



Solid Oxide Cell and Stack Testing, Safety and Quality Assurance

Collaborative Project - FCH JU GRANT AGREEMENT N° 621245

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DELIVERABLE REPORT

D.2.2 – LIST OF SOC TEST PROCEDURES

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NATURE OF THE DELIVERABLE

R	<i>Report</i>	X
P	<i>Prototype</i>	
D	<i>Demonstrator</i>	
O	<i>Other</i>	

SUMMARY	
Keywords	<i>SOFC, SOEC, terminology, definitions, test module</i>
Abstract	The objective of this deliverable is to survey and compile the available procedures for SOFC & SOEC testing and to specify the important terms, definitions and nomenclatures.

REVISIONS			
Version	Date	Changed by	Comments
0.1	September 19 th , 2014	T. Malkow (JRC)	First draft
0.2	September 26 th , 2014	M. Lang, C. Auer (DLR)	Second draft
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D.2.2 – LIST OF SOC TEST PROCEDURES

1 Introduction

This deliverable surveys and compiles a list of existent SOC test procedures for single cells and stacks especially those from previous projects, e.g. FCTESTNET, FCTESQA, METSOFC, REALSOFC600, and RELHY, and on-going FCH JU projects (ADEL, METSAPP, SCOTAS-SOFC, SOFC-LIFE, STACK-TEST) being public. In addition, the open literature is surveyed whether to include procedures exterior to the mentioned projects while being public. On this basis the important terms, definitions, nomenclatures and abbreviations will be specified. The most relevant test procedures will form the base for the harmonized test modules to be worked out in WP 3.

2 Documents used for this survey

The following tables contain the documents that were investigated for SOC terminology and test modules.

2.1 Documents containing definitions / terminology

Table 1: Documents containing definitions / terminology

Project	Document Title	Source	Publication Date
FCTES ^{QA}	Single Cell Performance and Endurance Test Modules	http://iet.jrc.ec.europa.eu/fuel-cells/sites/fuel-cells/files/files/documents/SOFC_SC_Performance_Endurance.pdf	2010
FCTESTNET	WP2 Stationary Fuel Cell Systems: Test Programs and Test Modules	Project document (FCTESTNET closed)	June 2006
FCTESTNET	Terminology Document	Project document (FCTESTNET closed)	June 2006
FCTESTNET	Glossary	Edited by Wolfgang Winkler et.al. (VDI/Hamburg University Applied Sciences -WP8) with contributions of the FCTESTNET members	January 2005
International	IEC 62282-7-2: Single	Final version to be published by the	2010

Electro-technical Commission: IEC TC 105	cell and stack test methods –Single cell and stack performance tests for solid oxide fuel cells (SOFC)	International Electrotechnical Commission (IEC) under http://webstore.iec.ch	
IEC TC 105	IEC 62282-1 TS: Fuel Cell technologies Part 1: Terminology	http://webstore.iec.ch	May 2013
STACKTEST	Master Document	http://stacktest.zsw-bw.de/downloads	2014
JIS C 8841-1	Small Solid Oxide Fuel Cell Systems– Part 1: General Rules	Japanese Standards Association Solid Oxide Fuel Cells	March 2011
JIS C 8842	Single cell and stack performance test methods for solid oxide fuel cells Adopted from IEC 62282-7-2	Japanese Standards Association Solid Oxide Fuel Cells	December 2013
Plan No. 20132465-T-604	Single cell/stack performance test methods for solid oxide fuel cells (SOFC). Adaptation from IEC 622282-7-2	China Fuel Cell Standards	Scheduled for completion by the end of 2015

2.2 Documents containing test modules

Table 2: Documents containing test modules

Project / Institution	Document Title	Source	Publication Date
FCTES ^{QA}	Single Cell Performance and Endurance Test Modules	http://iet.jrc.ec.europa.eu/fuel-cells/sites/fuel-cells/files/files/documents/SOF C_SC_Performance_Endurance.pdf	April 2010

