



BATTERIES IN AEROSPACE

VDL Battery Test Center

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Manager Testing and Proto Building



STRENGTH THROUGH COOPERATION

CONTENT

- Short overview VDL and VDL-ETS activities
- Battery testing Demand
- VDL-ETS Testing Solution
- Summary and Conclusions

VDL GROEP

FACTS AND FIGURES 2023

1953
Family business VDL Groep
was founded in 1953



71% of our
products are
exported to
114 countries
around the world



100+
We consist of more than 100 companies

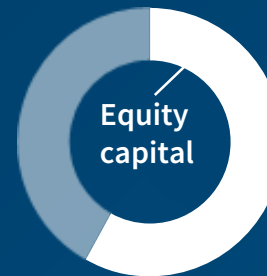
15.317
Employees in 19 different countries



Combined revenue
€6,4 billion



Net Result
€82 million



60,3%
of total assets



VDL Groep is in the top five on the
Dutch reputation ranking

Source: RepTrak

VDL ENABLING TRANSPORT SOLUTIONS (VDL ETS)

Facts & Figures

LOCATED IN
HELMOND & VALKENSWAARD (NL)



8.000 M²
PRODUCTION AND TESTING SURFACE AREA



TURNOVER
€20 MILLION



150 EMPLOYEES



Realizing **BATTERY COMPETENCE CENTER**

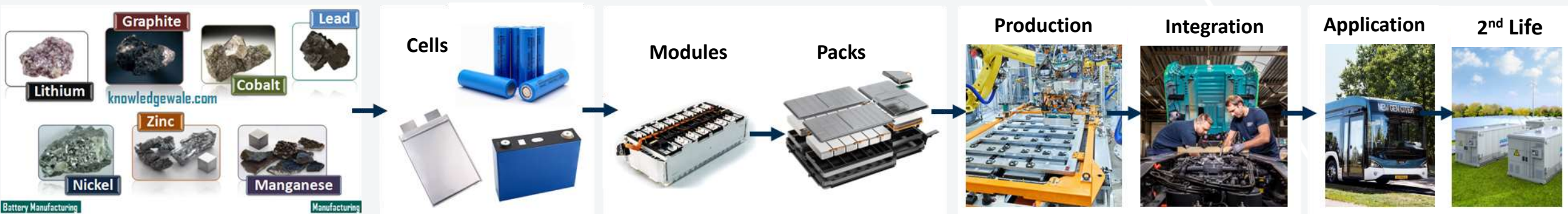


ENGINEERING, CONSTRUCTION AND TESTING OF **ZERO EMISSION** SOLUTIONS AND **COMPONENTS**



TESTING ALONG THE BATTERY VALUE CHAIN

Batteries require higher test and validation along the entire value chain



Cell Development

Application Development

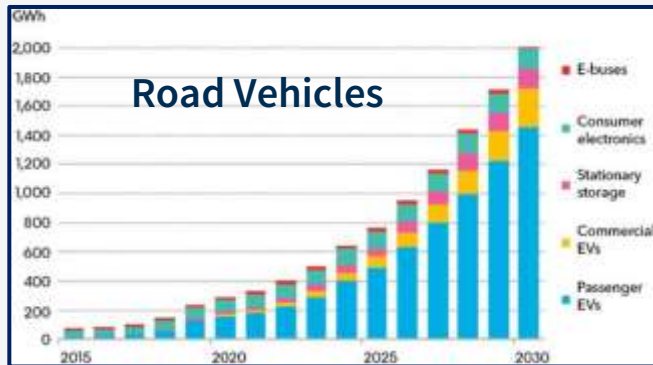
Life cycle

Battery Value Chain	Cell Chemistry	Cell Development	Cell Production	Battery System Design	Proto and small series	Battery system production	Integration, application, calibration	Product lifecycle	Recycling & 2 nd life
Testing Activities	<ul style="list-style-type: none"> New materials, new chemistries From coin cell to target format 	<ul style="list-style-type: none"> Activation and production quality Performance and ageing Data sheet 	<ul style="list-style-type: none"> Validation in designed environment Validation for target application 	<ul style="list-style-type: none"> Homologation test System level validation test 	<ul style="list-style-type: none"> Production validation, COP Modelling, ageing models 	<ul style="list-style-type: none"> In life monitoring Fleet management data generation 	<ul style="list-style-type: none"> Online damage and ageing calculation Predictive maintenance SOH 		

