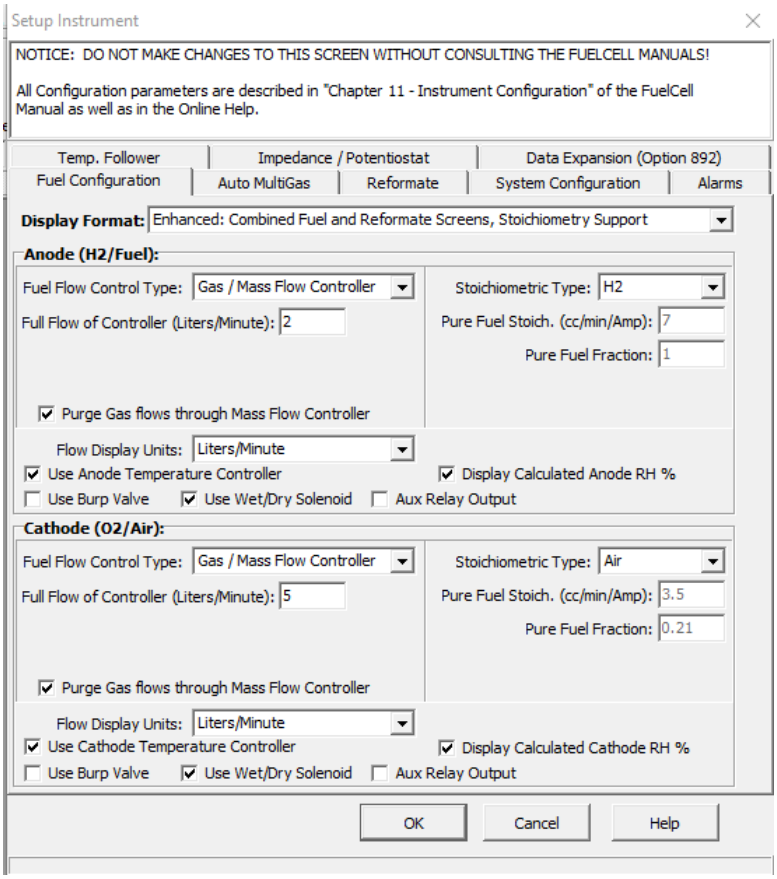
FuelCell Addendum – Enhanced Fuel and Stoichiometric Flow Control

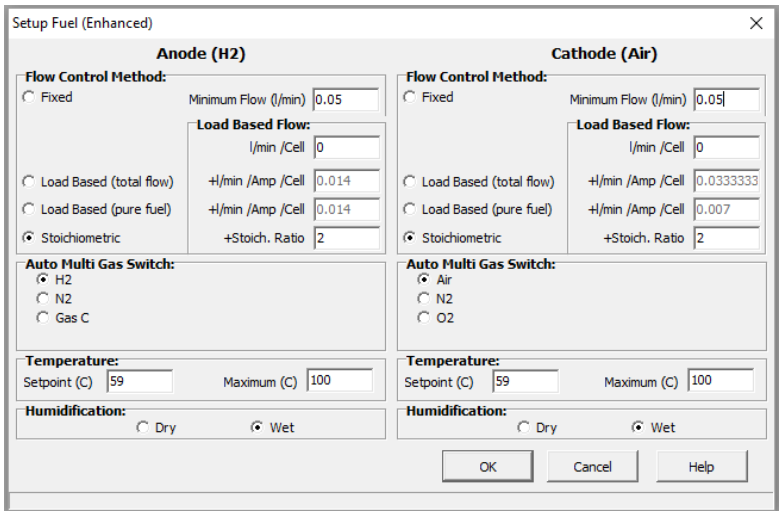
Q: Can I setup my Scribner fuel cell test system (850/855/890) and FuelCell software for stoichiometric flow control of my fuel cell?

A: Yes. To do this, enable the Enhanced Fuel menu in the FuelCell software. Select File | Instrument Configuration and enter the 850/855/890 serial number (found on serial plate on back of the unit). On the Fuel Configuration tab set the Display Format: "Enhanced: Combined Fuel and Reformate Screens, Stoichiometry Support".



