Test Module 14
Thermal Cycling

(Version 2.6, 06 June 2017)

Objective and Scope

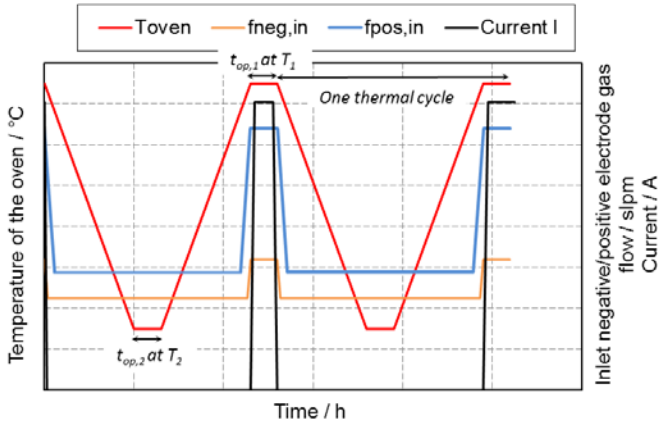
This test module deals with thermal cycling of solid oxide cell (SOC) either as a fuel cell (SOFC) or an electrolyser (SOEC), composed of several start-up/shut-down occurring for the overall SOC lifetime. It is a general characterization method that can be used in SOC R&D and for quality assurance.

Main Test Input Parameters (TIPs)

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

Test Procedure

- Decrease temperature from the operating one under way to d plateau value at its specified rate of change.
- Wait for $t_{op,d}$ to elapse and continuously record all TIPs & TOPs at their specified sampling rates, e.g. 1 Hz.
- Continue with the next d+1 plateau value until the number m of cycles is exhausted.
- Operating periods and/or electrochemical measurements (j-V curve and EIS) can be usefully performed between each cycle.
- 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 TM14 when temperature drops below 600°C with gas and current changes for instance

Critical Parameters and Parameter Controls

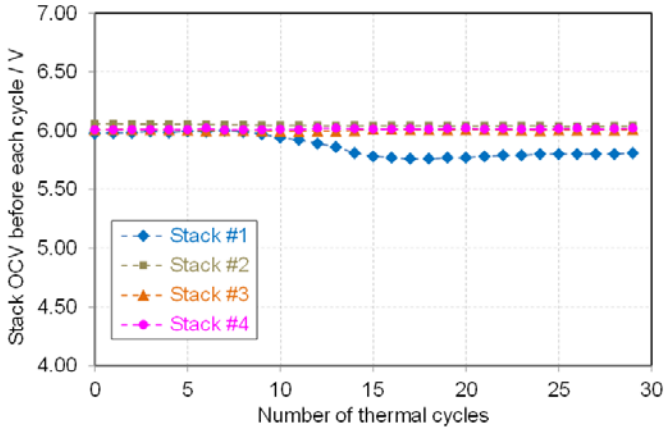
- The furnace thermal inertia very often limits the rate of the cooling down process which is then often lower than the heating up rate.
- When the lowest temperature is below 600°C, H_2 fraction at the negative electrode has to be kept below 4% to avoid explosive atmosphere.

Main Test Output Parameters (TOPs) and Derived Quantities

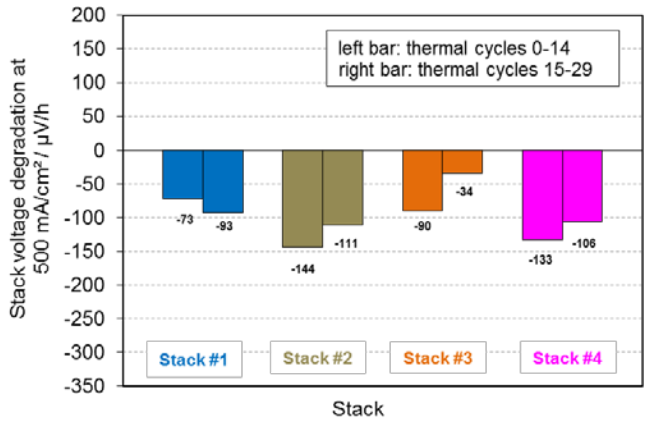
TOPs	Derived Quantities
Voltage of cell/RU/stack (V)	Current density (j)
Flow rates of outlet gases (f_{out})	Gas utilization (U_{gas})
Temperature of gas streams at cell/stack inlet/outlet, temperature of cell/stack (T)	Degradation rate of cell/RU/stack voltage ($\Delta V/\Delta t$)
Composition of outlet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

Data Post Processing and Representation

Data representation examples under thermal cycling:



Evolution of stack OCV with cycle number



Calculated stack voltage degradation rates at 0.5 A cm² (SOFC mode) during thermal cycling

SOCTESQA:
Solid Oxide Cell and Stack Testing, Safety and Quality Assurance
Project website: www.soctesqa.eu

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) for the Fuel Cells and Hydrogen Joint Technology Initiative under grant agreement n° 621245.