Wind Tunnel

Climatic Wind Tunnel **Vienna**

Quality in any weather

RAIL TEC ARSENAL

Rail Tec Arsenal

Competence Centre for Climatic Testing of Rail Vehicles

Rail Tec Arsenal (RTA) is an independent **research and testing institute** for rail and road vehicles, aircraft, and technical systems that are exposed to extreme climatic conditions. RTA operates two modern climatic wind tunnels. The focus is on optimising **thermal comfort** and **energy efficiency** in transport vehicles, as well as investigating and enhancing the **availability**, **reliability**, and **safety** of systems operating in sensitive industrial environments.

The Vienna Climatic Wind Tunnel allows the impact of a variety of weather conditions on vehicles and components to be analysed under **realistic operating conditions**. The facility is specially designed and sized for **rail vehicles**, allowing the simulation of a wide range of climatic scenarios at the push of a button – from **extreme solar radiation** and **heat**, to **cold** and **snow**, **rain**, **fog** and **ice**. In combination with wind, load, and drive cycle simulation, the facility is able to create **realistic test scenarios**.

As an internationally recognised competence centre, RTA provides **manufacturers**, **operators** and **system suppliers** with objective, reproducible test results.

RTA's expertise is rooted in decades of climatic testing. Building on its long-standing experience as an **accredited testing institute**, RTA ensures technically sound, traceable and compliant test procedures in accordance with international standards. Continuous involvement in research and development projects further strengthens RTA's competence in the climatic testing of modern rail vehicles under demanding operational conditions.

any weather

History of the Climatic Wind Tunnel

1961
Commissioning of the original climatic testing facility for rail vehicles at the Vienna Arsenal. The facility was established with the involvement of the International Union of Railways (UIC) and the Austrian public sector, laying the foundation for systematic climatic testing of rolling stock under extreme weather conditions.

1974
Upgrade of wind velocity and cooling device in order to be able to test high-speed trains such as TGV and ICE.

2002 / 2003
The new largest Climatic Wind Tunnel starts operation in Vienna-Floridsdorf after 2 years of construction. Ready for rests on rail vehicles as well as busses, trucks and aircraft.

2008
Extention of the auxiliary and test voltage.

2013
The development of icing simulation capabilities in the Vienna Climatic Wind Tunnel begins, laying the foundation for today's advanced testing capabilities.

2018
Solar radiation field in the Large Climatic Wind Tunnel is extended to 60 m.

2021
Additional preparation hall, depot, control room extension, new laboratory and office area built; Construction of permanent hydrogen supply station for large vehicles.

Climatic Testing



Expertise – for the Rail Industry

RTA operates one of the **world's largest climatic testing facilities** for rail vehicles, helping to ensure quality and reliability across the rail industry. RTA is a leading provider of tailor-made solutions for planning, executing and evaluating climatic tests under all weather conditions, and offers its customers technical proficiency and qualitative support. RTA provides the following **services** to ensure efficient testing and dedicated customer support:

Customer support and deliverables

- Test campaign **planning**, including **optimising testing schedules** according to customer specifications and/or standards
- Assistance with transport and customs clearance if requested
- Installation of the required **measurement equipment**
- Implementation of **data interfaces** between the test object and the RTA data acquisition system if requested
- **Integrated project support** through RTA expertise and on-site infrastructure – before, during and after testing
- Real-time **display and evaluation** of testing results throughout the campaign
- **Live remote** and **on-site access** to the data acquisition system and cameras installed in the Climatic Wind Tunnel
- Provision of **measurement data** including **assessments**
- Discussion of test results during **daily meetings** with RTA evaluation specialists
- **Accredited test report** or **summary of test results** and **presentation** at the end of the campaign
- Ensuring the **confidentiality** of sensitive project and testing information

Passenger Thermal Comfort

Standard Requirements

Passenger comfort, particularly thermal comfort, is a vital part of making public transport more attractive. Thermal comfort is influenced by personal, spatial, and ventilation-related factors which have a **complex impact** on a passenger's thermal balance and **individual perceptions of comfort**.

Extensive testing in climatic wind tunnels is the basis for creating positive thermal conditions in rail vehicles under all climatic conditions. The research, optimisation, and development stages are usually conducted on an early production vehicle.

