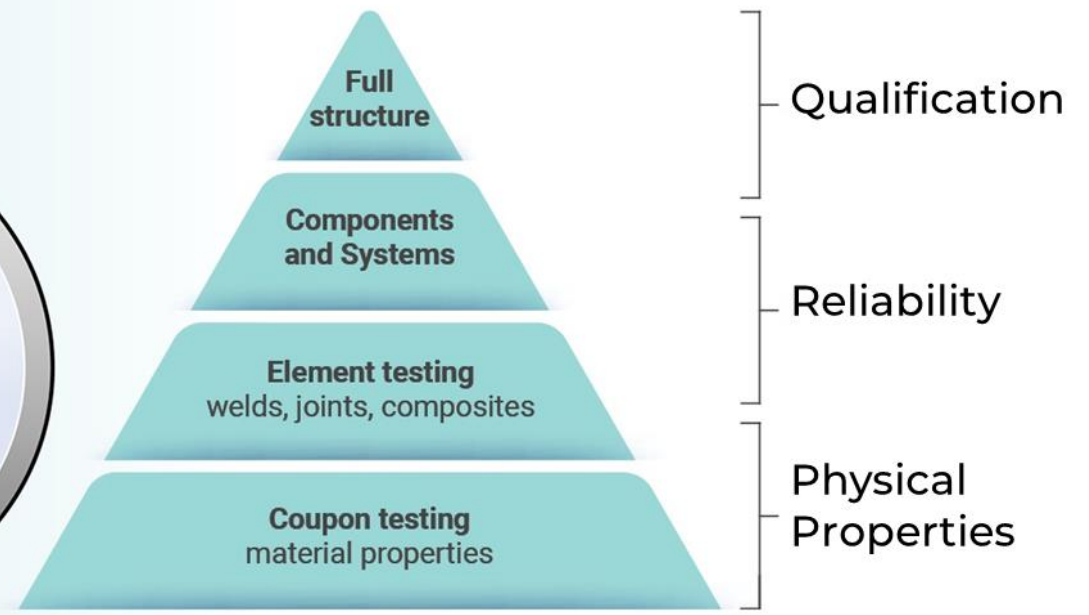
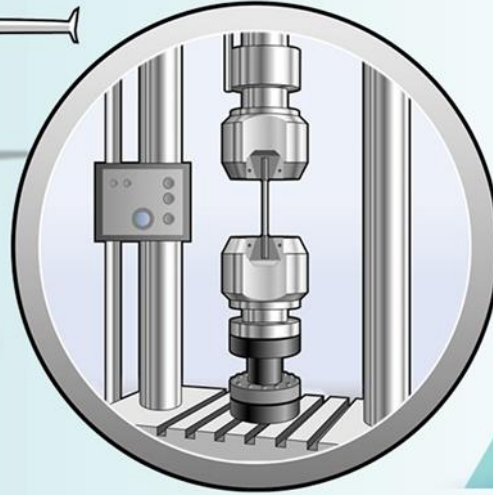
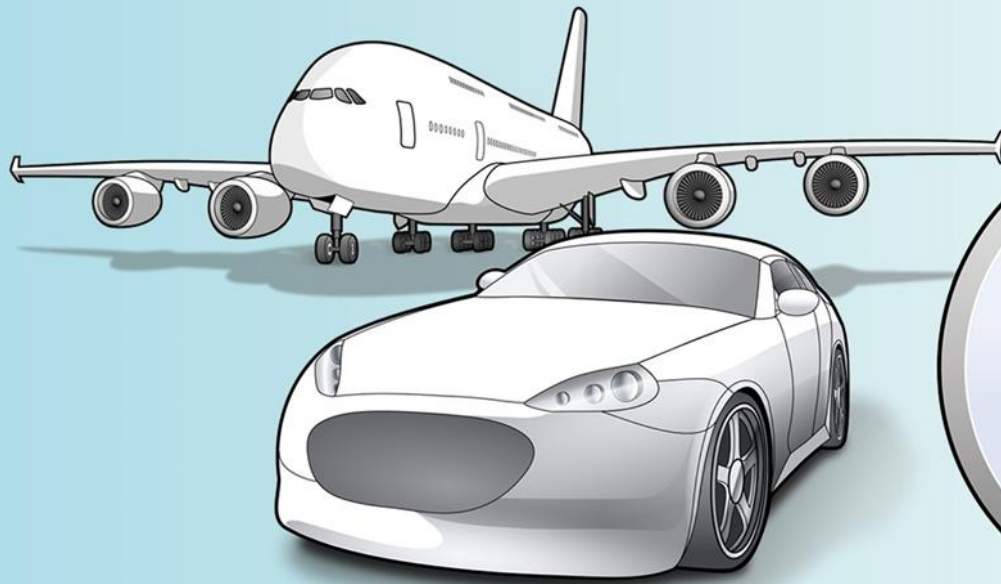




2023 HBK Technology Days

7 November 2023

Battery Cell Testing: AVL Safety Chamber

Possible Tests for Cells < 250Ah:

- Crush
- Nail Penetration/ Int. Short Circuit
- External Short Circuit
- Over-charge/ over-discharge (forced)
- Over-temperature/ Thermal Shock
- Altitude
- Vibration
- Mechanical Shock



- AVL Technology, Capability, and Applications for EV Battery Vibration Testing,

Armin Karner,
Senior Application Manager, AVL List GmbH

AVL Technology, Capability, and Applications for EV Battery Vibration Testing

Abstract

- Vibration and specific mechanical shock testing are important for battery development. For us at AVL, it is important to not only understand the battery shaker, but also to focus on our customer's application use cases to tailor our offerings accordingly. A holistic test environment with all required subsystems integrated into a working test system is essential. With our experience of existing labs and design studies, we support our customers from application to real test lab. We can even provide complete turnkey solutions to ensure a fast and efficient start-up. AVL's outstanding safety system underlines our extensive experience in battery testing and provides a safe and easy to use test environment. This presentation describes what is needed from a test system perspective and gives an overview of how we can support our customers on their successful journey.

