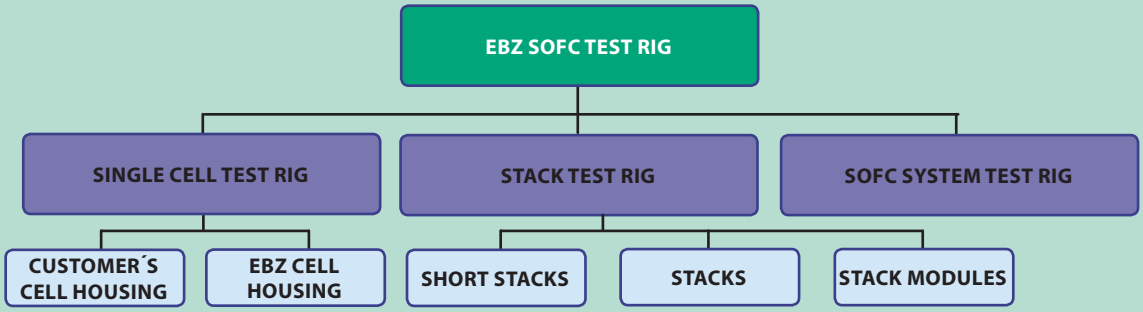
SOFC / SOEC Test Rig

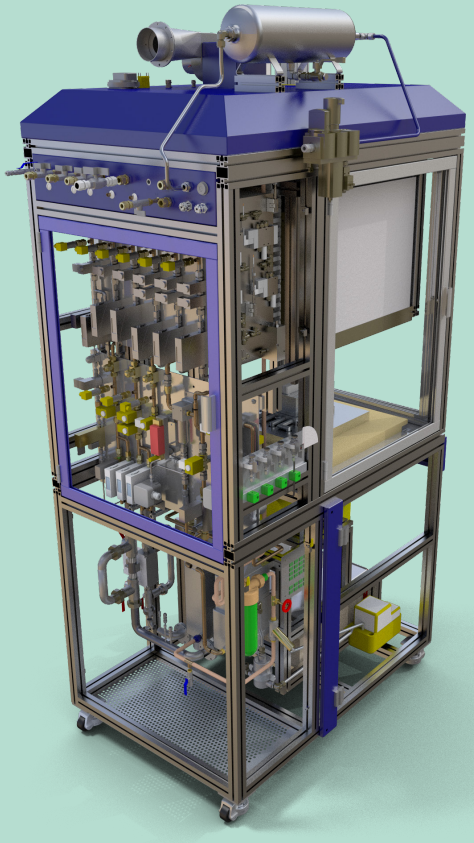


KEY FEATURES

- 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 heat-exchanger)
- 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)
- Remote access



Example: Stack test rig with liftable hood-type furnace

Fuel Cells

HARDWARE

Test rig dimensions

	FOOTPRINT	NO. OF FLUIDS
FCTR-S	1300 × 1000 mm²	up to 8
FCTR-E	1700 × 1000 mm²	up to 12

Height depending on application
Customer specific dimensions possible

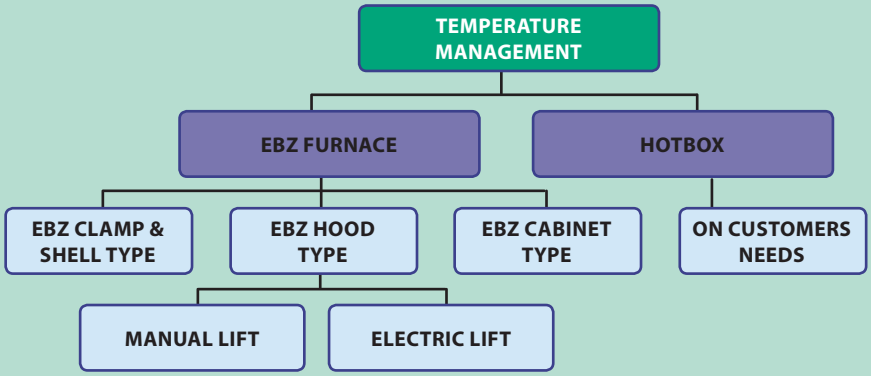
Example: Test rigs

EBZ FURNACE FEATURES

TYPE	INNER DIMENSIONS
Hood	450 × 450 × 450 mm³ 600 × 600 × 600 mm³
Clamp & shell	200 × 200 × 200 mm³
Cabinet	900 × 900 × 1300 mm³