FCTES ^{QA}	SOFC Stack Performance and Endurance Test Modules	http://iet.jrc.ec.europa.eu/fuel-cells/sites/fuel-cells/files/files/documents/SOFC_Stack_Performance_Endurance.pdf	April 2010
FCTES ^{QA}	Testing the voltage and power as function of current density (Single Cells)	http://iet.jrc.ec.europa.eu/fuel-cells/sites/fuel-cells/files/files/documents/SOFC_SC_polarisation_curve.pdf	April 2010
FCTES ^{QA}	Testing the voltage and power as function of current density (SOFC Stack)	http://iet.jrc.ec.europa.eu/fuel-cells/sites/fuel-cells/files/files/documents/SOFC_Stack_polarisation_curve.pdf	April 2010
FCTESTNET	WP2 Stationary Fuel Cell Systems: Test Programs and Test Modules	Project document (FCTESTNET closed)	June 2006
IEC TC 105	IEC 62282-7-2: Single cell and stack test methods – Single cell and stack performance tests for solid oxide fuel cells (SOFC)	Final version to be published by the International Electrotechnical Commission (IEC) under http://webstore.iec.ch	2014
METSOFC	Final Report	http://www.metsofc.eu/Publications/Publications	June 2012
STACKTEST	Test Module Drafts WP2	http://stacktest.zsw-bw.de/downloads	April 2014
STACKTEST	Test Module Drafts WP3	http://stacktest.zsw-bw.de/downloads	April 2014
STACKTEST	Test Module Drafts WP4	http://stacktest.zsw-bw.de/downloads	April 2014
Testcenter for brint og brændselsceller	Delrapport DGC1: Accelerated lifetime testing and standardization of SOFC systems	http://www.dgc.dk/sites/default/files/filer/publikationer/R1212_lifetime_testing_sofc.pdf	July 2012
US Fuel Cell Council's SOFC Focus	Introduction to Solid Oxide Fuel Cell Button Cell Testing	http://www.members.fchea.org/core/import/PDFs/Technical%20Resources/SOFCFG-	July 2007

Group		ButtonCellTesting-07-015.pdf	
FZ Jülich	Quality Assurance and Solid Oxide Fuel Cell Testing at Forschungszentrum Juelich	Journal of Fuel Cell Science and Technology, Vol. 4 (2007)	2007
FZ Jülich	A review of standardising SOFC measurement and quality assurance at FZJ	Journal of Power Sources 171 (2007)	2007
JRC	The dynamics of the stationary fuel cell standardisation framework	Journal of Hydrogen Energy 36 (2011)	2011
JIS C 8841-2	Small Solid Oxide Fuel Cell Systems – Part 2: General Safety Codes and Safety Testing Methods. Output less than 10kW	Japanese Standards Association Solid Oxide Fuel Cells	March 2011
JIS C 8841-3	Small Solid Oxide Fuel Cell Systems – Part 3: Performance Testing Methods and Environmental Testing methods. Output less than 10kW.	Japanese Standards Association Solid Oxide Fuel Cells	March 2011
JIS C 8842	Single cell and stack performance test methods for solid oxide fuel cells Adopted from IEC 62282-7-2	Japanese Standards Association Solid Oxide Fuel Cells	December 2013
Plan No. 20132465-T-604	Single cell/stack performance test methods for solid oxide fuel cells (SOFC). Adaptation from IEC 622282-7-2	China Fuel Cell Standards	Scheduled for completion by the end of 2015

3 Definitions / Terminology

The following tables give an overview of SOC nomenclatures and definitions, sorted by their underlying projects and institutions.