About the presenter, Armin Karner, Senior Application Manager, AVL List GmbH

- Armin Karner has graduated in the fields of Information Technology & Electrical Engineering. He joined AVL almost ten years ago and switched to electrified test systems in 2016. Since 2019, he has been working as Senior Application Manager for Battery and Electrified Test Systems in the Application Team Electrification. As an example, he is part of a standards working group to define test procedures for determining charging performance to provide reliable labelling in an understandable and reproducible way for end users. With his experience in these areas, Armin brings extensive technical and solution-oriented experience, especially in the field of battery environmental testing with electrodynamic shakers.



AVL Battery Test Systems

AVL Technology, Capability, and Applications
for EV Battery Vibration Testing

Armin Karner

About Us

At AVL, we are one of the world's leading mobility technology companies for development, simulation and testing in the automotive industry, and in other sectors. Drawing on our pioneering spirit, we provide concepts, solutions and methodologies for a greener, safer and better world of mobility.



AVL at a Glance



1948

Founded



26

Countries
Represented



11,200

Employees Worldwide



11 %

Of Turnover Invested
in Inhouse R&D

75

Years of Experience

45

Global Tech and
Engineering Centers

68 %

Engineers and
Scientists

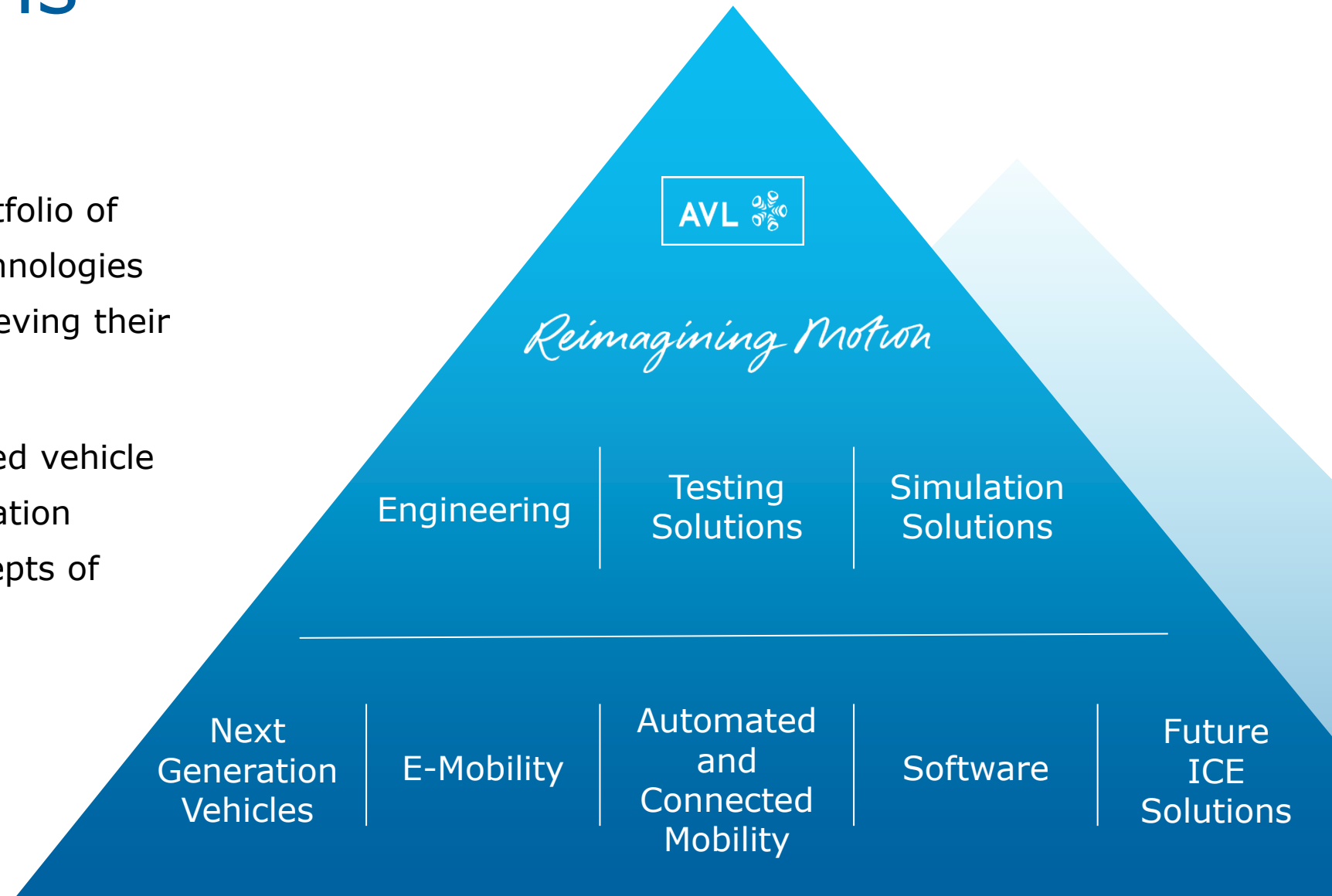
2,200

Granted Patents
in Force

Turning Visions Into Reality

We constantly transform our portfolio of high-end methodologies and technologies to support our customers in achieving their ambitions.

From future fuels to the connected vehicle ecosystem, we are driving innovation today, to build the mobility concepts of tomorrow.



Battery Development Overview

Testing and Validation Solutions

Facility Design



Engineering support for the design and realization of complete battery testing laboratories.

From Products to Test Fields



Complete portfolio of battery testing products.

Operate Testing Laboratories



Scalable automation and lab management system for efficient operation of testing fields of any dimension.

Data Driven Development



Ready-to-run global standard tests, along with templates for intelligent data analysis and reporting.

Environmental and Abuse Testing



Design and realization of turn-key facilities with AVL solutions and the integration of 3rd party equipment.

End of Line Production Testing



Standardized solutions for end of line tests - from simple test and charge to full load conformity test.