Set the anode and cathode gases types, usually H2 and Air (or O2). Selecting the correct gas type is important because the software needs to know the correct fraction of reactant in the gas (i.e., 21% O2 in air). Select OK and Save. Re-start the software to enable the changes.

Now the Setup Fuel window will show load and stoichiometric-based flow rate control.



By setting the Fixed Minimum Flow, Load Based Minimum Flow, and Stoichiometric values appropriately you will be able to achieve the desired stoichiometries at the different current densities. The FuelCell software manual describes in detail how these three parameters relate to one another and cell current.

Flow Control Methods:
When **Fixed** is selected, a constant flow rate is applied. The gas flow rate is independent of current.

Load Based (total flow) controls the total flow of gasses. The applied flow is the sum of a minimum amount (L/min/Cell × No. Cells) plus a load-dependent amount (L/min/Amp/Cell × Current (A) × No. Cells), where "No. Cells" is the number of cells in the stack and defined in the Setup Cell menu (see section 5.3.3). The **Load Based (pure fuel)** and **Stoichiometric** values are calculated from the entered total flow value.

Load Based (pure fuel) controls the flow of the fuel component. The **Total Flow** value will be larger than the **Pure Fuel** flow, based on the fuel content of the gas. The **Load Based (total flow)** and **Stoichiometric** values are calculated from the entered **Pure Fuel** flow.

Stoichiometric is the multiple of the theoretical flow required for full consumption of the pure fuel. The theoretical flow required is the Stoichiometic Factor and depends on the reactant. For H_2, the Stoichiometric Factor = 0.007 standard L/min for 1 A current. For O2, the Stoichiometric Factor = 0.0035 standard L/min for 1 A current. For that cathode settings shown above, using a Stoichiometric Ratio = 2x, the **Pure Fuel** flow is 0.007 L/min/Amp/Cell. Because air is 21% O_2, the **Load Based** total flow of air is 0.007 / 0.21 = 0.0333 L/min/Amp/Cell.

For Stoichiometric Load Based Flow, the flow rate is calculated as:

$$Y\left(\frac{L}{min}\right) = \left[Min.Flow\left(\frac{L}{min \cdot Cell}\right) + Stoich.Ratio \times Stoich.Factor\left(\frac{L}{min \cdot A \cdot Cell}\right) \times Current\ (A)\right] \times No.Cells$$

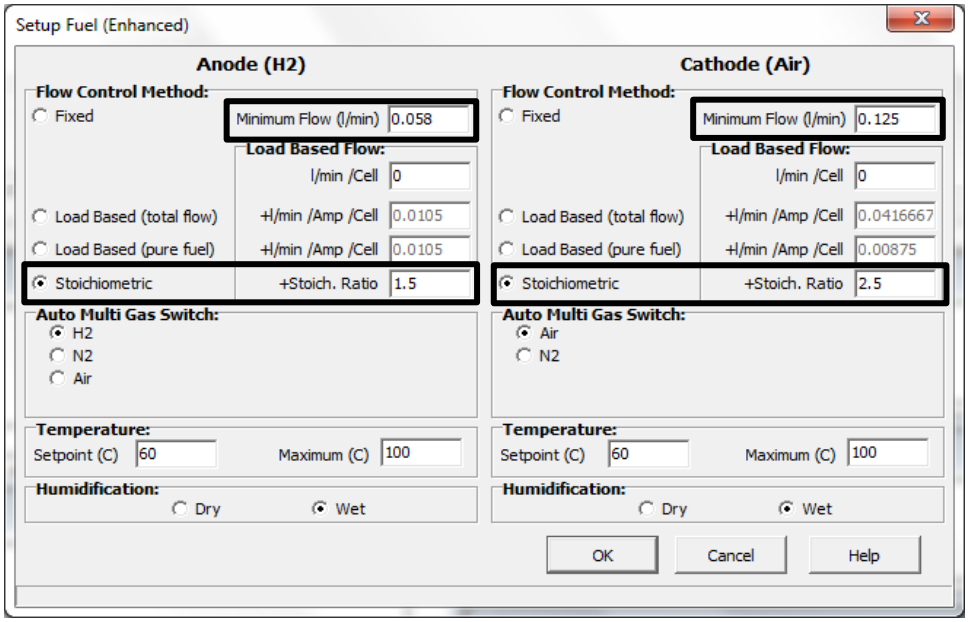
$$If\ Y > Minimum\ Flow, than\ Apply\ Y$$