3.1 Projects “FCTESTNET” and “FCTES^{QA}”

Table 3: FCTESTNET definitions / terminology

Document	Nomenclature
WP2 Stationary Fuel Cell Systems: Test Programs and Test Modules	Discharge water; Electric efficiency; Emission characteristics; Fuel cell combined heat and power system; Fuel cell power system; Heat recovery efficiency; Higher heating value (HHV); Lower heating value (LHV); Overall Energy Recovery Efficiency; Overall energy efficiency; Oxidant consumption; Parasitic load; Recovered heat; Test run; Uncertainty; Waste heat
Terminology Document	(fuel cell) module; (fuel cell) stack; acceptance test; accesible; activation; activation polarization; air; air bleed; air inlet, primary; alkaline fuel cell (AFC); ambient status; anode; appliance, cogeneration; area (cell); area (electrode); area (GDL); area (MEA); area, catalyst; auxiliary power unit (APU); availability factor; back pressure; background noise level; baffle; balance-of-plant (BOP); barrier layer; base load; biological inputs (biological conditions); biomass; bipolar plate; black start; blowdown; blower; boost regulator; burner; capacity factor; catalyst; catalyst coated membrane (CCM); catalyst layer; catalyst loading; cathode; cell; ceramic; cermet; channel (related to flow field); chemical conditions; climatic conditions; coal gas; co-firing; coflow; cogeneration; cold start; cold state; combustion; combustion chamber; combustion products; compression; compressor; condensate (condensation); conditioning facility; controls; convection; coolant; coolant heat; counter flow; cross flow; current collector; current density; dead end; delamination; desulfurizer; dew point (of a gas); dicretionary downtime; diffusion; direct fuel cell; direct internal reforming; direct methanol fuel cell (DMFC); discharge water; distributed generation; drain; durability inputs; efficiency; efficiency, electrical; efficiency, heat recovery; efficiency, thermal; effluent; ejector; electro farming; electrode; electrolyte; electrolyte leakage; electrolyte loss; electrolyte matrix; electrolyte migration; electrolyte reservoir; electroosmotic drag; end plate; energy (net, gross, electrical, thermal, total); energy management system (EMS); environmental conditions; equivalence ratio; excess air; exhaust air; exhaust gas; exhaust gas cooler; exhaust gas system; exhaust gas turbine generator; exhaust heat; exhaust steam; exhaust steam system; external manifolding; external reforming; failure modes and effects analysis (FMEA); fan; filling (level); filter; flat plate cells; flow field; flow resistance; flow through; forced

<p>derating hours; forced outage; forced outage rate; fuel; fuel cell; fuel cell electric vehicle (FCEV); fuel cell hybrid electric vehicle (FCHEV); fuel cell system; fuel processing system; fuel utilization; full load current; functional inputs; gas cleanup; gas crossover (fuel); gas diffusion electrode; gas diffusion layer, gas diffusion medium; gas leakage; gas seal; gas turbine; gasket; gas-tightness; grid connected; grid isolated; gross power; hazards; heat exchanger; heating value (total); hot start; hot time; humidification; humidifier; hybrid fuel cell / battery system; hybrid fuel cell / gas turbine plant (hybrid plant); I2R Loss; idle power; idle time; impurities; indirect internal reforming; interconnect; intercooler; interface point; interlock; internal manifolding; IR Loss (Ohmic Polarization); islanding; isolated operation; joints; land (related to flow field); leakage current; levelized cost; load duration curve; load-following; location, hazardous (classified); low emission vehicle (LEV); lower flammability limit (LFL); manifold; mass activity; mass transport (or concentration) loss; mean time between failures (MTBF); mean time between forced outage (MTBFO); mean time to repair (MTR); mechanical inputs; membrane; membrane electrode assembly (MEA); microporous layer; mixed conductor; mode; module; molten carbonate fuel cell (MCFC); nernst potential; net power; noise level (power system); nominal capacity; non-repeat components; open circuit voltage; operating pressure; operating pressure, maximum (MOP); operation; operational conditions; operational requirements; opportunity fuels; output voltage; overpotential; overvoltage; oxidant processing system; oxidant utilization; oxygen-to-carbon ratio; parasitic load; partial oxidation; partial oxidation burner; perovskite; phosphoric acid fuel cell (PAFC); pilot; pitch; plant footprint; plant heat rate; poisoning; polarization; polarization curve; polymer electrolyte fuel cell (PEFC or PEMFC); porosity; power; power conditioning (system); power density; power factor; power plant; preferential oxidation (PROX); pressure gradient monitor; programmable controller; proton exchange membrane (PEM); purge; rated power; reaction rate; recirculation; recovered heat; redox couple; redox potential; reference conditions; reformat gas; reformer; reforming; relative humidity; reliability; reliability, assessed; repeat components; residential power plant; resistance (electrical); response time; reversible fuel cell; ripple current; roughness factor; rupture member; safeguarding; schedule outage duration; scheduled outage; separator plate; series connection; service factor; shield, radiation; shift conversion; short stack; shutdown; shutdown time; single cell test; sintering; solid electrolyte / solid oxide; solid oxide fuel cell (SOFC); sound level; specific activity; specific power; stack (cell) conditioning; stack end frame; stack life; stack test; stacking; standard conditions; standby (state); start-up energy; start-up time; stationary fuel cell power plants; steam bottoming cycle; steam reforming; steam-to-carbon ratio; stoichiometric ratio; stoichiometry; storage state; substack; synchronization; syngas; temperature; test; test for power output change; thermal management system; thermal stability; thermostat; time to full power; trigeneration; triple phase boundary; tubular cells; turbocharger; turbocompressor; turboexpander; valve; valve, control; valve, relief; vent; ventilation; ventilation system; vessel, pressure; vessel, unpressurized;</p>

	vibration level; voltage, harmonic; waste heat; waste water; water gas shift conversion; water treatment system; wet seal; working pressure, allowable; working temperature; zero emission vehicle (ZEV)
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3.2 International Electrotechnical Commission “IEC 62282”