From Product to Test Center

– From Battery Cell to Battery Pack

Ready to Run Tests + Data Analysis

E-Library
Plug & Play Approach To E-Testing

Lab Management and
Energy Management



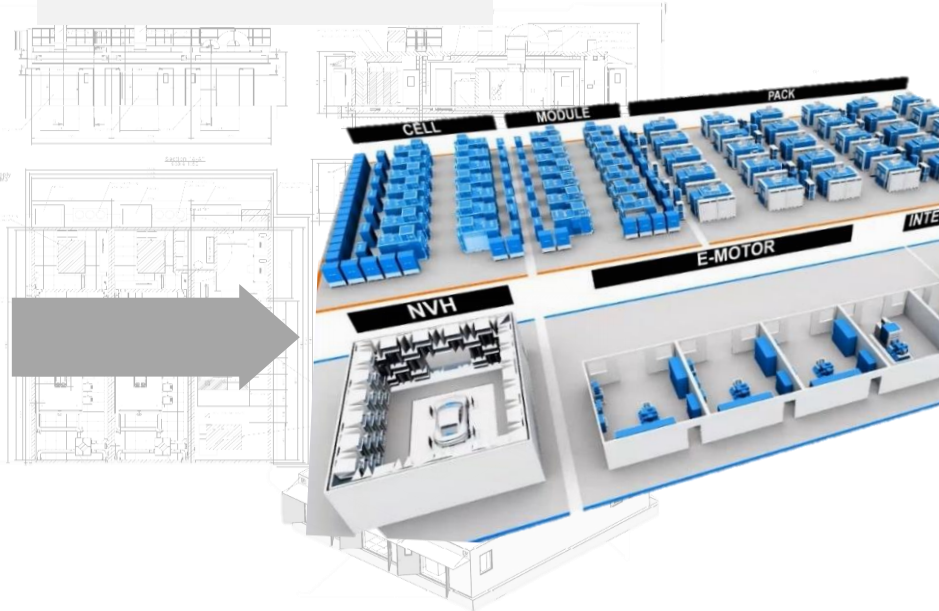
AVL Products

e.g. AVL CELL TESTER CT600™
(Battery Cell Cycler)



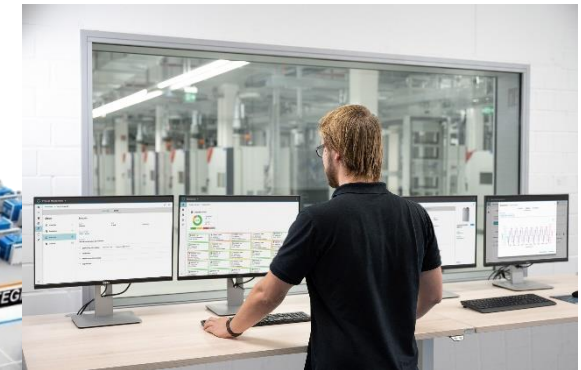
AVL Test Systems

e.g. AVL integrated solution in
container



AVL Test Center

e.g. Test lab in container design



AVL Battery Cell Test Lab Configuration

Overview

The Challenge

The Solution

The Added Value



Automation

Up to 64 channels/chamber
Up to 1 kHz control and logging frequency



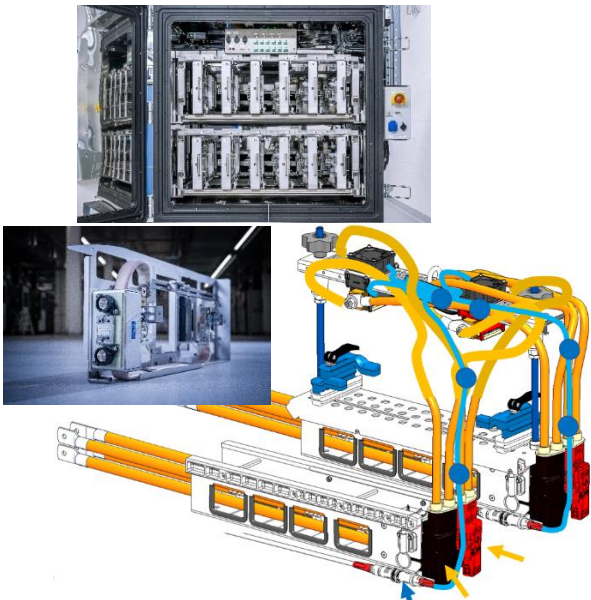
Battery Cell Tester

Voltage up to 5 V
Current low range 2 – 5 A
Current mid range 10 – 40 A
Current high range 250 – 1800 A



Climatic Chamber

Temperature range
-40 °C to 90 °C
Humidity control (optional)
Volume 0,8 / 1 / 1,5 / 2 m³



Cell Fixture

Cell types:
Cylindrical cell, prismatic cell,
pouch cell
preload, pressure and
temperature sensors



