

Objective and Scope

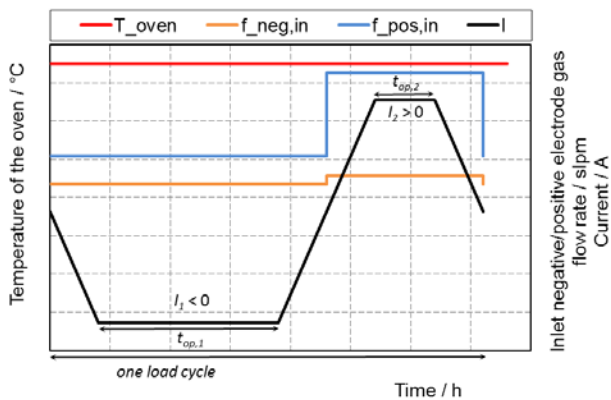
This test module deals with solid oxide cell (SOC) operation either as a fuel cell (SOFC) or an electrolyser (SOEC) under varying current under galvanostatic conditions to determine performance at relevant (intermittent) load profiles. It is a general characterization method that can be used in SOC R&D and for quality assurance.

Main Test Input Parameters (TIPs)

| Static TIPs | Variable TIPs |
|---|---|
| Temperature of the oven (T_{oven}) | Flow rates of inlet gases (f_{in}) |
| Rate of change of current ($\Delta I/\Delta t$) | Current (I) |
| Operating time at the plateau d ($t_{op,d}$) | Composition of inlet gases ($x_{i,in}$) |
| Number of cycles and plateaus (m and d) | |

Test Procedure

- Increase current from zero (open circuit voltage) to 1st plateau value of the current at its specified rate of change.
- Wait for $t_{op,1}$ to elapse and continuously record all TIPs & TOPs at their specified sampling rates, e.g. 1 Hz.
- Continue the current change/current holding until the d^{th} plateau for $t_{op,d}$ to finish one cycle. Repeat until the number m of cycles is exhausted upon which the current is lowered to zero at its specified rate of change.
- The test can be interrupted or terminated when operational abnormalities (such as unexpected temperature evolution, signal instabilities) are observed or certain predefined cut-off criteria are fulfilled (threshold values on voltage, temperature or degradation rate).



General evolution of TIPs during TM13 in combined SOFC/SOEC operation for instance

Critical Parameters and Parameter Controls

- Stability of T_{stack} and f_{in} at each load cycle plateau.
- Voltage measurement as a function of time has to be sufficiently clean to allow degradation rate determination during long-term

operation. In SOEC mode special attention has to be paid to a stable steam supply to minimize voltage fluctuations.

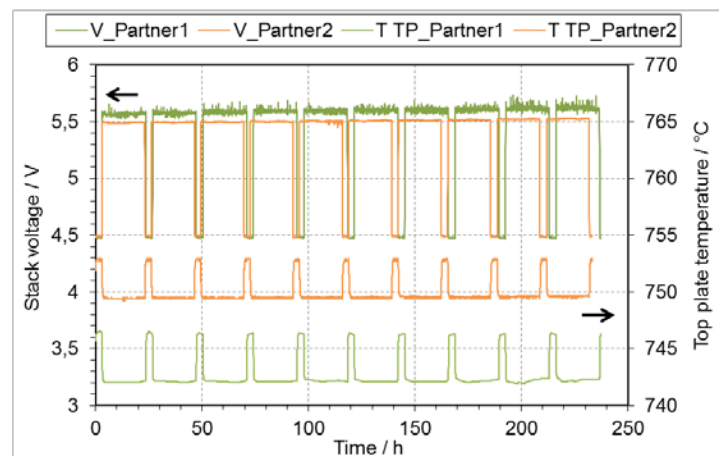
- It is important to avoid pollution from inlet gases and the test bench itself, since it has a strong influence on the degradation.

Main Test Output Parameters (TOPs) and Derived Quantities

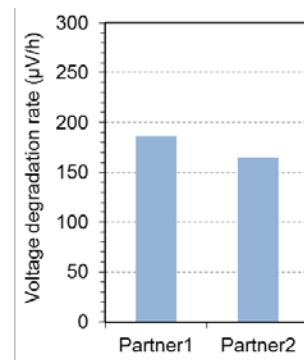
| TOPs | Derived Quantities |
|--|---|
| Voltage of cell/RU/stack (V) | Current density (j) |
| Flow rates of outlet gases (f_{out}) | Gas utilization (U_{gas}) |
| Temperature of gas streams at cell/stack inlet/outlet, temperature of cell/stack (T) | Degradation rate of cell/RU/stack voltage ($\Delta V/\Delta t$) |
| Composition of outlet gases ($x_{i,out}$) | Average temperature (T_{av}) |

Data Post Processing and Representation

Data representation examples under variable load in SOEC mode:



Evolution of SOEC stack voltage (V) and temperature of stack top plate (T_{TP}) for load cycling between 0 and -0.3 A cm^2



Calculated voltage degradation rates of two stacks of different testing partners