BOSMAL Research & development

AUTOMOTIVE

HOMOLOGATION

DESIGN AND AUTOMATION

DEFENCE AND MARITIME INDUSTRY

COMPOSITES

CONSTRUCTION INDUSTRY

THERMAL MANAGEMENT & REFRIGERATION

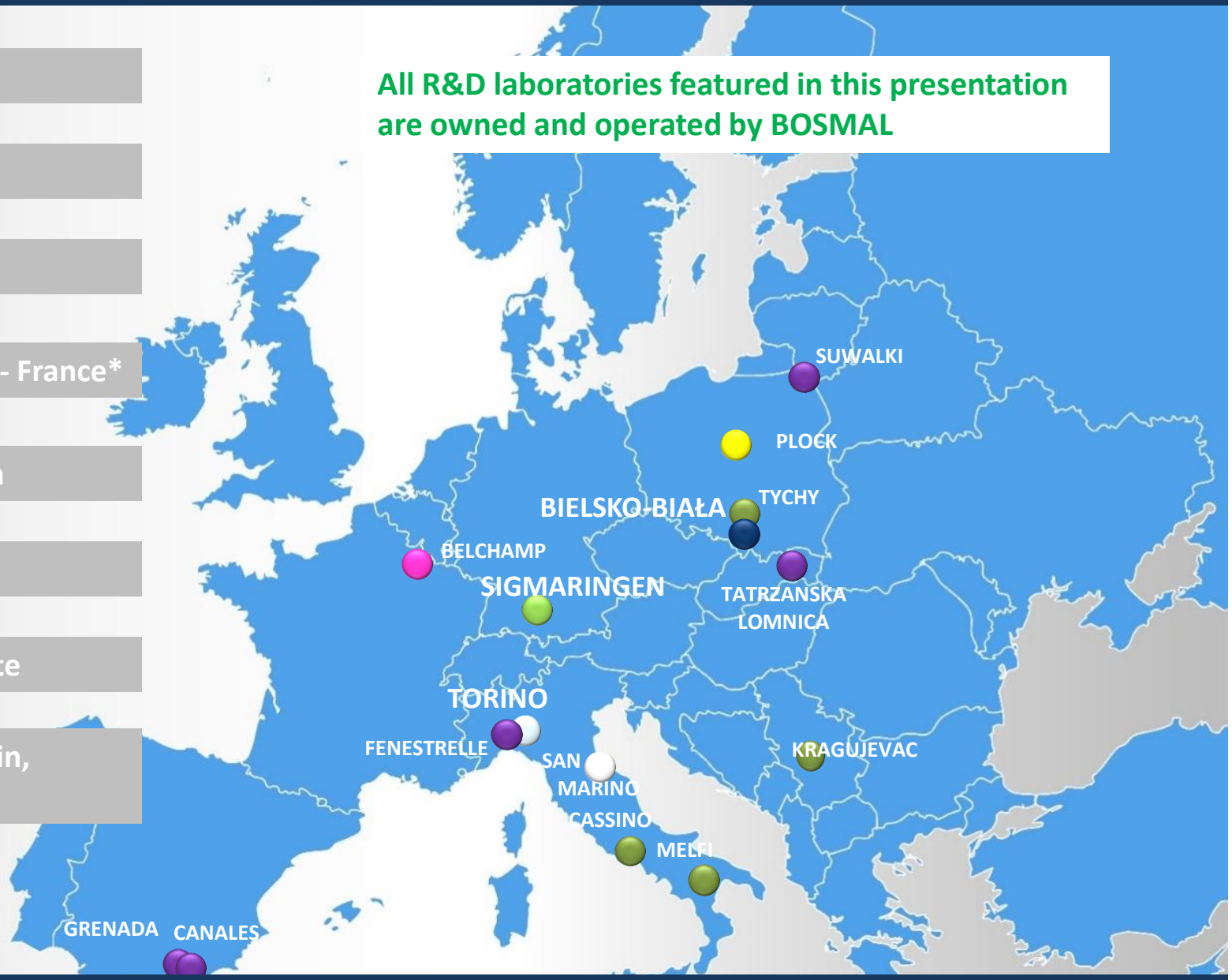
RAIL INDUSTRY

BOSMAL AUTOMOTIVE RESEARCH AND DEVELOPMENT INSTITUTE LTD

- The headquarter: Poland, Bielsko-Biała
- Subsidiary: BOSMAL Italia s.r.l. – Italy, Torino
- Subsidiary: BOSMAL SM s.r.l. – San Marino
- Temporary test site : BELCHAMP – France, Île-de- France*
- Customer representation: Germany, Sigmaringen
- BOSMAL Branch/ Customer site – Płock
- BOSMAL Customer site / temporary Customer site
- Other BOSMAL's temporary test sites – Italy, Spain, Sweden and other European countries

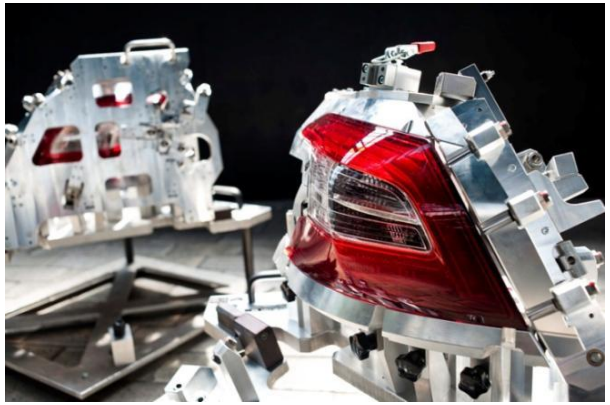
* - available soon

All R&D laboratories featured in this presentation are owned and operated by BOSMAL



BOSMAL RESEARCH & DEVELOPMENT

- **Research and Development Center** (with that legal status)
- **Research laboratory** meeting the requirements of PN-EN ISO / IEC 17025: 2018-02 - with a wide range of accreditation (over 600 methodologies)
- **License for approval tests of vehicles** (internal combustion and electric), as well as their equipment or parts (including internal combustion engines, electric engines and batteries)
- **Certified, integrated management system** (PN-EN ISO 9001:2015-10, PN-EN ISO 45001:2024-02 and PN-EN ISO 14001:2015-09)
- **TISAX label.** Results of Institute are available at https://enx.com/tisax
- **Certificate AQAP 2110:2016** - confirming compliance with NATO quality requirements in design, development and manufacture
- **License of the Ministry of Interior and Administration No. B-138/2023** to conduct business activities related to the production and trade of explosives, weapons, ammunition, products and technology for military or police use
- **Accreditation OiB (Defense and Security)** confirming that the BOSMAL Laboratory meets the requirements of the PN-EN ISO/IEC 17025:2018-02 standard under accreditation no. 67/MON/2024.
- **RINA Certificate** - official confirmation that the BOSMAL Research Laboratory meets the requirements set by RINA
- **Comprehensive range** of research, design and production, engineering and production implementations
- **Personnel:** 340 employees, with 220 engineers



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50 years on the automotive market & 25 years as an Accredited Testing Laboratory AB128

AUTOMOTIVE – MATERIALS TESTING

1. Material emissions/ VIAQ (Vehicle Interior Air Quality).
2. Corrosion testing.
3. Environmental and light resistance tests, ageing tests.
4. Tests of petroleum products and operating fluids
5. Testing of mechanical properties
6. Identification of products' materials and contamination, chemical composition.

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50+ years in the automotive market

25+ years as an Accredited Laboratory (AB 128)

AUTOMOTIVE – MATERIALS TESTING

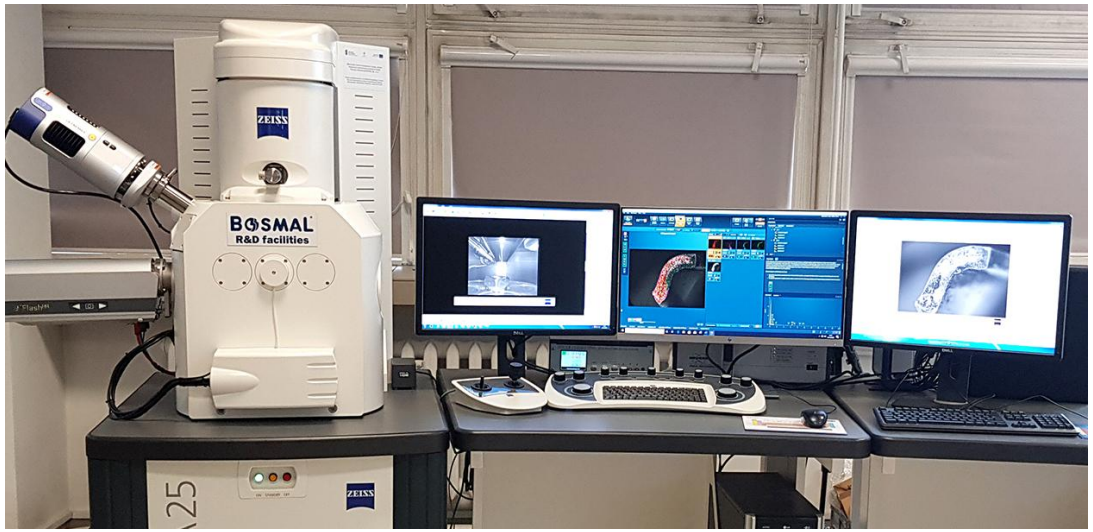
7. Technical cleanliness inspection – internal and external cleanliness of products.

