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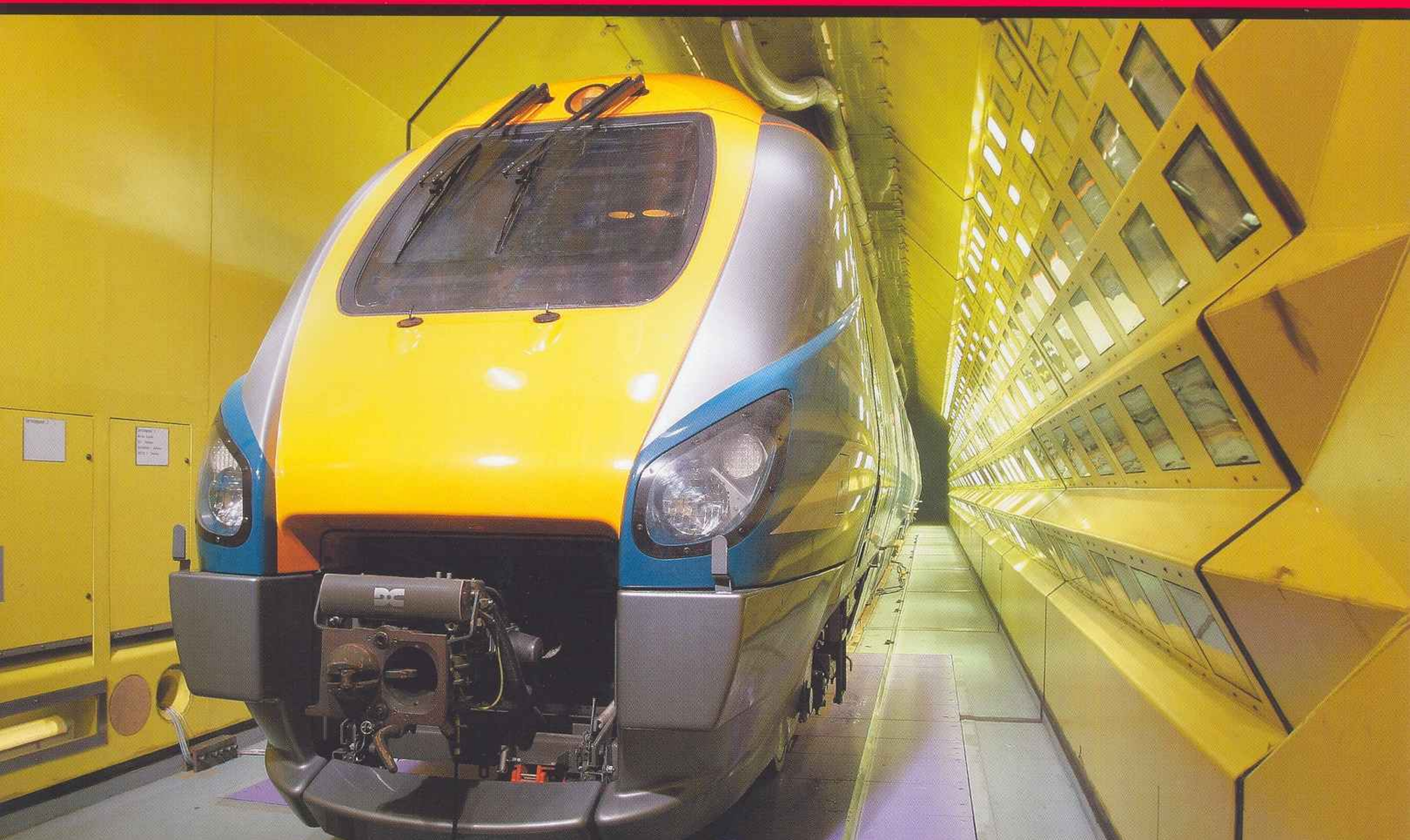


Rail Tec Arsenal Offprint

The Benefits Of Climatic Testing Of Rail Vehicles: *Experiences From Practice, Functional Tests, Thermal Comfort*

Railvolution No 1 In Europe

The CITADIS tram for RTE, Rotterdam, tested in Vienna by -20 °C to +30 °C from 31 March to 7 April 2003.

The Benefits Of Climatic Testing Of Rail Vehicles

Passenger expectations in terms of ticket prices, travel times and travel quality (punctuality, synchronised timetables and passenger comfort etc.) are an important criterion for the successful provision of public transport services. Modern rail vehicles must therefore meet high standards of safety, reliability and availability - as also passenger comfort. A climatic wind tunnel provides the opportunity to create a wide variety of „artificial" weather conditions to carry out climatic tests on entire rail vehicles.