RTA specialists install an extended measuring setup consisting of **air temperature**, **surface temperature**, **air velocity** and **air humidity** sensors. This setup allows to measure all parameters specified by relevant climatic standards, including EN 13129, EN 14750, EN 14813, ISO 19659-2 or VDV 181.

Investigations also require a passenger load simulation comprising **sensible and latent heat**. Sensible heat is introduced in the form of heating mats to simulate sitting passengers, and heaters for standing passengers. Humidifiers evenly distributed throughout the vehicle interior provide the latent heat share. After the customer's pre-adjustment phase and completion of the RTA sensor installation, RTA conducts official climatic test programmes. Based on the results, the comfort criteria defined by climatic standards, as well as additional contractual requirements are evaluated throughout the entire scope of testing. An **accredited test report** is then issued, including a **final assessment** of the test object's performance.

Passenger Thermal Comfort

PPD / PMV Measurements

In addition to measurements such as air temperature, humidity, air velocity, or surface radiation temperature, all taken according to the relevant climatic test standards, RTA offers measurements or calculations of the thermal comfort parameters **Predicted Mean Vote** (PMV) and **Predicted Percentage of Dissatisfied** (PPD).

Thermal comfort parameters provide a more realistic and user-oriented picture of the indoor conditions. While individual values describe physical environmental factors, they do not directly indicate whether passengers will actually feel comfortable. It creates a more comprehensive assessment of the indoor environment and supports better decision-making for optimising HVAC systems.

Determining k-value

The overall **heat transfer coefficient** (k-value) serves as a guide for assessing the thermal performance and airtightness of the vehicle body and is used to calculate the required heating and cooling capacity for the vehicle's HVAC system.

A common method of determining the k-value involves a **power-controlled heating system** positioned inside the vehicle. It consists of resistive radiators and fans spread throughout the passenger compartment and guarantees a **homogenous temperature distribution** in the interior of the test object.

Isolated areas of the vehicle (e.g. behind doors) can also be assessed individually.

Complementary Services

Tracer Gas Measurement

RTA performs tracer gas measurements using CO_2 to assess air distribution, fresh air supply and ventilation performance in rail vehicles with the following goals:

- Assessment of **air exchange** between different vehicle areas
- Verification of **fresh air volume** according to TSI LOC&PAS, based on RTA's accredited test procedure
- Validation of CO2-controlled or weight-controlled **passenger load detection system** to regulate the fresh air supply

Air flow rate measurements using the tracer gas method can also be applied on track tests.

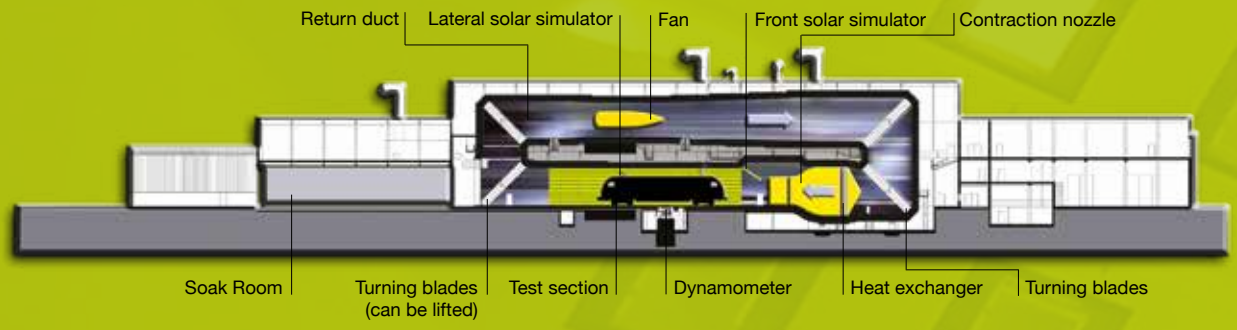
Alternating Climate Tests

RTA's alternating climate test methodology allows **abrupt changes in environmental conditions** and thermal loads to be simulated under controlled laboratory conditions. In the Small Climatic Wind Tunnel, this is achieved by transferring the test object between the Climatic Wind Tunnel and the adjacent temperature-controlled Soak Room. For larger and longer vehicles, equivalent climatic transitions can be reproduced directly in the Large Climatic Wind Tunnel. This allows realistic testing of systems and components exposed to rapidly changing environmental conditions, such as when **passing through long tunnels**.