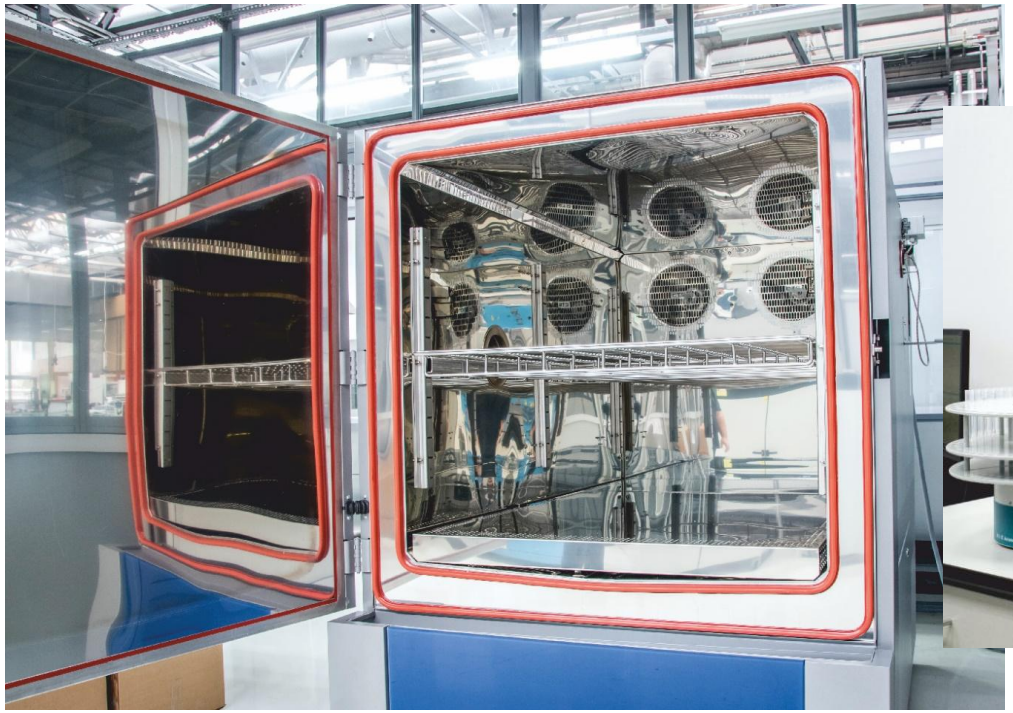
8. Microscopy and metallography.

9. Physicochemical, aesthetic and functional properties.

10. Mechanical properties of fasteners.

11. Testing of galvanic and paint coatings.





50+ years in the automotive market

25+ years as an Accredited Laboratory (AB 128)

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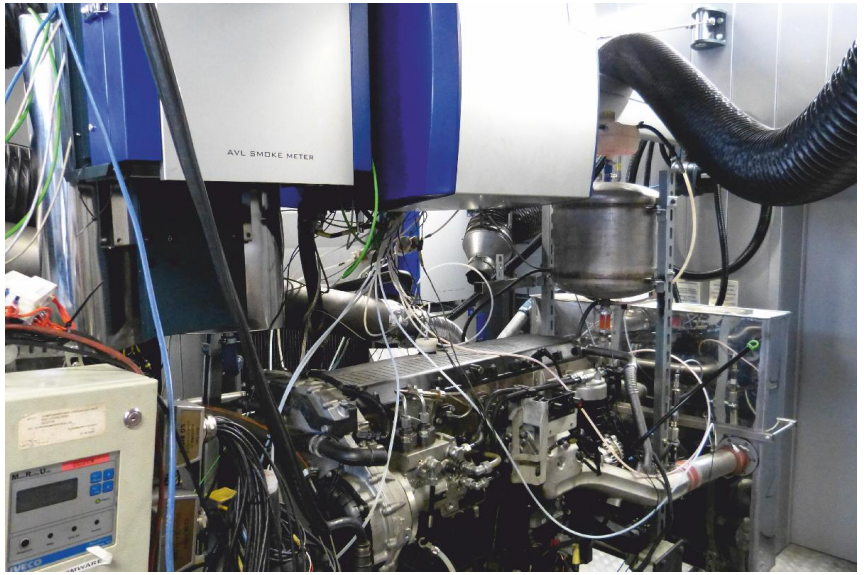
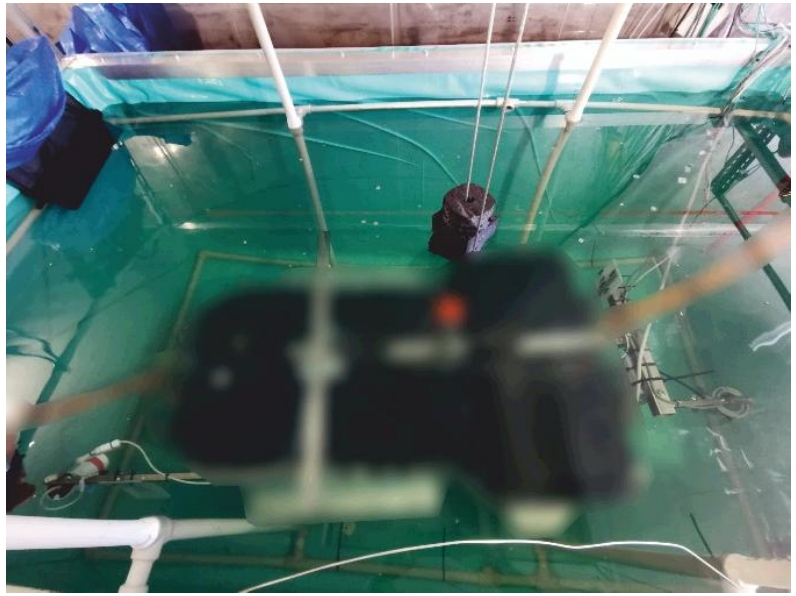
AUTOMOTIVE – TESTING OF AUTOMOTIVE PARTS AND ASSEMBLIES

1. Testing of electric vehicle bateries (accumulators).
2. Electrotechnical and electronic testing.
3. Testing of manual and automatic transmissions, gearboxes, and e-drives.
4. Testnig of engine oils, transmission fluids, liquid and gaseous fuels, fuel additives.
5. Optical and thermovision testing.
6. Testing of electrical and electronic vehicle equipment.
7. Testing of windows and wiper assemblies.
8. Durability, strength, fatigue, and functional testing.
9. Testing of braking systems.





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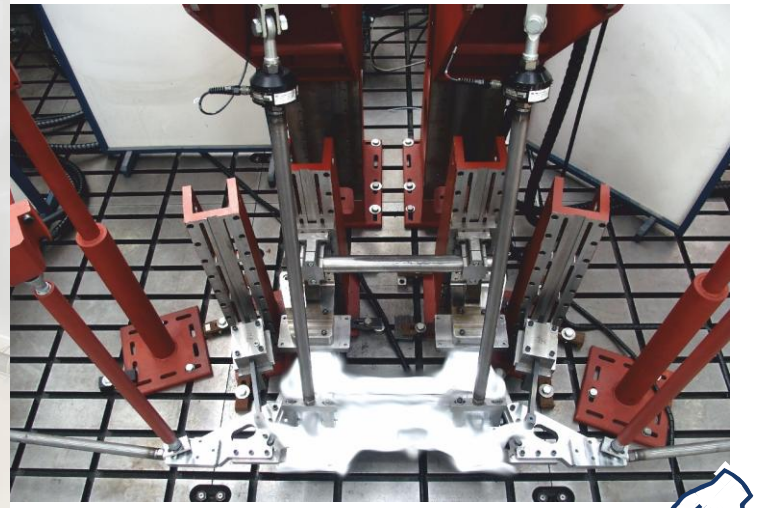
50+ years in the automotive market

25+ years as an Accredited Laboratory AB 128

AUTOMOTIVE – TESTING OF AUTOMOTIVE PARTS AND ASSEMBLIES

10. Testing of suspension systems, chassis, and body components.
11. Vibration, vibroacoustic (NVH), and strain gauge testing.
12. Testing of heat exchangers.
13. Testing of assemblies and components of internal, external, and road lighting.
14. Diagnostics and data analysis of E/E systems.
15. IP-code. Resistance to solid particles, dust, and moisture ingress.
16. Thermal shock testing.
17. Pressure testing.
18. Metrological measurements.



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50+ years in the automotive market

25+ years as an Accredited Laboratory AB 128

AUTOMOTIVE – VEHICLE, EXHAUST EMISSIONS, ENGINE, AND POWERTRAIN TESTING

1. Emission and fuel consumption testing, as well as vehicle dynamics testing on chassis dynamometers.
2. Road testing and measurements of vehicles.
3. Testing of electric and hybrid vehicles.
4. Testing of vehicles, machinery, and equipment in large-scale low and high temperature chambers.
5. Testing of engines and exhaust aftertreatment systems.

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50+ years in the automotive market

25+ years as an Accredited Laboratory (AB 128)

AUTOMOTIVE – VEHICLE, EXHAUST EMISSIONS, ENGINE, AND POWERTRAIN TESTING

6. Static testing of vehicles, machinery, and equipment.

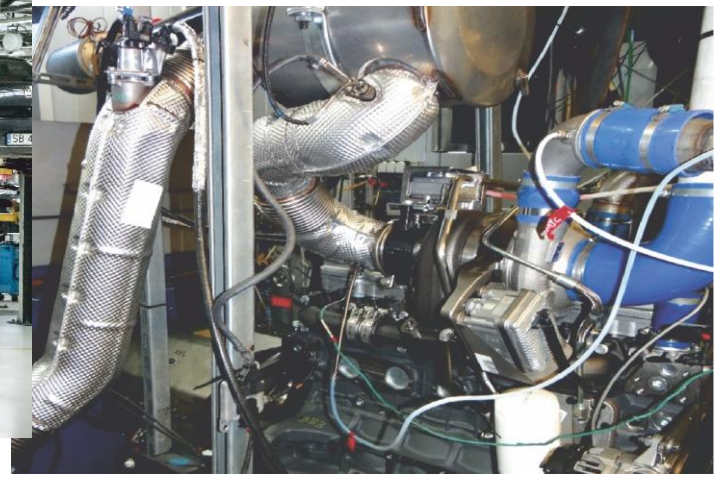
7. Testing of catalytic exhaust aftertreatment systems.

8. PEMS – emission testing of light-duty, heavy-duty vehicles, and nonroad machinery.

9. Electric Vehicle Testing in accordance with R101 (WLTP) requirements.

10. In-Service Conformity (ISC) - testing to verify emissions compliance of vehicles and machinery during real-world operation.