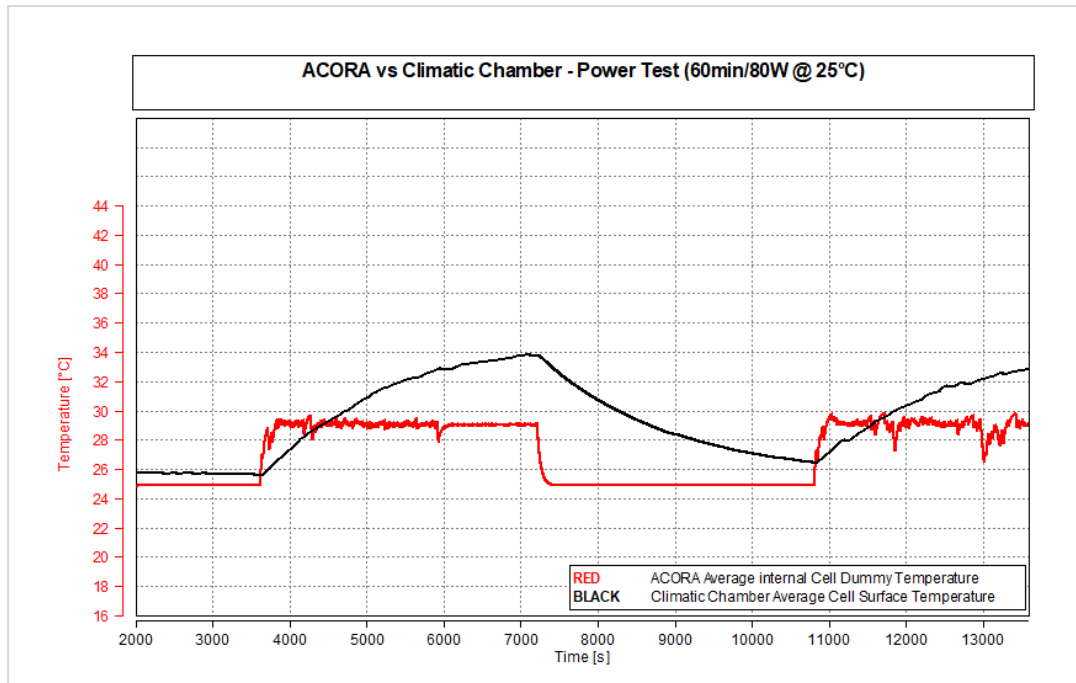
Safety System

Gas sampling unit
Pressure relief
Compressed air flushing
Inertization
Fire suppression

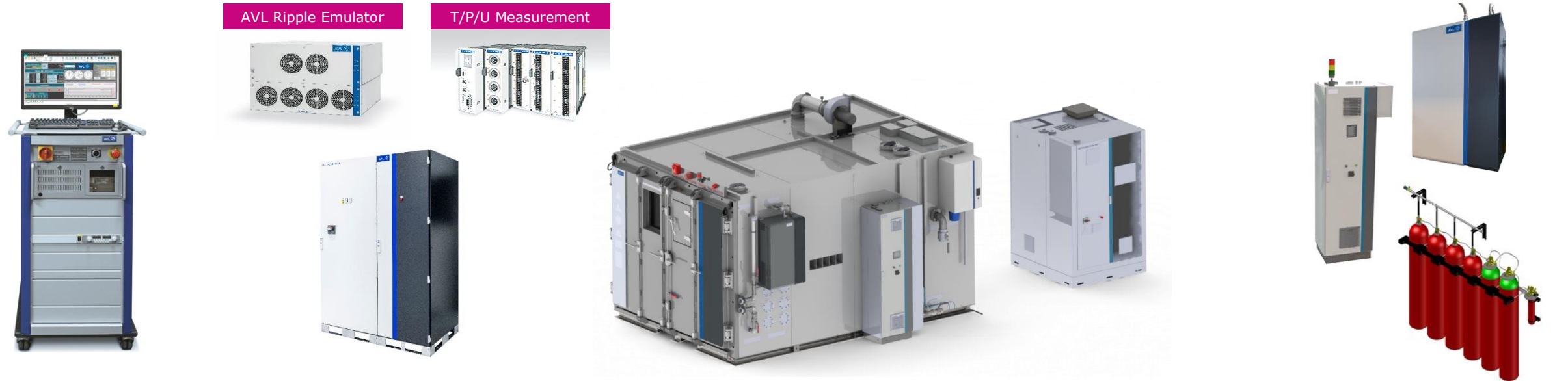
ACORA Battery Cell Test System

Test Time Optimization

- Fast thermal stabilization leads to high reduction of thermal relaxation time
- Automatic placement of unit under tests with 24/7 operation



AVL Battery Pack Testbed Configuration



Automation

Battery Pack tester

Climate Chamber

Battery Conditioning

Safety System

Up to 8 channels
Data exchange rate up to 1kHz
Different interfaces
Connection to „data management“

Voltage: 800V up to 1200 V
Power: 160kW up to 2.2 MW
Current: 600A up to 4000 A
(up to 4 systems in parallel)

Gradient ratio 2 or 4.5 K/min
Temperature range -40 to 90 °C
Humidity control up to 98 % rel.H.
Volume 16 or 22 m³

Cooling capacity up to 18.5 kW @20°C
Temperature range -(40) 30 to +90 °C

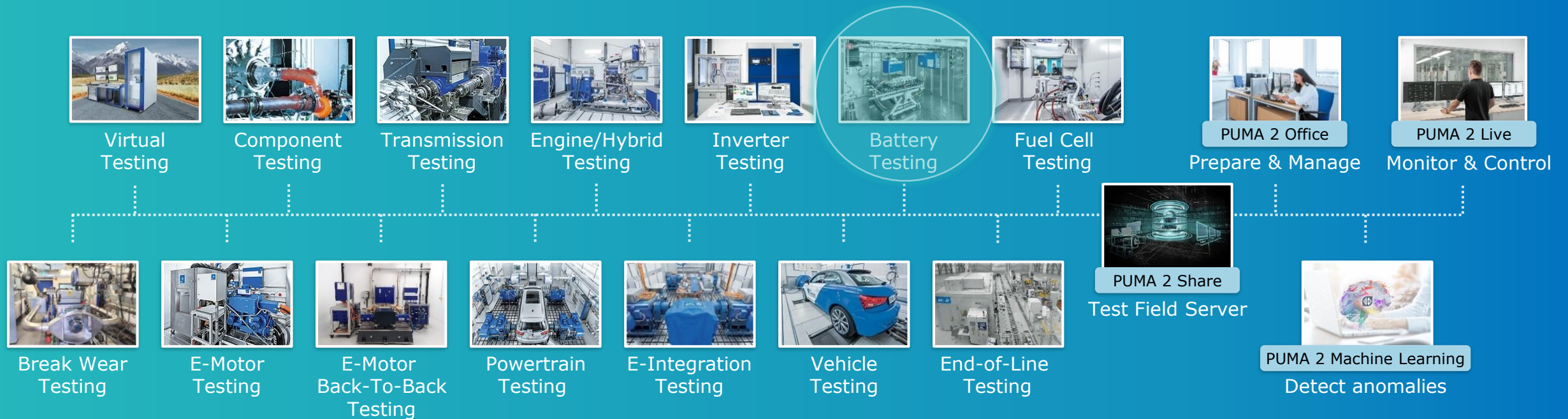
Gas detection
Pressure relief
Suction (ATEX fan)
Fire suppression (water mist)
Flooding