Customer specific dimensions possible

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



HOTBOX CONCEPTS

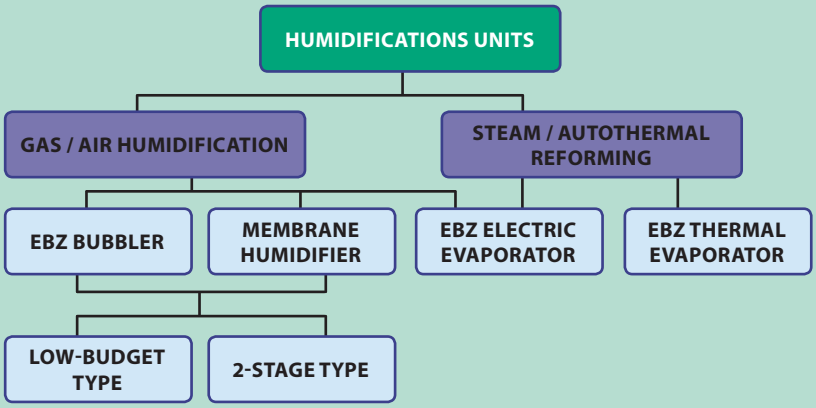
- Integration of any hotbox

COMPRESSION CONCEPTS

- Pneumatic system
- Mechanical weights system
- Spring tension

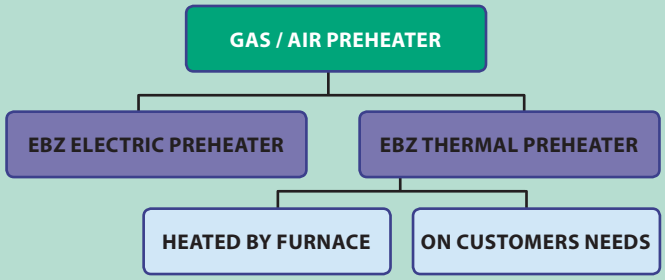
EBZ HUMIDIFICATION UNITS

- 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
  → 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



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

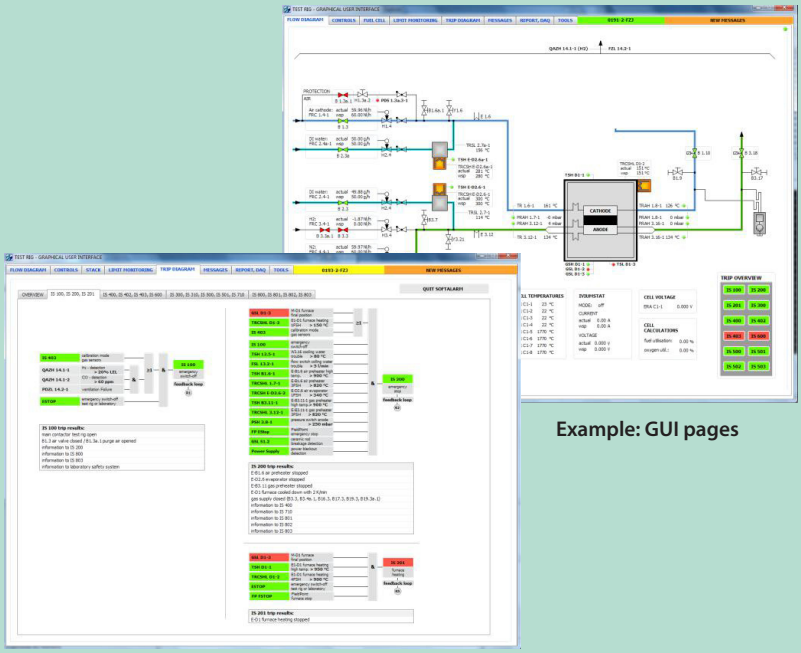
LEVEL 5 **emergency switch-off**	**dangers for life and limb**
LEVEL 4 **emergency stop**	**critical parameters according to safety**
LEVEL 3 **trouble break-off**	**troubles causing malfunctioning**
LEVEL 2 **gas warning**	**noncritical release of dangerous gases**
LEVEL 1 **soft alarm**	**noncritical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

