United States
Environmental Protection
Agency

EPA/540/MR-95/511
June 1995

SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

Demonstration Bulletin

Zenon Cross-Flow Pervaporation Technology

ZENON Environmental, Inc.

Technology Description: Pervaporation is a process that employs a membrane to remove volatile organic compounds (VOC) from aqueous matrices. Figure 1 displays a schematic diagram of the ZENON cross-flow pervaporation system in a typical field application. Contaminated water is pumped from an equalization tank through a prefilter to remove debris and silt particles, and then into a heat exchanger that raises the water temperature to about 165 °F (75 °C). The heated contaminated water then flows into a pervaporation module containing dense polymeric membranes.

The membrane material is a nonporous organophilic polymer, such as silicone rubber, formed into capillary fibers measuring less than 1 mm in diameter. Silicone rubber is highly permeable to organic compounds and resistant to degradation. The capillary fibers are aligned parallel on a plane and spaced slightly apart. This arrangement of capillary fibers forms one membrane layer.

Separate membrane layers are aligned in series, with the interior of the capillary fibers exposed to a vacuum (about 1 lb/in^2, absolute). The number of membranes used in a particular system depends on expected flow rates, contaminant concentrations in the untreated water, and target concentrations for contaminants in the treated water.

The organophilic composition of the membrane causes organics to adsorb to the membrane (capillary fibers). The organics migrate to the interior of the capillary fibers and are then extracted from the membrane by the vacuum. This organic migration into the fibers creates a concentration gradient that tends to facilitate transport. Contaminated water passing through the pervaporation module is depleted of organics and exits the ZENON system for reuse or discharge.

Organic vapor and small amounts of water extracted from the contaminated water through the membranes is called permeate. As the permeate exits the membranes, it is drawn into a condenser by the vacuum, where the organics and any water vapor are condensed. Because emissions are vented from the system downstream of the permeate condenser, organics are kept in solution, thus minimizing air releases.

The liquid permeate contains highly concentrated organic compounds and has a significantly reduced volume compared to the untreated water. Because of this high concentration, the liquid permeate generally separates into aqueous and organic phases, rendering the organic fraction potentially recoverable. The organic phase permeate is pumped from the containment vessel to storage while aqueous phase permeate can either be returned to the pervaporation module for further treatment or removed for disposal.

Waste Applicability: Cross-flow pervaporation can be applied to aqueous matrices contaminated with liquids containing VOCs such as solvents, degreasers, and gasoline. Pervaporation provides an alternative approach to treating organic-contaminated water at sites where conventional air stripping or carbon adsorption are currently used. Unlike air stripping, pervaporation releases

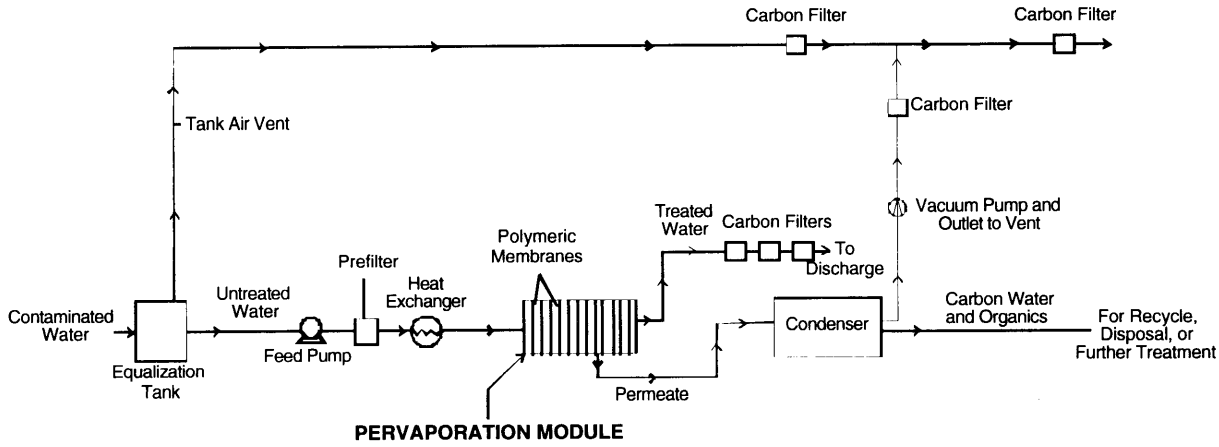

Figure 1. *Zenon Cross-Flow Pervaporation System*

United States
Environmental Protection
Agency

EPA/540/MR-95/511
June 1995

SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

Demonstration Bulletin

Zenon Cross-Flow Pervaporation Technology

ZENON Environmental, Inc.