Condensation on components due to changing conditions

Technical Data

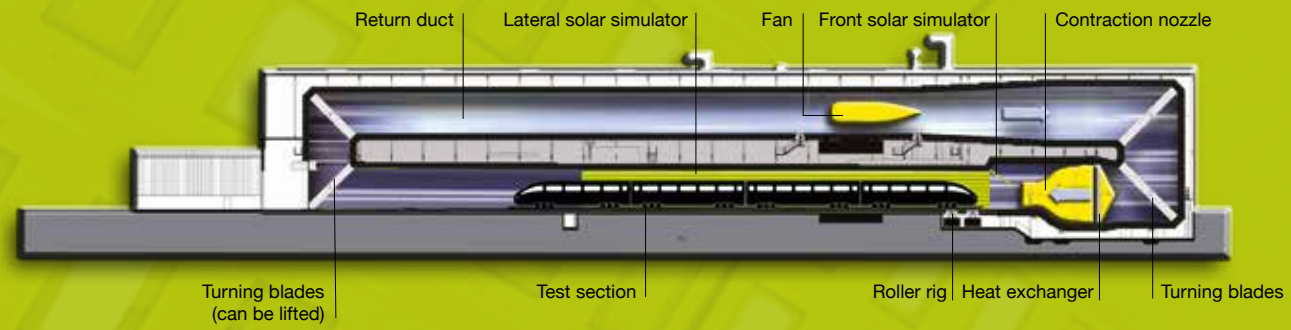
Small Climatic Wind Tunnel (CWT)



Description	Small CWT	Large CWT
Contraction nozzle dimensions width / height / area	3.5 m / 4.6 m / 16.1 m²	
Contraction ratio of nozzle	3.98	5.72
Test section width Test section height Test section cross sectional area	4.9 m to 5.1 m 5.9 m to 6.0 m 27.2 m² to 28.7 m²	4.9 m to 5.6 m 5.9 m to 6.2 m 27.2 m² to 32.2 m²
Distance between nozzle and start of test section (also begin of lateral solar simulator)	3.5 m	
Test section length	33.8 m	100.0 m
Distance between nozzle and dynamometer / roller rig	16.0 m	7.5 m
Maximum dimension for entry	height = 5.9 m / width = 4.2 m	
Smallest ground clearance	40 mm	
Dimensions of lateral solar simulator length / height	30.0 m / 4.3 m	60.0 m / 4.3 m
Maximum temperature range	-45°C to +60°C	
Maximum wind speed restrictions at low temperatures e.g. at -20°C	120 km/h 120 km/h	300 km/h 200 km/h
Maximum temperature gradient in the temperature range -20°C to +60°C	10 K/h	
Relative humidity at temperatures > +10°C	10% to 98%	
Solar intensity of lateral solar simulator at fixed 30° angle of incidence operating temperature > -10°C	200 W/m² to 1,000 W/m²	
Solar intensity of front solar simulator maximum wind speed (in operating temperature > -10°C): at incidence angles < 45° up to 120 km/h at incidence angles >= 45° up to 50 km/h	200 W/m² to 1,000 W/m²	

c Wind Tunnel

Large Climatic Wind Tunnel (CWT)



Description	Small CWT	Large CWT
Rain, snow and icing systems	stationary ceiling mounted rain and icing system; spray rig covering entire tunnel cross section; mobile (snow) nozzles	
Braking and load simulation	dynamometer with one driven axle	roller rig with one driven and one nondriven axle
Maximum power	250 kW drive power (from 45+ km/h)	850 kW drive and brake power
(Linear increasing until full power)	300 kW brake power (from 50+ km/h)	1.5 MW overload for 90 s
Maximum speed	160 km/h	280 km/h
Load simulation	4,000 to 20,000 kg	Up to 20,000 kg
Maximum axle load	14,000 kg	20,000 kg
Roller diameter	1,591.5 mm	1,000 mm
Roller surface	tungsten carbide coated	-
Roller spacing	1,000 mm	-
Roller width	1,000 mm	track profile
Distance between axels, adjustable	-	1,100 mm to 3,000 mm
Gauge of track	-	1,435 mm
Maximum wheel Force	20,000 N	-

Soak Room: for pre-tests and alternating climate tests in combination with the small CWT.
Temperature & humidity range depends on outside weather conditions.