One Eco System – AVL PUMA 2™

ONE automation system, **ONE** user experience
TAILORED to address specific needs

ONE office tool, **ONE** database

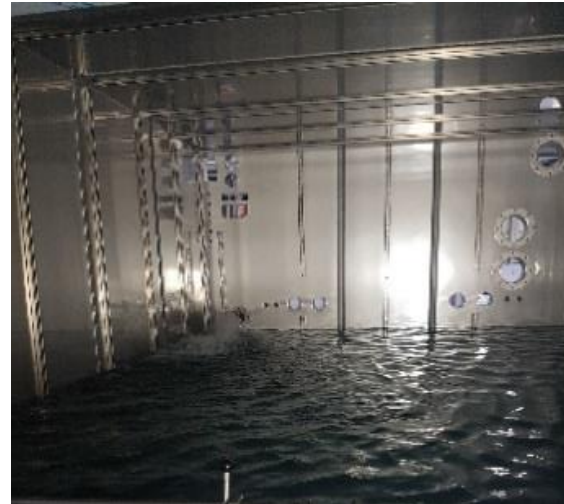
Manage parameters and results
from **ALL** test environments



ENHANCED productivity

AVL Climatic-Chamber Battery Pack - Highlights

Application-driven solution for best-in-class thermal development on latest safety standards



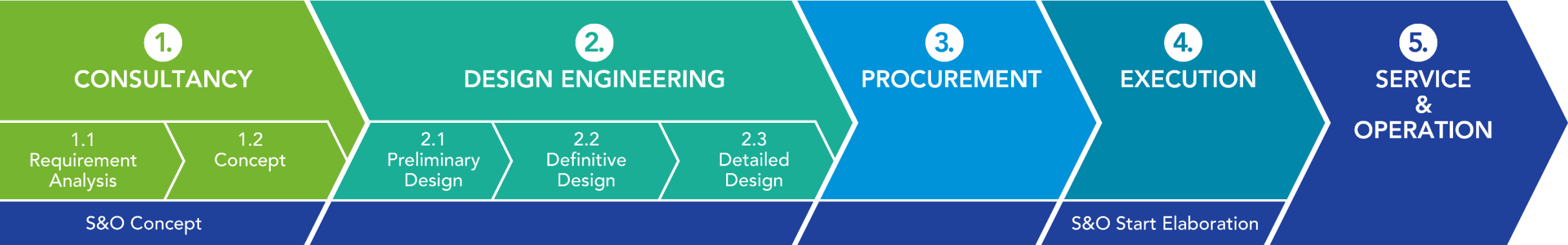
Low TCO by energy efficient design

Optimized space in the test cell

Installed refrigerant unit separated from the insulation cell

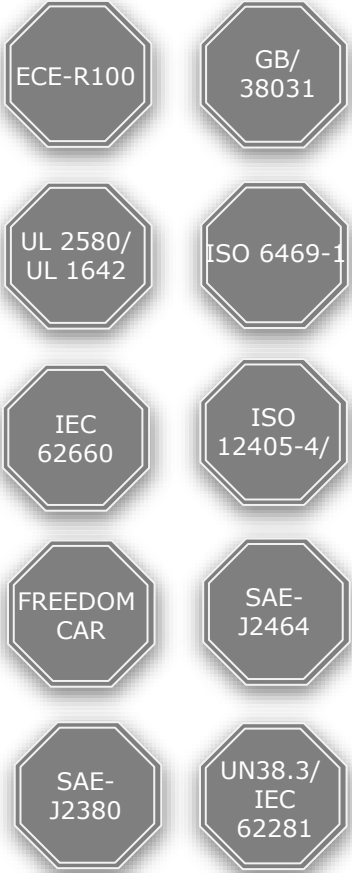
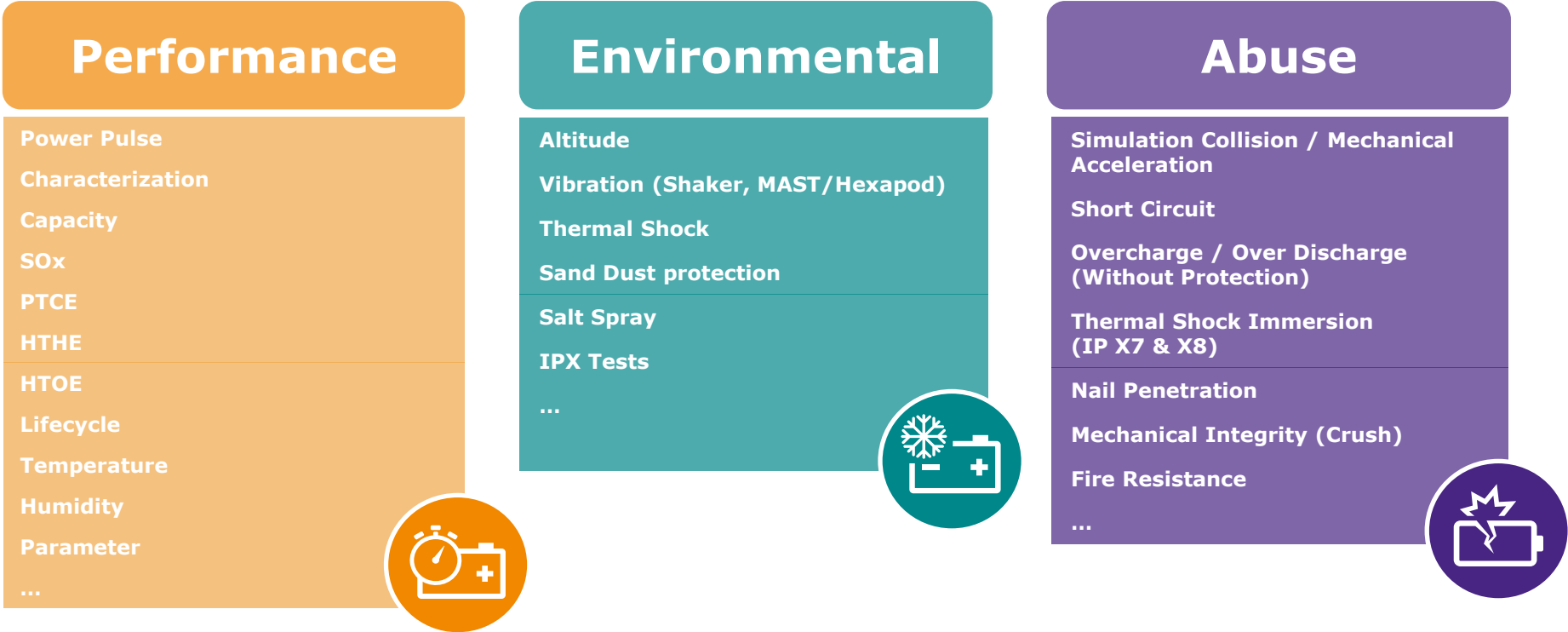
Design to the application