$$If\ Y < Minimum\ Flow, than\ Apply\ Minimum\ Flow$$

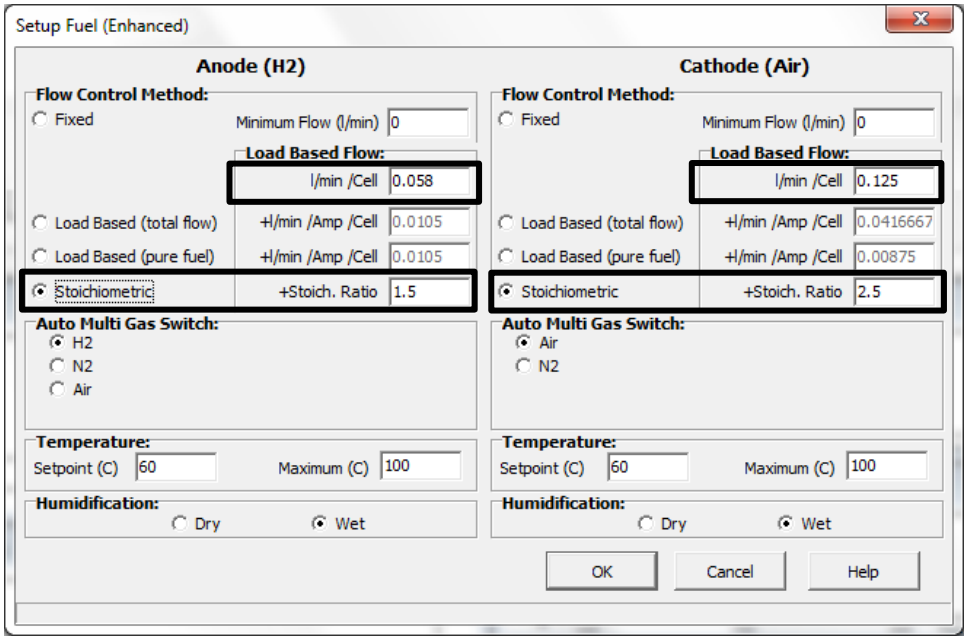
When using the Fixed Minimum Flow Rate, the flow rate is constant until the current is sufficient that the flow rate must increase to maintain the desired stoichiometry. Thus, the correct stoichiometry is applied for all currents where the required flow rate exceeds the minimum flow rate.

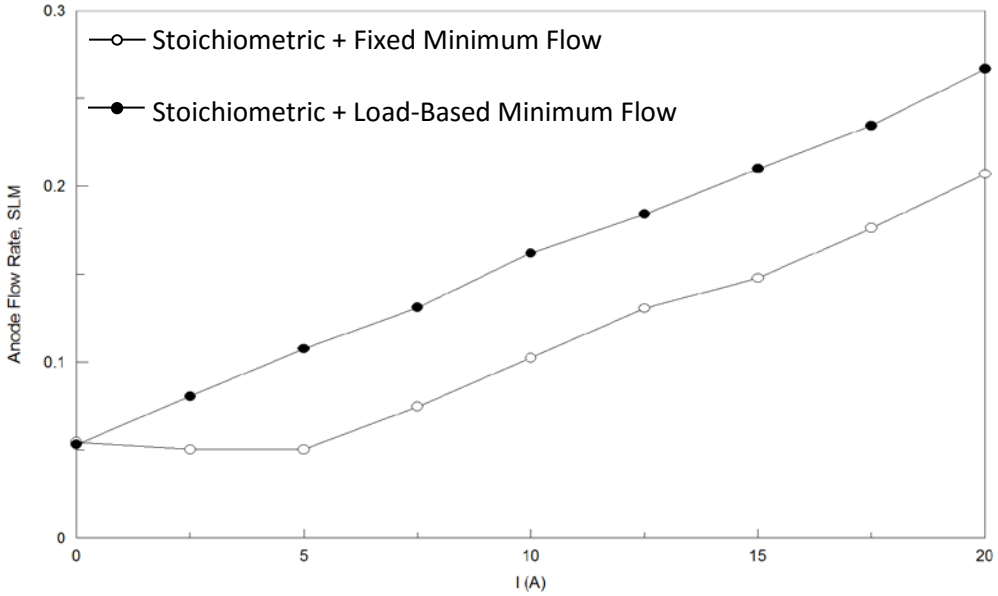
In contrast, when using the Load-Based Minimum Flow Rate, the total flow rate is this minimum value plus additional flow based on the load. So the actual flow rate always exceeds that required to obtain the desired stoichiometry, with the actual stoichiometry approaching the desired value with increasing current production.