Table 4: IEC 62282 definitions / terminology

Document	Nomenclature
IEC 62282-7-2: Single cell and stack test methods – Single cell and stack performance tests for solid oxide fuel cells (SOFC)	cell/stack assembly unit; active electrode area; current density; average cell voltage; normal temperature and pressure; anode gas; cathode gas; current collector; stable state; theoretical current; effective fuel utilization; effective oxygen utilization; maximum effective fuel utilization; minimum cell/stack assembly unit voltage; open circuit voltage (OCV); power density; total impedance; total resistance; stoichiometric ratio
IEC 62282-1 TS: Fuel Cell technologies Part 1: Terminology	air bleed; anode; active layer; area; cell area; electrode area; active area; effective area; electrochemical surface area; membrane electrode assembly (MEA) area; specific surface area; availability factor; axial load; balance of plant; base load operation; bipolar plate; bus bar; catalyst; catalyst coated membrane (CCM); catalyst coated substrate (CCS); catalyst layer; catalyst loading; catalyst poisoning; catalyst sintering; cathode; planar cell; single cell; tubular cell; clamping plate; compression end plate; conditioning; cross leakage; crossover; leakage current; rated current; current collector; current density; degradation rate; desulfurizer; efficiency; electrical efficiency; exergetic efficiency; heat recovery efficiency; overall energy or total thermal efficiency; overall exergy efficiency; electrocatalyst; electrocatalyst support; electrode; gas diffusion electrode; ribbed electrode; electrolyte; electrolyte leakage; electrolyte loss; electrolyte matrix; electrolyte migration; electrolyte reservoir; end plate; filling (level); co-flow; counter flow; cross flow; dead end flow; fuel cell; air breathing fuel cell; alkaline fuel cell; direct fuel cell; direct methanol fuel cell (DMFC); molten carbonate fuel cell (MCFC); phosphoric

	<p>acid fuel cell (PAFC); polymer electrolyte fuel cell (PEFC); proton exchange membrane fuel cell (PEMFC); regenerative fuel cell; solid oxide fuel cell SOFC; solid polymer fuel cell SPFC; fuel cell / battery hybrid system; fuel cell / gas turbine system; fuel cell gas turbine hybrid system; fuel cell cogeneration system; fuel cell module; fuel cell power system; micro fuel cell power system; portable fuel cell power system; stationary fuel cell power system; fuel cell stack; fuel cell vehicle; fuel utilization; fuelling coupler; gas cleanup; gas diffusion anode; gas diffusion cathode; gas diffusion layer GDL; gas distribution plate; gas leakage; gas purge; gas seal; humidification; humidifier; interconnector; interface point; internal resistance; IR Loss (Ohmic Polarization); land (related to flow field); catalyst life (reformer); cell or stack life; manifold; mass activity; mass transport (or concentration) loss; membrane electrode assembly (MEA); micro fuel cell power unit; no load voltage; non-repeat parts; constant current operation; constant power operation; constant voltage operation; full load operation; grid-connected operation; grid-independent or isolated operation; load following operation; standby operation; oxidant utilization; parasitic load; partial oxidation; poisoning; (fuel cell) polarization; activation polarization; ohmic polarization; concentration polarization; polarization curve; porosity; gross power; minimum power; net electrical power; rated power; specific power; pressure gradient monitor; differential cell pressure; maximum allowable differential working pressure; maximum allowable working pressure; maximum operating pressure; porous transport layer (PTL); purge; raw fuel; reactant recirculation; reformat gas; reformer; catalytic combustion type reformer; direct fired type reformer; reforming; external reforming; internal reforming; partial oxidation reforming (POX); steam reforming (SR); repeat part; roughness factor; safeguarding; separator plate; series connection; shift converter; short stack; shutdown; emergency shutdown; normal shutdown; scheduled shutdown; (mass) specific activity; stack; stack end frame; stack terminal; stacking; standard conditions; black start; cold start; hot start; warm start; start-up energy; cold state; operational state; passive state; pre-generation state; steady state; storage state; substack; acceptance test; freeze-thaw test; process and control test; routine test; single cell test; stack test; type test; thermal stability; three phase boundary; generating time; hot time; power response time; shutdown time; start-up time; forced ventilation; natural ventilation; minimum voltage; open circuit voltage (OCV); output voltage; waste water; water gas shift converter; water separator; wet seal</p>
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3.3 Project “STACKTEST”

