



Real-SOFC

**Realising Reliable, Durable,
Energy Efficient and Cost Effective
SOFC Systems**

Contract no SES6-CT-2003-502612

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Fuel Cell Project*



Real-SOFC Project

- Co-ordinated programme of European planar SOFC developers on generic topics of materials research
- Main goal: Understanding and reducing ageing

- Reduction of degradation to $<0.5\%$ / 1,000 hrs. **Enhanced lifetime**
- Extension of stack lifetime above 10,000 hrs.

- Tolerance against impurities **Ease of operation**
- Operation with dry methane

- Standard formats and testing routines **Cost & reproducibility**

- Life Cycle Analysis & environmental impact analysis **Sustainability**

Real-SOFC Project Approach and Consortium

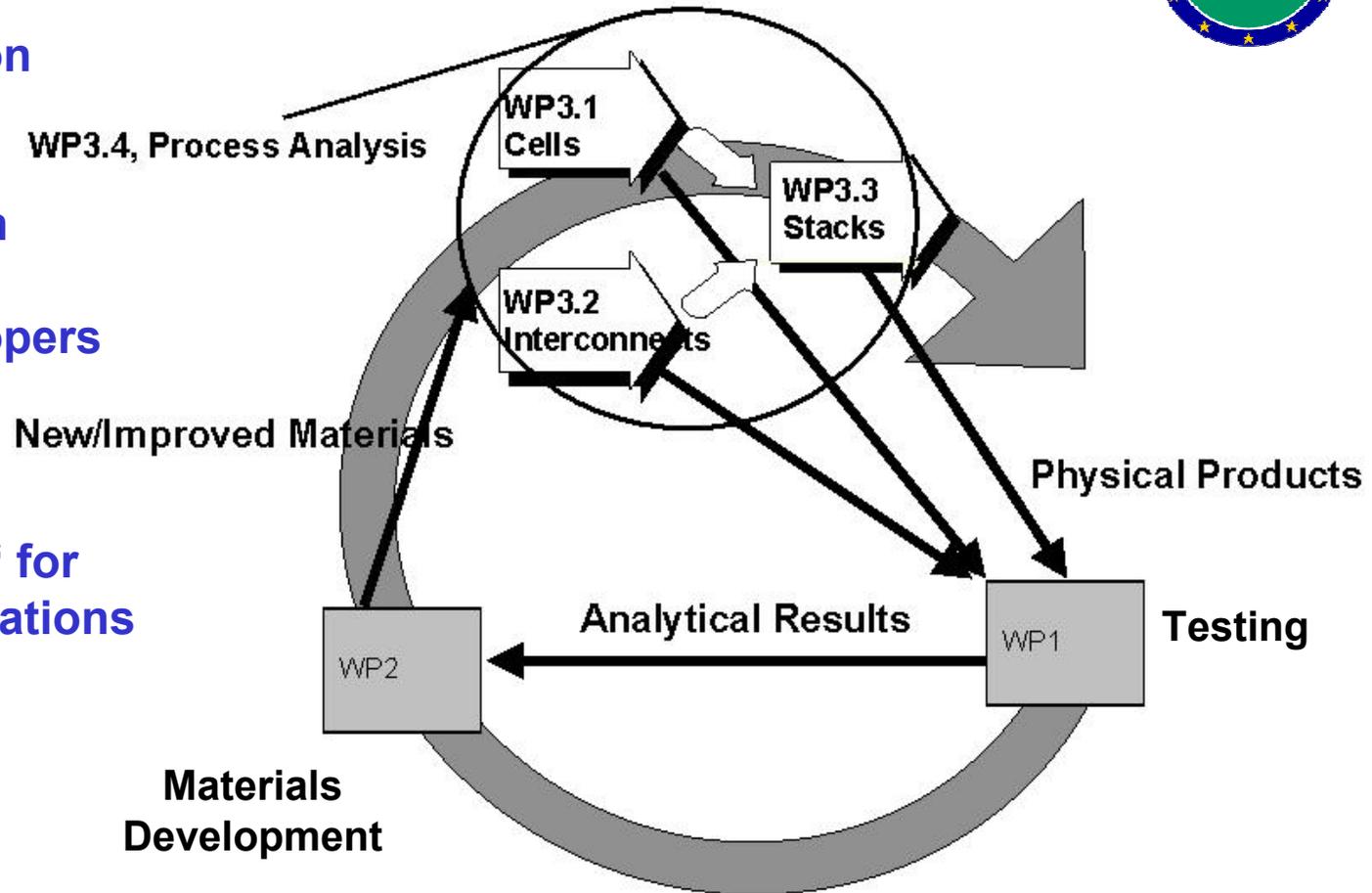


Close co-operation

- testing & characterisation laboratories
- materials developers
- component manufacturers

