Temperature and RH Targets

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Technical Targets: Membranes

Characteristic	Units	Calendar year		
		2004 Status	2005	2010
Membrane Conductivity at inlet water vapor partial pressure and				
Operating Temperature (Max. ?)	S/cm	0.1	0.1	0.1
Room Temperature (25°C ?)	S/cm	0.07	0.07	0.07
-20°C	S/cm	0.01	0.01	0.01
Operating Temperature	°C	≤ 80	≤ 120	≤ 120
Inlet water vapor partial pressure	kPa	50	25	1.5

50%RH at 25°C
0.8%RH at 120°C

Fuel Cell Technologies Roadmap, Aug. 10, 2005.

http://www.uscar.org/consortia&teams/techteamhomepages/FC.htm

High Temperature, Low Relative Humidity Membrane Program Goals

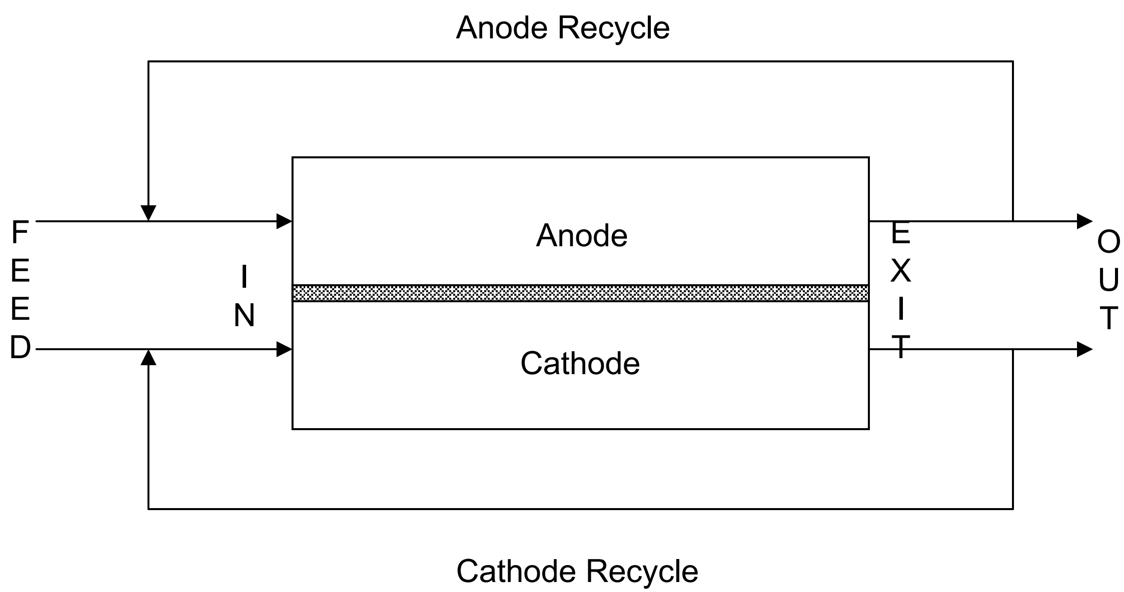
Milestone	Temperature	Relative Humidity	Conductivity (S/cm)
3Q Year 2	Room Temperature	80%	0.07
3Q Year 3 – Go/No-Go Decision Point	120°C	N/A	0.1

$K_{membrane}$ = f(Tcell, RH)
0.07 = f(25°C, 80%)
0.1 = f(120°C, ??RH) → RH Unknown

RH = f(Cell/Stack operating conditions)
$RH_{FuelCell}$ = f(T_{cell}, $P_{H2O,in}$, P_{cell}, Stoichiometry, Internal Humidification, ..)

