



# Test Module 13

## Operation under Varying Current

(Version 3.5, 02 June 2017)



### Objective and Scope

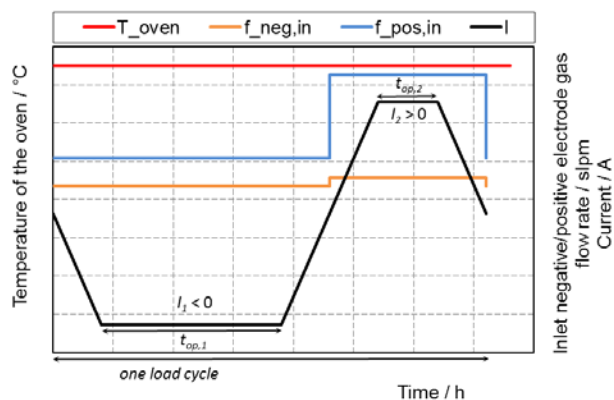
This test module deals with solid oxide cell (SOC) operation either as a fuel cell (SOFC) or an electrolyser (SOEC) under varying current under galvanostatic conditions to determine performance at relevant (intermittent) load profiles. It is a general characterization method that can be used in SOC R&D 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 1<sup>st</sup> 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  $d^{\text{th}}$  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.

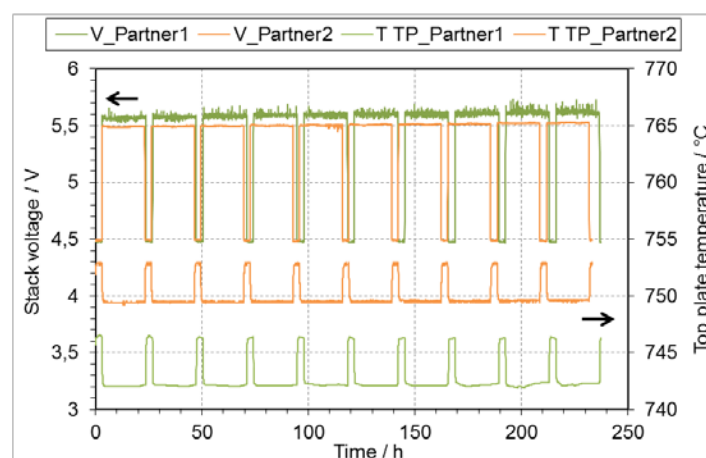
- It is important to avoid pollution from inlet gases and the test bench itself, since it has a strong influence on the degradation.

### Main Test Output Parameters (TOPs) and Derived Quantities

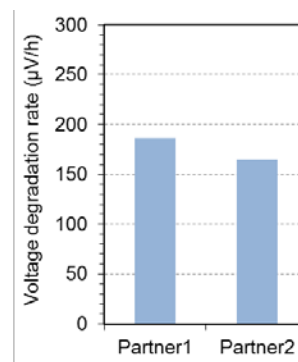
TOPs	Derived Quantities
Voltage of cell/RU/stack ( $V$ )	Current density ( $j$ )
Flow rates of outlet gases ( $f_{out}$ )	Gas utilization ( $U_{gas}$ )
Temperature of gas streams at cell/stack inlet/outlet, temperature of cell/stack ( $T$ )	Degradation rate of cell/RU/stack voltage ( $\Delta V/\Delta t$ )
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  $-0.3 \text{ A cm}^2$



Calculated voltage degradation rates of two stacks of different testing partners

SOCTESQA:

Solid Oxide Cell and Stack Testing, Safety and Quality Assurance

Project website: [www.soctesqa.eu](http://www.soctesqa.eu)

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