Testing Solutions for Li-Ion Batteries

Helmut Kipp

ENERGY STORAGE EVENT

12 februari 2019 | NH Conference Centre Koningshof

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Li-Ion Batteries – Different Sizes

Lithium-Ion battery cells come

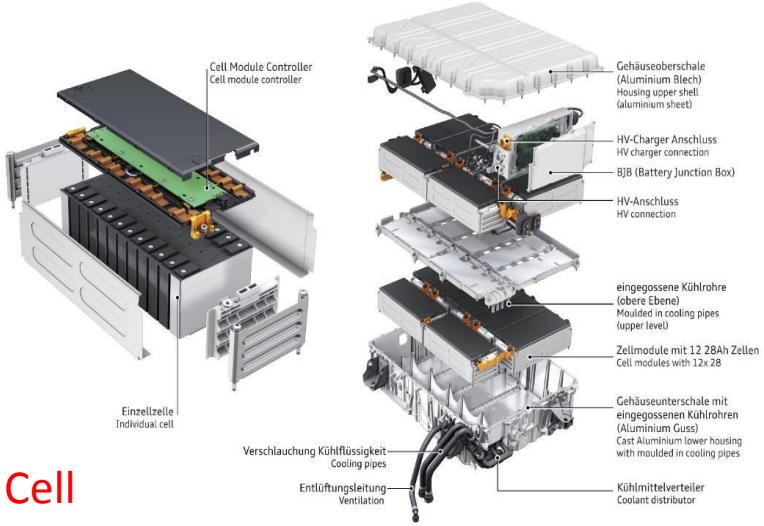
- In different sizes
- And shapes

Traction battery systems

- Are typically made of Cells which are combined in Modules
- The System or Pack consists out of modules
- Additionally the systems require
  - Structural enclosures
  - Management
  - Electronics
  - Cabling and cooling.

Module

System / Pack



Cell

Many different chemical combinations:

Which one is the best?

It always depends on your application…

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Future Trend – Solid State Battery

Research for solid state batteries increased in the last month

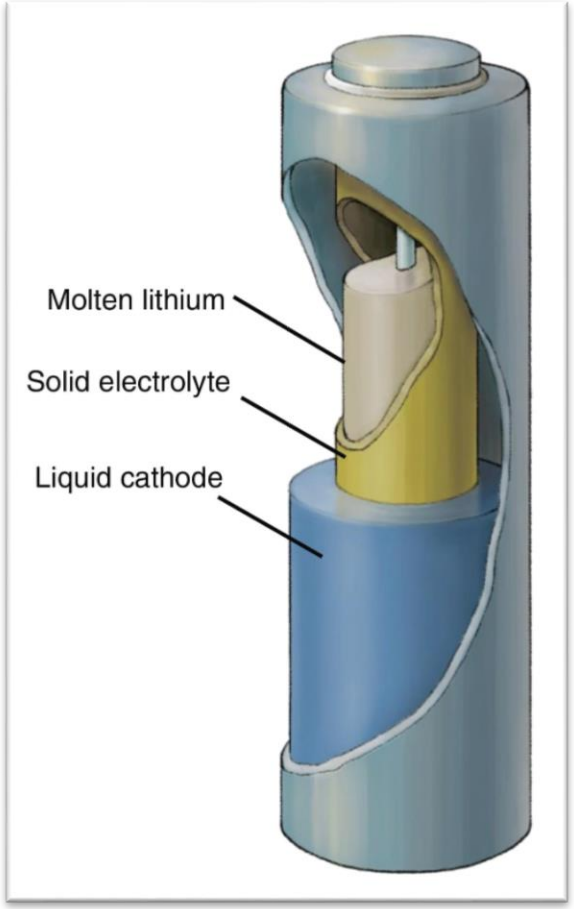
- Global race for commercializing started

Polymer of Li Ion batteries are liquid or polymer (gel)

- Flammable
- Generate heat → cooling system necessary

Polymer in Solid-State batteries is solid: Ceramics, Lithium Sulfide, Glass

- Not flammable
- Cheaper in production
- Smaller in size
- Greater energy density
- Higher number of charging cycles
- Less influence regarding external temperatures



To Avoid

To Avoid

To Avoid

To Avoid - Mistakes and Dangers with Energy Storages.

