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**Standardised Functional Tests
In The RTA Climatic Wind Tunnel
*Functional Testing For Different
Climates Of Various Subsystems***

Standardised Functional Tests In The Vienna Climatic Wind Tunnel

Safe and reliable operation of mainline rolling stock under all weather conditions is an essential prerequisite for enhancing passenger safety and comfort and thus increasing the attractiveness and acceptance of rail travel. Standardised tests under critical weather conditions can make a valuable contribution to reducing the risk of malfunctions as well as improving vehicle reliability.

The new Technical Report **CEN/TR 16251: 2016 02** „Railway applications - Environmental conditions - Design guidance for rolling stock“ contains design recommendations and test procedures for rail vehicles and components under defined operating and environmental conditions. The Vienna Climatic Wind Tunnel operated by Rail Tec Arsenal (RTA) provides an unique opportunity for carrying out these tests under standardised and reproducible conditions. A powerful wind turbine, spray and sprinkler installations and snow nozzles are available **to investigate the impact of extreme temperatures, rain, snow and ice on rail vehicles, components and systems (see photos 1 and 2).**

Functional Testing For Different Climates

The standard EN 50125-1 „Environmental conditions for equipment - Part 1: Equipment on board rolling stock“ defines specific environmental parameters such as temperature, relative humidity, wind speed, solar radiation, rain etc. for different climate zones. However, it lacks provisions for typical scenarios, which usually result from the interaction of several individual parameters during in-service operation. Both operating and climatic conditions must therefore be simulated simultaneously in order to identify potential problems in advance. Experience has also shown that testing components within the vehicle is essential, since even the best inspection cannot exclude the potential mutual interference between components and systems which may occur in regular service.

RTA has **longstanding expertise** in customer-specific functional tests under different climatic conditions and has systematically collected relevant data about the susceptibility of individual components and systems from railway operators and the rail vehicle industry. This information has provided the basis for developing customised test procedures for critical scenarios and operating modes, which are now being applied as „standard test procedures“ in the Vienna Climatic Wind Tunnel. The majority of these „standard test procedures“ have been included in the new CEN/TR 16251.

Ongoing innovation and progress in the sector require these test procedures to be continuously adapted to new functionalities or operating conditions and new test procedures to be developed.

The table below right lists the tested systems/components along with the relevant climatic test conditions as defined in CEN/TR 16251. The list also contains additional, more recent climatic test conditions and systems/components which have not (yet) been included in the CEN/TR 16251. As can be seen from the table, different **climatic conditions** are relevant for different components/systems:

- extreme temperatures and humidity levels have a negative impact on mechanical, electrical, electronic and pneumatic components,
- the ingress of rain and wind, notably via the connecting corridors, doors and windows, gives an indication of leakage; proper functioning of the windscreen wipers is also essential,
- wet snow has an impact on all mechanical components exposed to outside conditions, such as doors, steps, couplings and roof equipment,
- ingress of dry snow into air intakes and gaskets often leads to problems,
- ice formation on mechanical components, such as the pantograph, doors, steps and couplers may cause malfunctioning or blocking of the subsystem.

Vehicle

The thermal insulation and (vapour) tightness of the vehicle body is essential for both passenger comfort and proper functioning of components and systems. Insufficient insulation and/or leaks in the vehicle body often have a negative impact on interior temperatures and may cause condensate to form in the passenger areas or driving cab. This may cause the floor surface temperatures in the vestibules to fall below freezing point at low outside temperatures, leading to ice formation. It is therefore important to check the proper functioning of the whole vehicle in different scenarios.

A **typical test** which is also included in CEN/TR 16251 involves checking the functionality of the entire vehicle following sudden changes in climatic conditions, as for example experienced by a train travelling through warm humid tunnels in winter. For this test, the vehicle is soaked at temperatures lower than -10 °C for a minimum of 5 h with all systems in operation. The vehicle is then shunted to an environment with temperatures greater than +20 °C and a dew point greater than +15 °C.

