

SOFC / SOEC Test Rig



KEY FEATURES

- EBZ systems and components based on **customer specific** demands and on latest EBZ **R&D results**
- Testing facilities for single cells, stacks, stack modules and complete SOFC systems
- Testing up to 1000°C using furnaces or hotboxes
- Available with power feed-in or electronic load
- Six-stage safety management system
- Easy to operate NI laboratory software with graphical user interface (**GUI**)
- Configurable limit monitoring
- Easy programmable process control: EBZ ProControl
- Starter software: EBZ Plug & test
- Sophisticated data management solutions
- Remote maintenance

OPTIONAL

- Air and gas manifolds different suppliers for stacks and cells
- Fuel desulphurizing
- Fuel reforming (CPOX, steam reforming, ATR)
- Exhaust gas and waste heat usage (gas/gas heatexchanger)
- Safety equipment (gas sensors, monitored ventilation)
- Event messaging via e-mail and SMS available
- Supervisory and data acquisition PC with several client PCs at single test-rigs (for huge laboratories)



Example: Stack test rig with liftable hood-type furnace

Remote access

HARDWARE

Test rig dimensions

	FOOTPRINT	NO. OF FLUIDS
FCTR-S	$1300 \times 1000 \text{ mm}^2$	up to 8
FCTR-E	$1700 \times 1000 \text{ mm}^2$	up to 12

Height depending on application **Customer specific dimensions possible**

EBZ FURNACE FEATURES

ТҮРЕ	INNER DIMENSIONS
Hood	$450 \times 450 \times 450 \text{ mm}^3$ $600 \times 600 \times 600 \text{ mm}^3$
Clamp & shell	$200 \times 200 \times 200 \text{ mm}^3$
Cabinet	$900\times900\times1300~mm^3$

Customer specific dimensions possible

HOTBOX CONCEPTS

Integration of any hotbox

COMPRESSION CONCEPTS

- Pneumatic system
- Mechanical weights system
- Spring tension

EBZ HUMIDIFICATION UNITS

- Broad variety of humidification units
- Various performance classes
- Optimized concerning stability
 - → Low fluctuations in cell OCV
- Standard units as well as on customers needs

EBZ GAS PREHEATERS

- Electric heaters for highest requirements
 - → for durability tests
 - \rightarrow for thermal cycling tests
- Easy to handle due to solid housing
- Connections acc. to customers needs
- Optimized temperature management
 → minimized radiation influence
- Custom solutions possible



Example: Test rigs

- High-grade thermal insulation
- Optional: active cool-down







SAFETY MANAGEMENT SYSTEM

STAGED SYSTEM DESIGN

- Optimum safety combined with high degree of freedom for the user
- Hard-wired to guarantee safety of people
- Configurable safety measures to protect hardware

HARDWARE

- Safety PLC acc. to EN 954-1, cat. 2
- Modular system independent of control system
- Sensors and actors according to analyzed safety requirements

GRAPHICAL USER INTERFACE (GUI)

- Clear data display
- Easy access to all functions organized in pages
- Easy but error-tolerant input of setpoints
- Separate pages for
- P&ID
- Manual operation
- Safety functions
- Limit monitoring
- Error history
- Software tools

LEVEL 5 emergency switch-off	dangers for life and limb
LEVEL 4 emergency stop	critical parameters according to safety
LEVEL 3 trouble break-off	troubles causing malfunctioning
LEVEL 2 gas warning	noncritical release of dangerous gases
LEVEL 1 soft alarm	noncritical trouble
LEVEL 0	operation without any troubles



Example: GUI page "LIMIT MONITORING"