Dimensions length / width / height	30 m / 8 m / 6 m
Temperature range	+5°C to + 60°C
Relative humidity at temperatures > +10°C	10% to 98%

Preparation halls for setup	**Preparation hall 1**	**Preparation hall 2**	**Preparation hall 3**
Dimensions length / width / height	100 m / 11 m / 8.5 m	60 m / 11 m / 7.5 m	64.5 m / 9.5 m / 5.6 m
Ground controlled gantry crane	5 t / along entire hall		3.2 t / along entire hall

Auxiliary and test voltages		
	200 – 1,000 V DC	2x 175 kW 350 A max
	1,000 – 3,600 V DC	350 kW 235 A max
	3x 200 – 1,000 V 40 – 60 Hz	350 kVA 500 A max
	200 – 1,200 V 16 $^{2/3}$ Hz	350 kVA 350 A max
	500 – 1,800 V 40 – 60 Hz	350 kVA 350 A max
	3x 400 V 50 Hz	350 kVA 500 A max
	20 – 200 V DC	200 A max

Available accessories:

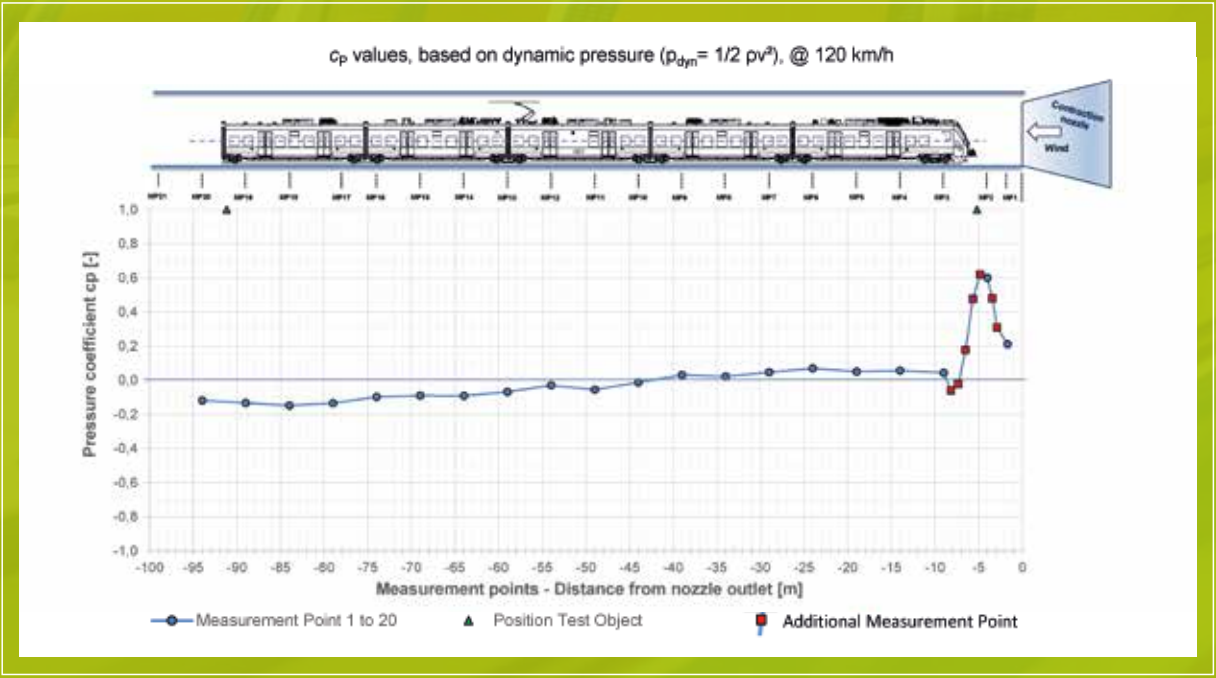
- Forklift (5 t)
- Shunting vehicle (Zagro) with the following couplings:
  - Towing hook
  - Towing rod / truck trailer hitch
  - Voith – Schaku Typ 10
- Work platform (6 m)
- Unloading track without ramp (smallest radius = 120 m)

Complementary Services

Pressure Profile and Air Velocity Distribution Measurements

Aerodynamic behaviour around test objects influences HVAC and air inlet performance. Understanding these **airflow characteristics** is therefore essential for comparing Climatic Wind Tunnel measurements and real-life operation in the field.