11. Conformity of Production (COP).



50+ years in the automotive market

25+ years as an Accredited Laboratory (AB 128)

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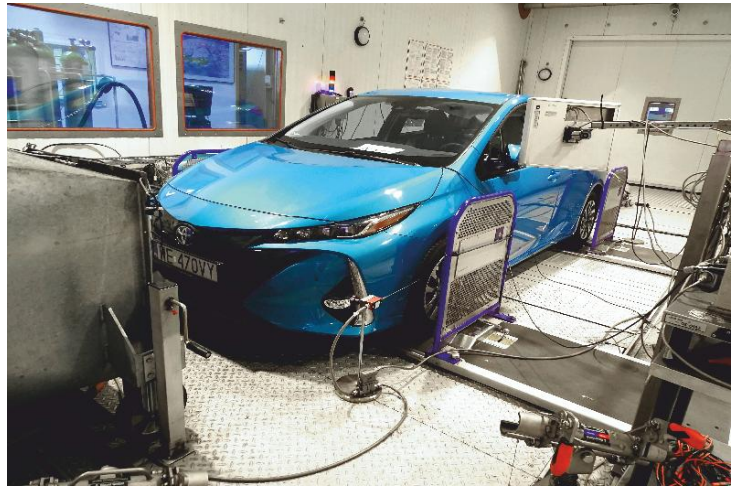
AUTOMOTIVE – ELECTROMOBILITY

1. Testing of electric and hybrid vehicles.
2. Testing of electric vehicle batteries (accumulators).
3. Electrical and electronic component testing.
4. On-road vehicle testing and measurements.
5. Testing of automotive electrical and electronic equipment.
6. Testing of vehicles, machines, and equipment in large-scale low- and high-temperature chambers.
7. Static testing of vehicles, machines, and equipment.
8. Diagnostics and data analysis of E/E (electrical/electronic) systems.

Testing of hybrid and electric vehicles - We test electric and hybrid vehicles in line with UN ECE Regulation No. 101 (WLTP), including range determination, wheel power and energy consumption measurements, and hybrid fuel and emissions testing – all under standard and extreme conditions.



Examples of vehicle conversions

Battery fire resistance

50+ years in the automotive market

25+ years as an Accredited Laboratory (AB 128)

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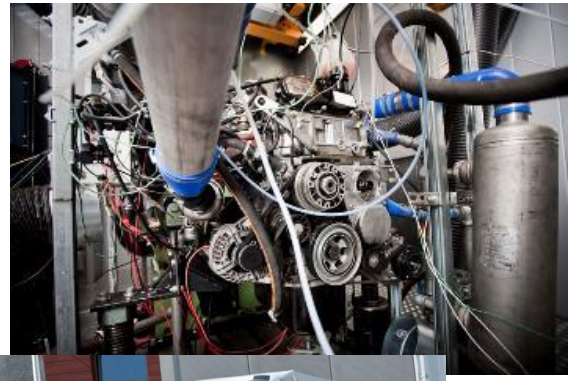
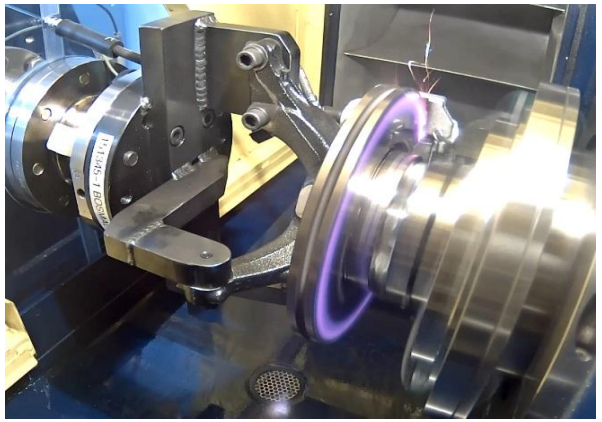
HOMOLOGATION - TYPE APPROVAL

1. **EU type-approval testig of vehicles or vehicle types** for the following vehicle categories: M, N, O, L, T, R, C, S.
2. **Type-approval testing of equipment or parts** for the following vehicle categories: M, N, O, L, T, R, C, S.
3. **Type-approval testing of additional gas fuel systems** for vehicle categories: M and N.
4. **Conformity of production checks for vehicles, equipment, or parts** (M, N, O, L, T, R, C, S), as well as conformity checks for additional gas fuel system installations (M, N).
5. Tests confirming compliance with relevant conditions or technical requirements for national **individual vehicle approval** for categories: M, N, O, L, T, R, C, S.
6. Tests confirming compliance with relevant conditions or technical requirements for **EU individual vehicle approval** for categories: M1, N1, and **special vehicles** M, N, O.





Vehicle categories subject to type approval:
M – motor vehicles (≥ 4 wheels) for passenger transport (M1–M3)
N – motor vehicles (≥ 4 wheels) for goods transport (N1–N3)
O – trailers and semi-trailers (O1–O4)
L – light two-, three- and four-wheeled vehicles (L1e–L7e)
T – wheeled agricultural or forestry tractors (T1–T5)
R – agricultural trailers (R1–R4)
C – tracked agricultural or forestry tractors (C1–C5)
S – interchangeable towed equipment (S1–S2)

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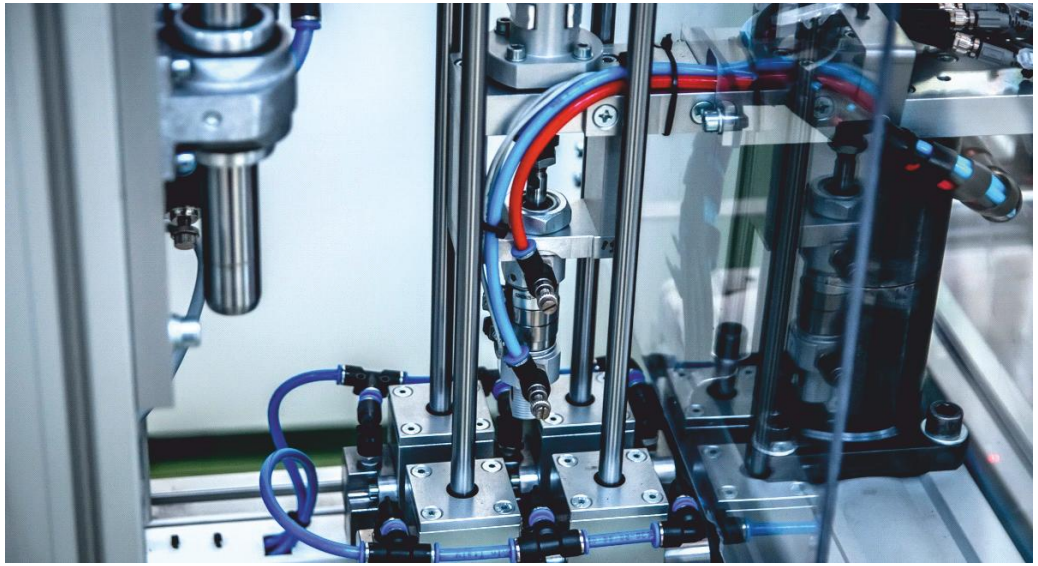
DESIGN AND AUTOMATION – INDUSTRIAL AUTOMATION AND ROBOTICS

Automation and Robotics in Industry

1. Production automation, special-purpose machinery, and test stations.
2. Precision production tooling and measuring fixtures – design and manufacturing.
3. Technological equipment for production lines.
4. Workshop aids and tools.
5. Mock-ups and prototypes.
6. Maintenance support and quality control assistance.



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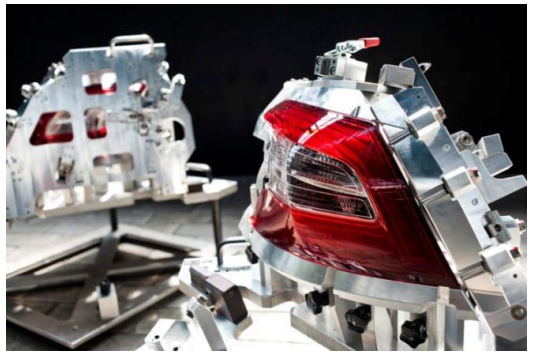
20 years of experience in industrial automation

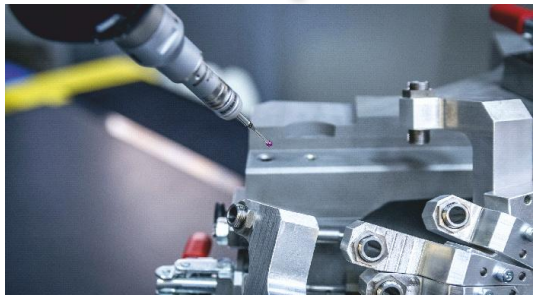
DESIGN AND AUTOMATION – DESIGN, ENGINEERING SERVICES, AND ENGINEERING CALCULATIONS

Design Office

- **Development of turnkey systems.**
- **Definition of design assumptions.**
- **Engineering calculations, including:**
  - CAM system programming.
- **Mechanical design.**
- **3D modeling.**
- **Prototype manufacturing.**
- **Verification and testing:**
  - Manufacturing and fabrication.
  - Metrological measurements.
  - Development of test plans for components and assemblies.
  - Analysis of existing designs and development of modification proposals.
- Production implementation**.**
- **Software:**
  - CAD/CAM/CAE systems.
  - Computer Simulation Software ANSYS 2024 R1.
- **Design, engineering, and calculation services.**
- **Engineering calculations (FEA/FEM).**



- **Production automation. Design and manufacturing of special-purpose machines and measuring & control devices.**
- **Control systems: development of custom PLC controllers for dedicated applications.**



CAD/CAE/CAM systems:

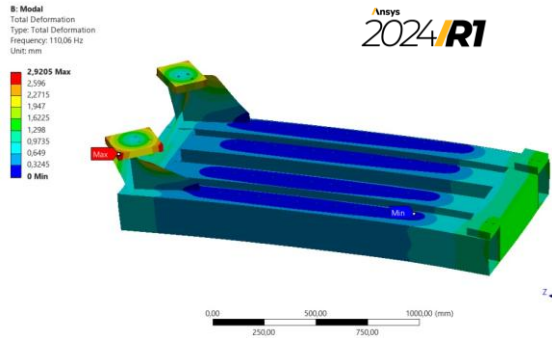
- Ansys 2024 R1
- Dassault Systemes CATIA V5
- Solid EDGE
- Siemens NX
- Autodesk INVENTOR
- SIEMENS NX CAM, Edge CAM
- Creo
- Autodesk AutoCAD
- Dassault Systemes Simulia ABAQUS, CATIA V5 Generative Assembly Structural Analysis

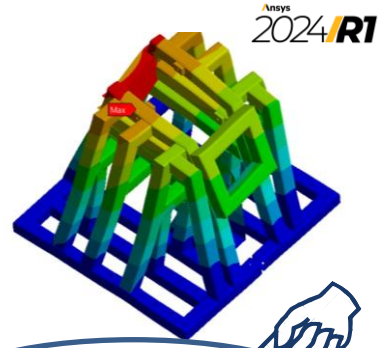
Ansys

- ANSYS Mechanical Premium.
- ANSYS CDF Premium.
- ANSYS LS-DYNA.
- ANSYS OptisLang Premium.
- ANSYS OptisLang Premium.
- ANSYS Discovery Modeling.