Top 3 most done mistakes with batteries:

- Too long in stock - with no control
- Stock in wrong environmental conditions - Temperature, Humidity …
- Wrong charging - wrong charger, charging process, charging time

Top 3 most dangerous mistakes with batteries:

- Overload or wrong loading
- Mechanical damage
- Overheating

Example:
ISO 12405-3, 2014 / 7.11
Chinese standard: GB/T 31467.3-2015

No chance for not testing...

(Only Li-Ion batteries have over 40 different test specifications)

Several Test Categories for Li-Ion Batteries.

Environmental Stress

- Humidity
- Temperature
- Thermal-Shock
- Temp.-Changes
- Vibration
- Gas
- Saltspray / Corrosion
- …

Visual Inspection

- Leakage
- Connectors
- Geometry
- Weight
- …

Electrical Tests

- Capacity, Power, Resistence
- Lifetime
- Self discharge
- Cold start

Safety

- Short circuit
- Power interrupt
- Plug interrupt
- Reset

Abuse tests

- Bruise / Squashing
- Fall
- Deep discharge
- Overload
- Reversed Polarity

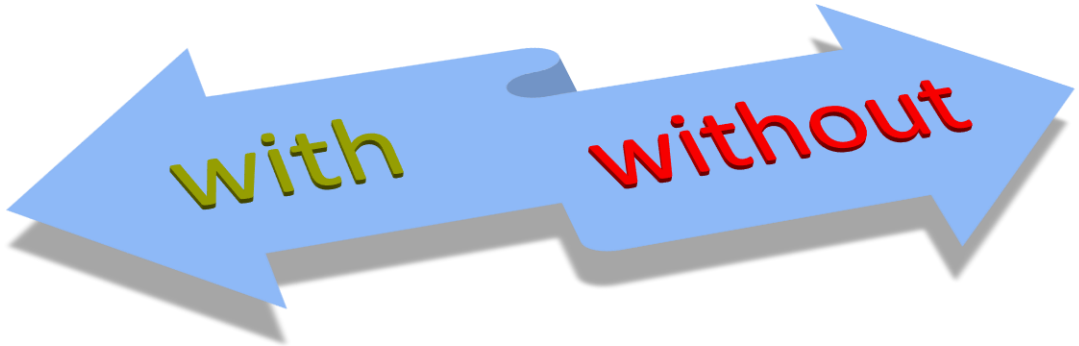
Batteries with high energy level und huge performance level.

→ **Potential dangers during test processes are increasing dramatically.**

Safety First with test systems:

1) People
2) Buildings

Different possibilities and opinions regarding the security installations:



Testing - Without Security Installations

Advantages

- Lower investment / costs
- Possible damage of test equipment is accepted / acceptable
- Let the test equipment burn down and buy a new one

Disadvantages

- Danger for workers in the test area
- Environmental harms
- Stop of company processes / possible lost of money
- Maybe lost of important and expensive prototypes

Who is EUCAR and what are Hazard Levels

European Council for Automotive R&D

- EUCAR

- Classified Security Level and results

  - Hazard Levels -

Advantages of this classification

- Everybody uses the same wording for the same principles/basics
- Common sense for risks, risk assessment and safety procedures
- Chance to response with modular safety equipment
- Standardization