➡ **Membrane testing conditions - What is the RH ??**

Water Balance Model



FEED – External input to cell/stack

IN – Internal input to cell

EXIT – Output from the cell

OUT – External output streams from the cell

<u>Assumptions</u>

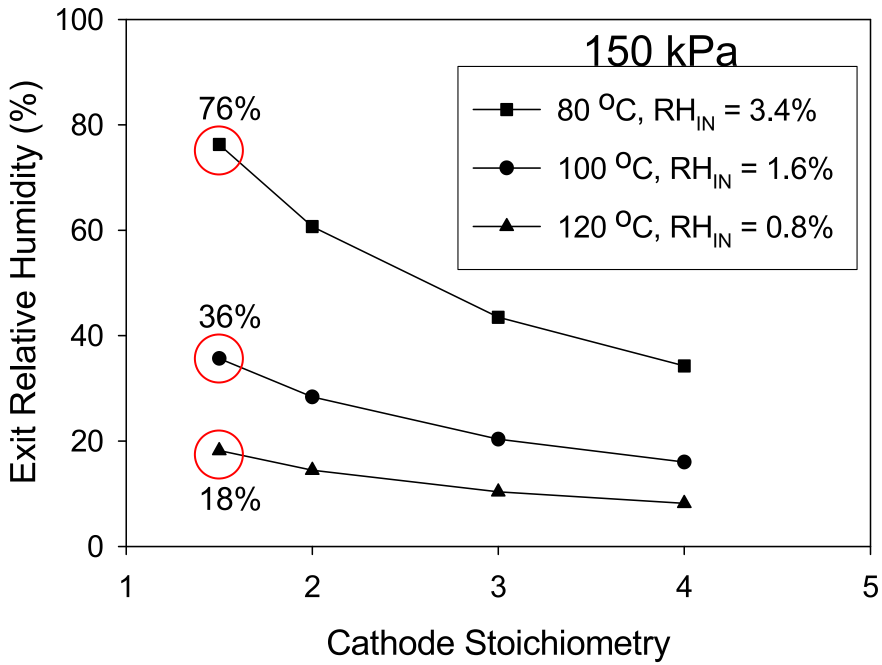
- Anode OUT RH =Cathode OUT RH
- $P_{H2O,FEED}$ = 1.5 kPa
- Stoichiometric flow (Results independent of current density)
- With recycle the reactant stoichiometry is fixed at IN streams

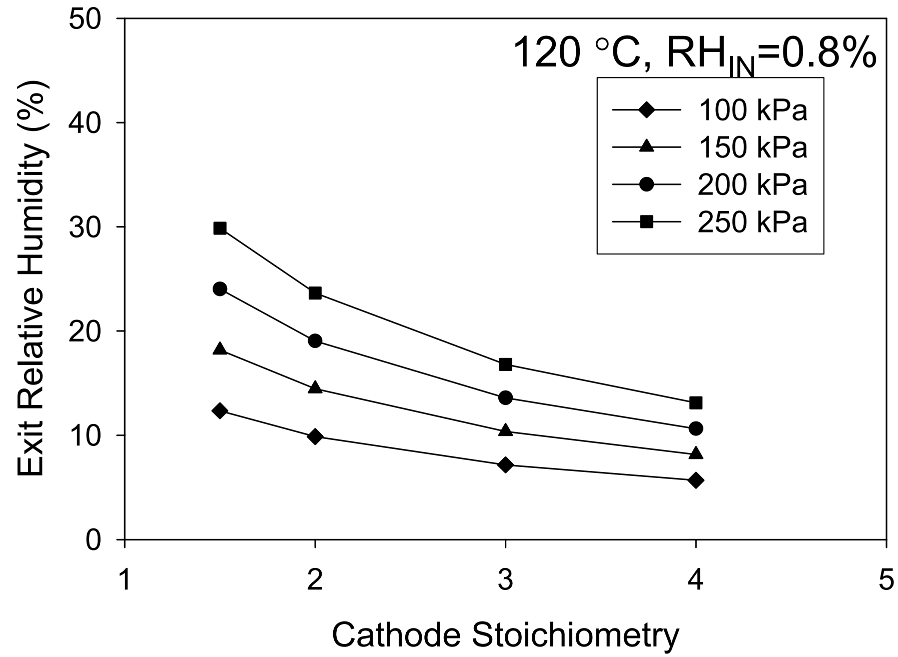
<u>Variables</u>

- Operating Temperature
- Operating Pressure
- Reactant Stoichiometry
- Recycle

Effect of Temperature and Pressure (No Recycle)

H_2/Air, H_2 stoic = 1.3, No Recycle, $P_{H2O,FEED}$ = 1.5 kPa





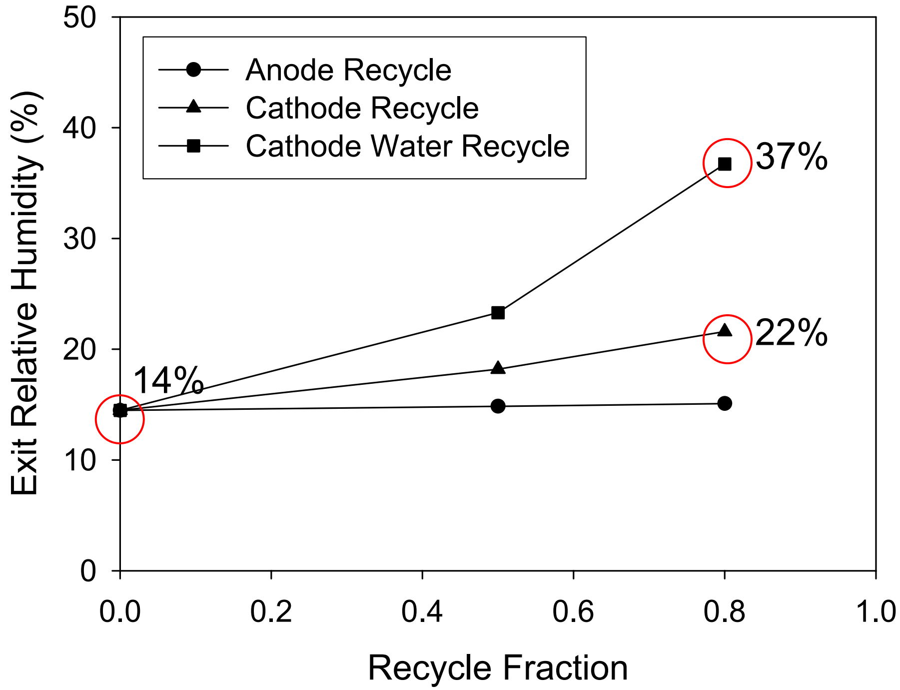
IN RH = f($P_{H2O,FEED}$, Cell temperature)

