United States
Environmental Protection
Agency

Risk Reduction
Engineering Laboratory
Cincinnati, OH 45268

Research and Development

EPA/600/SR-93/028 March 1993

EPA

Project Summary

Decision-Support Software for Soil Vapor Extraction Technology Application: HyperVentilate

Curtis A. Kruger and John G. Morse

The U.S. Environmental Protection Agency (EPA) estimates that 15% to 20% of the approximately 1.7 million *underground storage tank* (UST) systems containing petroleum products are either leaking or will leak in the near future. These UST systems could pose a serious threat to public health and the environment. Selection of appropriate corrective action technologies that can be rapidly implemented and that are efficient and cost-effective is essential to minimize the impact of UST releases on the environment and public health. Soil vapor extraction (SVE) is a proven, *in situ* corrective action technology that can remove volatile organic compounds (VOCs) and selected residual petroleum hydrocarbons from unsaturated soils. To assist regulators, investigators, and UST owners in evaluating whether SVE is an appropriate cleanup technology for use at UST sites, decision-support software entitled "HyperVentilate" has been developed by U.S. EPA and Shell Oil Company under a 1990 Cooperative Research and Development Agreement under the Federal Technology Transfer Act.

HyperVentilate is an interactive, software guidance system for evaluating the feasibility of using SVE at a specific site based on site and contaminant characteristics. HyperVentilate is designed to (1) identify the level of site data required to evaluate SVE systems, (2) evaluate soil permeability test results, (3) approximate the minimum number of extraction wells likely to be needed, and (4) provide a rough approximation of the system's desired and maximum removal rates.

The document summarized here provides guidance in evaluating the use of the IBM-compatible version of HyperVentilate that requires a computer equipped, at a minimum, with an 80386 processor, 4 MB RAM, DOS 3.1, Microsoft Windows 3.x, and Spinnaker PLUS 2.5. In the project report, an overview of SVE principles and procedures is presented along with the basic model principles and a sensitivity analysis of HyperVentilate. A sample application of the software is also presented by using data from an actual UST site. The case study demonstrates how to estimate and determine input parameters, goes through the steps involved in deriving estimates to evaluate whether SVE is appropriate, and discusses interpretation of the case study results.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Since promulgation of federal regulations, the number of leaking UST systems being discovered has rapidly outpaced the capabilities and resources of both industry and regulatory agencies to implement and complete corrective actions at these sites. Because the number of unaddressed sites is increasing, decision-support software such as HyperVentilate can be a valuable tool for expediting the process of selecting and implementing effective corrective actions.

The objective of HyperVentilate is to help the user engage in a systematic, iterative evaluation of the feasibility of SVE as a remedial alternative at a given site. The software uses data provided by the user to develop a rough approximation of the system's desired and maximum removal rates. At no point does the software give a definitive "yes" or "no" response to the question of feasibility. The software can provide two estimates of the minimum number of vapor extraction wells needed to achieve remediation. The first estimate is developed by simply comparing the anticipated extraction well radius of influence with the radial area of contamination. The second estimate is based on a calculation of the volume of air that needs to be extracted from the soil to remove residual contamination. The user is ultimately responsible for deciding if the estimates generated by the software are technically and economically practical for a particular site. HyperVentilate is primarily a software tool for evaluating SVE as a remediation alternative; it is not intended to be a detailed SVE modeling or design tool.

Soil Vapor Extraction Technology

SVE is a proven, cost-effective technique for removing VOCs and motor fuels from contaminated soil in the unsaturated or vadose zone. This technology is also referred to as vacuum extraction, soil venting, aeration, *in situ* volatilization, and enhanced volatilization. SVE is the term selected for use in the full report.

This report briefly discusses the principles influencing contaminant behavior in the vadose zone and describes site evaluation procedures, system design components, and system performance monitoring.

Recent SVE system designs for removing VOCs have mostly been empirically based because of the simplicity of the process and a lack of analytical tools capable of aiding system design. Many numerical models have practical applications in actual field situations that can evaluate the effectiveness of SVE in removing organic vapors. A variety of numerical models can be used to determine the role of soil moisture, temperature, soil heterogeneity, and other factors in controlling the migration of volatile constituents through the unsaturated zone. The process of contaminant desorption from soil particles can be used to determine final cleanup efficiency. It also can result in significant differences in removal rates for the various types of soils and volatile organic components.

Basic Model Principles

HyperVentilate, an interactive, software guidance system, is a useful tool for evaluating the feasibility of using SVE at a specific site. HyperVentilate was designed for use as a guide to achieve the following: (1) identify the level of site data needed to evaluate SVE systems, (2) determine if soil venting is appropriate at a site, (3) evaluate soil permeability test results, and (4) approximate the minimum number of extraction wells likely to be needed.