VDL Battery test center supports from research on coin cell level up to second life

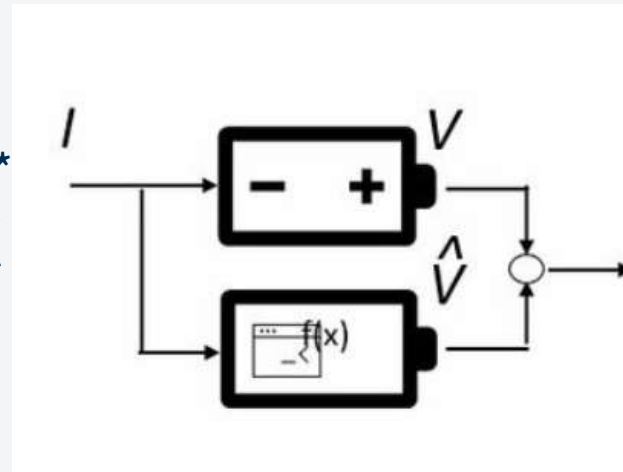
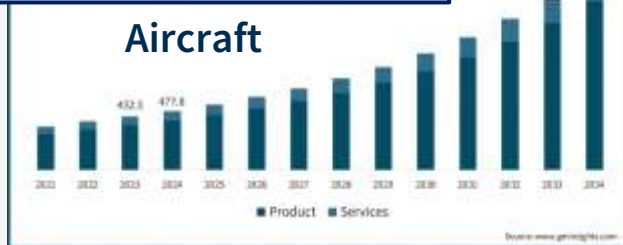
TESTING DEMAND AND COMPLEXITY WILL INCREASE

Different drivers all lead to more testing demand



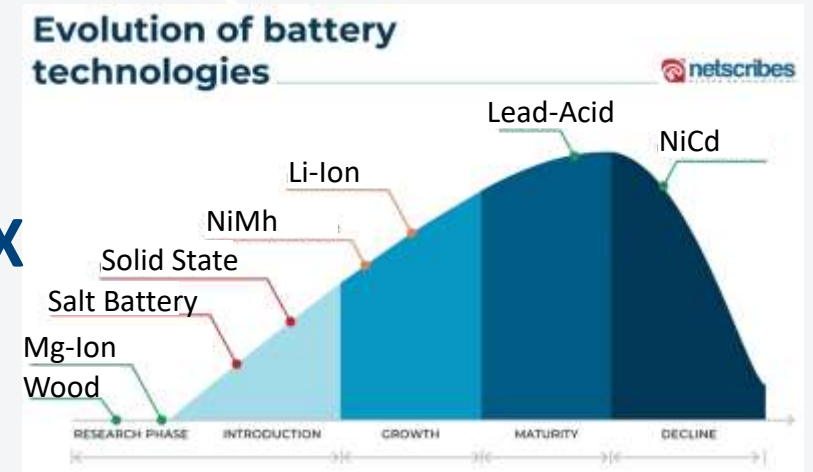
CAGR > 15%*

X



Advanced battery and SOx Modelling

X



Many new technologies in early maturity**

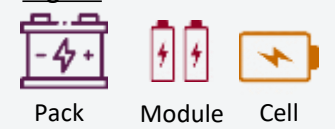
- Battery market is growing double digit CAGR (also when propulsion is hybrid/FC instead of electric)
- Strong shift towards cell testing (development on cell level, validation module and pack)
- High diversity requires high flexibility in equipment
- Demand will stay due to new technologies

* Source: Bloomberg New Energy Finance (BNEF) | <https://www.gminsights.com/industry-analysis/aircraft-battery-market>

**Source: <https://www.netscribes.com/ev-battery-technology-evolution/>

DIFFERENT TEST FOR BATTERIES

Legend



1 Electric Tests



In house

- Electric ageing
- Calenderic ageing
- Capacity, Power
- Cycling
- Self-discharge
- Cold start
- HPC Testing



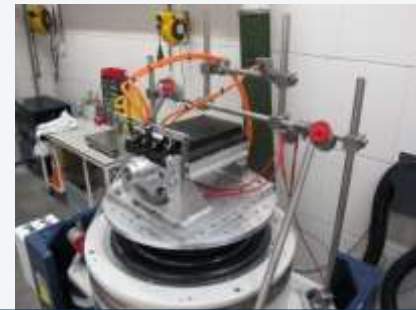
2 Mechanical



- Force, travel (Swelling)
- Connectors
- Geometry
- Microscopic
- Weight
- Leakage and gases
- Dedicated test setup



