Attachment C

Greenhouse Gas Emission Rate Testing Protocol for Electric-Only Technologies that Consume Fossil Fuels

This protocol refers to the testing of electric only fuel cells operating on fossil fuels under the 2011 Self Generation Incentive Program as required by CPUC Decision 11-09-015. This protocol utilizes the existing ASME PTC 50-2002, which is a performance test code for fuel cells. The ASME PTC 50 calculates the energy input to the fuel cell, the electrical power output, thermal and mechanical outputs, average net power, electrical efficiency, thermal effectiveness and heat rate under certain test conditions. These results can be used to calculate the gas emission rate of the fuel cells.

A summary of the test procedures and methods is as follows:

Before starting test, fuel cell shall run in steady-state conditions for an agreed-upon period of time. Test shall not run for less than one hour, and interval between readings shall not be less than 1 min. For participation in the SGIP it is required that the fuel cell generating system be tested under ISO conditions.

Primary Variables:

1. Class 1 have relative sensitivity coeff. Of 0.2 or greater. These require measurement instruments with higher accuracy and greater redundancy than Class 2
    a. Ex: Input fuel flow, fuel heating value, gross power output, aux/ parasitic power consumed by fuel cell system
2. Class 2 have relative sensitivity coeff of less than 0.2
    a. Ex: fuel cell system output voltage, output current, output frequency

INSTRUMENTS AND METHODS OF MEASUREMENT

Determination of Outputs:

1. Water or Heat Transfer Fluid Flow
2. Water or Heat Transfer Fluid Temperature
3. "Other Measurements"
    a. Water pressures
    b. Static Pressure
4. Electrical Output Measurements (true RMS required to account for harmonic distortion)

Determination of Fuel Input:

1. Fuel Types Considered

2. Consistent Gaseous or Liquid Fuels- heating values must vary less than 1%
3. Consistency of Fuel Flow- difference between max and min fuel flow should be less than 2%
4. Determination of Fuel Heating Value- can be measured by an on-line chromatograph or by taking a minimum of three samples per test and analyzing each for heating value.
5. Determination of Liquid Fuel Specific Gravity- each fuel sample taken shall have specific gravity evaluated at three temperatures covering the range of temps during the testing.
6. Measurement of Liquid Fuel Flow-
7. Measurement of Gaseous Fuel Flow- must meet uncertainty requirement of the code (with less than 2% total uncertainty (at 95% confidence))
8. Calculation of Fuel Input
9. Sampling- automatic sampling should be done in accordance with ASTM D 5287

Computation of RESULTS

Computation of Inputs

1. State of Input Fuel
2. State of Input Oxidant
3. Computation of Input Energy
    a. Fuel Chemical Energy Input
    b. Fuel Pressure Energy Input
    c. Fuel Thermal Energy Input
    d. Secondary Thermal Energy Input
    e. Oxidant Pressure Energy Input
    f. Oxidant Thermal Energy Input
    g. Auxiliary Electrical Input
    h. Shaft Work Input
    i. Total Energy Into System

Computation of Electrical Power Output

1. Averaging of Test Data
2. Real Power
3. Electrical Total Energy
4. Net Electrical Energy

Computation of Thermal and Mechanical Outputs

1. Computation of Thermal Energy Captured
2. Computation of Shaft work out of System

Computation of Average Net Power

Computation of Efficiencies

1. Computation of Electrical Efficiencies
2. Computation of Thermal Effectiveness
3. Computation of Heat Rate
4. Computation of Fuel Chargeable to Power Heat Rate

A post-test uncertainty analysis is required. Expected to give results with less than 2% total uncertainty (at 95% confidence).

The average net power of the fuel cell coupled with the fuel input rate (HHV) will be used to calculate the annual power generation (MWh) and fuel consumption (MMBtu) based upon an assumed capacity factor of 80%. The GHG output is calculated by multiplying the annual fuel consumption of the fuel cell in MMBtus by an emission factor of 53.02 kg CO_2/MMBtu[1] for the conversion of natural gas to CO_2. The GHG emissions rate for the generator is found by dividing the annual GHG emissions by the annual electrical output of the generator in MWh.

[1] Unspecified natural gas conversion emission factor from Appendix A of Section 95112 of the mandatory GHG reporting regulation. Title 17 of the California Code of Regulations.