Available Analytical Capabilities:

- Fatigue analyses.
- Large deformation analyses.
- Thermodynamic simulations.
- Design optimization.
- Advanced model editing tools.
- Computational fluid dynamics (CFD) modeling.





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DEFENCE AND MARITIME INDUSTRY

Testing and research services for the defense and maritime industry






1. Material Characterization, Cleanliness, and Material Emissions

- Identification of materials and product contaminants; chemical composition analysis.
- Microscopy and metallography.
- Physicochemical, aesthetic, and functional properties.
- Technical cleanliness inspection – internal and external cleanliness of components.
- Emission and odor testing (VOC/odor from materials).

2. Testing of Fluids and Lubricants

- Testing of petroleum products and operating fluids.
- Testing of engine and transmission oils, liquid and gaseous fuels, and fuel additives.

3. Resistance of Materials and Coatings to Environmental Factors

- Ingress Protection (IP) rating – resistance to dust, particulate matter, and moisture.
- Corrosion testing.
- Environmental and light resistance testing; ageing tests.
- Thermal shock testing.

4. Mechanical, Strength, and NVH Testing

- Mechanical property testing.
- Vibration, vibroacoustic (NVH), and strain gauge testing.
- Static testing of vehicles, machines, and equipment.
- Durability, strength, fatigue, and functional testing.
- Pressure testing.

5. Electrical, Electronic, and Optical Testing of Components

- Electrical and electronic testing.
- Optical testing.

6. Powertrain and Emissions Testing

- Testing of engines and exhaust aftertreatment systems.
- Testing of catalytic exhaust gas aftertreatment systems.
- Exhaust emissions, fuel consumption, and vehicle dynamics testing on chassis dynamometers.
- PEMS – emissions testing of light-duty vehicles, heavy-duty vehicles, and non-road machinery.

7. Vehicle and Machinery Testing under Extreme Conditions

- Testing of electric and hybrid vehicles.
- Testing of vehicles, machinery, and equipment in large-scale low- and high-temperature climatic chambers.

8. Specialized Testing for Defence Applications

- Testing of military and special forces equipment. Testing of mobile shelters.

9. Control Measurements and Calibration

- Metrological measurements.

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AQAP 2110:2016 Certification, MSWiA License No. B-138/2023, OiB Accreditation, RINA Recommendation

Testing in large-scale environmental chambers

- Strength and functional testing of vehicles, devices, machinery, and components at temperatures ranging from –65°C to +75°C.
- Defrosting and demisting tests of vehicle windows at temperatures from –65°C to +75°C.
- Cold start testing of combustion engines within the –65°C to +75°C temperature range.
- Testing of bateries and heating/air conditioning systems in electric vehicles at temperatures from –65°C to +75°C.
- Testing of vehicle HVAC systems (heating, ventilaton, and air onditioning) in the –65°C to +75°C temperature range.

Certificates, Licenses, and Accreditations

CERTYFIKAT

Nr A - 73/2/2024

Instytut Badań i Rozwoju Motoryzacji
BOSMAL Sp. z o.o.
ul. Sarni Stok 93, 43-300 Bielsko-Biała

AQAP 2110:2016

projektowanie, badania oraz produkcja
elementów do samochodów i ich wyposażenia
oraz stanowisk i oprzyrządowań badawczo-produkcyjnych

AQAP 2110:2016 – confirming compliance with NATO quality assurance requirements.

MINISTER SPRAW WEWNĘTRZNYCH I ADMINISTRACJI

KONCESJA

Nr B-138/2023

udziela

INSTYTUTOWI BADAŃ I ROZWOJU MOTORYZACJI BOSMAL
SPÓŁKA Z OGRANICZONĄ ODPOWIEDZIALNOŚCIĄ

License No. B-138/2023 issued by the Ministry of the Interior and Administration of Poland (MSWiA) for conducting business activities in the manufacturing and trade of explosives, weapons, ammunition, as well as military or police-dedicated products and technologies.

WOJSKOWE CENTRUM NORMALIZACJI, JAKOŚCI I KODYFIKACJI

MON

Akredytacja OiB

JC

OiB accreditation confirming that the BOSMAL Laboratory meets the requirements of PN-EN ISO/IEC 17025:2018-02, under accreditation No. 67/MON/2024.

RINA STATEMENT OF RECOGNITION OF TEST LABORATORY

No. REC051822XP

RINA - recommendation by the certification body, ref. no. REC051822XP

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COMPOSITES – TESTING AND PROCESSING

Testing of Composite

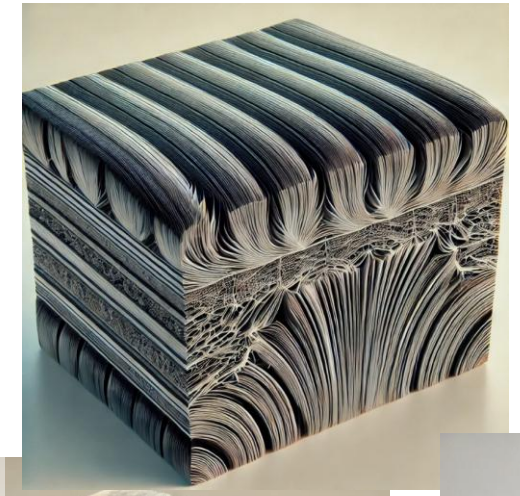
1. Material Characterization and Initial Cleanliness
- Identification of materials and product contaminants; chemical composition analysis.
- Microscopy and metallography.
- Physicochemical, aesthetic, and functional properties.
- Emission and odor testing (VOC/odor emissions from materials).
- Technical cleanliness inspection (external and internal).

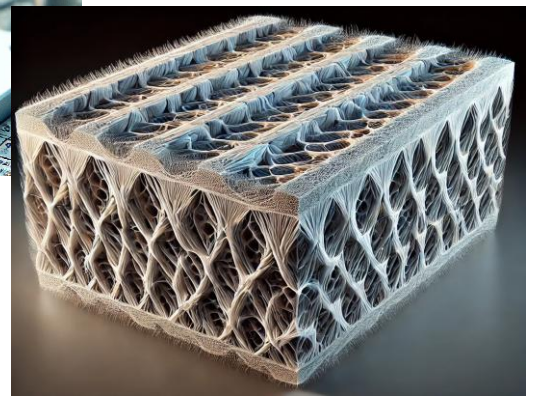
2. Chemical and Environmental Resistance
- Corrosion testing.
- Environmental and light resistance testing; ageing tests.
- Ingress Protection (IP) rating – resistance to dust, particulate matter, and moisture.
- Thermal shock testing.
- Testing in large-scale low- and high-temperature climatic chambers.

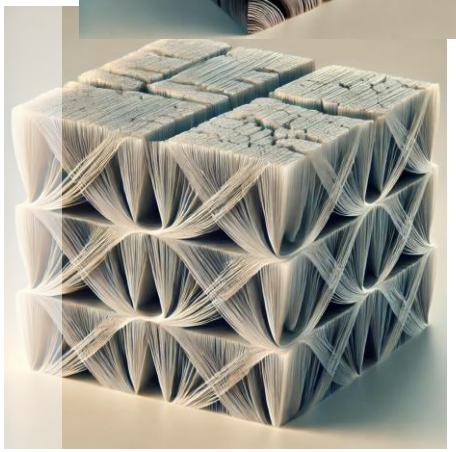
3. Mechanical, Durability, and Functional Testing
- Mechanical property testing.
- Pressure testing.
- Vibration, vibroacoustic (NVH), and strain gauge testing.
- Durability, strength, fatigue, and functional testing.

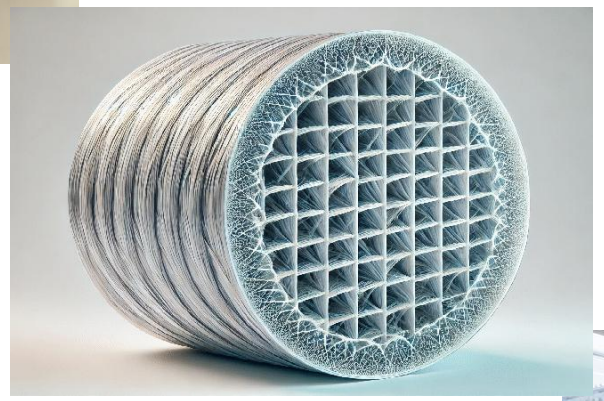
4. Compliance and Compatibility with Operating Media
- Testing of petroleum products and operating fluids.

5. Final Control Measurements and Calibration
- Metrological measurements.



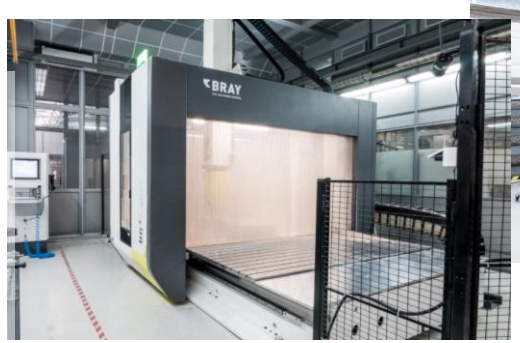






Composite Machining and Processing:

1. 3- and 5-axis CNC milling
2. Cuting (including waterjet cutting).
3. Wire electrical discharge machining (WEDM).
4. Turning.
5. Grinding.



