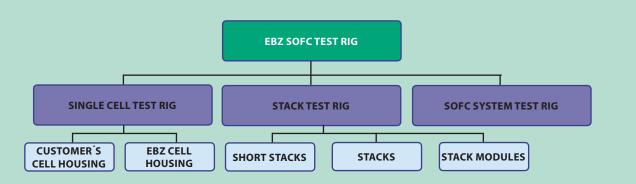


# **SOFC / SOEC Test Rig**

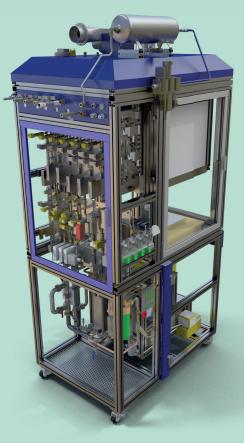


#### **KEY FEATURES**

- 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 desulphurising
- 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	$200\times200\times200~mm^3$
cabinet	$900 \times 900 \times 1300 \text{ mm}^3$

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
- optimised concerning stability
   → low fluctuations in cell OCV
- standard units as well as on customers needs

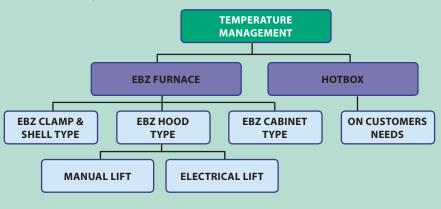
#### **EBZ GAS PREHEATERS**

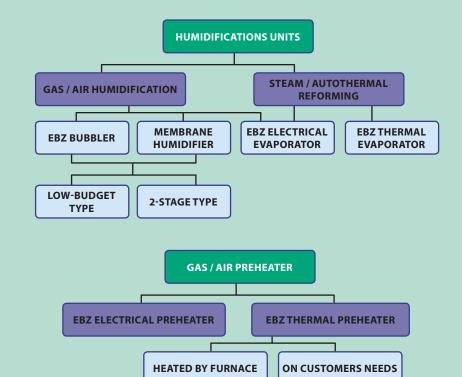
- electrical heaters for highest requirements
  - → for durability tests
  - $\rightarrow$  for thermal cycling tests
- easy to handle due to solid housing
- connections acc. to customers needs
- optimised temperature management
   → minimised radiation influence
- custom solutions possible



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

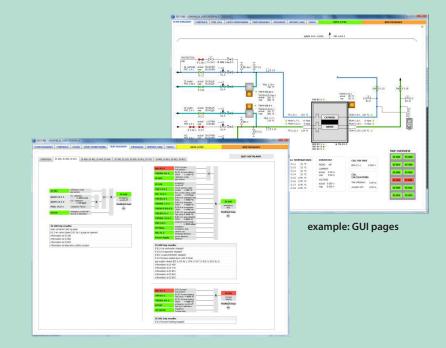
# HARDWARE

- safety PLC acc. to EN 954-1, cat. 2
- modular system independent of control system
- sensors and actors according to analysed safety requirements

# **GRAPHICAL USER INTERFACE (GUI)**

- clear data display
- easy access to all functions organised 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"

W DIAGRAM CONTI	ROLS	OC LOAD	STACK VOLTAGES	IONITORING TR	IP DIAG	RAM	REPORT AND D	AQ MESSAGE	5 TOOLS			BUR	NER ST
IMIT MONITORI	NG												
ISM S1 TEMPERATURES	15M S2	TEMPERA	TURES SYSTEM TEMPERATURE	SYSTEM FLOWS	E Ba	it					-83	1	
sensor	actual	value	settings				IONITORING					low alarm 2nd 1st 1	st 2nd
TR 9.118.1-T1001	237	°C				sensor	actual value						
TRS 9.128-1-T1002	351	°C				TR S1-T		435 °C					
TR 1.10a.1-T2001	560	°C											
TR2H 1.11a.1-T200	2 432	۹C				1st low				<b>t high limit</b> ctive 📃			
TR 51-T2004	516	۹C				setpoint	0 🔄 40			tpoint 0 🔄 °C			
TRS2H 51-T2005	433	°C	2nd high limit: 848 °C, delay: 1	20 s, emergency stop		action	FP EStop	[	• act	tion PP EStop			
TR S1-T2101	435	°C				2nd lov	e liesit			id high limit			
TR \$1-T2102	466	°C	2nd high limit: 870 °C, delay: 3	00 s, emergency stop		inactive				ctive 🛅			
TR S1-T2103	470	°C	2nd high limit: 870 °C, delay: 3	00 s, emergency stop		setpoint			set	tpoint 0 😫 °C			
TR 51-T2104	446	°C				delay	0 🕁 s		del				
TR 51-T2105	455	۹C	2nd high limit: 860 °C, delay: 3	00 s, emergency stop		action	FP EStop		• act	tion FP EStop	•		
TR S1-T2106	449	۹C								OK	cancel		

#### **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
  - $\rightarrow$  event-controlled execution
  - → mixed mode
- control structures support
  - → logical connections (and, or, not)
  - → conditions (if-then-else)
  - → loops (while, for, case)
  - → timers
  - $\rightarrow$  comparisons (<, >, =, !=, >=, <=)
- process variables can be
  - → set to a dedicated value,
  - → increased and decreased using gradients
- sequences can be saved and reloaded

EBZ P	ProControl V3.0			09.02.2011 11:44
STEP L	IST: Operating point 20 A			
Step No.	Step name overribing event management	ACTI	ONS (Set flows)	
1	Set flows	Action	No. Action name	active state
2	Heat-Up	1.		0000 31010
3	Start evaporator	2	Event editor	
4	Switch D0-water			
5	Set NG		Event editor	
6	Set current		name of event	Air flow reached 200 M(min? active
7	Increase current		event type	comparison
		GO	comparison	
		EVE	variable for y	psp://jlocalhost/0131 VRC 1_4-1_actualValue browse
		Ever	data type	numeric 💌
			compariton type	
			minimum period of true condition	00:00.00 C accepted absolute ± 4.000 C deviation
			lmit variable (for x)	browse
		GO	constant limit	200.000
		G0 0	relative time target	00:00:00 (2) hhomess
VAVIG.			absolute time target	01.00:00 hhmm:ss 01.00//904 ddimm/yyry

example: GUI page "performance measurement"

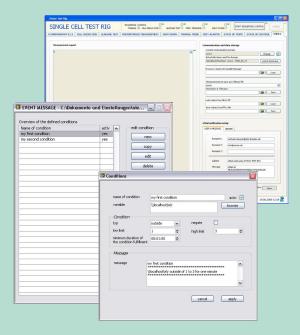
🖡 Overview.txt - Editor	
Datei Bearbeiten Format Ansicht ?	
	^
Step No.1: Set flows	
Action No.0: Air valve on Active state: active	
Path of 'y' variable: psp:\\localhost\0131\81_3_isActive Allocation:set direct to boolean value = true	
Action No.1: Air flow = 200 Nl/min	
Active state: active Path of 'y' variable: psp:\\localhost\0131\FRC 1_4-1_setpoint Allocation:set direct to numeric value = 200.000000	
Allocation:set direct to numeric value = 200.000000	
Action No.2: Protection gas manually on Active state: active	
Active state. active Path of 'y' variable: psp:\\localhost\0131\SafetySystem_manPG_1sActive Allocation:set direct to boolean value = true	
	~
6	

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
  - $\rightarrow$  errors



example: event messaging e-mail version



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