Technology Description: Pervaporation is a process that employs a membrane to remove volatile organic compounds (VOC) from aqueous matrices. Figure 1 displays a schematic diagram of the ZENON cross-flow pervaporation system in a typical field application. Contaminated water is pumped from an equalization tank through a prefilter to remove debris and silt particles, and then into a heat exchanger that raises the water temperature to about 165 °F (75 °C). The heated contaminated water then flows into a pervaporation module containing dense polymeric membranes.

The membrane material is a nonporous organophilic polymer, such as silicone rubber, formed into capillary fibers measuring less than 1 mm in diameter. Silicone rubber is highly permeable to organic compounds and resistant to degradation. The capillary fibers are aligned parallel on a plane and spaced slightly apart. This arrangement of capillary fibers forms one membrane layer.

Separate membrane layers are aligned in series, with the interior of the capillary fibers exposed to a vacuum (about 1 lb/in^2, absolute). The number of membranes used in a particular system depends on expected flow rates, contaminant concentrations in the untreated water, and target concentrations for contaminants in the treated water.

The organophilic composition of the membrane causes organics to adsorb to the membrane (capillary fibers). The organics migrate to the interior of the capillary fibers and are then extracted from the membrane by the vacuum. This organic migration into the fibers creates a concentration gradient that tends to facilitate transport. Contaminated water passing through the pervaporation module is depleted of organics and exits the ZENON system for reuse or discharge.

Organic vapor and small amounts of water extracted from the contaminated water through the membranes is called permeate. As the permeate exits the membranes, it is drawn into a condenser by the vacuum, where the organics and any water vapor are condensed. Because emissions are vented from the system downstream of the permeate condenser, organics are kept in solution, thus minimizing air releases.

The liquid permeate contains highly concentrated organic compounds and has a significantly reduced volume compared to the untreated water. Because of this high concentration, the liquid permeate generally separates into aqueous and organic phases, rendering the organic fraction potentially recoverable. The organic phase permeate is pumped from the containment vessel to storage while aqueous phase permeate can either be returned to the pervaporation module for further treatment or removed for disposal.

Waste Applicability: Cross-flow pervaporation can be applied to aqueous matrices contaminated with liquids containing VOCs such as solvents, degreasers, and gasoline. Pervaporation provides an alternative approach to treating organic-contaminated water at sites where conventional air stripping or carbon adsorption are currently used. Unlike air stripping, pervaporation releases

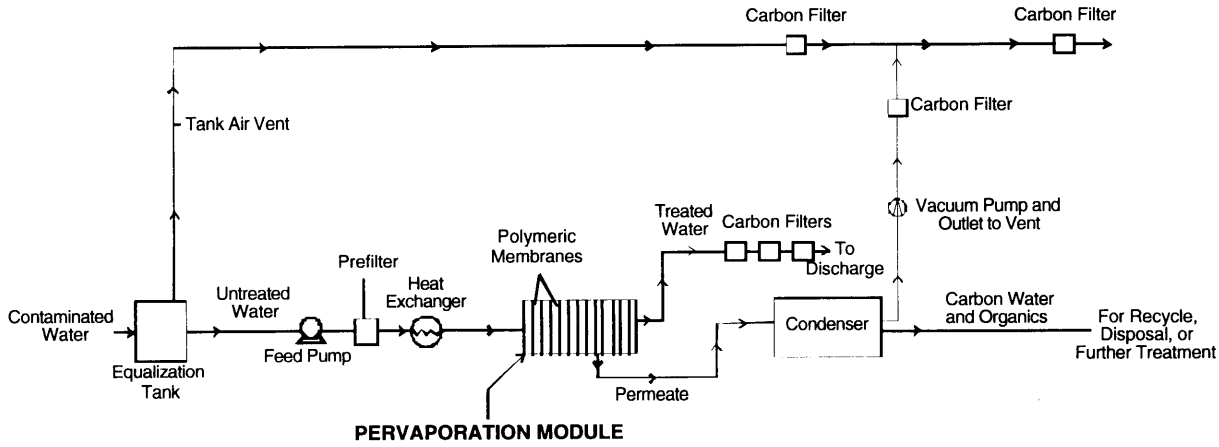

Figure 1. *Zenon Cross-Flow Pervaporation System*