Table 5: STACKTEST definitions / terminology

Document	Nomenclature
Stacktest Master Document	fuel cell system; fuel processing system (FPS); oxidant processing system (OPS); conditioning; thermal management system (TMS); power distribution system (PDS); fuel cell stack

3.4 Conclusion for SOC definitions and terminology

The definitions & terminology for use in the test procedures to be drafted in WP3 shall be those of IEC 62282 where needed supplemented by the FCTESTNET Glossary to avoid repetition and to preserve consistency with international standards. Definitions missing in these documents may be defined during the drafting of the test procedures by the consortium. The project consortium consented that all definitions & terminology to appear in the Master document (StackTest approach) to be drafted in WP3.

4 Test Modules

The following table lists the SOC test modules as part of the test programs. The corresponding test specimen (cell/stack), operating mode (SOFC/SOEC/Other fuel cells) and the relevant test modules from the test matrix of WP3 (see deliverable D2.1) are assigned. For better comprehension of the following tables, the test matrix that was defined in deliverable D3.1 is shown in Table 6.

Table 6: Test matrix

Generic Test Modules		Applications			
		Stationary SOFC- μ CHP	Mobile SOFC- APU	SOEC for H ₂ production <i>power-to- gas</i>	Combined SOFC/SOEC for electricity storage <i>power-to- gas-to-power</i>
TM01	Leakage test	x	x	x	x
TM02	Start-up	x	x	x	x
TM03	Current-voltage characteristics	x	x	x	x
TM04	Electrochemical impedance spectroscopy	x	x	x	x
TM05	Current interruption	x	x	x	x
TM06	Cyclic voltammetry	-	-	-	-
TM07	Lambda sensitivity	x	x	x	x
TM08	Reactant gas composition	x	x	-	-

TM09	Temperature sensitivity	x	x	x	x
TM10	Pressure sensitivity	-	-	x	x
TM11	Mechanical load sensitivity	x	x	x	x
TM12	Endurance test under constant current	x	x	x	x
TM13	Endurance test under varying current	x	x	x	x
TM14	Thermal cycling	x	x	x	x
TM15	Redox cycling	x	x	x	x
TM16	Shut-down	x	x	x	x
TM17	Vibration test	-	x	-	-
TM18	Emergency Stop	x	x	x	x

4.1 Project “FCTES^{QA}”

Table 7: FCTESQA test modules

Project document	Test Module	Single Cell	Stack	SOFC	SOEC	Other fuel cells	Relevant for Test Matrix
Single Cell Performance and Endurance Test Modules	Light Duty Test Module with Hydrogen	x		x			TM08, TM12, TM13
	Light Duty Test Module with ISR Methane	x		x			TM08, TM12, TM14
	Light Duty Test Module with ESR Methane or Diesel	x		x			TM07, TM08, TM12, TM15
	Light Duty Test Module with POX or ATR Diesel	x		x			TM07, TM08, TM12, TM16

	Heavy Duty Test Module with Hydrogen	x		x			TM07, TM08, TM12, TM17
	Heavy Duty Test Module with ISR Methane	x		x			TM07, TM08, TM12
	Heavy Duty Test Module with ESR Methane or Diesel	x		x			TM07, TM08, TM12
	Heavy Duty Test Module with POX or ATR Diesel	x		x			TM07, TM08, TM12
Testing the voltage and power as function of current density (Single Cell)	Polarisation curve for a SOFC single cell	x		x			TM03, TM07, TM08, TM09, TM10, TM13
SOFC Stacks Performance and Endurance Test Modules	Heavy Duty Test Module with Hydrogen		x	x			TM07, TM08, TM12
	Heavy Duty Test Module with ISR Methane		x	x			TM07, TM08, TM12
	Heavy Duty Test Module with ESR Methane or Diesel		x	x			TM07, TM08, TM12
	Heavy Duty Test Module with POX or ATR Diesel		x	x			TM07, TM08, TM12
Testing voltage and power as function of current density (SOFC Stack)	Polarisation curve for a SOFC Stack		x	x			TM03, TM07, TM08, TM09, TM10, TM13

