

Application Note - Fuel Cell Start-Up and Shut-Down

This application note describes recommended procedure for safe start-up and shut-down for a PEMFC and fuel cell test system. The main objective during safe start-up and shut-down of a fuel cell is to avoid establishing hazardous conditions due to mixing of hydrogen and oxygen (air) in the test system and/or fuel cell. This is accomplished by extended purging of the fuel cell test system and fuel cell with an inert gas such as nitrogen (N₂) at start-up and shut-down.

This document does not describe other types of common tests, standard operating procedures, and best-practices which may include but are not limited to:

- Cell wet-up and/or humidification.
- Cell break-in and conditioning procedures
- Fuel crossover and electrochemical surface measurement
- Polarization curve testing

It is assumed that the fuel cell test system and fuel cell are correctly installed and working.

Gas Cylinders

At the beginning of each day of testing:

1. Verify that all gas (N₂, H₂, Air, *etc.*) cylinders have enough pressure (> 1.4 MPa or 200 PSI).
2. Open gas tanks for all gases required.
3. Verify that each gas regulator is set to 414-517 kPa (60-75 PSI).

Preparation of the Cell Hardware on the Test Station

1. Use a multimeter to measure the resistance between the anode and cathode graphite flow fields or current collector plates. Wait until the value is stabilized.
 - This step checks that electronic resistance of the fuel cell is high enough ($\sim 1 \text{ k}\Omega\text{-cm}^2$) that there is no indication of severe electrical short. If the resistance is less than $\sim 250 \text{ }\Omega\text{-cm}^2$, it is advisable to re-build the cell.
 - Example calculation: for 25 cm² cell the resistance should be at least 40 Ω , preferably greater.
2. Connect four (4) gas tubes from the fuel cell test system to the fuel cell hardware (anode inlet to fuel cell, cathode inlet to fuel cell, fuel cell anode outlet to vent, fuel cell cathode outlet to vent)
 - Make sure there are no leaks at any connections. Check with soapy water.
3. Insert the cell heater thermocouple into the thermocouple hole in the cathode graphite plate.
 - **Caution:** Make sure that the thermocouple stays at the end of the hole. If the thermocouple is not in place, the cell will be overheated as the system tries to maintain the cell set point temperature.
4. Insulate the cell and gas line fittings with fiberglass insulation

5. Connect the voltage sense leads to their appropriate connections on the load box or test station (red for cathode, black for anode).
6. Connect the load cables to their appropriate connections on the fuel cell hardware (red for cathode, black for anode).
 - Be certain that the load cable connections are tight.
 - Always ensure the voltage sense leads and load cables are attached before applying a load.

Start-Up Procedure

1. Turn on Computer and Fuel Cell Test System and start the FuelCell software.
2. The Setup Cell window will open
 - Set the cell surface area as appropriate for the MEA being tested
 - Set cell temperature at 25 °C
 - If the Beep box is checked, the FuelCell program will produce a beep from the computer when the Min or Max limits are exceeded.

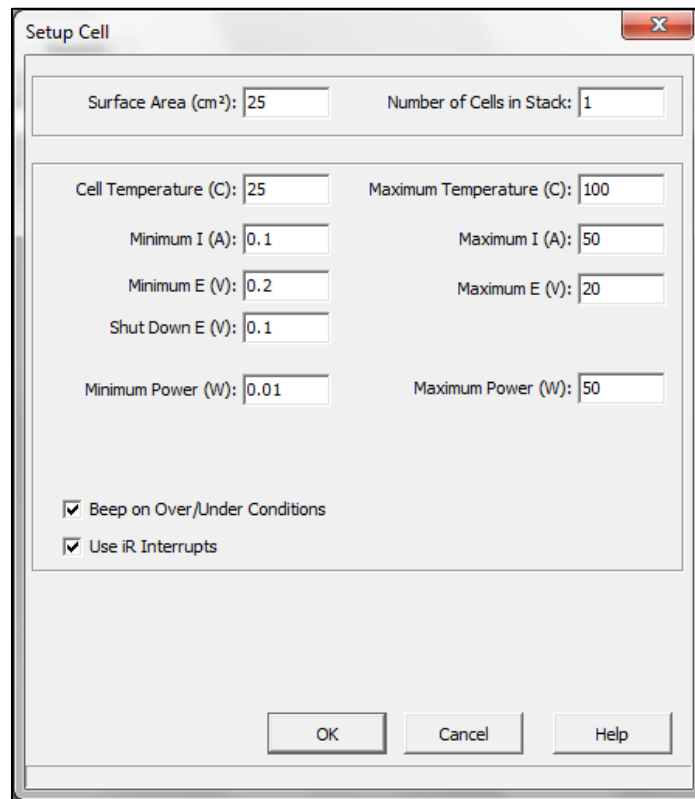


Figure 1. Setup Cell Menu

3. Next, the “Setup Fuel” Window will open.
 - Set the Anode and Cathode Minimum Flows to the desired value, *e.g.*, 0.2 L/min
 - Set the Anode and Cathode Humidifier Temperature to 25 °C