At present, however, the vast majority of these tests are carried out because vehicle operators require them as proof of conformity with relevant standards in respect to the proper functioning of components and passenger comfort.

The opportunity to carry out such tests with a view to cost and risk reduction is used only in exceptional cases. This may be largely due to the lack of information about how climatic wind tunnel tests can contribute to reducing risk and increasing reliability. The following is intended to close this information gap.

Initial Situation

Railway experts recognised the necessity of reproducible climatic conditions for the development of modern rail vehicles more than 40 years ago. This led to the establishment of the world's **first vehicle testing facility** for locomotives and coaches on the Arsenal premises in Vienna in 1961. This large-scale project became possible through exemplary international cooperation between the Office for Research and Experiments (ORE) of the International Railway Union (UIC), the Austrian Federal Government and numerous European railway authorities. The facility was modernised in 1973/74 in order for it to continue to meet the requirements of modern testing.

After the end of the facility's service life, its successor, the **new Vienna climatic wind tunnel**, went into operation on 1 January 2003. The participation of major rail vehicle manufacturers in the new operating company Rail Tec Arsenal underlines the demand for such a facility and clearly indicates the shift in the roles of operators and manufacturers.

Rail vehicle manufacturers have integrated various tasks previously assigned to the **operators** into their product development process. This is especially the case for preventive quality assurance, which also encompasses climatic tests. Despite this shift in roles, however, the vast majority of climatic tests are still carried out as proof of conformity upon the buyer's (operator's) request.

Furthermore, most **manufacturers** have not yet implemented climatic tests in their product development process as a quality assurance measure for cost and risk reduction, although warranty costs of vehicles already in operation usually far exceed repair costs on prototypes or first series vehicles. The concomitant delivery delays, standstill costs due to non-availability or additional costs resulting from the withholding of final payments can lead to significant cost increases.

The search for solutions does not begin until safety and reliability problems have already occurred, since practically no research and development activities are performed outside the scope of specific projects.

Installation of temperature sensors in CITADIS preparing the final k-value measurement. The k-value is a heat transfer coefficient, describing the heat transfer of the air from the interior through the walls to outside.

Siemens TS metro unit for Shanghai was tested in time from 2 to 10 August 2004 in the small CWT.

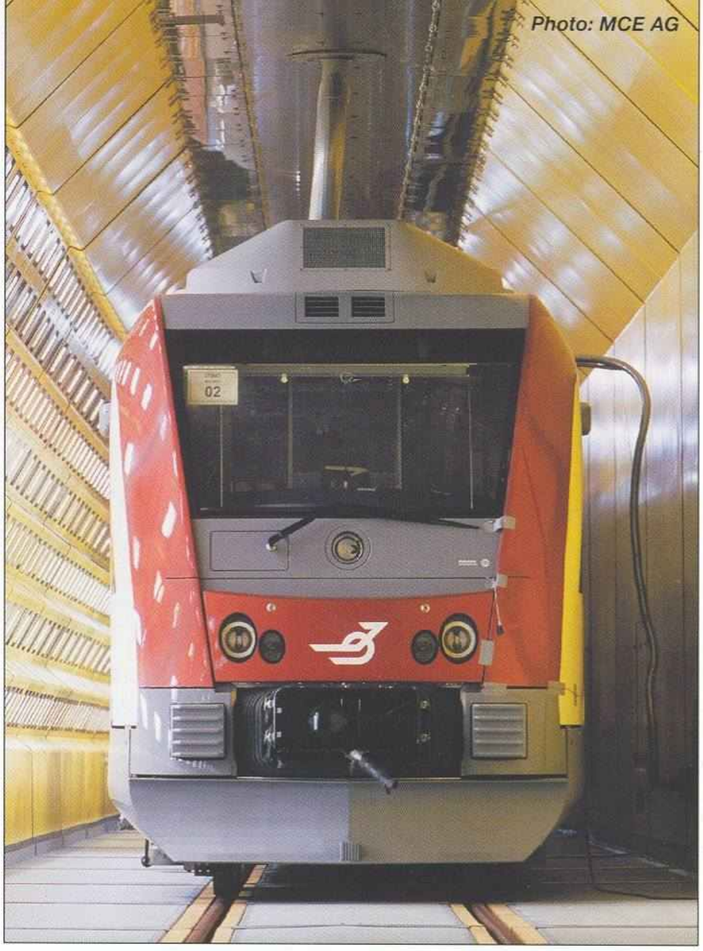


Photo: MCE AG

ITINO for the Swedish operator TiB was tested during the acceptance phase of the CWT in September 2002.