4.2 Project “FCTESTNET”

Table 8: FCTESTNET test modules

Project document	Module	Single Cell	Stack	SOFC	SOEC	Other fuel cells	Relevant for Test Matrix
WP2 Stationary Fuel Cell Systems: Test Programs and Test Modules	Normal Efficiency Test under constant Load	x	x	x			TM03, TM08, TM12
	Testing of Thermal Load Following for Stationary Fuel Cell Systems	x	x	x			TM14
	Testing of Electrical Load Following for Stationary Fuel Cell Systems	x	x	x			
	Behavior of Stationary Fuel Cell Systems upon Start-Stop Cycles	x	x	x			TM02, TM05, TM13, TM16, TM18

4.3 International Electrotechnical Commission “IEC 62282-7-2”

Table 9: IEC 62282-7-2 test modules

Project document	Module	Single Cell	Stack	SOFC	SOEC	Other fuel cells	Relevant for Test Matrix
IEC 62282-7-2: Single cell and stack test methods – Single cell and stack performance tests for solid oxide fuel cells (SOFC)	rated power test	x	x	x			
	current-voltage characteristics test	x	x	x			TM03
	effective fuel utilization dependency test	x	x	x			TM12
	long term durability test	x	x	x			TM08, TM12, TM13
	thermal cycling durability test	x	x	x			TM14
	internal reforming performance test	x	x	x			TM08
	resistance components identification test	x	x	x			TM04, TM05

4.4 Project “METSOFC”

Table 10: METSOFC test modules

Project document	Module	Single Cell	Stack	SOFC	SOEC	Other fuel cells	Relevant for Test Matrix
Final Report	Single Cell Testing - Long Term and Cycling Stability	x		x			
	Performance test		x	x			
	Load Variation Test		x	x			TM11
	Thermo Cycle Test		x	x			TM14
	H2S Poisoning Test		x	x			TM08
	Stack Vibration Test		x	x			TM17

4.5 Project “STACKTEST”

Table 11: STACKTEST test modules

Project document	Module	Single Cell	Stack	SOFC	SOEC	Other fuel cells	Relevant for Test Matrix
Test Module Drafts WP2	Humidity Sensitivity		x			x (PEM)	TM08, TM11
	Temperature Sensitivity		x			x (PEM)	TM09
	Pressure Sensitivity		x			x (PEM)	TM10

	Lambda Sensitivity		x			x (PEM)	TM07
	Fuel/Oxidant Composition (CO sensitivity)		x			x (PEM)	TM08
	Freeze Start		x			x (PEM)	TM09
	Continuous operation at constant load		x			x (PEM)	TM12
	Polarization Curve		x			x (PEM)	TM03
	Impact of ambient conditions to PEMFC stack performances		x			x (PEM)	
	Electrochemical Methods		x			x (PEM)	TM04
	Dead End Operating Conditions		x			x (PEM)	
Test Module Drafts WP3	Steady State		x			x (PEM)	TM12
	Load Cycling		x			x (PEM)	TM11
	Start/stop		x			x (PEM)	TM02, TM16, TM18

Test Module Drafts WP4	Gas Leakage Test		x			x (PEM)	TM01
	Vibration		x			x (PEM)	TM17
	Allowable Working Pressure		x			x (PEM)	TM10
	Short-time rated current		x			x (PEM)	
	Dielectric Strength Test		x			x (PEM)	
	Excess temperature test		x			x (PEM)	TM09

4.6 Testcenter for brint og brændselsceller

Table 12: Testcenter for brint og brændselsceller test modules

Project document	Module	Single Cell	Stack	SOFC	SOEC	Other fuel cells	Relevant for Test Matrix
Delrapport DGC1: Accelerated lifetime testing and standardization of SOFC systems	Not specified		x	x			TM12