3 Environmental



- Humidity
- Extreme Temperature
- Vibration, shock
- Salt spray / corrosion
- Shock



4 Safety



With partners

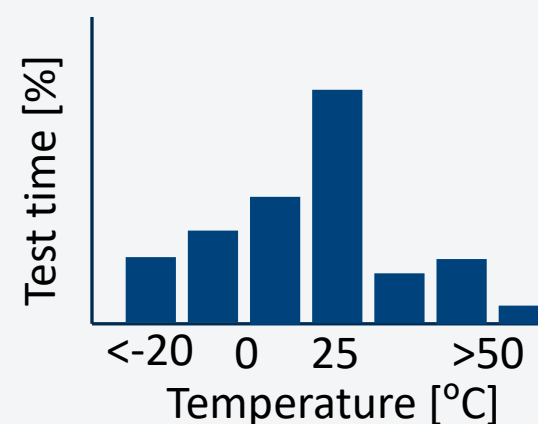
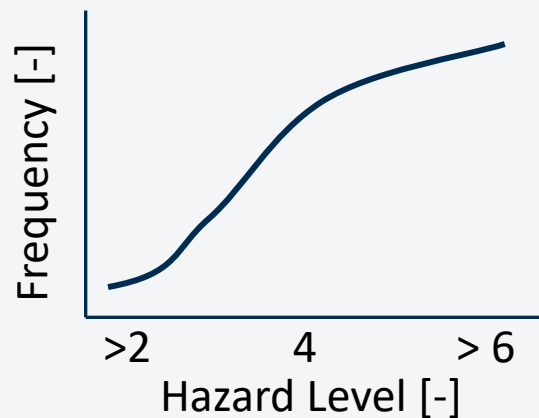
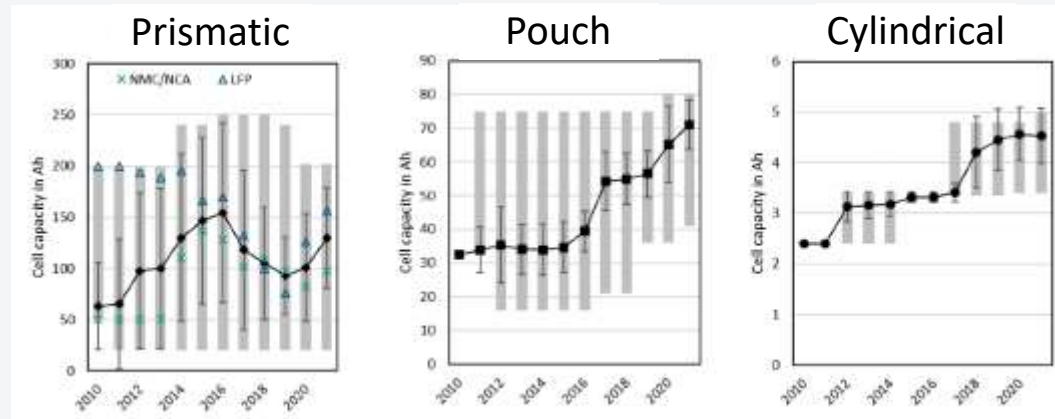
- Short circuit
- Reversed polarity
- Deep discharge
- Fire test
- Bruise/squash
- Salt spray / corrosion
- Shock up to 3 axis



Work load

RIGHT SIZING OF A BATTERY TEST LAB

Use of Road Mapping, statistical and project data to setup right sized test center