Thermal Comfort

The Vienna climatic wind tunnel can draw on a wealth of expertise gained from decades of rail vehicle testing at the Arsenal premises. The experience gathered from these thermal comfort tests has also been integrated in **UIC Code 553** „Heating, ventilation and air-conditioning in coaches", which defines the comfort standards for passenger coaches. UIC Code 553-1 describes the tests required to prove conformity with the above standards.

The new **CEN standards** take specific operating requirements into account:

- Air conditioning for main line rolling stock (EN 13129-1 and 2).
- Air conditioning for urban and sub-urban rolling stock (EN 14750-1 and 2).
- Air conditioning for driving cabs (EN 14813-1 and 2).

The above standards define uniform European criteria for thermal comfort in rail vehicles and should thus contribute to better planning and reduced risk for rail vehicle manufacturers, higher quality systems for operators and, last but not least, increased passenger comfort. The stipulated criteria, however, must also be applied and implemented. The climatic concept must be adapted to specific design parameters, depending on the vehicle concept.

Even **air conditioning** systems meeting all thermal comfort requirements may produce unsatisfactory results in practice due to poor adjustment, optimisation and maintenance. It is especially important to adjust air distribution parameters to the different heating and cooling loads of the vehicle and to optimise the control unit for all climatic operating conditions. This can only be sensibly done when testing the entire vehicle in an appropriate climatic testing facility.

While numerical methods such as CFD (Computational Fluid Dynamics) can help in selecting the most suitable air-conditioning concept, they cannot replace practical optimisation and adjustment work. This is understandable because actual air flows in the vehicle interior, and thus also comfort conditions, are different from computational results calculated on the basis of specific ideal assumptions.

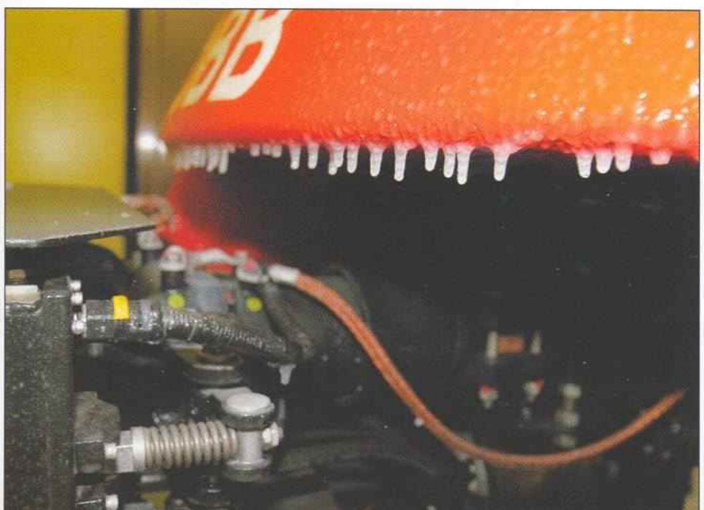
Functional Tests

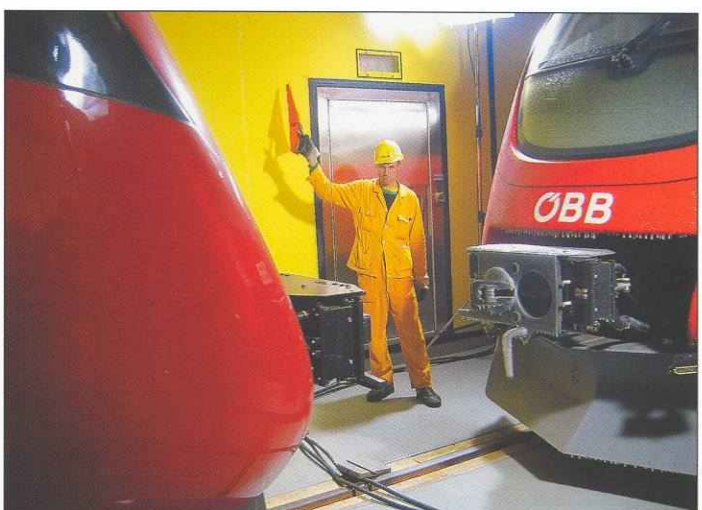
Safety-relevant parameters and the proper functioning and reliability of individual components can be tested by carrying out special functional tests under extreme climatic conditions. Functional tests can be divided into the following **categories**, depending on the climatic test conditions required:

- Extreme temperatures and humidity (all mechanical, electrical, electronic, pneumatic components).
- Rain and wind (proper sealing of entire vehicle, corridors, doors, windows, proper functioning of windscreen wipers).
- Wet snow (all mechanical components subject to outside conditions, such as doors, steps, coupling, brake system etc.).
- Dry snow (penetration of powder snow into air intakes, seals etc.).
- Ice (all mechanical components subject to outside conditions, such as doors, steps, coupling, brake system etc.).