„Feedback Loops“ for 2 improved generations of components

Direct linkage to commercial production



Working on Ageing Mechanisms

	Poisoning / low- σ phases by contact layer	R_{pol}, R_{ohmic}	3	SEM-EDX, ICP-AES
	Coking	$R_{ohm} (R_{pol})$	2	Visual inspection, tactile inspection
Anode substrate	Ni sintering	R_{pol}, R_{ohmic}	2	OM, SEM
	Redox at high j and/or U_f	R_{pol}, R_{ohmic} Ni loss	2	Visual inspection
	S-poisoning	R_{ohmic}	1	SEM-EDX, ICP-AES
Anode	S-poisoning	R_{ohmic}	1	SEM-EDX, ICP-AES
	Ni sintering (TPB reduction)	R_{pol}, R_{ohmic}	2	OM, SEM
	Interdiffusion (low- σ phase formation)	R_{ohmic}	3	SEM-EDX
Electrolyte	Phase instability (ageing)	R_{ohmic}	2	XRD
	Interdiffusion (low- σ phase formation)	R_{ohmic}	1	SEM-EDX
	Phase changes, demixing	R_{pol}, R_{ohmic}	2	XRD
Cathode	Particle sintering (TPB reduction)	R_{pol}, R_{ohmic}	2	OM, SEM
	Cr-poisoning	R_{pol}	1	SEM-EDX, XRD, ICP-AES

WP 2
WT 1.6



WP 1 - Testing

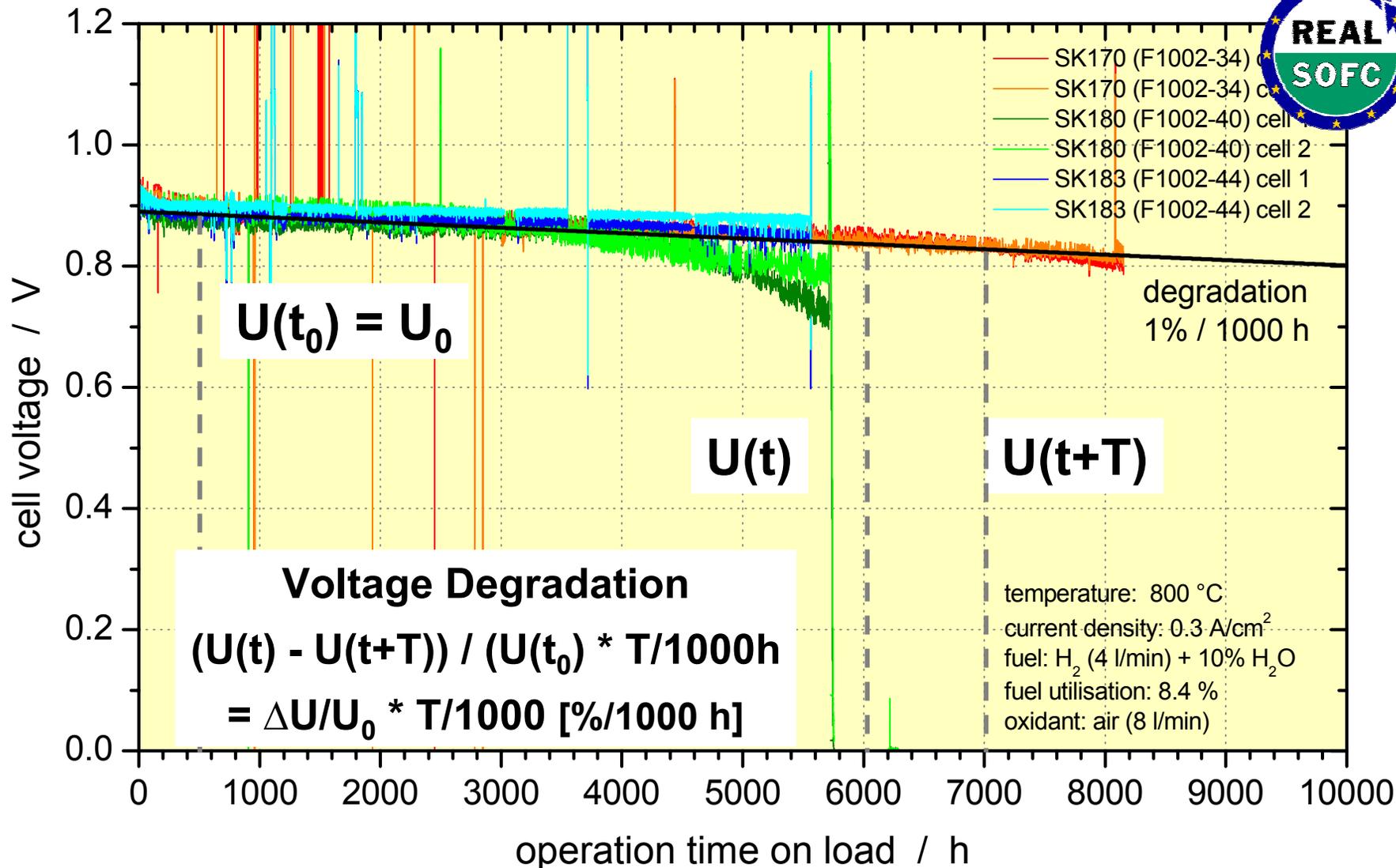
- **Sensitivity matrix** for establishing the dependency of degradation effects on different parameters:
 1. current density
 2. fuel utilisation
 3. gas composition
- **Lifetime testing (static)**
- **Benchmarking at realistic conditions**
at high level of strain on cells: $0,8 \text{ A/cm}^2$, $u_f = 75\%$, simulated reformat
- **Transient conditions (thermal and redox)**
- **Influence of fuel impurities**
- **Operation on reformat**
- **Post-operational analysis**