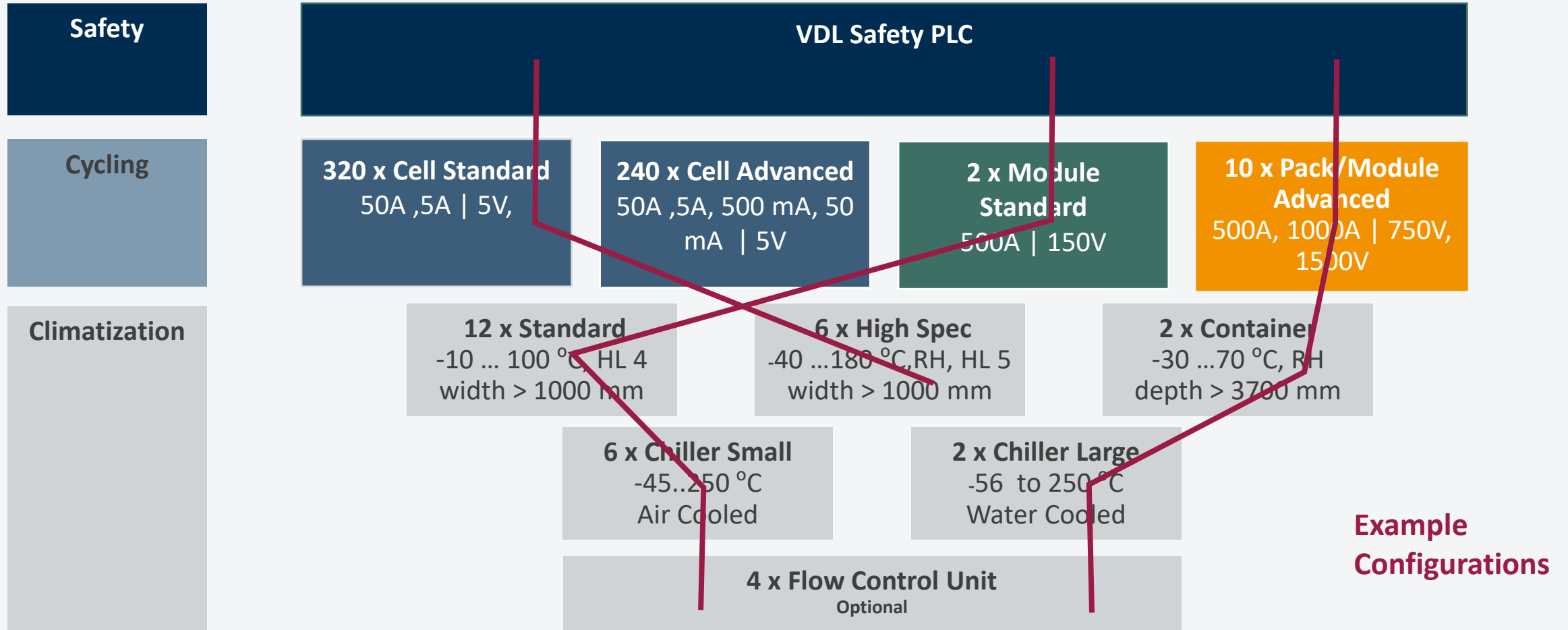


- Cell size and cell Capacity will remain very diverse thru applications, reaching from coin cell to from 18650 cylindrical to 1000 mm long blades to >300 Ah prismatic
- Low TRL level development, consumer electronics and high specific power use small cells
- More than 80% of all operating hours are between 0 and 50 °C
- More than 75 % of all cycling testing require a Hazard Level $\leq 4^*$
- Approx. 95 % of all cycling testing require a Hazard Level $\leq 5^*$

➤ * EUCAR Hazard Levels: <https://www.batterydesign.net/eucar-hazard-levels/>

RIGHT SIZING OF A BATTERY TEST LAB – ETS SOLUTION

Solution for an ultimate flexible test center



BATTERY TESTING – ELECTRIC TEST

Cell testing



- 560 Channels / 50A / 5V
- Current range 50 mA, 500 mA, 5A, 50A
- Combined 50, 100, 150 ...4000A
- 10 Standard climate -10 to +100 C, 700 L, $\pm 0,5$ K
- 4 High spec climate chambers, 700 L, -40 °C to +180 °C, 10 % to 98 % RH
- Hazard level 4 and 5
- Rise Time Current 10-90% fs ohmic load $\ll 1$ ms
- Accuracy: Control 0,03% FSR, measure 0,005% FSR

Module testing



- 8 Channels 500A / 150-750V
- 2 Standard climate -10 to +60 C, 700 L, $\pm 0,5$ K
- 2 High spec climate chambers, 700 L, -40 °C to +180 °C, 10 % to 98 % RH
- Hazard level 4 and 5
- Rise Time Current 10-90% fs ohmic load < 5 ms
- High precision coolant cyler -40..110C
- Setpoint accuracy:
 - 0,04% FSR for U and I
 - Resolution 20 mA, 5 mV