After more than 10 min of operation, the condensation effects on the windows and signal lights (visibility) are



Photo 1: Vehicle prepared with ice layer for function tests (testing of Tram-Train Karlsruhe).

checked. Following the functional test, the vehicle is again returned to the winter environment (temperatures lower than -10 °C). After a minimum of 1 h,

the proper functioning of all relevant components is checked. If required, the test can be repeated several times to demonstrate freeze/thaw capability.

System/Component	Clause acc. CEN/TR 16251	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Vehicle	5	x	x	x	x	x	x	x
Subsystems								
Snow plough	6.1		x	x				
Bogie and running gear	6.2	x	x	x	x	x	x	x
Brakes	6.3	x	x	x			x	x
Compressed air	6.4					x	x	x
Sanding equipment	6.5	x	x	x	x	x		x
Level control system	6.6	x	x	x			x	x
Tilting system	6.7	x	x	x			x	x
Flange lubrication system	6.8						x	x
View ahead	6.9	x		x	x	x		x
Side mirror/cameras	6.10	x				x		x
Lights	6.11	x		x		x		x
Horns	6.12	x	x	x				x
Doors	6.13	x	x	x	x	x	x	x
Movable door steps	6.14	x	x	x	x	x	x	x
Pantograph	6.15	x		x				x
Automatic couplings	6.16	x	x	x				x
Cooling systems	6.17		x	x		x		x
Traction	6.18						x	
Battery	6.19							x
Toilet and water systems	6.20							x
External cabinets, boxes for equipment, cables and connectors	6.21	x	x	x	x	x		
Driver door and steps	-	x	x	x	x		x	x
Front cover for coupling	-	x	x	x				x
Destination display	-	x		x			x	
Magnet track brake	-	x		x				x

Legend

x	test procedure according to CEN/TR 16251
x	additional tests

Table: Overview of functional tests of different components under specified climatic conditions.



Photo 2: Water tightness test of roof components.

Subsystems

Bogie Components

Bogie components such as the axle and gear box, suspension components, sanding, level control, tilting and flange lubrication systems are safety relevant components that should never fail under any circumstances. These components are very exposed to outside conditions and are thus extremely prone to the accumulation of snow and ice. The consequences of ice or snow build-up may range from partial malfunction to complete failure, as in the case of ice formation on the sanding system, which is decisive for proper friction between wheel and rail.

All winter conditions with a negative impact on underframe components can be realistically simulated on the dynamometer in a climatic wind tunnel. **The tests help both in developing measures to reduce the problems, such as fitting a heater or housing to the sanding system, and for validating their effectiveness (see photo 3).**

Brakes

Brake tests according to CEN/TR 16251 include the general functions of brake engagement and release in ice conditions as well as extended braking distances due to snow conditions. Depending on the vehicle to be tested, however, it will be necessary to

define specific test requirements (acceptable braking distance, braking speed, etc.) or apply other standards.

For example, the requirements for winter approval of brake blocks (e. g. new low-noise composites for retrofitting brake freight waggons) are defined in **UIC Leaflet 541-4**. Together with UIC experts, RTA has developed an appropriate test programme and is now authorised to carry out winter certification tests for these components. The tests involve mounting the entire bogie of the freight waggon on the dynamometer and testing the braking performance at velocities of 100 km/h and 120 km/h at a temperature of -10 °C.

Once the specified velocity is achieved, emergency braking is activated and the braking distance is measured. The braking tests are performed five times for each velocity under dry conditions and subsequently five times under snow conditions. The results can then be used to determine the mean braking distance. The big advantage of **this test procedure is that the whole brake system, including wheel-rail contact, can be tested under reproducible conditions in a planned timeframe of three days without the need for track tests (see photos 4).**

Automatic Couplings

Winter conditions also pose a challenge to the coupling mechanism, which



Photo: Siemens

Photo 3: Winter testing of bogie components.



Photo 5: Testing the effectiveness of the coupling heater under snow conditions.

provides a mechanical and electrical connection between rail vehicles. Following reference tests in „dry“ conditions, the coupling is covered with ice at -20 °C to simulate freezing rain on the parked vehicle and with wet snow at -7 °C to simulate the front coupling of the running vehicle during heavy snowfall. Tests with dry snow at -20 °C are also included to simulate the snow entrained from the track, which is compressed during the coupling process and accumulates on the rear coupling.