MIT MONITORI	NG													
SM S1 TEMPERATURES	15M S2	TEMPERAT	URES SYSTEM TEMPERATURES	SYSTEM FLOWS,	🛃 Edi	t)						. D	3	
sensor	actual	value	settings			IMIT M	ONITORING						low ala	rms high t 1st 2nd
TR 9.11a.1-T1001	237	۹۵				sensor	actual value							
TRS 9-128-1-T1002	351	°C				TR S1-T2	101	435	°C					
TR 1.10a.1-T2001	560	°C												
TRZH 1.11a.1-T2002	432	۹C				1st low	limit			1st high	n limit			
TR 51-T2004	516	۹С				setpoint	0 🔅	с		setpoint	0 🔅 C			
TRS2H \$1-T2005	433	۹C	2nd high limit: 848 °C, delay: 120	s, emergency stop		action	FP EStop			action	FP EStop			
TR S1-T2101	435	°C				and loss	limit			and him	h limit			
TR \$1-T2102	466	°C	2nd high limit: 870 °C, delay: 300	s, emergency stop		inactive				inactive				
TR \$1-T2103	470	°C	2nd high limit: 870 °C, delay: 300	s, emergency stop		setpoint	0 🚖 •	с		setpoint	0 🕀 90			
TR 51-T2104	446	90				delay	0 🕀	s		delay	0 🔶 s			
TR 51-T2105	455	°C	2nd high limit: 860 °C, delay: 300	s, emergency stop		action	FP EStop			action	FP EStop			
TR 51-T2106	449	°C									- C (1)	cascal		

LIMIT MONITORING

- 4 limits for each sensor
- 2 limits with delay function
- Choice of 5 safety levels to be tripped
- Easy configuration by drag & drop
- No overriding of safety measures protecting life and limb



SOFTWARE TOOL FOR SEQUENTIAL PROGRAMMING

- Easy programmable process control software
- Graphical programming without scripting language
- Choice of
 - → Time-controlled serial execution
 - → Event-controlled execution
 - → Mixed mode
- Control structures support
 - → Logical connections (and, or, not)
 - → Conditions (if-then-else)
 - → Loops (while, for, case)
 - → Timers
 - → Comparisons (<, >, =, !=, >=, <=)
- Process variables can be
 - → Set to a dedicated value,
 - → Increased and decreased using gradients
- Sequences can be saved and reloaded

EBZ F	ProControl V3.0				09.02.2011 11:44
STEP L	IST: Operating point 20	A			
Step No.	Step name OVERRIDING EVENT MANAGEMENT	^	ACTI	ONS (Set flows)	
2	Heat-Up Start evaporator		Actor 1	No. Action name	active state
4 5 6 7	Switch DI-water Set NG Set current Increase current		E	Event editor name of event event type	Air flow reached 200 M[hin7] editive comparison 💌
			GO EVE	comparison variable for y	psp:((localhost(0131 VPC 1_4-1_actualValue browse
			Ever 1 2	data type compariton type minimum period of true condition limit variable (for x)	nument W a W 00:00:00 C accepted aborator + 4.000 C deviation deviation
			GO	constant limit	200.000 \$
		*	Go o	relative time target	00:00:00 C
NAVIG		_	2	absolute time target	01:00:00 hhomess

Example: GUI page "Performance measurement"

D Overview.txt - Editor	
Gatel Bearbeiten Pormat Anakhit ?	
	<u>^</u>
Step No.1: Set flows	
Action No.0: Air valve on Active state: active	-
Path of 'y' variable: psp:\\localhost\0131\81_3_isActive Allocation:set direct to boolean value = true	
Action No.1: Air flow = 200 Nl/min	
Active state: active Path of 'y' variable: psp:\\localhost\0131\FRC 1.4-1_setpoint Allocation:set direct to numeric value = 200.000000	
Action No.2: Protection gas manually on	
Active state: active Path of 'y' variable: psp:\\localhost\0131\SafetySystem_manPG_fsActive Allocation:set direct to boolean value = true	
	~
	2.4

Example: Sequence overview txt-file

EBZ EVENT MESSENGER

Notification tool

- Separate software for fast reaction to test rig events
- SMS or e-mail, if a certain event occurred
- All registered data usable for event definition, e.g.
 - → Results
 - → Status
 - → Errors



Example: Event messaging e-mail version



EBZ Entwicklungs- und Vertriebsgesellschaft Brennstoffzelle mbH A member of AST Group Marschnerstrasse 26 01307 Dresden, Germany www.ebz-dresden.de
 Phone
 +49 (0) 351 479 39 -0

 Fax
 +49 (0) 351 479 39 -18

 E-Mail
 sales@ebz-dresden.de