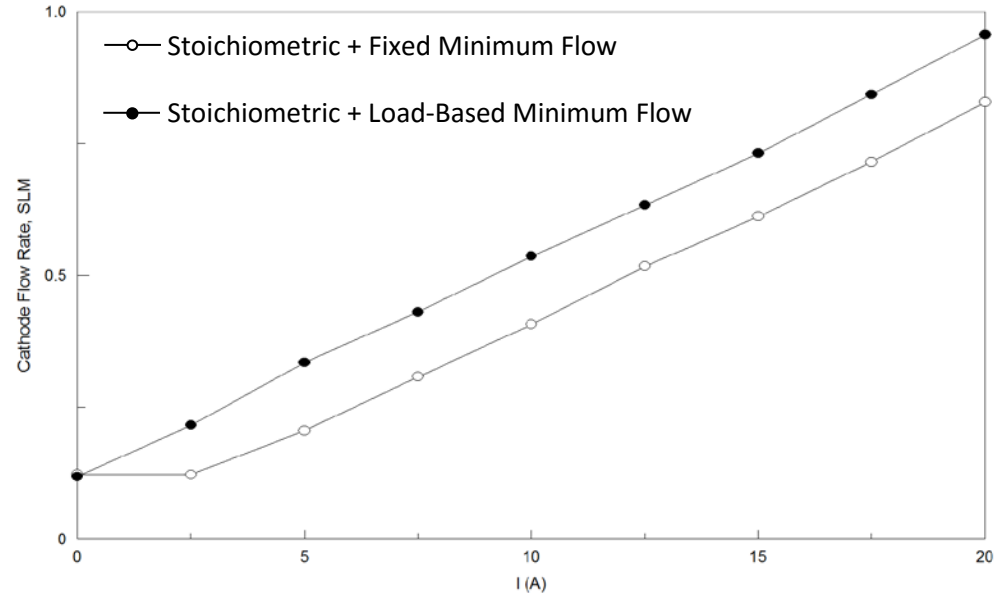
Stoichiometric-based flow rate control with a Fixed Minimum Flow:

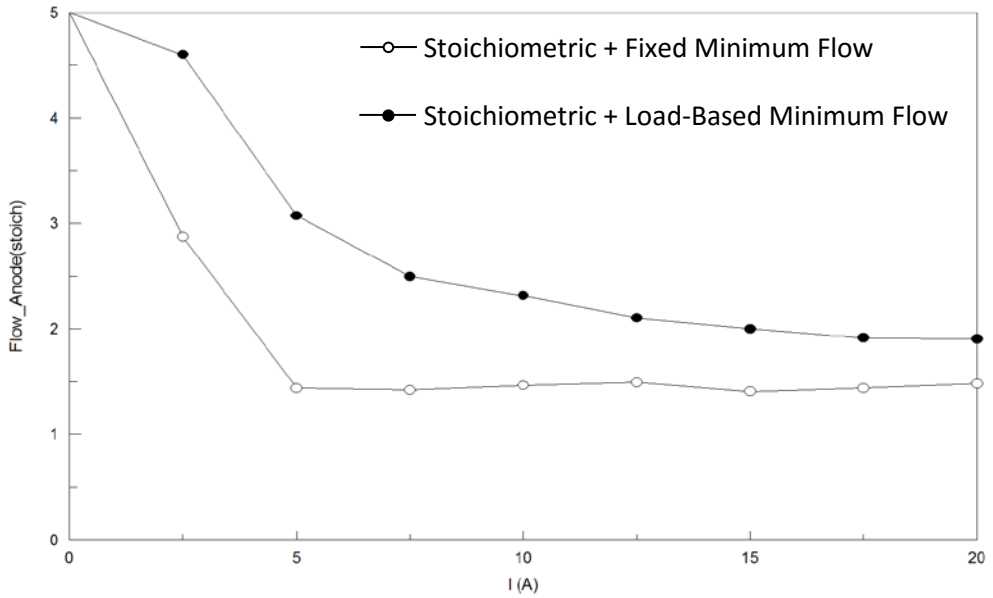


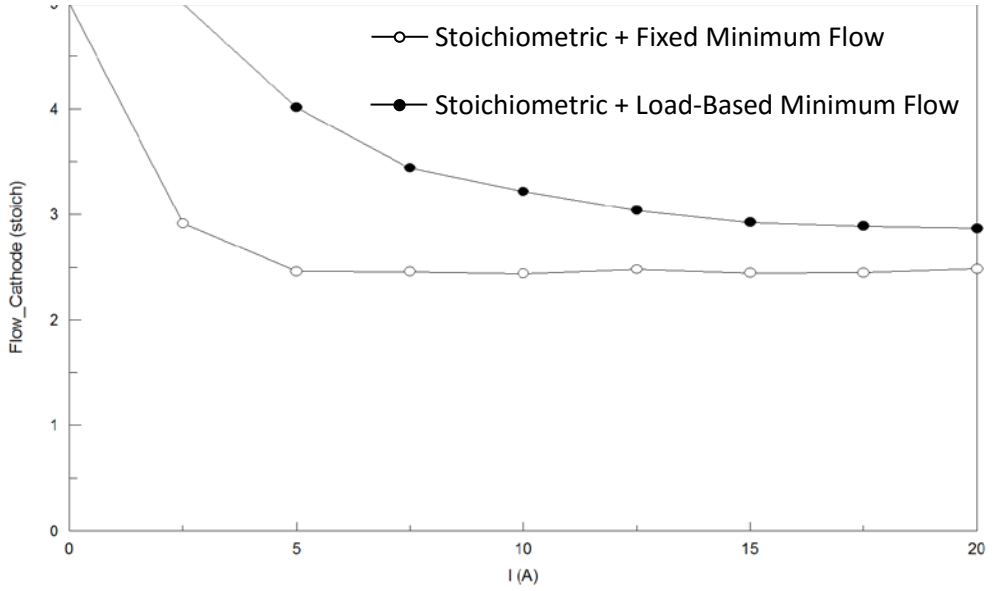
Stoichiometric-based flow rate control with a Load-Based Minimum Flow:


Setup Fuel (Enhanced)
Anode (H2)
Flow Control Method:
Fixed
Minimum Flow (l/min) 0
Load Based Flow:
l/min /Cell 0.058
Load Based (total flow)
+l/min /Amp /Cell 0.0105
Load Based (pure fuel)
+l/min /Amp /Cell 0.0105
Stoichiometric
+Stoich. Ratio 1.5
Auto Multi Gas Switch:
H2
N2
Air
Temperature:
Setpoint (C) 60
Maximum (C) 100
Humidification:
Dry
Wet
Cathode (Air)
Flow Control Method:
Fixed
Minimum Flow (l/min) 0
Load Based Flow:
l/min /Cell 0.125
Load Based (total flow)
+l/min /Amp /Cell 0.0416667
Load Based (pure fuel)
+l/min /Amp /Cell 0.00875
Stoichiometric
+Stoich. Ratio 2.5
Auto Multi Gas Switch:
Air
N2
Temperature:
Setpoint (C) 60
Maximum (C) 100
Humidification:
Dry
Wet
OK
Cancel
Help


Stoichiometric + Fixed Minimum Flow
Stoichiometric + Load-Based Minimum Flow
Anode Flow Rate, SLM
0.3
0.2
0.1
0
0
5
10
15
20
I (A)


Stoichiometric + Fixed Minimum Flow
Stoichiometric + Load-Based Minimum Flow
Cathode Flow Rate, SLM
1.0
0.5
0
0
5
10
15
20
I (A)


Stoichiometric + Fixed Minimum Flow
Stoichiometric + Load-Based Minimum Flow
Flow_Anode(stoich)
I (A)
0
1
2
3
4
5
0
5
10
15
20


Stoichiometric + Fixed Minimum Flow
Stoichiometric + Load-Based Minimum Flow
Flow_Cathode (stoich)
I (A)
0
1
2
3
4
0
5
10
15
20