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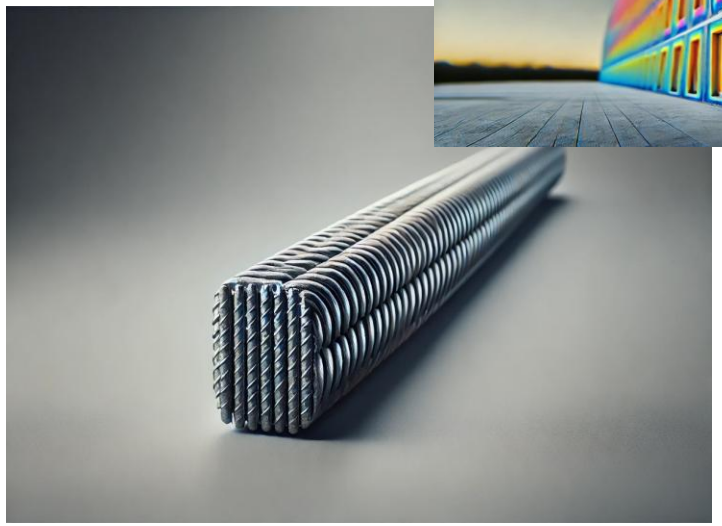
CONSTRUCTION INDUSTRY – TESTING

Testing Services for the Construction Industry

1. Identification of materials and product contaminants; chemical composition analysis.
2. Microscopy and metallography.
3. Physicochemical, aesthetic, and functional properties.
4. Technical cleanliness inspection – internal and external cleanliness of products.
5. Optical testing.
6. Emission and odor testing.
7. Testing of compound emissions in a 250-litre emission chamber for construction applications.
8. Testing of petroleum products and operating fluids.
9. Corrosion testing.
10. Environmental and light resistance testing; ageing tests.
11. Ingress Protection (IP) rating – resistance to the ingress of solid objects, dust, and moisture.
12. Pressure testing.
13. Thermographic (infrared) services.
14. Mechanical property testing.
15. Durability, strength, fatigue, and functional testing.
16. Electrical and electronic testing.
17. Metrological measurements.



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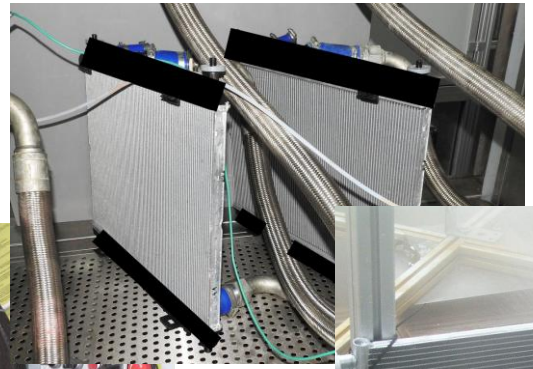
THERMAL MANAGEMENT & REFRIGERATION

Heat Exchanger Testing:

1. Metallographic examination of heat exchangers.
2. Internal and external corrosion/erosion testing.
3. Water resistance testing.
4. Ageing tests.
5. Fatigue and strength testing of heat exchangers.
6. Refrigerant (freon) emission testing – leak testing of automotive air conditioning systems.
7. Testing of electric fans.
8. Fan performance characterization.
9. Thermal performance testing.

Materials Testing::

1. Identification of materials and product contaminants; chemical composition analysis.
2. Microscopy and metallography.
3. Physicochemical, aesthetic, and functional properties.
4. Technical cleanliness inspection – internal and external cleanliness of products.
5. Emission and odor testing.
6. Testing of petroleum products and operating fluids.
7. Corrosion testing.
8. Environmental and light resistance testing; ageing tests.
9. Mechanical property testing.



Testing of Parts and Components:

1. Technical cleanliness inspection – internal and external cleanliness of products.
2. Ingress Protection (IP) rating – resistance to the ingress of solid objects, dust, and moisture.
3. Corrosion testing.Environmental and light resistance testing; ageing tests.
4. Thermal shock testing.
5. Testing of vehicles, machines, and equipment in large-scale low- and high-temperature climatic chambers.
6. Vibration, vibroacoustic (NVH), and strain gauge testing.
7. Pressure testing.
8. Durability, strength, fatigue, and functional testing.
9. Electrical and electronic testing.
10. Metrological measurements.

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30 years of heat exchanger testing 25 years as an Accredited Laboratory (AB 128)

RAIL INDUSTRY – TESTING AND TESTS

Rolling Stock and Onboard Equipment
Stationary Electrical Equipment, Infrastructure
Signaling, Telecommunications, and Trackside Devices

1. Environmental and climatic resistance testing.
2. Electrical and electronic testing.
3. Mechanical property testing of materials and metallographic examination.
4. Lighting and display testing, including photometric measurements, gloss, and color evaluation.
5. Non-destructive testing (NDT).
6. Mechanical and fatigue testing, as well as acoustic and strain gauge measurements.
7. Chemical testing and physical property testing.

Rolling Stock

On-board Equipment

Signalling and Telecommunications Equipment, Trackside Devices

Electrical Stationary Equipment and Infrastructure

20 years of railway testing 25 years as an Accredited Laboratory (AB 128)

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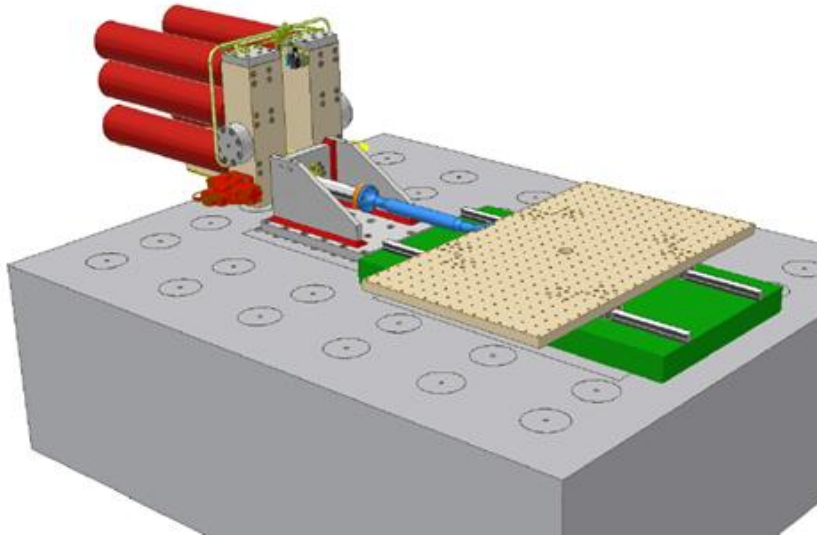
BOSMAL’s new investments

Dynamic Hydraulic Test Bench for Mechanical Shock and Inertial Load Testing (UNECE R100 / ISO 6469-1)

The dynamic hydraulic test bench is designed for the performance of 9C "Mechanical Shock" tests in accordance with UNECE Regulation No. 100, and "Inertial Load at Vehicle Crash" tests according to ISO 6469-1:2019, section 6.4.1.1.2. The system allows testing of components and assemblies with a total mass of up to 600 kg (including instrumentation), enabling validation of structural integrity and electrical safety of high-voltage systems during simulated crash-like mechanical shocks.

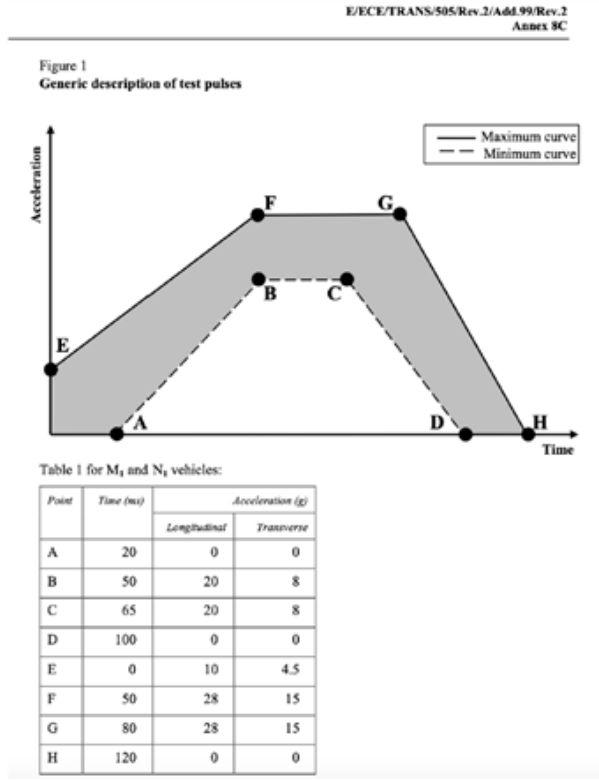
Main technical parameters:

- Hydraulic actuator: 400 kN force, 800 mm stroke, maximum speed 9 m/s
- Hydraulic accumulators and actuator bracket for energy storage and dynamic impulse generation
- Test table: linear-bearing platform with a surface area of 245 × 145 cm
- Hydraulic power unit (air-cooled): working pressure ≥ 280 bar, tank capacity ≥ 200 L, nominal flow ≥ 40 L/min
- Hydraulic manifold: rated working pressure ≥ 280 bar
- Controller: closed-loop feedback control with dedicated test software enabling the generation and iteration of test signals in compliance with the acceleration pulse profile defined in UNECE R100 and ISO 6469-1



Test Bench picture

Example photo from Regulation No. 100, showing the requirements for the acceleration pulse to be applied to the test sample.



E/ECE/TRANS/505/Rev.2/Add.99/Rev.2
Annex 8C

Figure 1
Generic description of test pulses

Table 1 for M_1 and N_1 vehicles:

Point	Time (ms)	Acceleration (g)	
		Longitudinal	Transverse
A	20	0	0
B	50	20	8
C	65	20	8
D	100	0	0
E	0	10	4.5
F	50	28	15
G	80	28	15
H	120	0	0

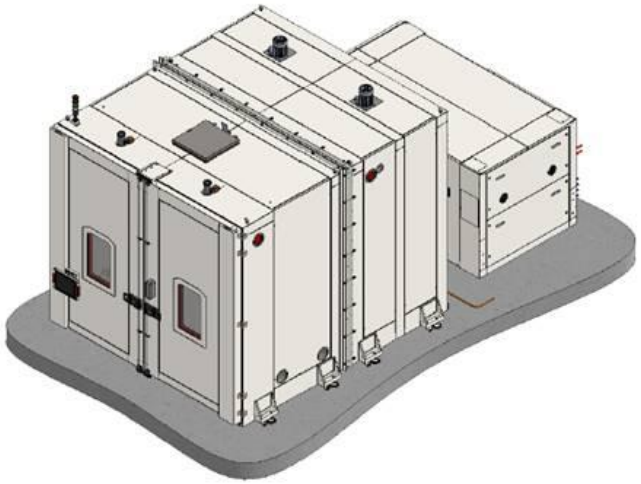
This advanced setup allows precise reproduction of high-energy mechanical shocks and acceleration pulses to assess the durability and crash safety of battery systems and other components used in vehicles.