WP 4 - Standardisation

- **Standardisation of Testing Conditions**
important prerequisite for project performance!
- **Quality Assurance Standards**
 - selection of criteria for acceptance of cells
 - quality gates and assessment methods
- **Standard Interface Definition**
 - between components and systems (component data sheet)
 - referring to
 - * size of components, connections etc.
 - * performance figures of merit
 - * minimum expected performance per application

Definition of Degradation





SOFC Stack F1002-60 Messung Nr: SK217 (90 x 90 mm², 2 Ebenen, Real-SOFC 1st generation)

Start: 11.07.2005 15:09
Ende: 31.03.2006 08:14

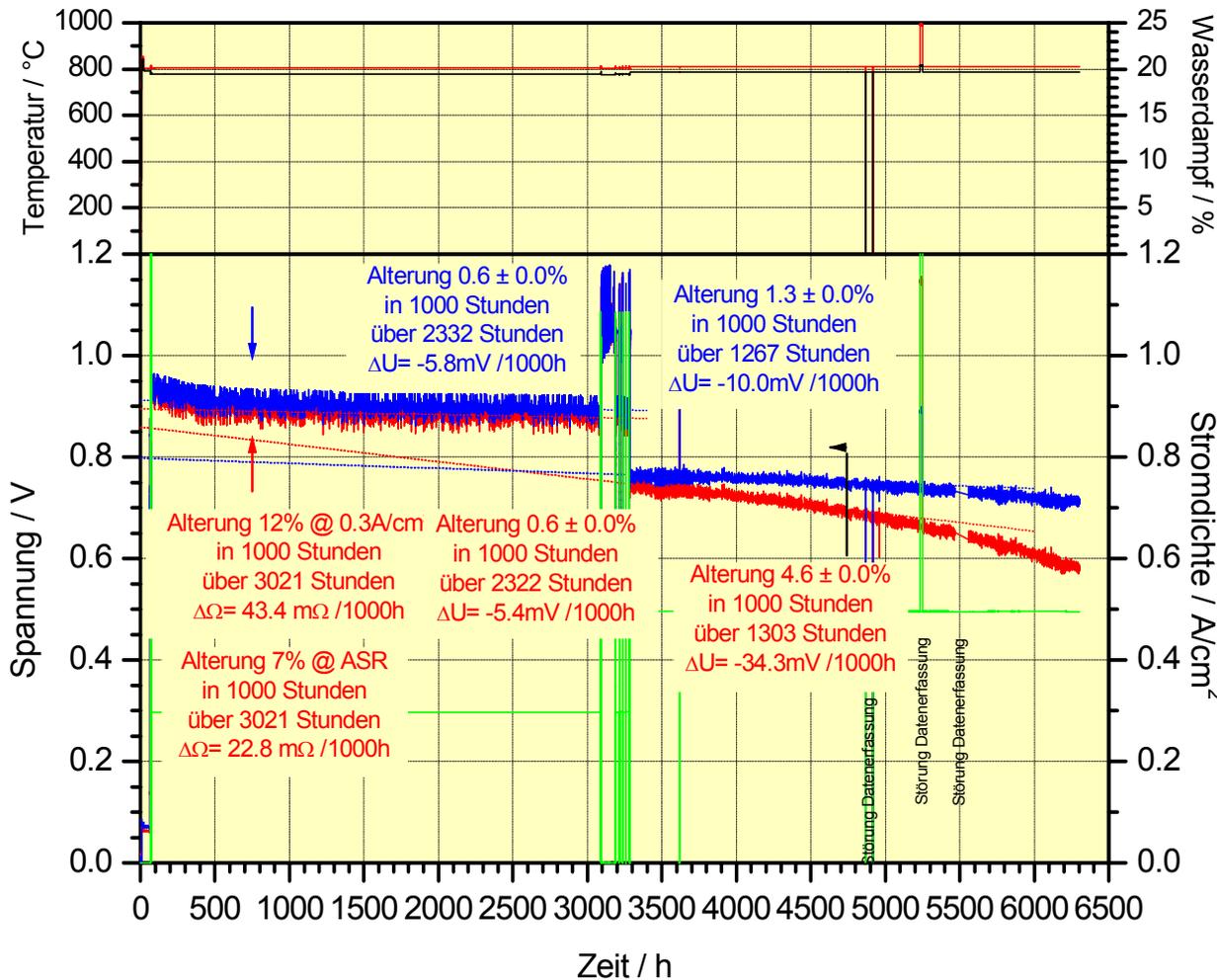
Prüfstand : MP23

SEK: 10x10S4920Z 10x10S4921Z

Interkonnektoren: JS3 (KDH/KDL)
Rahmen: JS3 (KDB,KDC,KDF,KDG)

Kontaktschicht Anode: Ni-Netz
Kontaktschicht Kathode: LCC10 + MnOx

Abdichtung: 76GA5P1



Galvanostatischer Betrieb

t_{start} : 70 / 3287 Stunden
 t_{Laufzeit} : 3019 / 3018 Stunden
 $i = 0.300 / 0.500 \text{ A/cm}^2$

H ₂	4000 / 1400	ml/min
H ₂ O	373 / 373	ml/min
Luft	8000 / 5280	ml/min
Brenngasnutzung:	8.4 % / 39.8 %	
Luftnutzung	10.5 % / 26.4 %	



Action taken:

- **Standardised SOFC Testing Conditions**
 - coordinated with FCTESTNET
 - standards need reworking (evolving process)