The software is available for both the Apple Macintosh and IBM-compatible personal computers. HyperVentilate version 1.01 for the Apple Macintosh requires an Apple Macintosh computer equipped with 2 MB RAM and the Apple HyperCard Software Program 2.0 or greater. HyperVentilate version 2.0 for IBM PC-compatible requires a computer equipped with at least an 80386 processor, 4 MB RAM, and VGA through the use of Spinnaker PLUS (a run-time version) in a Microsoft Windows (3.0 version) environment. HyperVentilate is composed of a system of multiple stack cards in which each computer screen view is called a card. Related cards that follow in sequential order are organized into card stacks, and the main card stack is called the "Soil Venting Stack." To obtain further explanation of individual cards within this stack, secondary card stacks can be accessed through the "Soil Venting Help Stack." Other supporting stacks include the "Air Permeability Test" stack, the "Aquifer Characterization" stack, and the "System Design" stack. The multiple card file system has the flexibility to allow the user to access part of the software without having to work through the entire program.

The HyperVentilate software system addresses the following nine major card topics associated with implementing SVE:

- Information about SVE,
- General overview of the "Shell Oil Company Practical Approach,"
- Site investigation needs,
- Feasibility of soil venting,
- Analyses of field test information to provide permeability estimates and aquifer characterization,
- SVE system design estimates,
- System monitoring needs,
- Ways to determine when the system should be shut down, and
- Economics of implementing SVE.

Most SVE system parameters are estimated under the topics that deal with SVE feasibility, system design, and field testing.

Computer Software Structure

HyperVentilate is interactive software with a dual nature. On one level, it is tutorial, intended to help the user understand the nature and distribution of hydrocarbons in the subsurface and to determine if SVE is an appropriate remedial technology at a given site. On another level, it is computational, allowing the user to work through several sequences of operations to determine if SVE is appropriate for use under specific site conditions.

HyperVentilate comprises 100 cards divided into five stacks. Twenty-eight of these cards from the main stack, referred to as the "Soil Venting Stack," take the user through the systematic evaluation of SVE. The other four stacks support the main stack as Help cards (Soil Venting Help Stack) or by providing details concerning the Air Permeability Test, Aquifer Characterization, or System Design.

Document Contents

Section 1 includes a capsulized discussion of the SVE technology and the factors that influence contaminant fate and vapor-phase transport in the vadose zone.

Section 2 provides a detailed summary of the HyperVentilate software. The major elements discussed in this section include the basic model principles, software characteristics, and the computer software structure.

Section 3 presents a model application case study with the use of data from an actual UST site. The case study demonstrates the process of reviewing a remedial investigation/corrective action plan in order to determine input parameters for HyperVentilate. Initially, the software will help to examine the site from a very basic point of view—one that includes a number of simplistic but important assumptions about subsurface conditions and contaminant behavior that are explained within the software. Data needs for this part of the analysis are not rigorous, and an interactive approach is encouraged. Subsequently, the software will help revise the initial assumptions, develop better input data, and refine the understanding of the use of SVE at the site.

Section 4 discusses model analysis. The modeling analysis of HyperVentilate is conducted to address two considerations: (1) variations in output parameters that were identified over a range of input parameter values, and (2) the sensitivity of each output parameter to changes in input parameter values. The purpose of this analysis is to identify those site conditions and system design considerations that most strongly affect the potential success of a vapor extraction system at a given site and to identify those parameters over which a system designer can exert some measure of control.

The full report was submitted in fulfillment of Contract No. 68-C2-0108 by International Technology Corporation under the sponsorship of the U.S. Environmental Protection Agency.

*U.S. Government Printing Office: 1993 — 750-071/60203

C. A. Kruger is with Midwest Research Institute, Falls Church, Va 22041, and John G. Morse is with International Technology Corporation Knoxville, TN 37923.
***Chi-Yuan Fan** is the EPA Project Officer (see below).*
The complete report consists of paper copy and two diskettes (one for IBM-PC and one for Apple Macintosh) entitled "Decision-Support Software for Soil Vapor Extraction Technology Application: HyperVentilate."
Paper Copy (Order No. PB93-134880/AS; Cost: $27.00; subject to change)
Diskettes (Order No. PB93-502664/AS; Cost $140; subject to change)
The above items will be available only from
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
Edison, NJ 08837

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

Official Business
Penalty for Private Use
$300

EPA/600/SR-93/028

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35