AVL Services



From Requirements to Reality

Core Fields of Battery Testing



All over different standards in different countries, there are three fields of testing: **Performance**, **Environmental** and **Abuse**.

Challenges

Refine battery designs, optimize performance, enhance safety, and ultimately deliver reliable and efficient batteries to the market



High Flexibility

Adaptable to different battery types and sizes to guarantee high throughput.



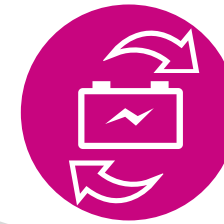
Safe Testing Environment

Prevent incidents like overheating, thermal runaway, or fire, ensure up to Hazard Level 6.



Efficient Lab Operation

High optimization potential in data organization, analysis and storage, as well in energy consumption.



Accuracy and Consistency

Achieving consistent and reliable performance across different conditions and usage scenarios.

The AVL Generic A&E Lab Example



Battery Cell Testing: AVL Safety Chamber

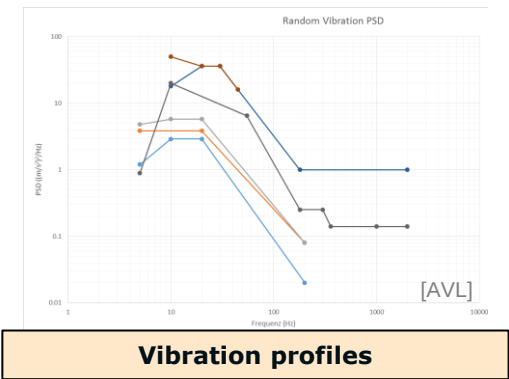
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- Altitude
- Vibration
- Mechanical Shock



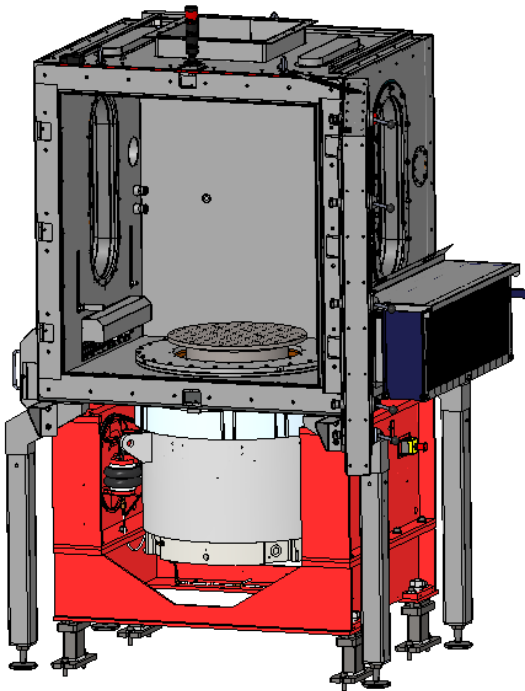
Electrodynamic Shaker

Vibration, Mechanischer Shock



Key standards

Vibration	- Intl.: UN 38.3, ISO 6469, SAE J2929, IEC 62660-2 - Europa: ECE R100 - USA: UL 2580, US ABC, FreedomCAR - Indien: AIS-048 - China: QC/T 543
Shock	- Intl.: UN 38.3, ISO 6469, SAE J2464, SAE J2929 - Europa: ECE R100 (sled Testbed) - USA: UL 2580, US ABC, FreedomCAR - Indien: --- - China: GBT xxx



Description

The purpose of this test is to evaluate the effect of **long-term vibration profiles** – representative of driving – on the battery, both in terms of the durability and in terms of identification of design flaws. The vibrations are produced by a **shaker** device in a laboratory. Sine waves (with certain amplitude and frequency) or random profiles are used. Sine swept testing is commonly used to identify **product resonances**, while random vibration simulates **everyday life scenarios** that a DUT would experience.

The mechanical shock test aims at evaluating the robustness of a battery in situation of **sudden acceleration/deceleration** of a vehicle. The shock forces are defined in terms of acceleration and shock duration adapted to different conditions (normal in-use driving, highspeed over curbstone, vehicle crash).

The shock signal is represented by a certain pulse shape (e.g. a half-sine curve) parametrized by the **peak acceleration** (g) and **time duration** (ms) along certain **directions** at a given **SOC** and **Temperature**. A certain number of shocks are repeated.

