FUEL CELL OPERATION ON LANDFILL GAS

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The U.S. Environmental Protection Agency (EPA), in conjunction with International Fuel Cells Corporation, conducted two projects to define, design, test, and assess a fuel cell energy recovery system for application at solid waste facilities (landfills). The projects were the first usages of fuel cell technology for operation on landfill gas. EPA has promulgated standards and guidelines for the control of air emissions from municipal solid waste landfills. Landfill gas is produced as a result of a natural biological reaction whereby microbes consume organic matter in the absence of O_2 and convert the solids to a gas containing methane in the range of 50% by volume. The other major constituents of landfill gas are: CO_2 ~32%, N_2 ~17%, and O_2~1%. Additionally, landfill gas contains trace amounts of fuel cell contaminants consisting of sulfur-bearing compounds (principally H_2S) and halogen compounds. The two projects addressed two major issues: development of a cleanup system to remove fuel cell contaminants from the gas and testing/assessment of a modified phosphoric acid fuel cell power plant (ONSI PC 25) which operated on the cleaned, but dilute, landfill gas.

Performance data were collected at two sites determined to be representative of the U.S. landfill market. At the first test site (Penrose), located in greater Los Angeles, CA, landfill gas was gathered and recovered from four nearby landfills comprised primarily of industrial waste material. This gas had a heating value of about 16.6 kJ/SL at 44% methane concentration After tests were concluded at Penrose, the equipment (fuel cell and gas cleanup unit) was moved to the Groton, CT, landfill. This was a relatively small landfill, but methane levels were higher (~50%) with a corresponding greater heat content of 18.6 kJ/SL.

The assessment/test at these sites primarily addressed contaminant removal efficiency of the cleanup system, power production of the fuel cell system, and fuel cell exhaust emissions. The gas cleanup unit logged approximately 6500 hours between the two sites and removed total sulfur (as H_2S) to levels below 0.047 and 0.022 ppbv at Penrose and Groton, respectively. Total halides (as Cl) at Penrose and Groton were reduced to levels below 0.032 and 0.014 ppbv, respectively. These very small outlet concentrations reflect greater than 99% removal efficiency, and thereby protect the fuel cell's catalysts for their projected operating life of 40,000 hours. The fuel cell was operated for ~ 700 hours at Penrose and for ~ 3300 hours at Groton with adjusted availability of over 96% at both sites. The power produced at Penrose peaked at 137 kW, while the Groton landfill produced a maximum power output of 165 kW due to a higher energy gas. The overall fuel cell efficiency was determined to be 37 and 38% at Penrose and Groton, respectively. Fuel cell emissions, as actual dry concentrations, were measured according to EPA methods and are as follows: SO_2 emissions were below the method detection limit of 0.23 ppmv; NO_x emissions averaged 0.12 ppmv; and CO emissions were near the detection limit, averaging 0.77 ppmv.