4.7 US Fuel Cell Council's SOFC Focus Group

Table 13: US Fuel Cell Council's SOFC Focus Group test modules

Project document	Module	Single Cell	Stack	SOFC	SOEC	Other fuel cells	Relevant for Test Matrix
Introduction to Solid Oxide Fuel Cell Button Cell Testing	Not specified	x		x			TM03, TM04

4.8 FZ Jülich

Table 14: FZ Jülich test modules

Project document	Module	Single Cell	Stack	SOFC	SOEC	Other fuel cells	Relevant for Test Matrix
Quality Assurance and Solid Oxide Fuel Cell Testing at Forschungszentrum Juelich	Not specified	x		x			TM03, TM07, TM09
A review of standardising SOFC measurement and quality assurance at FZJ	Not specified	x		x			TM03

4.9 Test Modules Conclusion

Figure 1 shows the number of relevant documents for each test module of the test matrix and the operating mode.

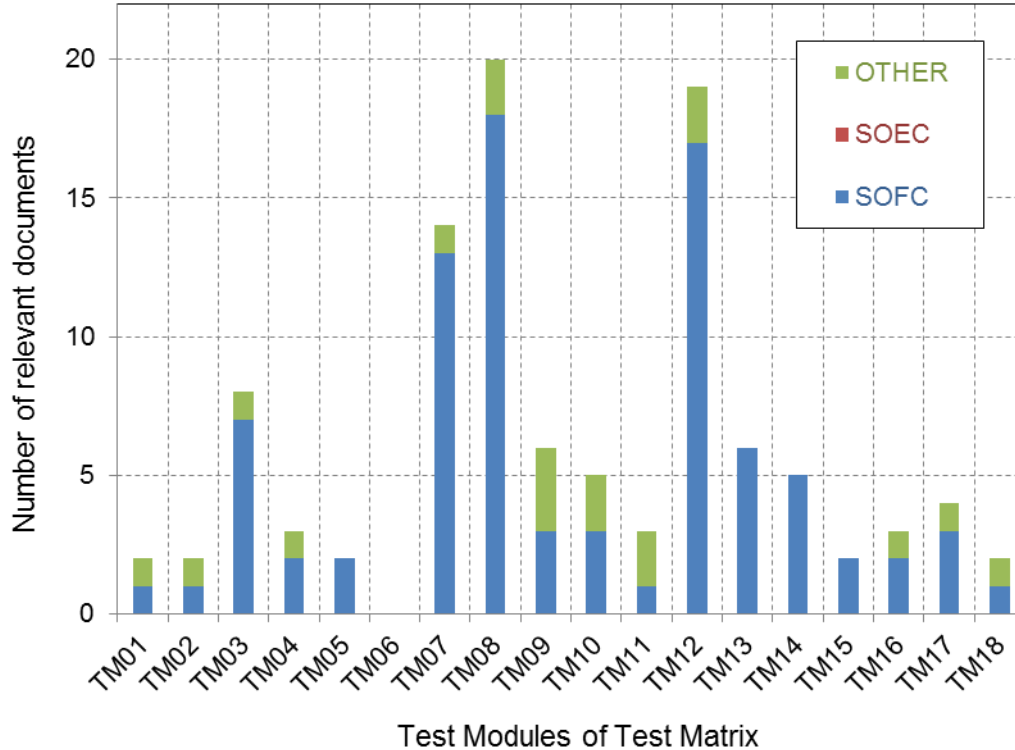


Figure 1: Number of relevant documents for each test module

Based on the available test procedures generic test procedures for SOC stacks for performance and durability / endurance under steady-state & dynamic operation (load & thermal cycling) of SOFC, SOEC and combined SOFC/SOEC operation should be drafted in WP3 followed by their experimental validation and finally revision. The basis for these drafts that was found in the investigated literature already offers a large number of tests for reactant gas compositions, lambda sensitivity and cell/stack endurance whereas other modules can hardly be found. Individual modules may be defined for the different test methods and parameter variations. Also, specific test procedures should be drafted for SOC systems when operated in SOFC, SOEC or combined mode for performance and durability with load cycles applied to the specific application (APU, CHP, etc.). So far, most of the modules refer only to SOFC testing. The lack of SOEC test modules shows that the development of test programs for electrolysis mode needs the most effort within the present project.

The consortium consented that the Stacktest approach of a Master document to which individual test modules are annexed should be followed.