Testing - With Security Installations: EUCAR Hazard Level

External influences, internal topics with results on the Li-Ion battery

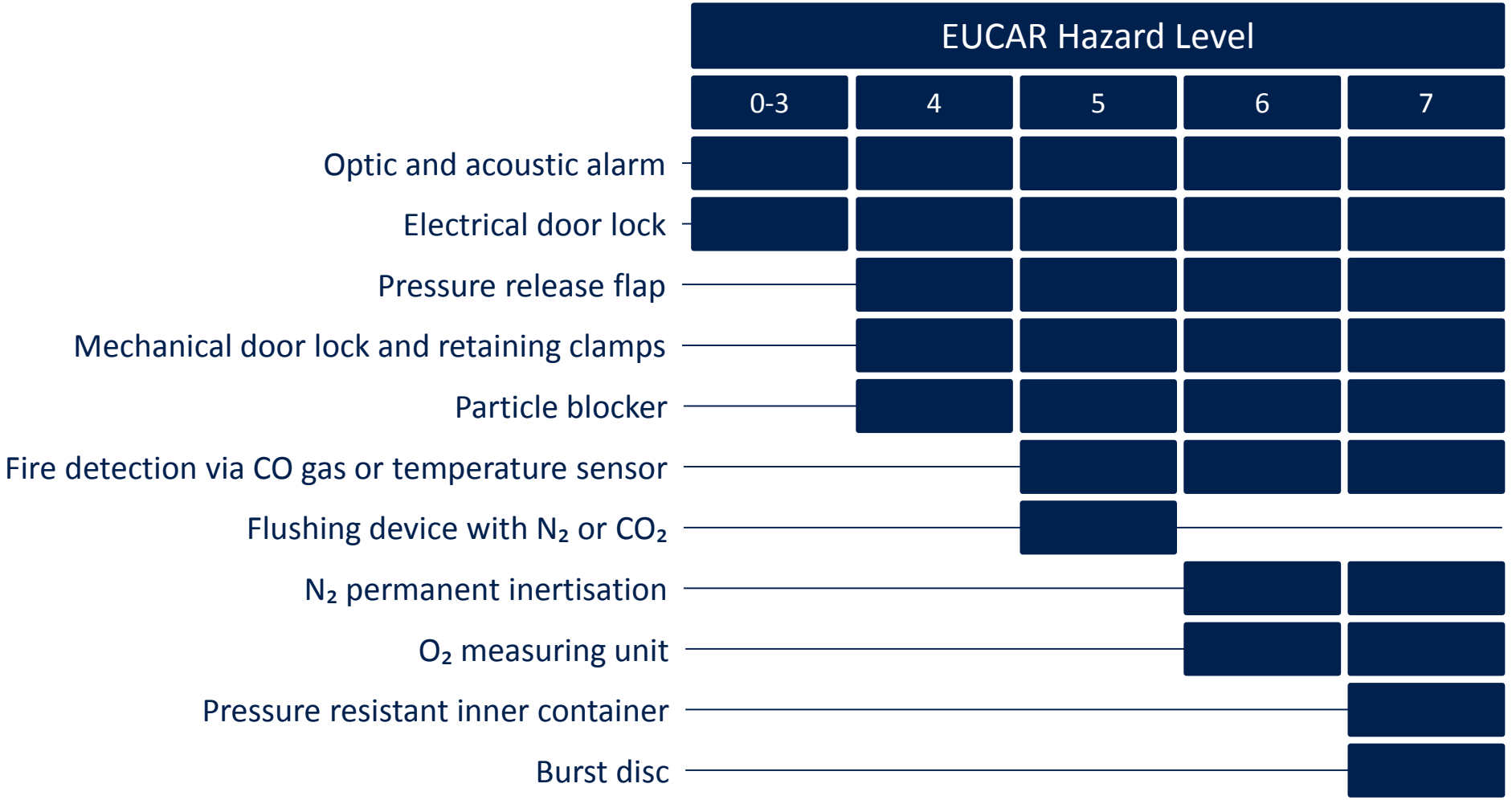
Hazard Level	Description	Security Level and results
0	No effects.	No effect, no functional limitation
1	Start of passive security system.	No damage, no leakage, no gas leak, no fire, no explosion, no reaction, no thermal runaway. **Cell broken reversible, repairs of security installations necessary.**
2	Damage	No leakage, no gas leak, no fire, no explosion, no reaction, no thermal runaway. **Cell broken irreversible, repairs of security installations necessary.**
3	Leakage (Weight loss < 50%)	No gas leak, no fire, no explosion. Leakage of electrolyte <50%.
4	Gas leakage (Weight loss > 50%)	No fire, no explosion. Leakage of electrolyte >50%.
5	Fire	No explosion, no flying parts.
6	Fraction	No explosion, but flying parts of the active mass.
7	Explosion	Decomposition of battery cell.