Pack testing

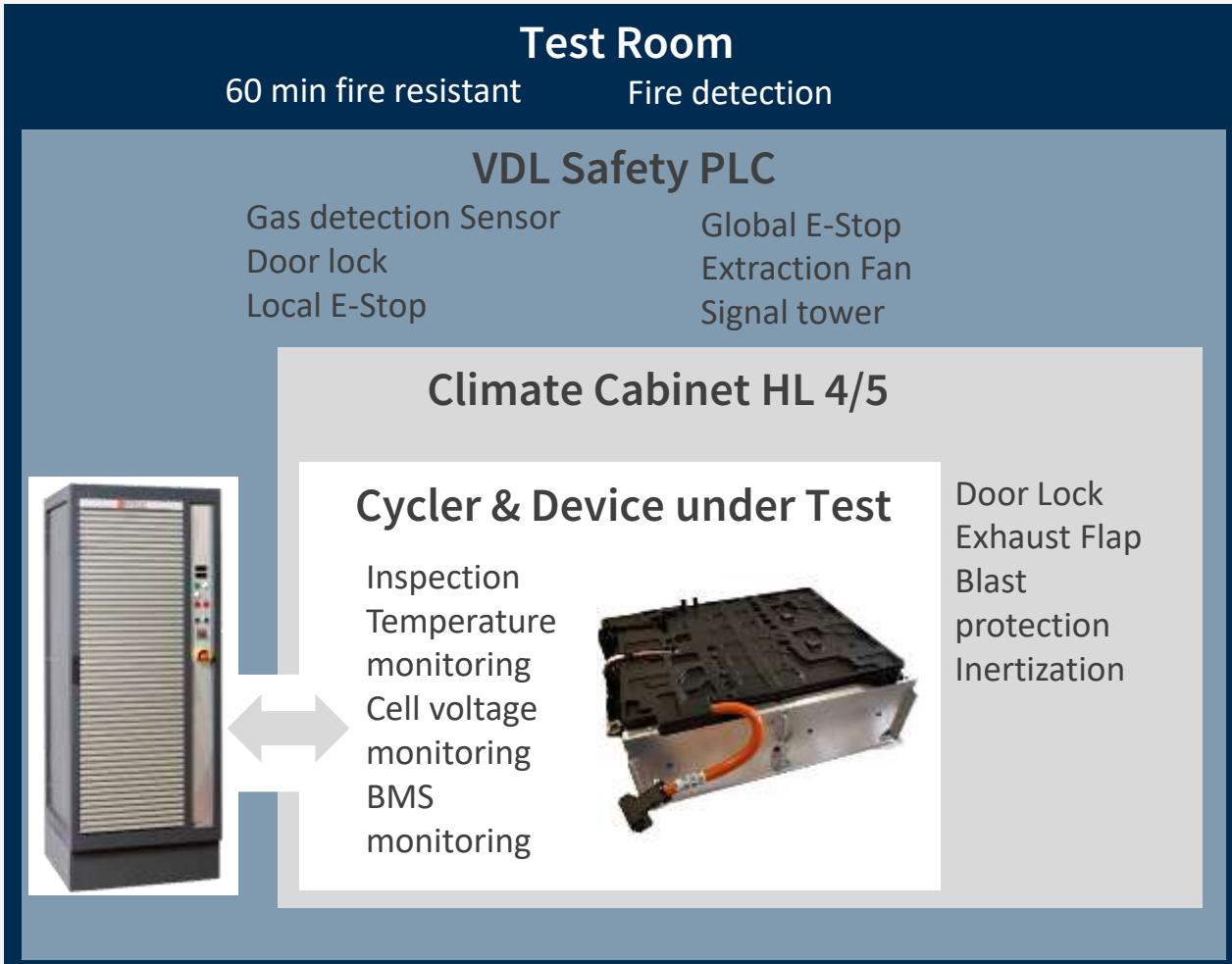


- 4 Channels 500A / 125kW / 750V (S+P)
- Max 2000A / 1500V / 640 kW
- 2 containers 20 ft, -30 to +80 °C ± 1 K
- Outdoor solution
- High precision coolant cyler -40..110C
- Rise Time Current 10-90% fs ohmic load < 10 ms
- 3 calibrated ranges 10...150 V, 10..750V, 10..1500 V
- Setpoint accuracy:
 - 0,04% FSR for U and I
 - Resolution 20 mA, 40 mV

VDL-ETS TESTING: How to test SAFE and LEAN at the same time?

