Test Module 12
# Operation under Constant Current

Objective and Scope

This test module deals with solid oxide cell (SOC) operation under constant current either as a fuel cell (SOFC) or as an electrolyser (SOEC). The aim is to establish a widely accepted method for performing a long-term steady-state endurance test. A calculation method of the SOC degradation rate is also recommended from the continuously recorded SOC voltages as a function of time. Together with data obtained from other test modules (TM03 "*Current-voltage characteristics*" and TM04 "*Electrochemical impedance spectroscopy*") performed before and after the long-term steady-state operation, a comprehensive representation of the degradation behaviour of SOC can be achieved.

Main Test Input Parameters (TIPs)

Static TIPs	Variable TIPs
Current (I)	(None)
Flow rates of inlet gases (f_{in})	
Composition of inlet gases ($x_{i,\,in}$)	
Pressure of outlet gases (p_{out})	
Temperature of the oven (T_{oven})	

Test Procedure

- Set the operating conditions according to the predefined operating point and check the stability of static TIPs.
- Let operation last for a predefined duration t_{op}. Record all relevant TIPs and TOPs during the operation.
- 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).
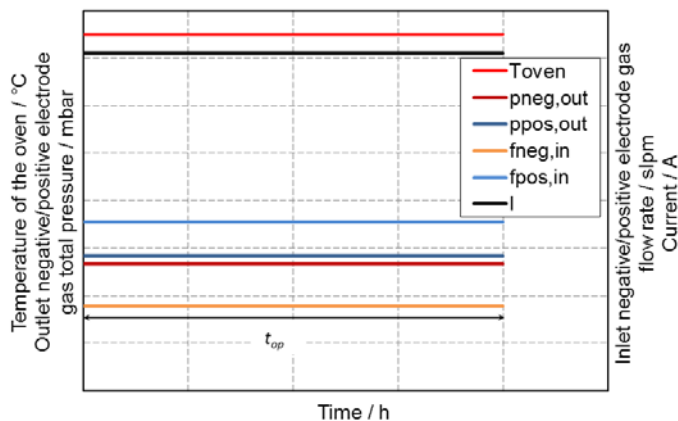
General evolution of TIPs during TM12

Critical Parameters and Parameter Controls

- Particular attention has to be paid to the stability of the operating conditions (temperature, pressure, gas flows and current).
- 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 supply of steam to minimize voltage fluctuation.

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

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

Data Post Processing and Representation

Examples of data representation in SOEC mode during TM12:
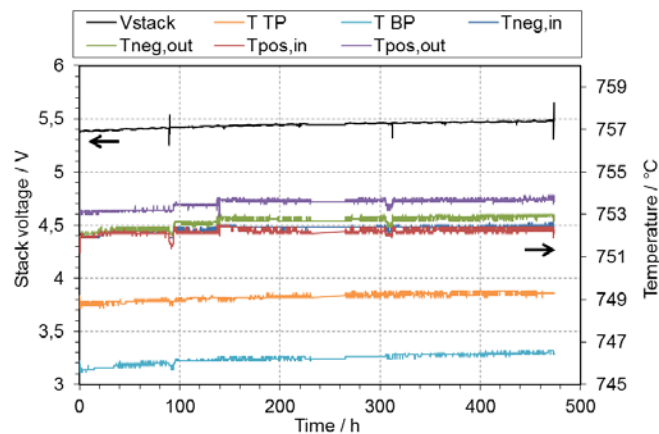
Evolution of stack voltage and temperatures with time for a steady-state operation at a constant current density of -0.3 A cm^{-2}
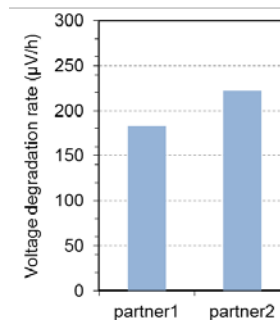
Calculated voltage degradation rates between two test partners