Walk-in climatic chamber for cyclic corrosion and aggressive climate testing (salt mist, condensation, temperature and humidity cycling)

The walk-in climatic chamber is designed for cyclic corrosion and aggressive climate testing in accordance with:

- VDA 233-102:2013-06,
- PV 1210:2016-02,
- PV 1209:2023,
- PN-EN IEC 60068-2-52:2018-05 (Test Kb),
- DIN 55635:2019-05 and EN ISO 11997-3:2023-10.

It enables controlled simulation of salt mist exposure, humidity condensation, temperature variation and drying cycles for the evaluation of corrosion resistance of coatings, components, and assemblies.



Parameters	value
Workspace (H x L x W)	2 x 4 x 2,5
Cooling rate	5 K/min (max 10 K/min)
Heating rate	5 K/min (max 10 K/min)
Temperature range	–50 °C to +180 °C (up to +200 °C)
Humidity range	10 % RH – 98 % RH

Graphics and photos - illustrative

Large Dust and Sand Test Chambers for Ingress Protection and Surface Erosion Testing

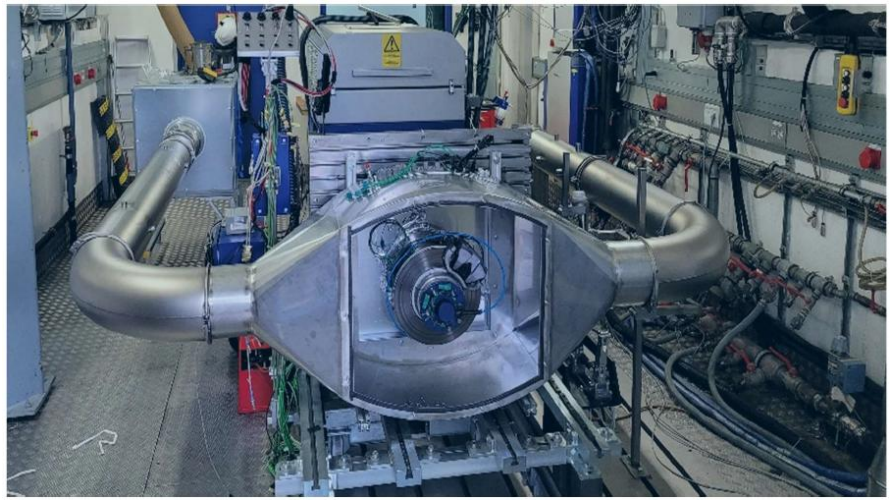
The Large Dust and Sand Test Chambers are designed for evaluating the resistance of components and enclosures to dust ingress and abrasive particle exposure under controlled conditions.

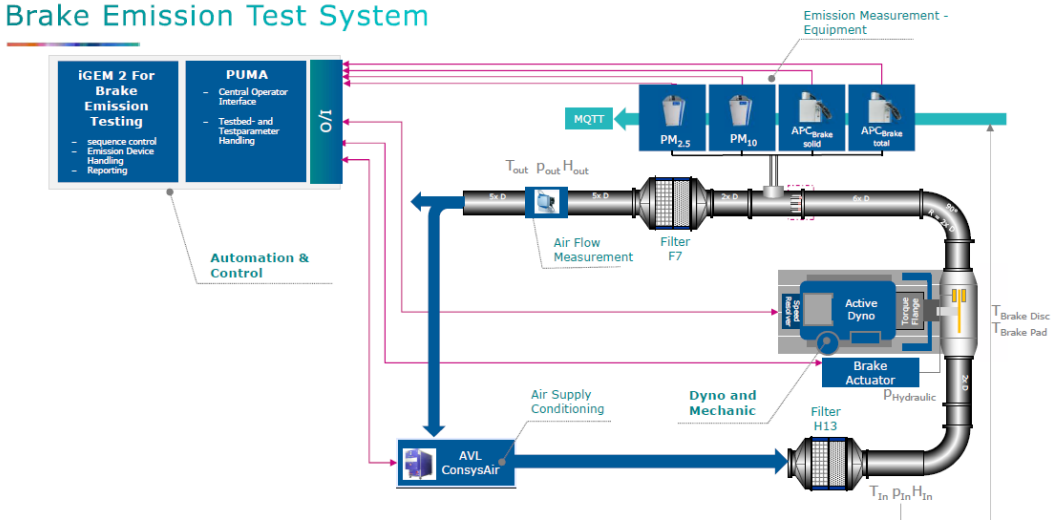
- The vertical dust chamber operates according to ISO 20653, IEC 60529, and EN 60068-2-68 standards, providing uniform dust flow for testing large components such as battery pack housings, e-drive units, and electronic enclosures.
  It features internal dimensions of approximately 2.5 × 2.0 × 2.5 m (H × D × W) and a maximum load capacity of 700 kg.

- The horizontal dust and sand chamber complies with MIL-STD-810 H and EN 60068-2-68, enabling simulation of wind-blown dust or sand exposure and the sandblasting effect on component surfaces.
  Different media such as Arizona dust, talc, and cement powder can be used, with adjustable dust concentration and airflow velocity to replicate real environmental stress conditions.

Brake Emission Test Stand according to UN GTR No. 24 (EURO 7 compliant)

- The Brake Emission Test Stand enables testing in accordance with the United Nations Global Technical Regulation No. 24 (UN GTR 24) methodology, ensuring full compliance with the upcoming EURO 7 emission requirements.
- The system allows precise measurement of brake wear, particulate matter (PM) emissions, and particle number (PN) emissions generated during braking events.
- It supports testing of Light-Duty Vehicles category 1-1 (M1) and 2 (N1) with a fully laden mass below 3500 kg, under controlled thermal and dynamic conditions representative of real-world operation.





Advanced "Euro 7 Ready" Emission Measurement Benches for Engine Dynamometer Testing - AVL AMA i60 SII and AVA SESAM i60 FT:

- The AVL AMA i60 SII and AVL SESAM i60 FT emission benches represent state-of-the-art systems for exhaust gas analysis in accordance with the latest and upcoming emission legislation, including Euro 7, Euro VI, Stage V, and EPA 1065/1066.

- Designed for continuous measurement of raw exhaust gases from diesel, gasoline, CNG, LPG, and alcohol-fuelled engines, they provide outstanding accuracy and long-term stability.

- Both systems employ ISO 17034 certified calibration gases (Certified Reference Materials), ensuring traceability, accreditation compliance, and high data reliability.

- The AMA i60 SII enables precise determination of THC, CH_4, $NO/NO_2/NO_x$, CO_2, CO, and O_2, while the SESAM i60 FT allows simultaneous quantification of more than 20 gas components, including N_2O and NH_3 for current standards, as well as formaldehyde and other species foreseen for future Euro 7 regulations.

Particulate matter counter PN10 / PN23 - AVL APC xAPP 10/23 nm

Light – Duty Vehicles

Euro 7 tailpipe emission limits for passenger cars of category M_1 and light-duty vans of category N_1

Category and class	CO		THC		NMHC		NO_x		THC + NO_x		PM	PN_{10}
	SI	CI	SI	CI	SI	SI	SI	CI	CI	CI	SI & CI	SI & CI
M_1 & N_1 class I	1000	500	100	–	68	–	60	80	–	170	4.5	$6x10^{11}$
N_1 class II	1810	630	130	–	90	–	75	105	–	195	4.5	$6x10^{11}$
N_1 class III	2270	740	160	–	108	–	82	125	–	215	4.5	$6x10^{11}$

Notes: SI: Spark ignition; CI: Compression ignition; CO: Carbon monoxide; THC: Total hydrocarbons; NMHC: Non-methane hydrocarbons; NO_x: Nitrogen oxides; PM: Particulate matter; PN_{10}: Number of particles larger than 10 nm

Source:
Euro 7: The new emission standard for light- and heavy-duty vehicles in the European Union, 2024 INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION (ID 116)

AVL APC xAPP Duel 10nm/23nm (certificated)					
L.p.	Parameter	CPC 10 nm		CPC 23 nm	
1	Principle of operation	Condensing particle counter (CPC)			
2	Method of removing volatile particles	Heated catalytic system (HCS)			
3	Evaporation of tetracontane ($CH_3(CH_2)_{38}CH_3$) particles with a diameter of: > 50 nm and mass > 1 mg/m³,	> 99.9%			
4	Particle concentration reduction factor $f_r(d)$:				
	d = 15 nm	< 2			
	d = 30 nm	< 1.3			
	d = 50 nm	< 1.2			
	d = 100 nm	> 0.95			
5	Dilution factor accuracy	Within ±10% of the nominal value			
6	Particle concentration measurement range:				
	Particle number concentration	0 – 40 000 [#/cm³]			
	Particle number concentration after internal dilution	0 – 50 000 [#/cm³]			
7	Nominal diameter particle electrical mobility	10 nm	15 nm	23 nm	41 nm
	PNC counting efficiency	65 ±12%	> 90%	50 ±12%	> 90%

Second parallel CPC
> 23nm

Main CPC
> 10nm

The AVL Particle Counter is a measurement device for counting engine's exhaust particle number emissions. The APC xApp 10/23™ fulfill the specifications according to the draft requirements GTR15 10nm for sub-23nm emission measurements as proposed by the UNECE PMP Group. Parallel measurement of 10nm and 23nm provide valuable data for actual and future PN specifications.

MEXA Cube PEMS System - RDE emission testing

Light – Duty Vehicles

Euro 7 Light Duty: Summary of Limits. Cars up to 8 Seats and Goods Vehicles up to 3.5 tonnes

Conditions	NO_x	PM	PN_{10}	CO	THC	NMHC	NH_3
RDE Test (mg/km)	60	4.5	$6x10^{11}$	500	100	68	20
Trips<10km (mg/trip)	600	45	$6x10^{12}$	5000	1000	680	200

NO_x: Oxides of nitrogen
PM: Particulate mass
PN_{10}: Particulate number (minimum size 10nm)
CO: Carbon monoxide
THC: Total hydrocarbons
NMHC: Non-methane hydrocarbons
NH_3: Ammonia

IRLAM Analyzer (XL)

CO-L, CO-H,
CO_2,
NO, NO_2, N_2O,
NH_3,
HCHO,
CH_4-L, CH_4-H
THC

MEXA Cube PEMS System

MEXAcube measures a comprehensive range of emission concentrations. HORIBA's new MEXAcube is suitable for both real-world and laboratory measurements. Designed to meet various testing needs, MEXAcube is suitable for Euro 7 / GB 7 regulatory components testing, Real Driving Emissions (RDE) testing, and alternative fuel / H2 engine analysis.