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

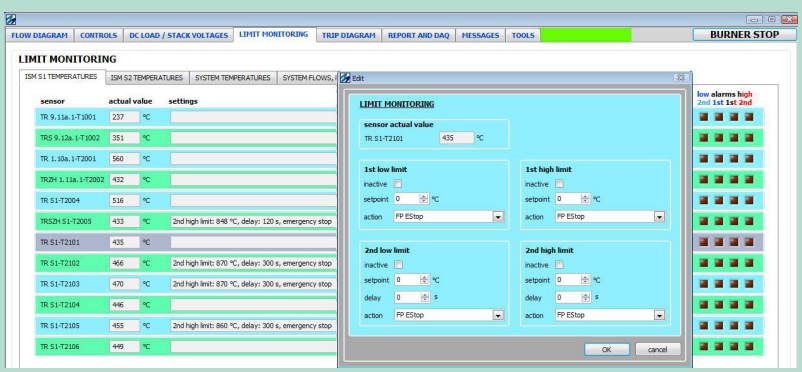


Example: GUI pages

LIMIT MONITORING

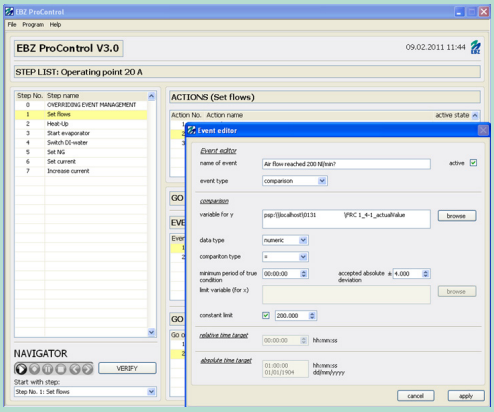
- 4 limits for each sensor
- 2 limits with delay function
- Choice of 5 safety levels to be tripped
- Easy configuration by drag & drop
- No overriding of safety measures protecting life and limb

Example: GUI page “LIMIT MONITORING”

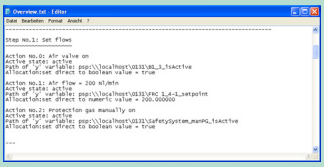


SOFTWARE TOOL FOR SEQUENTIAL PROGRAMMING

- 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



Example: GUI page "Performance measurement"

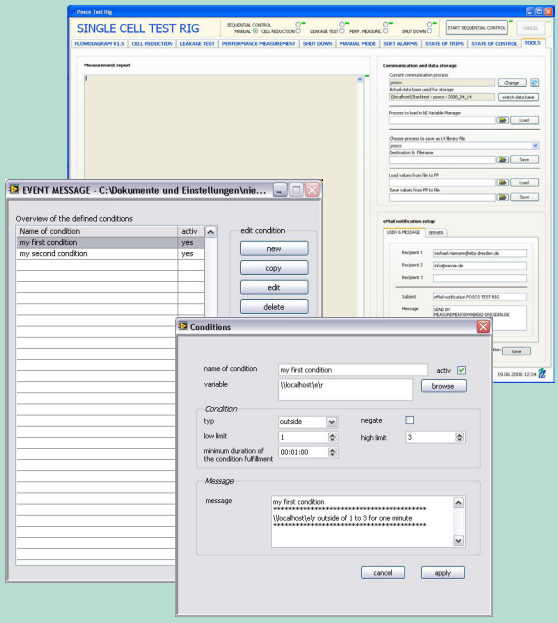


Example: Sequence overview txt-file

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

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