Standstill climatic tests alone, however, are not always sufficient. In addition to climatic and wind conditions, tests must also simulate **realistic operating conditions** at the bogie as well as vehicle traction and brake performance. These tests are carried out using a dynamometer, which can also be operated as a brake dynamometer.

The design of the cooling system is an essential aspect in diesel vehicles. The climatic wind tunnel is designed to realistically simulate both environmental conditions, such as tempera-





The testing of electrical Talents for ÖBB included not only the „usual freezing" by -25 °C but also the connecting of two trains under winter conditions by -10 °C with a 3 mm ice layer on the coupling.

ture, humidity and solar radiation, and mechanical loads. Wind simulation plays an important role in providing a realistic simulation of flow conditions at the specific cooling unit.

The **dynamometer** can also be used to measure the traction or braking forces transmitted. This allows the wheel force curve to be measured as a function of the driving speed, taking into account the power consumption of auxiliary units in specific operating states. Dynamometer tests should be complemented by additional functional tests under extreme climatic conditions:

- Cold start behaviour.
- Warm-up at low ambient temperatures (design of pre-heating units).
- Penetration of powder snow into air intakes (motor cooling air, fresh air intake of air conditioning unit...).
- Proper functioning of various components such as brake pads in ice and snow conditions.
- Performance losses as a result of ventilation short circuits caused by warm exhaust air being sucked back into the system (e.g. motor cooling or air conditioning unit).

Furthermore, **brake** performance can be tested in various conditions, such as snow, ice, or water. Advantages over friction test rigs include direct rail contact, precise simulation of wind, snow and ice conditions and the ability to test the entire vehicle together with its major components.

Aerodynamics

Aerodynamic tests in the climatic wind tunnel are carried out, for example, on components such as pantographs and windscreen wipers. Measurements on vehicle models may, however, also include side wind effects and air flow at the air conditioning unit (fresh air intake, condenser exhaust air). Changes in aerodynamic properties due to ice or snow in particular can only be tested on a 1:1 model, since contour changes may strongly influence the aerodynamic behaviour of the components.

Experiences From Practice

Climatic tests help in proving vehicle reliability prior to delivery. Any defects detected can usually be eliminated during the tests with only a small amount of effort. The advantage of this approach is that the measures taken can be immediately tested for their effectiveness under the same conditions.

Since **defects** are detected in practically every test, climatic wind tunnel testing has repeatedly proven its worth. Every defect identified prior to roll-out reduces the risk of malfunctions and additional costs during operation. Let me give you three examples from practice:

Insufficient insulation and/or air leaks in the vehicle body often have a negative impact on thermal comfort in the passenger compartments or driver's cab and may cause condensate to form. In the case of low outside temperatures, this may cause the floor surface temperatures in the entrance area to fall below the freezing point, leading to ice formation and thus even posing a serious safety risk.

The main building of RTA, containing two climatic wind tunnels, two preparation halls, the cooling plant and the power converter units.

The causes can be identified quite simply and quickly in the climatic wind tunnel: air leaks can be located on the basis of smoke and wind simulation, and insulation problems of the vehicle body, doors, windows, corridors etc. can be identified using a thermography camera.

Doors and steps do not function properly when covered with ice and snow. Accumulations of ice and snow in the door area obstruct or even prevent opening or closing of doors (automatic reversal) and cause retractable steps to become stuck. Some targeted design modifications or improvements in the control system are often sufficient to eliminate these problems or improve the situation considerably. These measures can be investigated and tested efficiently under reproducible snow and ice conditions.

Insufficient visibility for the driver in extreme climatic conditions. Insufficient functioning of the windscreen heater or air inlets at the windscreen or side windows of the driver's cab may cause them to mist up, while snow and ice build-up leads to insufficient visibility, or even to complete failure of the windscreen wiper. Poor adjustment between the windscreen washer, wiper and heating systems and the air conditioning unit of the driver's cab may be one possible reason for this. Optimisation runs under different climatic conditions may provide solutions to such misting, frosting problems etc.

Conclusions

The climatic wind tunnel testing options presented in this paper contribute to reducing technical risks during operation and to increasing vehicle reliability in all weather conditions. Testing practice has repeatedly shown that tests of the entire vehicle are absolutely necessary, since even the most advanced component inspection procedures cannot guarantee the proper functioning of the vehicle as a whole. The great **advantage** of climatic wind tunnel tests is the exact repeatability of climatic conditions, which allows improvements to be verified immediately, thus saving time and costs.

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Photos unless cited:
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Maintenance work in the 0.5 MW fan for the small CWT.