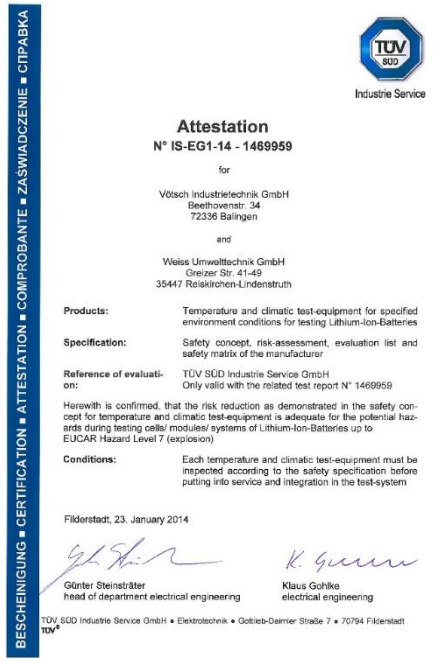
Test Equipment INDOOR or OUTDOOR

Indoor

- Personal protection has to be guaranteed
- Security installation on the building in some cases necessary
- Necessary approval procedures
- Security to other facilities in the neighborhood has to be clarified
- Existing space can be used.

Modular Approach – Li-Ion Safety Equipment for Cabinets





BESCHEINIGUNG ■ CERTIFICATION ■ ATTESTATION ■ COMPROBANTE ■ ZAŚWIADCZENIE ■ СПРАВКА

TÜV SÜD Industrie Service

Attestation
N° IS-EG1-14 - 1469959

for

Vötsch Industrietechnik GmbH
Beethovenstr. 34
72336 Balingen

and

Weiss Umwelttechnik GmbH
Greizer Str. 41-49
35447 Reiskirchen-Lindenstruth

Products:	Temperature and climatic test-equipment for specified environment conditions for testing Lithium-Ion-Batteries
Specification:	Safety concept, risk-assessment, evaluation list and safety matrix of the manufacturer
Reference of evaluation:	TÜV SÜD Industrie Service GmbH Only valid with the related test report N° 1469959

Herewith is confirmed, that the risk reduction as demonstrated in the safety concept for temperature and climatic test-equipment is adequate for the potential hazards during testing cells/ modules/ systems of Lithium-Ion-Batteries up to EUCAR Hazard Level 7 (explosion)

Conditions:	Each temperature and climatic test-equipment must be inspected according to the safety specification before putting into service and integration in the test-system

