PI.3 Membrane System for Recovery of Volatile Organic Compounds from Remediation Off-Gases

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Abstract

In situ vacuum extraction, air or steam sparging, and vitrification are widely used methods of remediating soil contaminated with volatile organic compounds (VOCs). All of these processes produce a VOC-laden air stream from which the VOC must be removed before the air can be discharged or recycled to the generating process. Treatment of these off-gases is often a major portion of the cost of the remediation project. Carbon adsorption and catalytic incineration, the most common methods of treating these gas streams, suffer from significant drawbacks.

Membrane Technology and Research, Inc. (MTR) proposes an alternative treatment technology based on permselective membranes that separate the organic components from the gas stream, producing a VOC-free air stream. The technology we propose to develop can be applied to all of these off-gas streams and is not tied to a particular off-gas generating source. We propose to develop a completely self-contained system because remediation projects are frequently in remote locations where access to trained operators and utilities is limited. The system will be a turnkey unit, skid-mounted and completely automatic, requiring power but no other utilities. The system will process the off-gas, producing a concentrated liquid VOC stream and a purified gas containing less than 10 ppm VOC that can be discharged or recycled to the gas-generating process.

Removal of VOCs from air streams with membranes is a relatively new technology. To date, most membrane systems have been installed on process streams in the refining and petrochemical industries. The first demonstration plants were installed by MTR in 1990-91, with the first commercial plants being sold in 1992-93. Currently, more than 30 units are operating in the United States, all supplied by MTR. Off-gases produced in DOE remediation operations are much less concentrated in VOCs than the chemical plant streams treated by our membrane technology to date. A pilot test of a membrane system at the Hanford Nuclear Reservation on an off-gas stream containing 200-1,000 ppm carbon tetrachloride showed the overall feasibility of the process. The membrane system consistently achieved greater than 95% VOC removal and produced dischargeable air containing less than 20 ppm VOC. The test also showed that modifications to the system design are required to tailor the technology to this application. In particular, the module design must be modified to improve the VOC/air separation. Also, the system design must be changed to allow operation with flammable VOCs and to remove water

coextracted with the VOCs, to reduce the volume of hazardous waste requiring disposal.

After completion of a Design Phase, in which laboratory experiments were carried out, MTR constructed a Field Demonstration System and installed the unit at the national Environmental Technology Test Site at the McClellan Air Force Base near Sacramento, California. Initial performance data demonstrated a VOC removal efficiency of 95%. Composition data are obtained by an independent environmental laboratory which analyses twenty different VOCs.

During the operation of the test system we have identfied two issues which will have to be addressed:

(1) The off-gas contains about 1.5% carbon dioxide, which was not tsaken nto account during the design of the demonstration system. The membranes are very permeable to carbon dioxide and this significantly increases the flowrate of recirculating gas streams, thereby reducing the treatment capacity of the demonstration system.

(2) The system has experienced shutdowns because of water build-up in one of the compressors. The origin of the water is under investigation, but the leading explanation is carryover from the air stripper which cleans the condensed water.

Completion of the field test is expected in November 1999.

Acknowledgements

We thank William J. Huber and Vijendra P. Kothari, METC Contracting Officer's Representatives, for their support. The contract period of performance is September 9, 1996 through March 8, 2000.

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