Example: Module Test

Hardware Setup



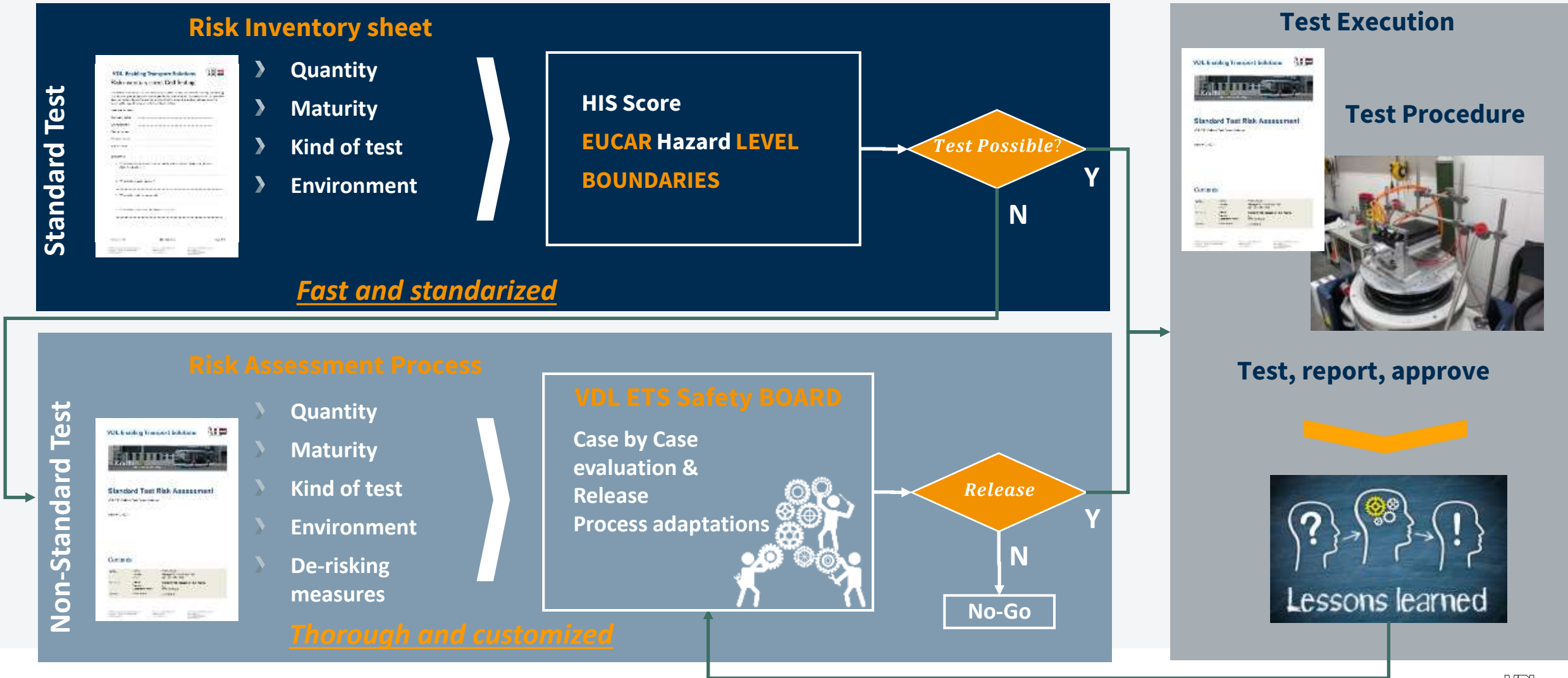
Methods & Procedures

- General Quality ISO 9000, ISO 14000, PGS37
- Machine setup released by Machine safety group
- Cell/Module/Pack Safety Questionnaire
- Test Release process
- Sign-off by Customer
- Clear working instructions
- Module check-in and inspection
- Intermediate checks
- Safety Storage

VDL-ETS TESTING: How to test SAFE and LEAN at the same time?