Aerodynamic measurements can also be carried out on components including pantographs and windscreen wipers.



Example of pressure profile and velocity distribution

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Energy Consumption Measurement

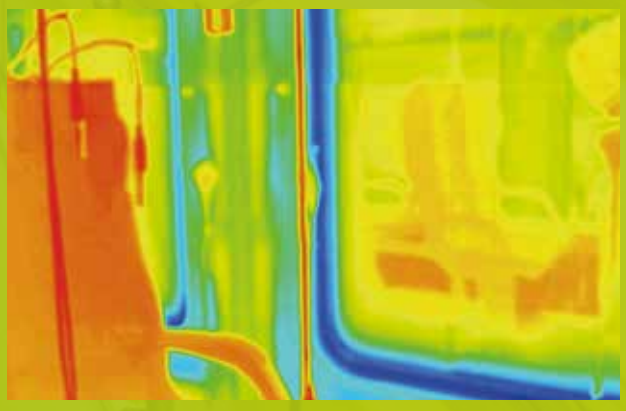
Determining the energy consumption of the entire test object and/or selected components provides the most straightforward basis for identifying **potential energy savings**. Installing power metres on selected supply lines within the test object is recommended for test campaigns which focus on passenger comfort. RTA supports customers by developing efficient power measurement concepts. Energy consumption measurements always exclude traction as test objects like IEC 63593 (EN 50591) remain stationary during Climatic Wind Tunnel testing. Nevertheless, significant savings potential remains, as the HVAC system is the second-largest source of energy consumption after traction.

Energy consumption cycles (ECCs including specific operating modes) like ISO 19659-3, IEC 63593 (EN 50591) or VDV 183 are used to estimate a vehicle's annual consumption, an important factor in determining a vehicle's overall **energy efficiency.**

Thermographic Imaging

The aim of thermographic investigations is to obtain a qualitative impression of the surface temperature distribution of the test object in order to **localise potential heat bridges**. Irregularities in the heat flow can be detected and easily interpreted.

Thermographic image of passenger seat next to a window



Functional Tests

Reliability in Any Weather

Long-term operation under extreme climatic conditions demands exceptional reliability, low maintenance requirements and sustained component functionality. RTA conducts **reproducible tests on critical components** under a wide range of weather conditions, in accordance with CEN/TR 16251, a guideline that incorporates RTA's long-standing expertise in functional testing. In addition to providing **evidence of conformity** with contractual requirements, such tests help to **improve and further develop** these components.

Testing vehicle components in advance helps detect potential failures and operational issues at an early stage. This **reduces repairs and bottlenecks**, leading to **lower costs** and **fewer disruptions** to planned operations and timetables.

Sample test scenarios:

- **Extreme temperatures and humidity levels** to test mechanical, electrical, electronic and pneumatic components
- **Wind and rain** to identify water ingress and assessment of windscreen wipers, joints, doors and windows, etc.
- **Wet snow** on doors, steps, couplings, roof equipment, braking systems, etc.
- **Dry snow** for leak detection
- **Icing** on pantographs, disconnectors, doors, steps and couplings, etc.

As different weather conditions affect individual components to varying degrees, it is not necessary to test every component under all weather conditions. An overview of appropriate functional tests is shown in table on the next page.

RTA also simulates **customised weather conditions** tailored to the specific environmental challenges reported by operators around the world.

