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TECHNOLOGY EVALUATION

Emerging Technology Bulletin

Destruction of Organic Contaminants in Air Using Advanced Ultraviolet Flashlamps

Purus, Inc.

Technology Description: This technology uses photolytic oxidation to destroy volatile organic compounds (VOCs) in soils and groundwater. The system uses a xenon pulsed-plasma flashlamp that emits short wavelength ultraviolet (UV) light at very high intensities. The process strips the contaminants into the vapor phase, where the UV treatment converts the VOCs into less hazardous compounds. (See figure 1)

Direct photolysis does not form hydroxyl radicals. Direct photolysis occurs when the contaminants absorb sufficient UV light energy, transforming electrons to higher energy states and breaking molecular bonds. The process requires the UV light source to emit wavelengths in the regions absorbed by the contaminant. An innovative feature of this technology is the ability to shift the UV spectral output to optimize the photolysis.

The process uses vacuum extraction or air stripping to volatilize VOCs from soils or groundwater, respectively. VOCs then enter the photolysis reactor, where a xenon flashlamp generates UV light. The plasma is produced by pulse discharge of electrical energy across two electrodes in the lamp. Ninety-nine % destruction of the contaminants occurs within seconds, allowing continu-

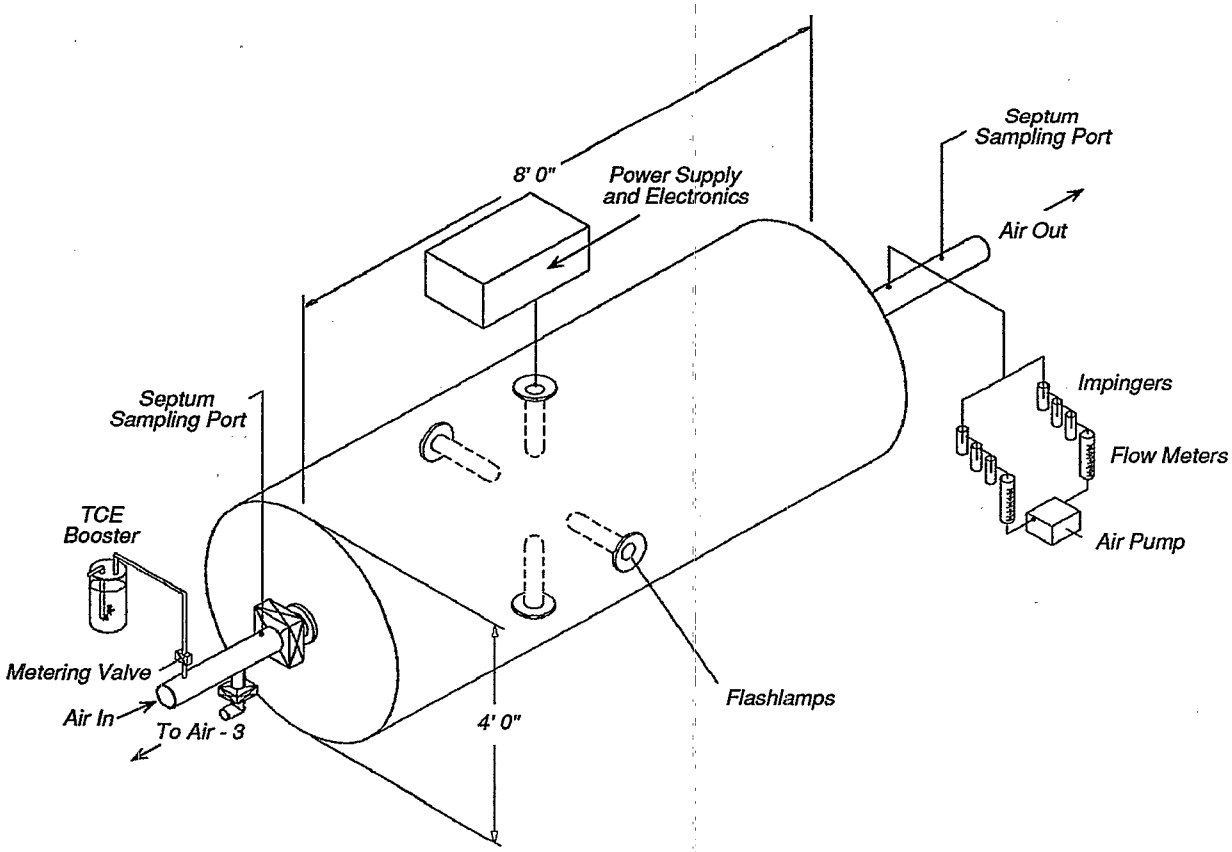

Figure 1. *Schematic of Air-2 photochemical reactor.*

ous operation. Because organics are destroyed in the vapor phase, the process uses less energy than a system treating dissolved organics.

Waste Applicability: The Purus, Inc. photolytic oxidation process is designed to destroy VOCs, including dichloroethylene (DCE), tetrachloroethylene (PCE), trichloroethylene (TCE), and vinyl chloride volatilized from soil or groundwater. Other VOCs, such as benzene, carbon tetrachloride, and 1,1,1-trichloroethane, are being investigated.

Test Results: A full-scale field test began in October, 1991, and was completed in July, 1992. The results are listed in table 1. The test was conducted at the Lawrence Livermore National Laboratory Superfund site 300, about 15 miles east of Livermore, CA. The site contains soil zones highly contaminated with TCE. A vacuum extraction system delivered contaminated air to the Purus unit at