TEST RELEASE PROCESS

Test Release Process consists of fast track for standard test and safety board release for non-standard tests



CONTROL ACCURACY

Solution for an ultimate flexible test center

➤ Current:

- Cell: 0.03% FSR
- Module, pack: 0.04% FSR

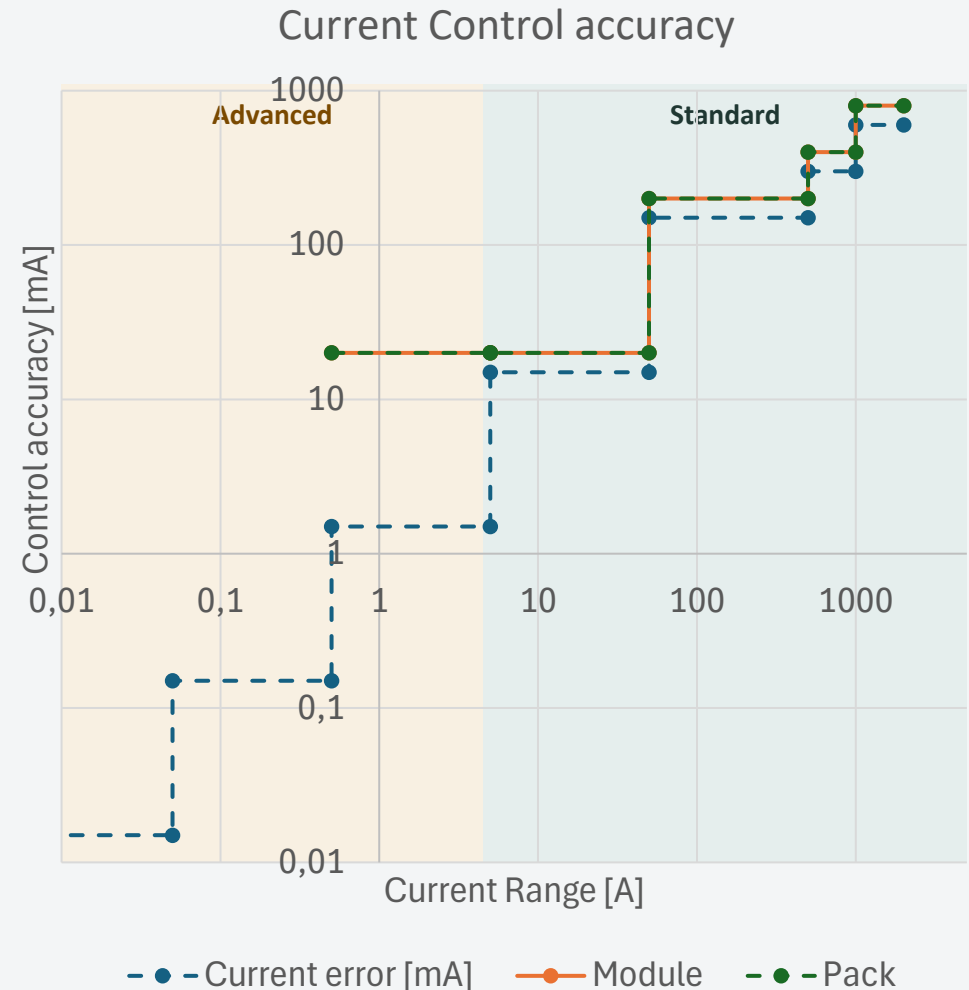
➤ Voltage:

- Cell: 0,03% FSR
- Module, pack: 0.04% FSR

➤ Temperature:

- Standard K-type thermocouple $\pm 1.5K$
- Advanced PT100 down to $\pm 0.1 K$ (AA Class)

Accuracy From 400 mA @ 1000A down to micro amps!



VDL-ETS TESTING

Example Cell Testing

- ✓ Extraction fan per room, controlled by Safety PLC
- ✓ One cycler (80 Channels 50A) per 2 rooms
- ✓ Up to 40 specimens in one chamber
- ✓ Cabinet size 720l (both Standard and high Spec)
- ✓ CAN based data acquisition
- ✓ One Safety PLC per Cabinet
- ✓ Local and Global E-Stop



SUMMARY

- Battery testing is a key asset during the entire battery value chain
- Demand for battery testing will increase in double digit CAGR rates, but not in all areas
- High flexibility and right sizing are key to a successful test Center
- Most of development and modelling can be done on cell Level
- VDL-ETS realized one of the largest test centers in the BeNeLux
- We can support from the smallest coin cell to the biggest pack.
- **Accurate, flexible and of course Safe!**





VDL ETS

KRACHT DOOR SAMENWERKING

Thank you for your attention! Questions??

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