Listed Functional Tests

Group	System / component	CEN/TR 16251: 2016	Ice	Dry snow	Wet snow	Low temper-ature	Dry	Rain	High humidity	High temper-ature
	Vehicle complete	5	X			X			X	X
	External cabinets, boxes for equipment, cables and connectors	6.21	X	X	X			X	X	
Roof area	Pantograph	6,15	X		X	X				
	Cooling systems	6.17		X	X				X	
Vehicle's front	Horns	6.12	X	X	X	X	X			
	Lights	6.11	X		X	X		X		
	Windscreen	6.9	X		X			X	X	
	Side mirrors/cameras	6.10	X		X	X			X	
	Side mirrors	-	X			X				X
	Automatic couplers	6.16	X	X	X	X				
	Front cover	-	X	X	X	X				
	Front destination display	-	X		X					X
Vehicle's side	Doors	6.13	X	X	X	X		X	X	X
	Moveable steps	6.14	X	X	X	X		X	X	X
	Driver's cab doors' step	-	X	X	X	X		X		X
Underframe area	Sanding equipment	6.5	X	X	X	X		X	X	
	Battery	6.19				X				
	Engine cooling system (diesel)	6.18	X							X
	System complete	-					X			
	Flange lubrication system	6.8				X	X			X
	Suspension level control system	6.6	X	X	X	X				X
	Tilting system	6.7	X	X	X	X				X
	Magnetic rail brakes	-	X		X	X				X
Vehicle's interior	Toilet and water systems	6.20				X				
Others	Snow plough	6.1		X[1)]	X[1)]					
	Bogie and running gear	6.2	X[2)]	X[2)]	X[2)]	X[2)]		X[2)]		X[2)]
	Brakes	6.3	X[2)]	X[2)]						
	Compressed air	6.4				X			X	X
	Traction (electric)	6.18								X[2)]

X Functional test in accordance with CEN/TR 16251:2016

X RTA recommended test

[1)] Functional tests cannot be carried out in the Climatic Wind Tunnel

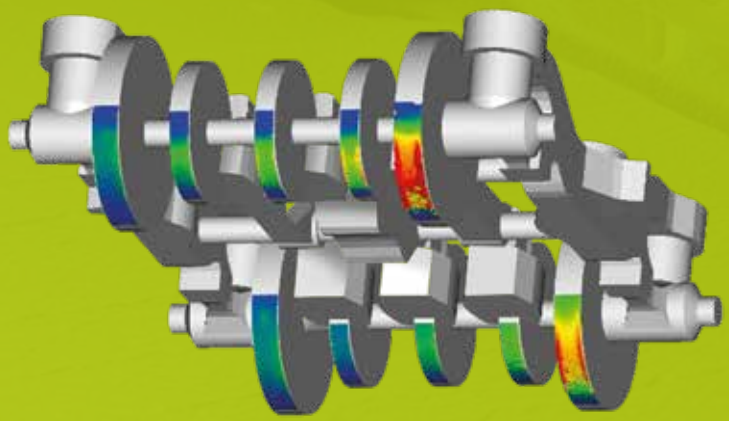
[2)] Limited test execution possible

Open to New Challenges

Research, Development Support and Standardisation Activities

As the world's first partner for climatic testing of rail vehicles, RTA expertise extends far beyond measurement activities: RTA supports the development of advanced test procedures for rail applications through its continuous **research and development** activities, publication of **technical papers**, active **participation in standardisation committees**, close **collaboration with customers**, and **organisation of international workshops**. This equips RTA to refine climatic and thermal comfort test methods, validate vehicle HVAC performance under realistic operating conditions, and adapt testing standards to evolving technical requirements, environmental conditions, and passenger comfort expectations.

An integral part of this expertise is the capability to supply and test next-generation propulsion systems, including batteryelectric and hydrogen-powered trains, within the Climatic Wind Tunnel. By providing the necessary infrastructure and energy supply under controlled environmental conditions, RTA enables **realistic performance, functionality, and system validation** across the full range of climatic operating scenarios.



Experiments for snow accumulation on a boogie mock-up with a 3D scan for validation of particle tracing codes

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Quality Certification

Ensuring **quality in any weather** requires internal **quality assurance**.

ISO 9001 certification provides the foundation for high testing standards.

A continuously monitored **ISO/IEC 17025 accreditation** enables the issuance of internationally recognised test reports according to accredited testing procedures. RTA is also approved to perform in-house **calibration** for all sensors, measurement devices and testing equipment used in its testing activities.

RTA places the highest value on **occupational health and safety**. Certification according to **ISO 45001** reflects the commitment to maintaining a safe working environment and ensuring that all testing activities are carried out with the utmost care, responsibility and risk awareness.

As a member of the **TISAX network**, RTA is certified for prototype testing and meets the highest standards of information security based on ISO 27001.

The **ISO 50001** certification shows RTA's commitment to **responsible energy management**, continuous improvement and the sustainable operation of the energy-intensive testing facility.

www.rta.eu

IMPRESSUM

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Vienna Climatic

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