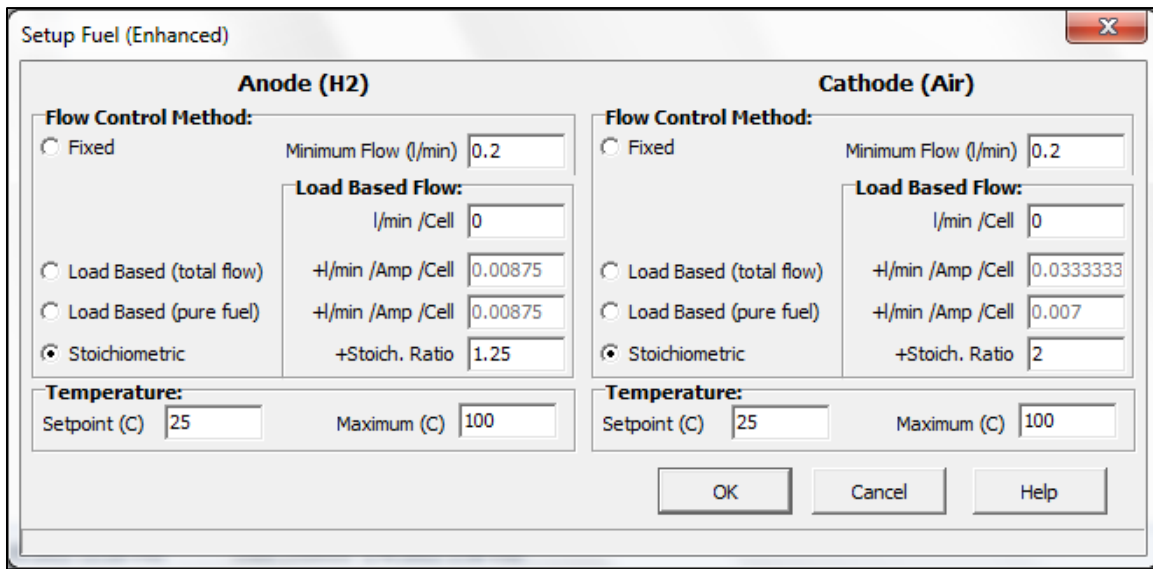


Figure 2. Setup Fuel Menu

4. From the main FuelCell window
 - Make sure the fuel is OFF (Apply Fuel button is blue)
 - With the Fuel turned off, the system will flow N₂ purge gas at the minimum flow rate set above.
 - Make sure the Temperatures are OFF (Apply All Temps button is blue)

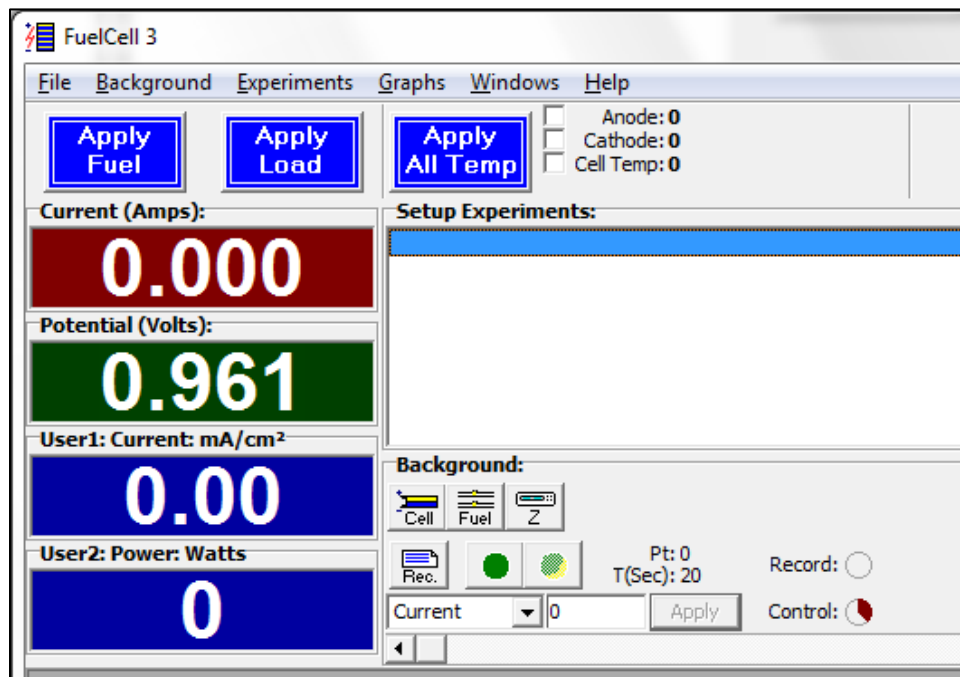


Figure 3. Main FuelCell window.

5. Purge the system for at least 15 minutes before proceeding

- Shorter purge times can be used with high purge flow rates, *e.g.*, 1.0 L/min for 5 minutes
 - **WARNING:** Insufficient purging of the test system and fuel cell prior to starting fuel flow can lead to hazardous conditions by introducing a mix of H₂ and oxygen (O₂ from air) into the fuel cell. This mix of potentially highly combustible fuel and oxidant in the presence of a catalyst (*i.e.*, platinum) can lead to spontaneous combustion and a fire hazard.
6. After sufficient purging, proceed with testing.

Shut-Down Procedure

1. Turn load OFF
2. Turn Temperature OFF
3. Turn Fuel OFF
 - This starts purging the fuel cell and fuel cell test system with N₂ purge gas
4. Set the anode and cathode minimum flow rate to 0.2 L/min
5. Purge the system for at least 15 minutes before proceeding
6. Set the anode and cathode flow rate to zero
7. Exit the FuelCell software
8. Turn fuel cell test system power OFF
9. Close all valves of the gas cylinders
10. Close anode and cathode valves of the test station

Reporting

The conditions under which a fuel cell is operated strongly impact its performance. As such, pertinent test parameters should be reported when presenting fuel cell performance data:

- Anode and cathode reactant composition
- Anode and cathode reactant moisture content (*i.e.*, relative humidity or temperature of humidifier)
- Anode and cathode reactant stoichiometry (based on consumption rate at 1 A/cm²)
- Cell temperature
- Anode and cathode pressure