The OBS-ONE PN unit is an on-board emissions measurement system for analyzing the solid particle number concentration within the specified particle size range under real-world driving conditions.

OBS-ONE

PN > 10nm

Ready for Euro 7

MEXA Cube PEMS System - HDV RDE emission tests

Euro 7 tailpipe emission limits for heavy-duty vehicles of categories M_2, M_3, N_2 and N_3

	WHSC (only CI engines)			WHTC (CI and SI engines)			On-road emissions limit		
	Euro VI (mg/kWh)	Euro 7 (mg/kWh)	Change compared to Euro VI	Euro VI (mg/kWh)	Euro 7 (mg/kWh)	Change compared to Euro VI	Euro VI (mg/kWh)	Euro 7 (mg/kWh)	Change compared to Euro VI
NO_x	400	200	-50%	460	200	-56%	690	260	-62%
PM	10	8	-20%	10	8	-20%	–	–	–
PN_{10}[a]	$8x10^{11}$	$6x10^{11}$	No change	$6x10^{11}$	$6x10^{11}$	No change	$9.8x10^{11}$	$9x10^{11}$	-8%
CO	1500	1500	No change	4,000	1,500	-62%	6,000	1,950	-68%
NMOG	–	80	-38%[c]	160[b]	80	-50%	240	105	-56%
THC	130	–	–	160[c]	–	–	–	–	–
NH_3	–	60	New	–	60	New	–	85	–
CH_4	–	500	New	500[b]	500	No change	750	650	-13%
N_2O	–	200	New	–	200	New	–	260	–

Notes: WHSC: World Harmonized Stationary Cycle; WHTC: World Harmonized Transient Cycle; CI: Compression ignition; SI: Spark ignition; [a] Particle number limit in #/kWh; [b] Only for gas engines; [c] Only for diesel engines; [d] compared to Euro VI THC

Source:
Euro 7: The new emission standard for light- and heavy-duty vehicles in the European Union, 2024 INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION (ID 116)

MEXAcube (IRLAM Analyzer (XL)) measures a comprehensive range of emission concentrations, including CO, CO_2, NO, NO_x, NO_2, N_2O, NH_3, HCHO, CH_4, by using QCL-IR (quantum cascade laser infrared spectroscopy) and THC by using FID (flame ionization detection) principles. It also monitors air-to-fuel ratio, exhaust flow rate, GPS data, and environmental conditions while calculating mass emissions. The accompanying Data Post Processing (PP) software performs basic calculations such as mass emissions and fuel consumption. Additionally, it enables regulation-based analysis and reporting, enhancing the analyzer's utility in various applications.

IRLAM Analyzer (XL) OBS-ONE

CO-L, CO-H,
CO_2,
NO, NO_2, N_2O,
NH_3,
HCHO,
CH_4-L, CH_4-H,
THC,
PN>10nm

MEXA Cube

Control Software (DMC)

Heavy – Duty Vehicles

High-Power Engine Test Bench (2.1 MW) for Heavy-Duty and Non-Road Applications

- The new high-power engine test bench has been designed exclusively for testing large engines used in:
  - heavy-duty,
  - military,
  - rail,
  - NRMM,
  - and marine applications.

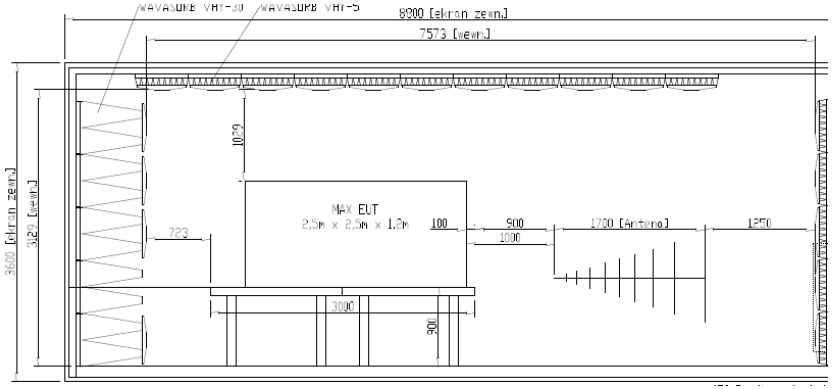
- Equipped with a HORIBA hydraulic dynamometer capable of absorbing up to 2.1 MW of power and torque up to 15 000 Nm, the facility allows comprehensive development, durability, and certification testing under fully controlled operating conditions.

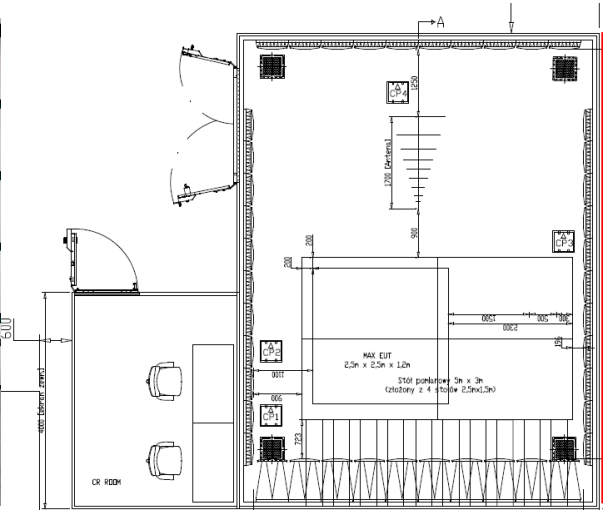
- A dedicated cooling circuit enables continuous operation of high-output powertrains, while flexible fuel infrastructure supports multiple fuel types, including:
  - diesel,
  - gasoline,
  - military and jet fuels,
  - as well as gaseous fuels such as CNG and LPG.

- The test bench is fully instrumented for advanced performance, emissions, and endurance evaluation.

EMC testing in <u>ALSE chamber</u> (Absorber-Lined Shielded Enclosure)

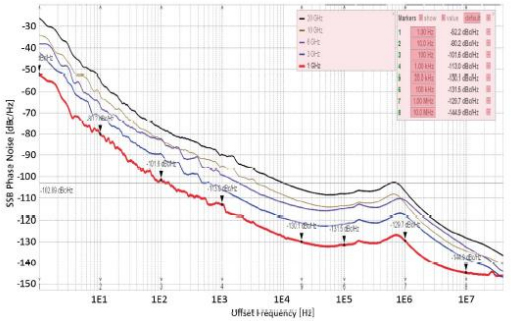
- The ALSE chamber enables full-compliance electromagnetic compatibility testing in accordance with CISPR 25, ISO 11452, and MIL-STD-461G standards.
- The facility allows component testing with masses up to 700 kg and offers usable internal dimensions of 7.55 m × 6.05 m × 3.10 m (D × W × H).
- The working frequency range extends from 10 kHz to 40 GHz, covering conducted and radiated emission as well as immunity testing for automotive, military, and industrial applications.
- The test setup provides a programmable DUT power supply up to 1500 VDC / 2 × 500 A, as well as connections for cooling circuits, compressed air, and communication interfaces.
- The chamber is equipped with video monitoring and dedicated control software enabling continuous visual supervision and functional verification of the Device Under Test during exposure.

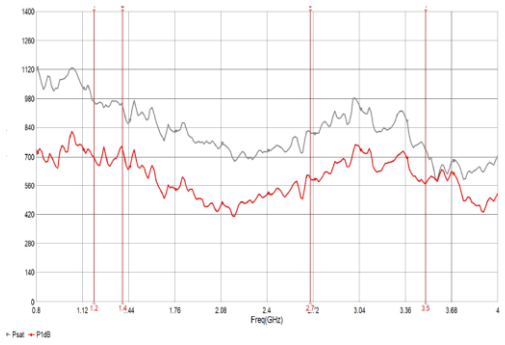


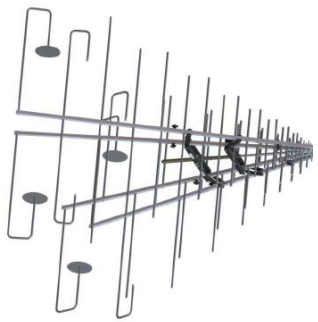


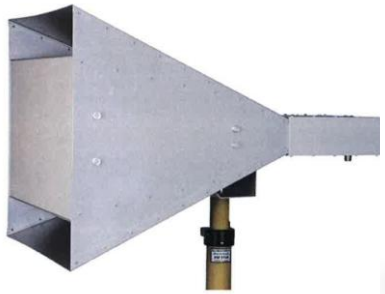
EMC testing - <u>System for Testing Immunity to RF</u> (Radio-Frequency) Disturbances

- The RF Immunity Test System enables evaluation of the resistance of electrical and electronic vehicle components to narrowband radiated electromagnetic energy.
- Testing is carried out in compliance with a wide range of international and manufacturer-specific standards, including **ISO 11452-2**, **ISO 11452-4**, **UN Regulation No. 10 Rev.06 (20 MHz – 2 GHz; draft Rev.07 – 6 GHz)**, **PSA B21 7110D**, **VW TL 81000**, **BMW GS 95002-2**, **FCA CS-00054**, **Ford FMC 1278**, and **MBN 50284-2**.
- The system allows testing within the **100 kHz – 7.12 GHz** frequency range, with **field strengths up to 600 V/m**, including **radar pulse** and **Bulk Current Injection (BCI)** methods.
- It ensures accurate simulation of electromagnetic fields encountered in vehicle environments, enabling comprehensive validation of EMC immunity for control modules, inverters, and high-voltage components.



