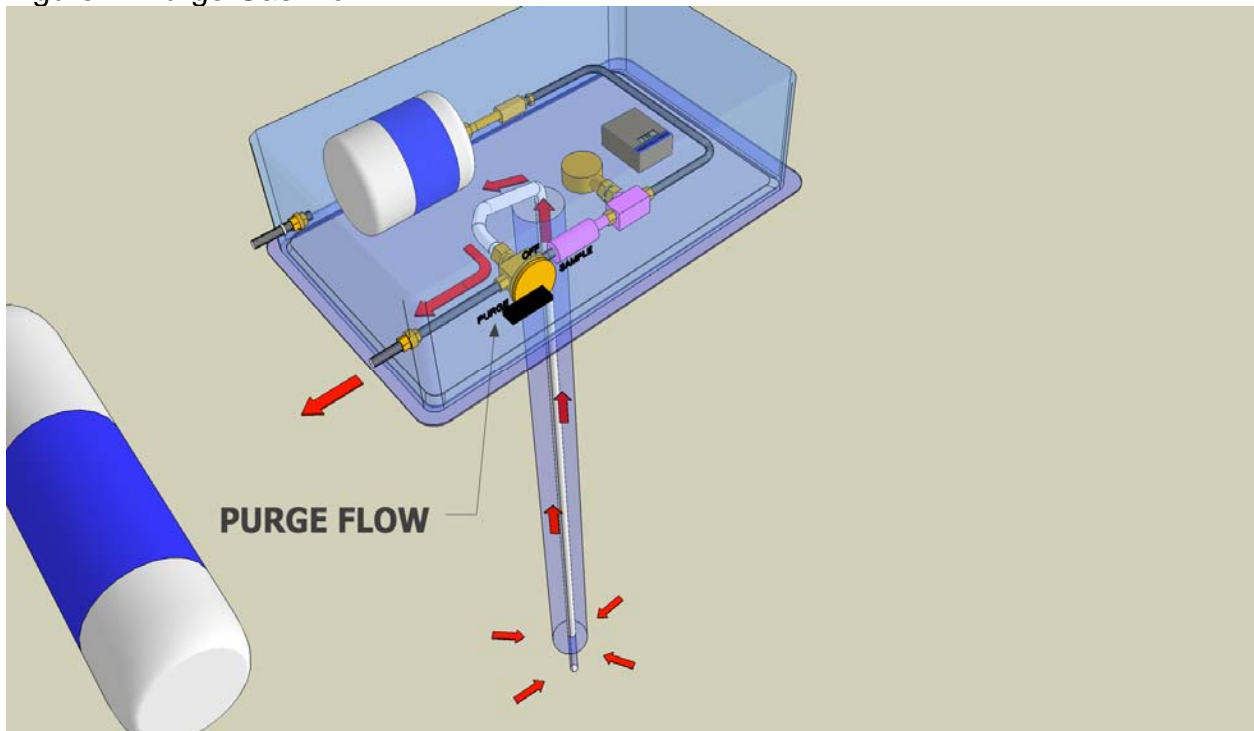


Figure 2: Dual Well Level Sampling Shroud, (showing purge flow in red)