Filderstadt, 23. January 2014

Günter Steinsträter
head of department electrical engineering

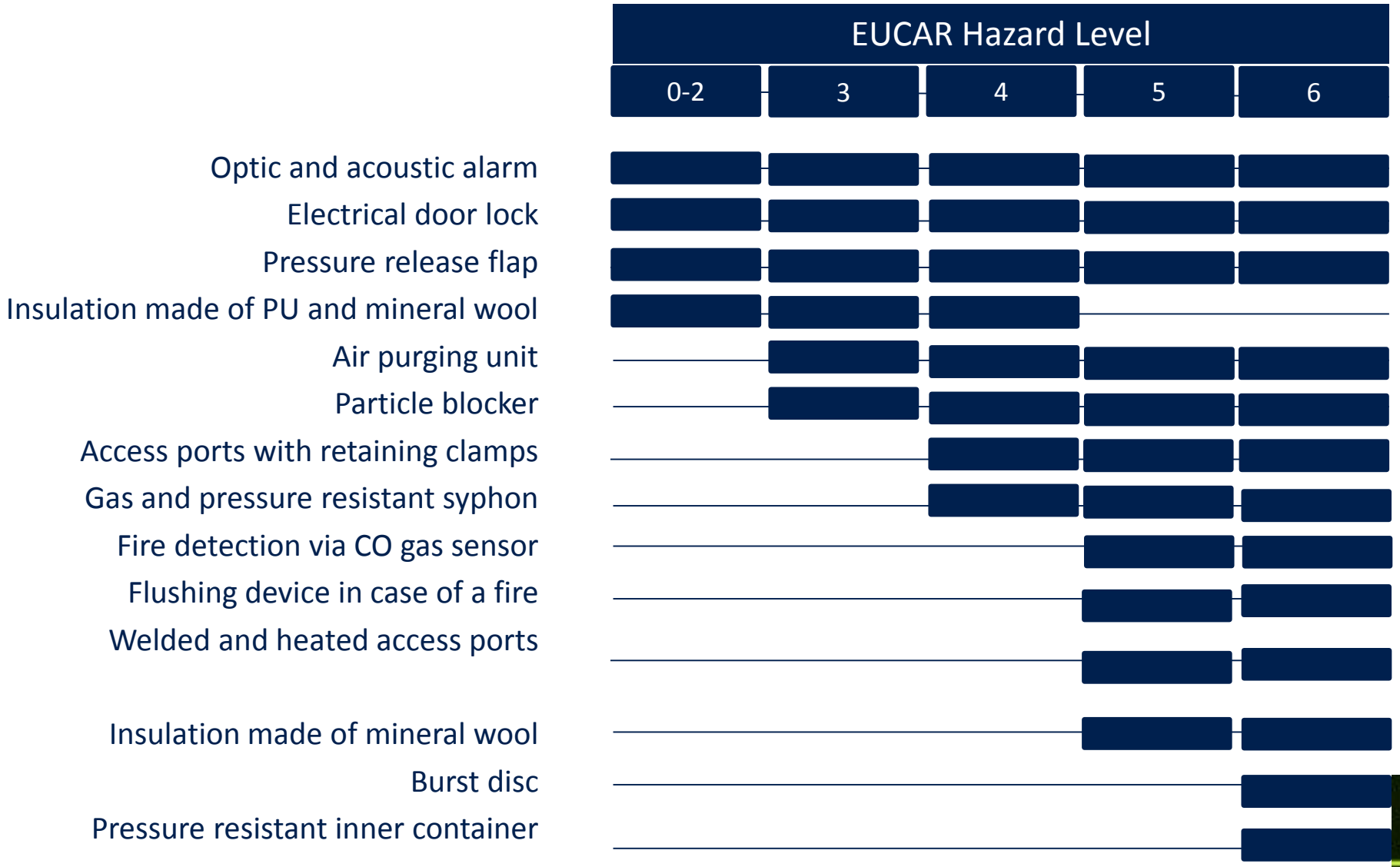
Klaus Gohlke
electrical engineering

TÜV SÜD Industrie Service GmbH • Elektrotechnik • Gottlieb-Daimler Straße 7 • 70794 Filderstadt

With Security Installations: EUCAR Hazard Level

Hazard Level 0-3	Hazard Level 4	Hazard Level 5-6		Hazard Level 7
Status display	Reversible pressure release flap	Permanent inertization using nitrogen or argon	Fire alarm system	Tolerable residual risk without further safety test
				
Electrical door lock	Mechanical door lock	Oxygen measurement	Fire detection via temperature measurement	
				
	Sealing plug with retaining clamp	Burst disc	Flushing device for inertization in case of fire	
				

Modular Approach – Li-Ion Safety Equipment for Chambers



Example: Chamber 16 m³ Hazard Level 6

Optic and acoustic alarm

Burst Disc

Pressure release flap

Air purging unit

Electrical door lock

Particle blocker

Fire detection via CO gas sensor

Access ports with retaining clamps

Gas and pressure resistant syphon

Inertisation

Outdoor

- Container, bunker, separately building etc.
- Security installations only focused on this
- Easier and faster approval processes
- Shorter installation time in many cases
- Laws of fire protection are easer in realization
- Disadvantage: Need more space…

Don´t forget the chamber is not alone - Supplemental Equipment

Communication and Interfaces.

- Software-Interface:
  - Ethernet
  - RS 232 (optional)
    for set values etc. via ASCII protocol
- Hardware-Interface:
  - Potential-free contact „ Switching-off of test specimens“
    in Performance Level PLc (EN 13849-1)
- Additional signals (optional):
  - Fault signal lead onto potential-free contact, in Performance Level Pla
  - External malfunction alarm, in Performance Level PLc
  - Further additional signals and functions upon request