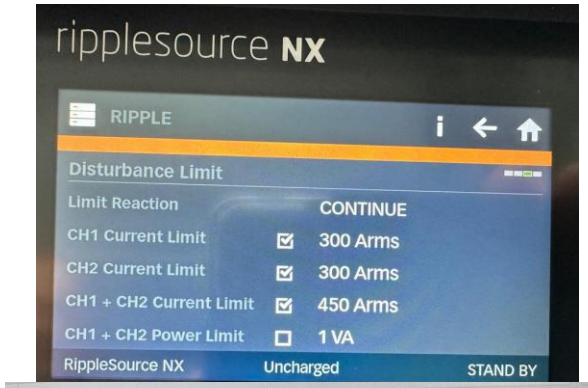


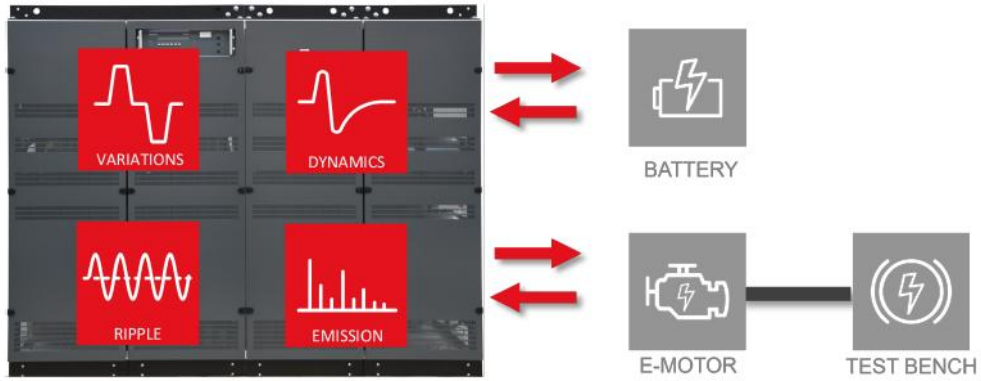




HV EMC Test System for High-Voltage Component Testing (Battery Packs, E-Drives, Inverters)

- The High-Voltage EMC Test System enables electromagnetic compatibility testing of components used in electric powertrains, including battery packs, inverters, and e-drives, in accordance with **ISO 21498-2 Ed.2 (sections 6.2–6.12)** and **VW80300 (parts EHV-01, 02, 03, 04, 05, 06, 08, 09, 10, 11, 13, 16)**.
- The setup incorporates a universal programmable AC/DC power supply system rated at **1500 VDC / 250 kVA**, allowing simulation of realistic high-voltage network conditions.
- It includes a **noise generator module** reproducing fast switching transients typical of HV DC lines in electric vehicles, a **ripple generator** for high-voltage circuits, and a **set of artificial networks** for conducted emission and immunity testing.
- The operating frequency range extends from **DC up to 500 kHz**, covering the spectral domain relevant for EMC evaluation of modern electric and hybrid propulsion systems.





Solar Irradiation Test Bench for Environmental and Durability Testing

- The Solar Irradiation Test Bench enables simulation of solar radiation and heat load effects on large components and systems under controlled laboratory conditions.
- The setup employs advanced solar simulators (metal halide and halogen types) with a calibrated spectral power distribution covering the full wavelength range of 280–3000 nm.
- The test stand allows evaluation of materials, components, and assemblies with dimensions of approximately 2 m or greater, in accordance with international test standards such as EN 60068-2-5:2018, DIN 75220:1992, MIL-STD-810H (Method 505.7-1), D45 5232, and equivalent procedures.
- It supports both thermal and photochemical load testing for durability, performance, and ageing assessments of automotive, aerospace, and industrial components.

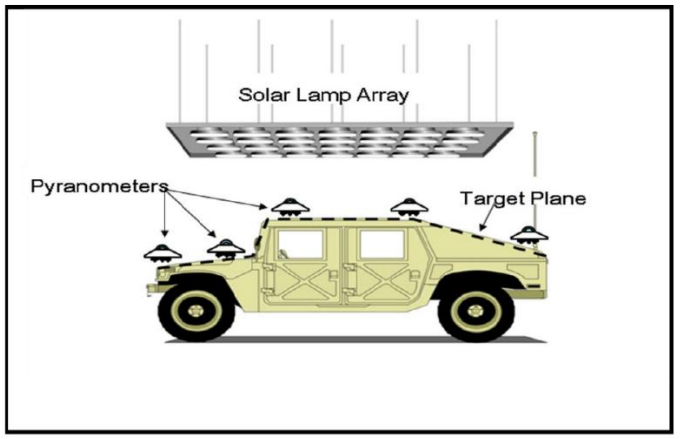


Figure 505.7C-3. Example 2 - Test item surface shape exposure.

Table 505.7C-II. Example calculation of spectral energy distribution and permitted tolerance.

Spectral Region	Bandwidth (nm)[2]	Natural Radiation (% of total)[2]	Tolerance (% of total)[2]		Calculated Irradiance Tolerances For a Given Total Irradiance (W/m2) → 822.5[1]				
			Min	Max	Nominal	Min		Max	
Ultraviolet - B	280-320	0.5	0.3	0.7	4.1	2.5	2.5	5.8	5.8
Ultraviolet - A	320-360	2.4	1.8	3	19.7	14.8	34.5	24.7	60.9
	360-400	3.2	2.4	4.4	26.3	19.7		36.2	
Visible	400-520	17.9	16.1	19.7	147.2	132.4	360.3	162	468.8
	520-640	16.6	14.9	18.3	136.5	122.6		150.5	
	640-800	17.3	12.8	19	142.3	105.3		156.3	
Infrared	800-3000	42.1	33.7	50.5	346.3	277.2	277.2	415.4	415.4

Note: 1. The sum of energy in all spectral bands shall not exceed ±4% of total irradiance or ±15 W/m² (whichever is greater)
2. The values in columns 2 through 5 were obtained from CIE-85 and DIN 75220, Table 1.

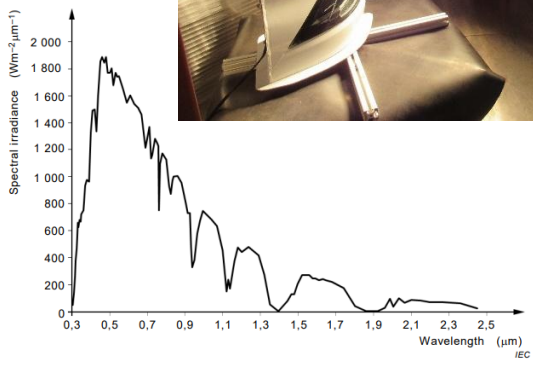


Figure 1 – Global solar spectral irradiance at sea level

Photometric and Spectroradiometric Test Bench (UV–VIS–NIR Range 200–2500 nm)

- The Photometric and Spectroradiometric Test Bench enables precise optical and photometric characterization of materials and radiation sources across the UV–VIS–NIR range (200–2500 nm).
- The setup is based on a PerkinElmer Lambda spectrophotometer, allowing high-accuracy measurements of material reflectance and transmittance in compliance with ASTM C1036-21, ISO 12543, STANAG 2338, ISO 13468-1/2, ISO 4892, and ASTM E903-20.
- The test bench also supports spectroradiometric measurements of light and radiation sources according to CIE 250:2022, providing full spectral power distribution analysis.
- Additionally, it enables the testing of photovoltaic modules in accordance with IEC 61215 and IEC 61646 standards, including the assessment of optical and conversion performance under controlled illumination and environmental conditions.

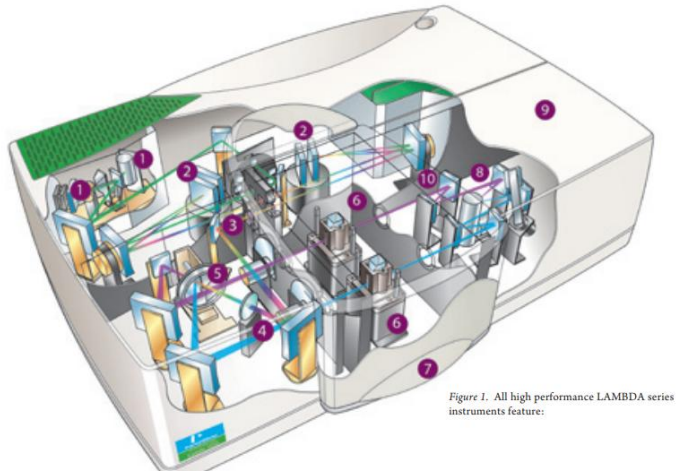
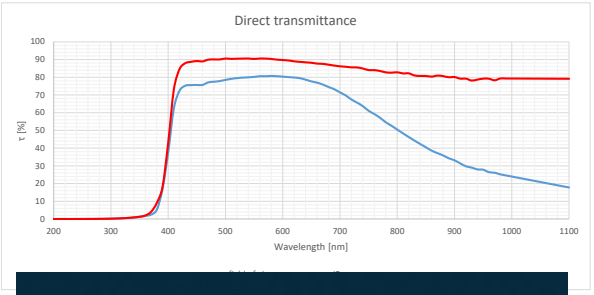
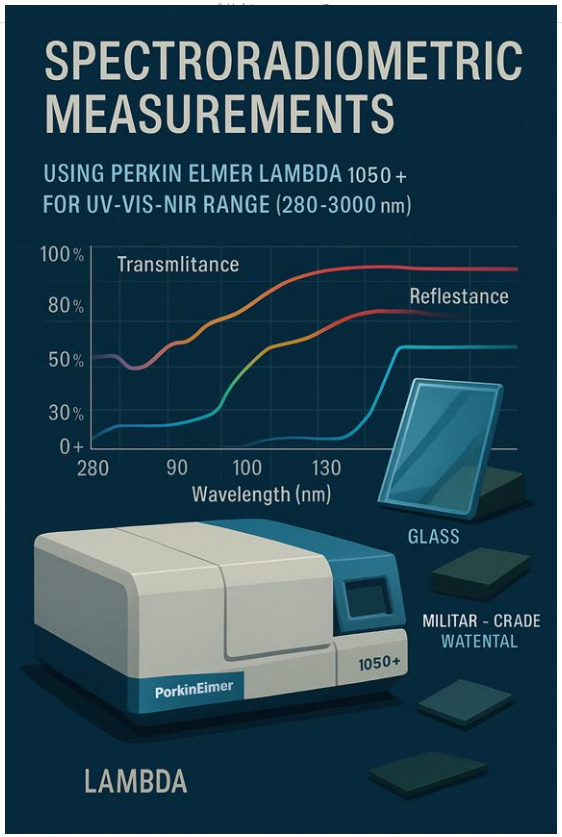


Figure 1. All high performance LAMBDA series instruments feature:





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Scope-ID: SN7P72, Assessment-ID: ANY5K5-1. TISAX and TISAX results are not intended for general public.
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