The subsequent coupling tests reveal whether mechanical, electrical and pneumatic coupling and uncoupling has been successful and whether the coupling heater ensures proper de-icing of the coupling face. A visual inspection is carried out to check **if the automatic opening of the protective caps has led to snow and water ingress, which may allow moisture to get into the electrical contacts, resulting in a risk of short circuiting (see photo 5).**



Photos 4: Test setup with freight waggon for brake block winter certification tests.





Photo: Siemens



Photo: Siemens

Photos 6: Defrosting of wind screen for driver visibility (testing of a DB's Class 407 Velaro high speed train).

View Ahead

Driver visibility is of key importance for safe train operation. Inadequately functioning windscreen heaters or air inlets in the driving cab may cause the windscreen and/or side windows to mist up. Visibility may also be impaired by snow and ice build-up on the windscreen, which may restrict or even prevent operation of the wiper blade.

One possible reason for these problems may be poor adjustment between the windscreen washer, wiper and heating systems and the air conditioning unit of the driving cab. **Climatic tests make it possible to adjust the settings of these components under different climatic conditions and thus help eliminate visibility problems under extreme service conditions (see photos 6).**

Doors And Movable Steps

Accumulations of ice and snow in the door area obstruct or even prevent opening, closing or automatic reversal of doors and may cause retractable steps to become stuck.

Some targeted design modifications or improvements in the control system are often sufficient to eliminate these problems. **In a climatic wind tunnel these measures can be investigated**

and tested efficiently under reproducible snow and ice conditions (see photos 7). As the malfunction of doors and steps is one of the most frequent problems reported by railway operators, **two test procedures** will be described in more detail:

- 1) The door icing tests are carried out at ambient temperatures of $-20\text{ }^{\circ}\text{C}$ simulating a **parked vehicle overnight**. The passenger areas are cold and the air conditioning unit is switched off. The vehicle doors are covered with an ice layer of about 2 mm using a manual sprinkler. Once the last water film has been applied, the ice is allowed to harden for 10 minutes. This procedure is designed to simulate freezing rain. The following pass criteria should be achieved:
 - the doors open and close completely,
 - the entrapment protection device detects the test piece and the door reverses, or the test piece can be withdrawn with a force $\leq 150\text{ N}$,
 - the emergency unlocking system is fully functional,
 - no snow (water, ice) ingress behind the door.

- 2) The movable step test under wet snow conditions is carried out with the passenger areas in regulated mode, **simulating regular service**. A wet snow layer of approx. 2 cm is applied to the extended step using mobile snow

nozzles. The snow layer is compacted by foot and the step is subsequently retracted. The vehicle is then switched to driving mode, which causes the snow to cool down and turn to ice.

This procedure is designed to simulate a normal drive cycle where the step is extended, stepped on by passengers and subsequently retracted. The snow from passengers' shoes may cause ice build-up on the step and the step enclosure, resulting in potential malfunction. This effect can be further enhanced by alternating climate tests, where the vehicle is moved to another environment ($+10\text{ }^{\circ}\text{C}$) to simulate partial thawing during a station stop. The following pass criteria should be achieved:

- the step extends and retracts completely,
- the step detects obstacles and reverses; peak force on contact is below 300 N,
- the step does not move when the door is fully opened.

Conclusions

The functional tests described above are only some examples of the comprehensive set of standardised test procedures available for different components and systems. Each procedure includes a detailed description of the test

conditions and assessment methods used to verify whether the specified compliance criteria have been met. The tests and functional requirements laid down in these procedures have been adapted to real-world conditions based on many years of experience in climatic wind tunnel testing and feedback from regular service operation. They ensure a high degree of comparability, providing a sound basis for further standardisation of functional tests on rail vehicles at an European level.

Functional tests in a climatic wind tunnel make a substantial contribution to reducing the risk of failure in service and increasing the reliability of rail vehicles in all weather conditions. The biggest advantage of climatic wind tunnel tests is that the climatic conditions can be reproduced with great accuracy. This helps to immediately verify the effects of improvements and modifications, thus saving time and money.

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Photos 7: Movable door step with snow and ice build-up on a step.