Signal		VW -> VIT							VIT -> VW									
	Safety Matrix 22612580 WK3-1000/40/S [] action is not achieved [X] action is achieved (X) action is conditional achieved Version 25.01.2013, Draftsman: Gs, Vt Chamber-Nr.:_____	External malfunction alarm							External units ON (e.g release battery tester)	Prealarm CO 200 ppm	Mainalarm CO 1000 ppm	Prealarm H2 1200 ppm (=3% UEG)	Mainalarm H2 2800 ppm (=7% UEG)	Prealarm O2 5Vol %	Mainalarm O2 5Vol%	Error message (all faults incl. SOFTWARE)		Date/Inspector ✓
VIT (Reactions, events)	Chamber STOP	X									X		X	X	X			
	Chamber running								X									
	Signal light ON	X							(X)	X	X	X	X	X	X	X		
	Buzzer ON	X									X		X	X	X	X		
	Cooling to ≤ 20°C								X	X		X				X		
	Prealarm CO 200 ppm								X	X						X		
	Mainalarm CO 1000 ppm										X					X		
	Prealarm H2 1200 ppm (=3% UEG)								X			X				X		
	Mainalarm H2 2800 ppm (=7% UEG)												X			X		
	Prealarm O2 5 Vol %													X		X		
	Mainalarm O2 5 Vol %														X	X		

Remarks:
- The matrix shows the potential free contacts which we provide the customer and show the reactions of the chamber.
- The customer must create an FMEA (Failure Mode Effects Analysis) whether the signals are sufficient for its safety device.
- Dew point range reaches from -3°C to +81°C
- By key switch the test chamber can be operated without inert
- Safety door lock, normally closed (Euchner TP), with programm start the door gets locked
- The gas detection sensors are Dräger Polytron 7000 (CO, H2, O2 monitoring)

Approval by the customer

Date: Name: Department:

Signal exchange matrix

Standard LV 124 - Battery Packs for Cars

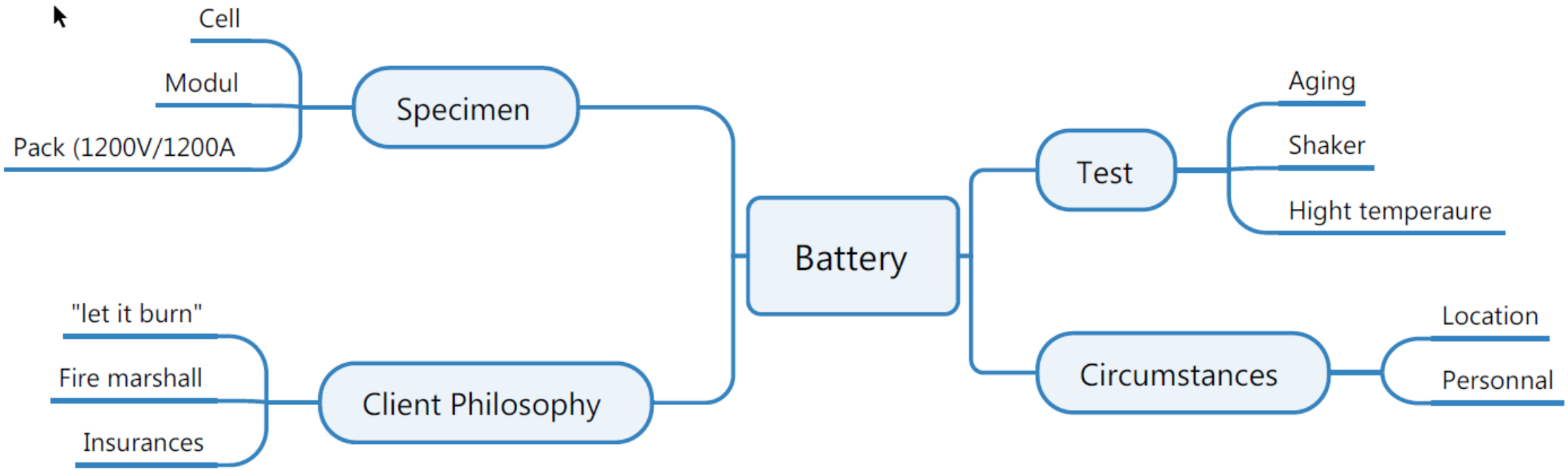
The standard describes requirements and test

- Temperature tests
- Climatic tests
- Dust test
- Salt spray test
- Stone chip test
- Thermal shock chamber
- Spray water system
- Splash water system
- Thermal shock immersion test
- Damp heat plus frost test
- 3-Axis vibration test

Splash water system

3-Axis vibration test system

Further Thoughts



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