air flows of up to 500 cubic feet per minute (cfm). Initial concentrations of TCE in the air were approximately 250 parts per million by volume. The contaminant removal goal for the treatment was 99%. Vapor phase carbon filters were placed downstream of the Purus unit to comply with the California Air Quality emmissions control standards during the field test.

*Table 1. Summary of Field Results with the Air-3 Photoreactor**

Freq. (Hz)	No. of 3.7-kW Lamps	Res. Time (sec)	TCE Destruction (%)	Mole % DCC†	Mole % DCAC*	Mole % Cl^-	Chlorine Balance (Mole %)
30	4	9.6	≥99.99	nd‡	25.8	61.6	78.8
30	4	10.1	≥99.99	19.6	24.4	89.9	106.2
30	4	10.4	≥99.99	26.0	34.6	91.4	114.5
30	2	4.6	99.92	17.3	53.7	55.3	91.1
15	4	10.1	≥99.99	21.3	nd	68.2	nd
15	2	4.8	≥99.99	12.4	64.5	43.2	86.2
5	4	10.4	≥99.99	8.3	72.2	41.9	90.0
5	2	4.8	≥99.99	9.3	75.2	38.6	88.8
1	4	9.3	99.16	12.3	81.8	35.8	90.3
1	2	4.8	86.57	6.9	86.2	35.8	93.3

**Flowrate-100 cfm, initial [TCE] = 100 ppmv. †Dichlorocarbonyl (phosgene). * Dichloroacetyl chloride. ‡ Not detectable.*

The low-wavelength UV emissions allowed direct photolysis of many VOCs, particularly chlorinated compounds and freons, that would not have been possible with commercial mercury lamps. Very rapid and efficient destruction was observed for TCE, PCE, and DCE. Some VOCs required either photo-sensitization or a lower-wavelength light source for rapid photolysis.

The TCE removal resulted in undesirable intermediates. The main product (greater than 85%) from the chain photo-oxidation of TCE is dichloroacetyl chloride (DCAC). Further oxidation of DCAC is about 100 times slower than the photolysis of TCE and forms dichlorocarbonyl (DCC) in about 20% yield. At this level of treatment, the DCC concentration may be excessive, requiring additional treatment. Further studies should focus on the effectiveness of dry or wet scrubbers for removing acidic photo-oxidation products, developing thermal or other methods for post-treatment of products, and examing the use of shorter-wavelength UV lamps or catalysis, to treat a broader range of VOCs. Purus will examine several of these issues with Argonne National Laboratory in continued demonstrations at the Department of Energy Savannah River site.

A paper and project summary have been submitted for printing and will be available in the near future.

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