EXIT RH = f(IN RH, Pressure, Stoichiometry)

* In an *ex-situ* conductivity measuring cell the EXIT RH is independent of Pressure and Stoichiometry

Stack Internal Humidification (With Recycle)

120°C, 150 kPa, H_2 stoic = 1.3, Air stoic = 2, $P_{H2O,FEED}$ = 1.5 kPa

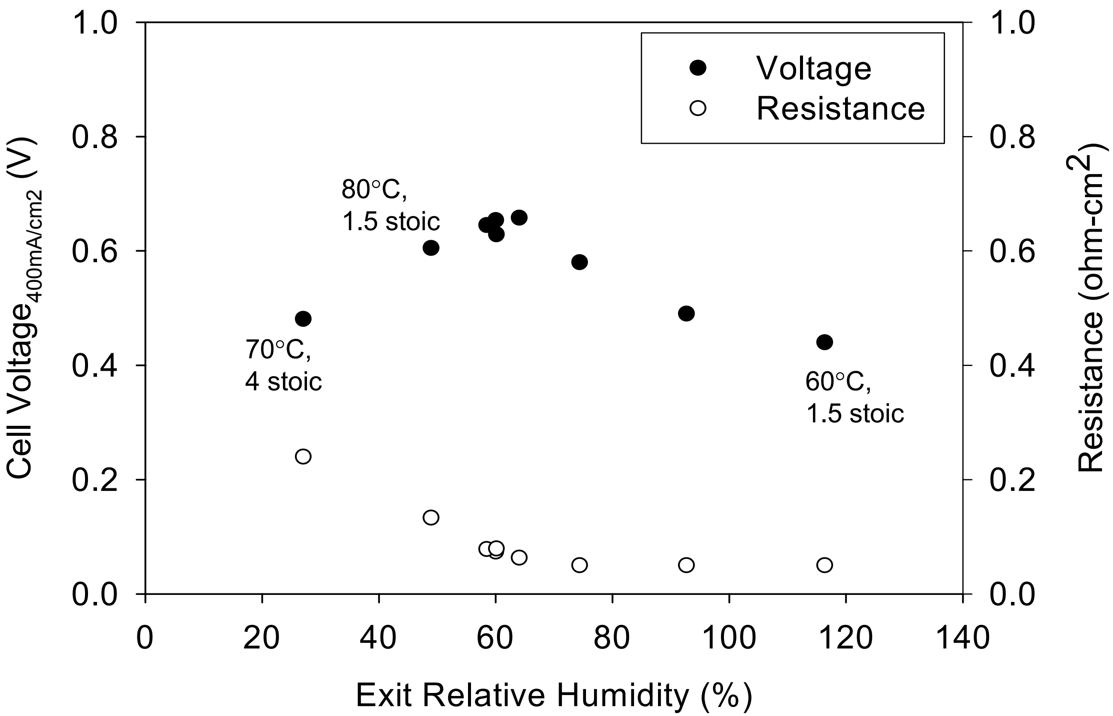


- ✦ Water generated in the fuel cell can be recycled to increase the RH
- ✦ Cathode recycle will deplete the oxygen partial pressure
- ✦ Water in the cathode exit stream can be separated from air by using a condenser/membrane
- ✦ 80% cathode water recycle increases the Exit RH to 37% compared to 14% RH with no recycle

* Recycle Fraction – Fraction of EXIT stream that is recycled

Effect of Operating Conditions on Conductivity and Performance

Cell temperature range = 60-80°C, Pcell =100 kPa, **No external humidification**, H_2 stoic =1.3, Air stoic range = 1.5-4, Active Area = 5cm^2



- ✦ Variation in resistance ~ Factor of five
- ✦ In the range of temperatures and stoichiometry tested the Exit RH varies between 27% -116%
- ✦ At low temperatures (<80°C) with appropriate stoichiometry reasonable performance can be obtained from the cell with no external humidification
- ✦ Performance loss due to flooding and ohmic loss

* Exit RH calculated using the water balance model on Slide 4

M. V. Williams et al. Journal of Power Sources 135 (2004) 122-134

Summary

- The RH in an operating fuel cell is dependent upon the operating conditions (Temperature, Pressure, Inlet water vapor partial pressure, Stoichiometry) and stack design (Recycle)
- Range of conditions need to be specified at which the membrane could be tested to measure the conductivity
- The specified RH should be the effective RH to which the membrane is exposed during testing