E-Mobility Center Graz (EMZ)

Sustainable electromobility for 20 years

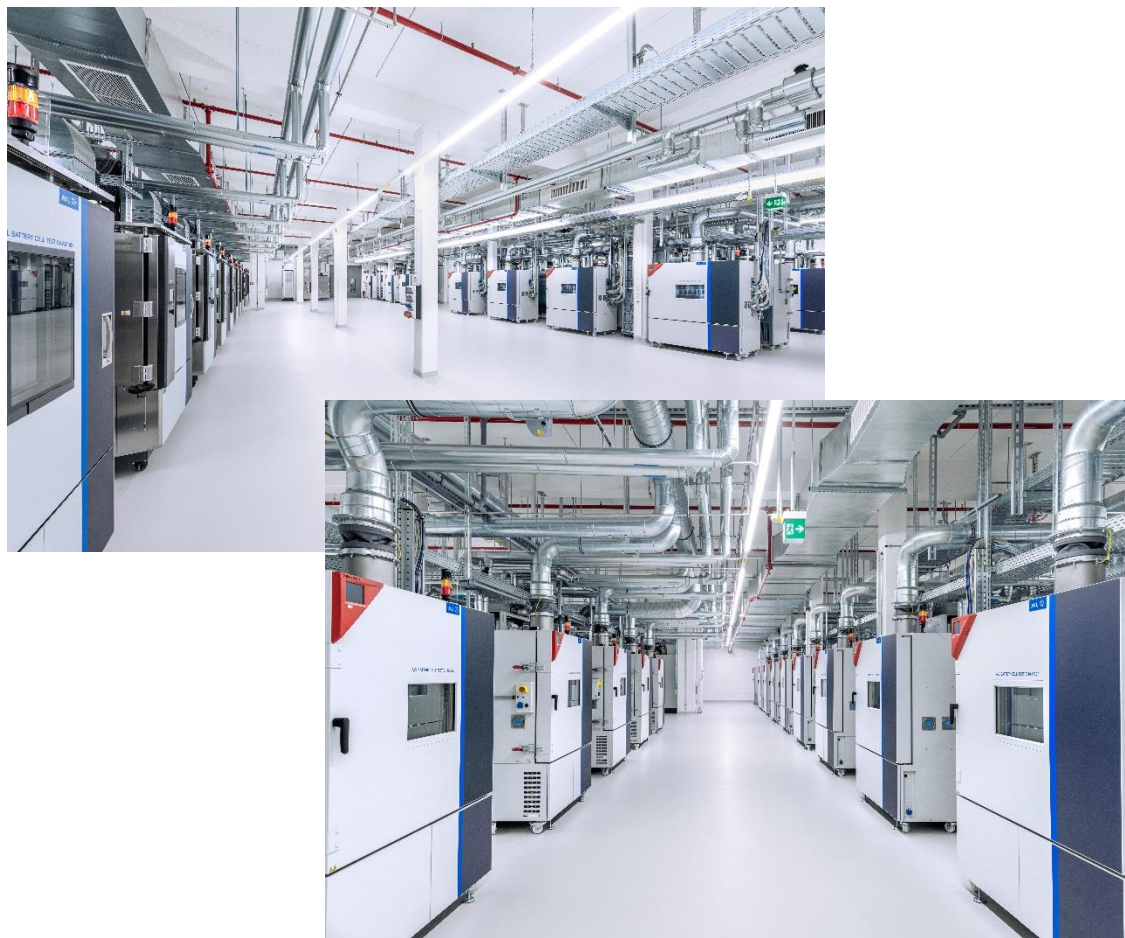


Testing capabilities cover battery testing on cell-, module- and pack level

8 test chambers on an area of 700 sqm for electric and thermal battery testing – up to 1200 V

Floodable walk-in chamber for the testing of up to 3 systems in parallel

VW Salzgitter

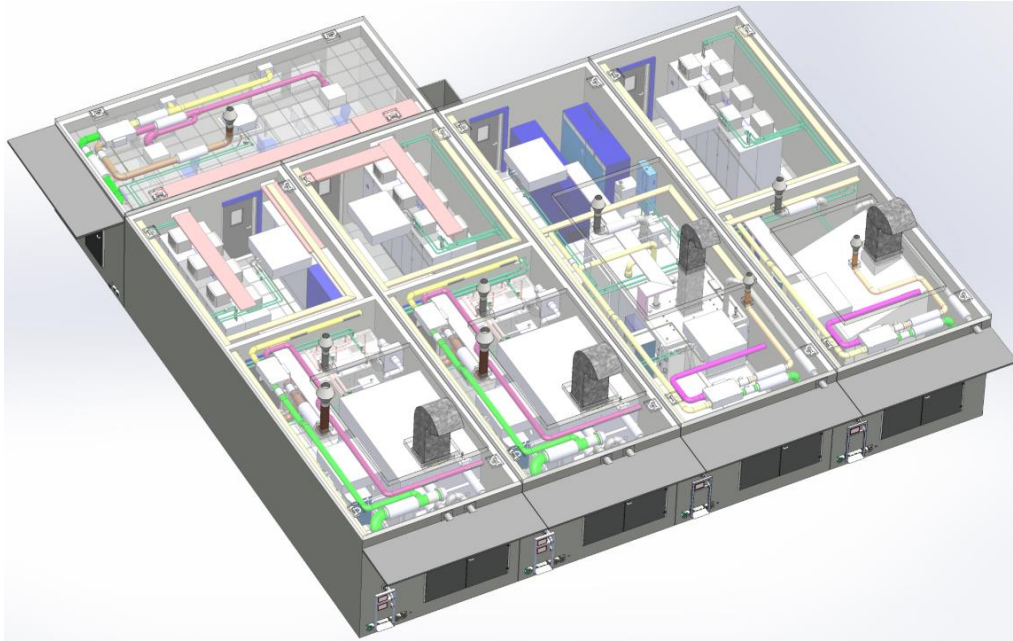


Project Name	VW Battery Cell Lab CoE Salzgitter Phase 1
Scope	Development, delivery, installation and commissioning of a large amount of test systems for battery cells in 3 laboratories including an intelligent lab management software solution with integration into the VW control system
Customer	Volkswagen AG
Location	Salzgitter/Deutschland
Year of OI	2019

Public source: [Development laboratories at Volkswagen in Salzgitter - Next Generation battery cells. | Videos & Footage | Volkswagen Newsroom \(volkswagen-newsroom.com\)](#)

Valmet Automotive

Battery Pack Testing Laboratory in Germany – containerized solution



Valmet Automotive and AVL initiated a joint project to achieve common strategic goals for the development and testing of high-performance batteries.

"I appreciated the trusting relationship we had right from the start. And I was particularly pleased that we'd found a team in Graz that worked with a high level of motivation and the necessary drive. From a technical point of view, AVL offers a powerful turnkey solution that gives us the experience and safety we need to achieve our objectives in the shortest time possible."