 - transient and accelerated testing standards necessary
- **Workshop on SOFC Quality Assurance and Standardisation**

held in June 2005 in Einruhr with international participation
- **Agreed procedure for defining degradation using the ASR of an SOFC cell**

ORMS model developed at FZJ and supplied to the project for validation

ORMS: Ohmic Resistance from Long Term Measurements of SOFC Stacks



ORMS version 1.2

I. Dateibehandlung

Messwerttabelle:

Optionaler Name der Ausgabedatei:

II Eingabe spezifischer Informationen

Anzahl genutzter Zellen: Startzeit:

Zellengroesse in cm²: Optional: Endzeit:

Nummer des verwendeten Messplatzes:

Auswahl der Temperatur-Spalte:

T1

T2

III Eingabe der Betriebsdaten - Volumenstroeme in ml/min ...

an H2:

an H2O:

an Luft:

Start

**programme for
calculating the
ASR from $U(t)$
data at given
current I**



Conclusions and Recommendations

- comparability of testing results of fuel cells components is not given today (maybe excluding whole system testing)
- defining testing conditions is vital in ensuring equal market opportunities, referring to
 - single cell tests
 - stack testing
 - component testing
 - accelerated and transient testing
- standardisation of components may be too early, nevertheless quality assurance standards and standard methods should be considered