Stefan Sommer, responsible for testing at Valmet Automotive

ISP – The Testing Institute

[Watch the video](#)
(external link)

ISP Battery Test Center in Germany – complete lab including facility and concept design



Market analysis and concept studies in close cooperation with the customer

Performance and lifecycle testing

Scope of supply:
12 battery pack testbeds
24 battery module testbeds
Complete facility

Benefits



Global Footprint

Global presence with local competence and support



Efficiency

Reduce complexity and effort in battery testing with highly efficient tools from planning to execution and analysis

TCO optimized overall test system approach



Safety Concept

Safety concept based on intensive experiments and simulation of cell venting scenarios with thermal runaway



Application Support

Support the customer from DVP creation, testing methodology and application knowledge thanks to AVL in-house battery expertise from PTE and ITS

Contact



LOCATION

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Austria



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WEBSITE

<https://www.avl.com/>

AVL Homepage

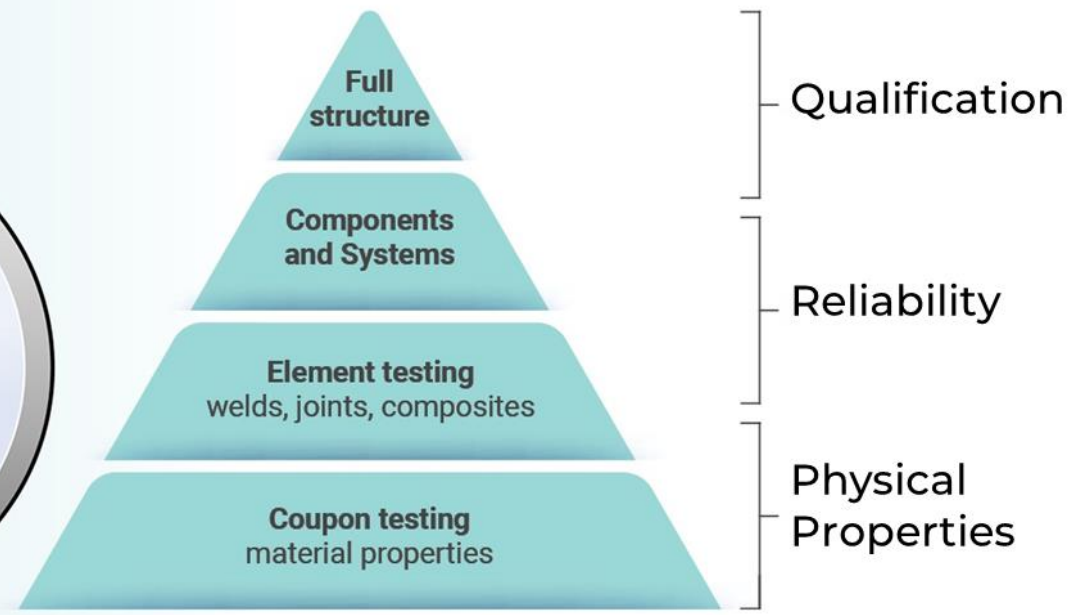
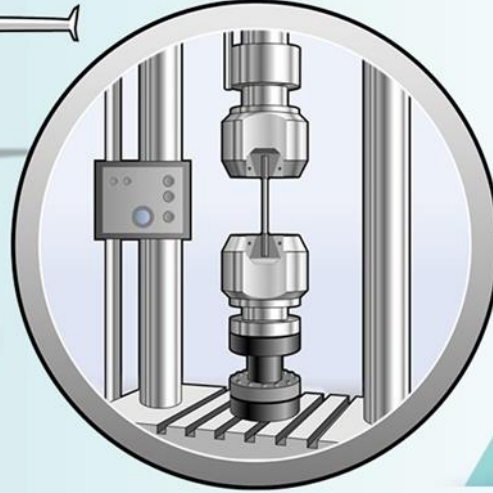
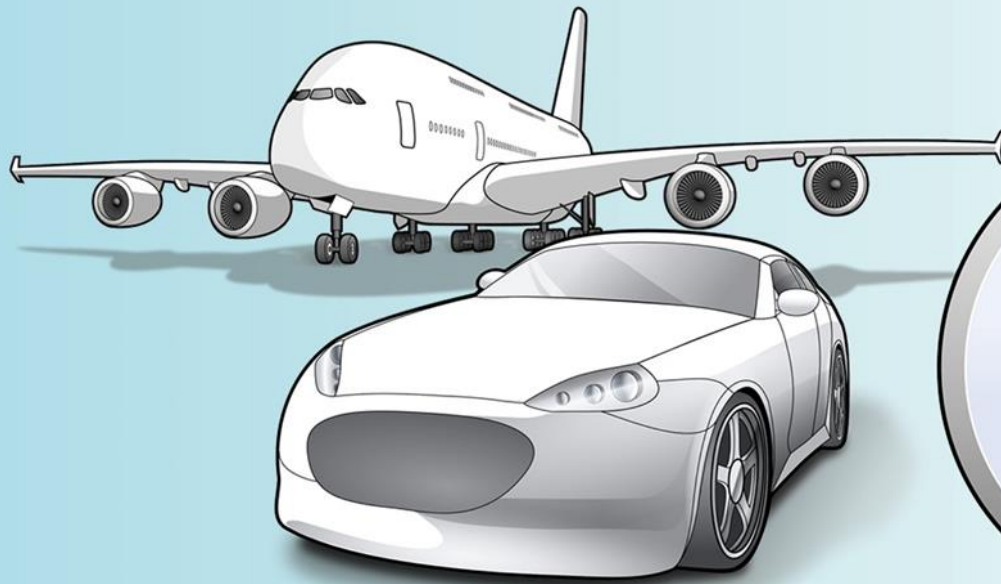
- [Battery Test Systems | AVL](#)
- [AVL Battery Cell TS™ | AVL](#)
- [AVL Battery Cell TS™ ACORA | AVL](#)



Thank you



www.avl.com



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