PD CEN/TR 16251:2016

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Railway applications — Environmental conditions — Design guidance for rolling stock

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National foreword

This Published Document is the UK implementation of CEN/TR 16251:2016.

The UK participation in its preparation was entrusted by Technical Committee RAE/4, Railway Applications - Rolling stock systems, to Panel RAE/4/-/5, Railway applications - Environmental conditions.

A list of organizations represented on this panel can be obtained on request to its secretary.

When speeds in km/h require unit conversion for use in the UK, users are advised to use equivalent values rounded to the nearest whole number. The use of absolute values for converted units should be avoided in these cases. Please refer to the table below for agreed conversion figures:

INS, RST and ENE speed conversions	
km/h	**mph**
2	1
3	1
5	3
10	5
15	10
20	10
30	20
40	25
50	30
60	40
80	50
100	60
120	75
140	90
150	95
160	100
170	105
180	110
190	120
200	125
220	135
225	140
230	145
250	155
280	175
300	190
320	200
350	220
360	225

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Bahnanwendungen - Umweltbedingungen - Konstruktionsempfehlungen für Schienenfahrzeuge

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European foreword

This document (CEN/TR 16251:2016) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

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Introduction

In this Technical Report, environmental conditions are related to climate and big animals. Separately and in combination environmental conditions can represent considerable challenges to the railway sector as availability, economy, reputation and safety can be severely affected. Both severe summer and winter conditions occur, and more intense weather is predicted for the future.

The intention of this Technical Report is to help reduce technical risks related to environmental conditions.

All tests of the different clauses in this Technical Report can be performed either in a climate chamber or on track, if the corresponding test conditions are given.

1 Scope

This Technical Report gives guidance for designing rolling stock for its specified ranges of environmental conditions according to EN 50125-1. This guidance covers environmental conditions in Europe.

The relevant clauses for the particular vehicle should be chosen and described in the vehicle specification. Depending on the ranges selected, design and/or testing provisions described in this Technical Report should be taken into account. This Technical Report is a collection of existing test descriptions and design guidance based on long lasting experience of operators, test centres and industry.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50125-1, *Railway applications — Environmental conditions for equipment — Part 1: Equipment on board rolling stock*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
environmental conditions
physical, chemical or biological conditions external to a product to which it is subject at a certain time

[SOURCE: EN 50125-1]

3.2
winter conditions
conditions with temperatures below freezing point of water, where snow and ice can accumulate on the vehicle

3.3
summer conditions
conditions with temperatures above 35 °C in addition to intensive solar radiation and hot ballast effect

3.4
ice
is considered as glaze ice or clear ice

Note 1 to entry: It tends to accumulate rapidly and is very hard and therefore more difficult to remove. Such ice forms when large drops of water strike and spread over a surface whose temperature is below the freezing point. Mechanical components and the windscreen are elements typically tested with ice. For the test, a certain thickness of the ice layer is defined.

3.5
dry snow
form of precipitation where tiny ice crystals bond together into flakes, which have little to no liquid water content and a particle size of about 20 µm MVD (Median Volumetric Diameter)

Note 1 to entry: The density of this snow is about 200 kg/m^3 and can go up to 350 kg/m^3 if wind pressed.

Note 2 to entry: The snow intensity in kg/m^3 is defined.

3.6
wet snow
form of precipitation where tiny ice crystals bond together into flakes, which have a high liquid content and a particle size of 50 µm or more

Note 1 to entry: The density of this snow is about 350 kg/m^3 to 500 kg/m^3.

Note 2 to entry: The snow intensity in kg/m^3 is defined.

3.7
rain
precipitation in the form of water drops; both the amount that falls and the actual falling action of the water drops are often called rainfall

Note 1 to entry: Rain intensity is measured in mm/min.

Note 2 to entry: This standard does not scope with tests concerning water tightness of the vehicle and components.

3.8
condensation
precipitation of water vapour on a surface when the surface temperature is lower than the dew point temperature of the ambient air whereby water is transformed from vapour to the liquid state of aggregation

3.9
temperature class
classification system defined in EN 50125-1

3.10
hot ballast effect
heat accumulation of the ballast caused by solar radiation

Note 1 to entry: Heat accumulation of the ballast is caused not only by solar radiation but also by exhausts from cooling systems, braking resistors or similar devices and subsystems along the train.

4 Overview – List of covered topics

The following Table 1 is an overview of the covered topics of this document and helps to identify the relevant clause for the user.

Table 1 — System overview

System/ component	Clause/ Sub-clause	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Design guidance for vehicle	5	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Sub systems								
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
Suspension level control system	6.6	X	X	X				
Tilting system	6.7	X	X	X				X
Flange lubrication system	6.8						X	X
Windscreen	6.9	X		X	X	X		X
Side mirrors/cameras	6.10	X				X		X
Lights	6.11	X		X				X
Horns	6.12	X	X	X				X
Doors	6.13	X	X	X	X	X		X
Moveable steps	6.14	X	X	X	X	X		X
Pantograph	6.15	X		X				X
Automatic couplers	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		

5 Design guidance for vehicle

5.1 General

This clause includes vehicle design guidance related to environmental conditions.

The environmental conditions in Table 2 are covered.

Table 2 — Design guidance for vehicle

Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
X	X	X	X	X	X	X

5.2 Temperature related

When choosing materials and their combinations, thermal expansion characteristics should be considered, e.g. aluminium car bodies have approximately 3 times the thermal expansion compared to steel bodies.

Bending and/or tension caused due to thermal expansion differences can be avoided by e.g. arranging gaps between interior panels and at the ends of floor elements which take care of the expansion movement. Material used for components for underframe and bogie should withstand temperatures higher than the upper extreme temperatures which are caused by e.g. hot ballast.

Materials used for components outside of the vehicle body and bogies can be exposed to temperatures lower than the lowest and higher than the highest specified extreme temperatures (see EN 50125-1).

5.3 Snow and ice related

5.3.1 Ice related

The vehicle should be designed to avoid damage to. E.g. side walls, underframe equipment, cables, hoses, windows and doors from:

— ice falling down from accumulations in underframe and running gear;

— ballast stones lifted by the ice falling down from underframe and running gear;

— ice lumps from the snow plough thrown into, for instance cutting walls reflected back to the train;

— ice build-ups falling from tunnel roofs and walls;

— ice lumps lifted by the air turbulence generated by the movement of the train.

5.3.2 Snow related

Bogies, coupler and its ancillaries, roof, cab and underframe are areas, which are exposed to snow accumulation. As measurement of thickness or weight of snow and ice layers is difficult to perform in service to get limit values, design should be chosen in such a way that accumulation is minimised and preferably avoided.

This can be achieved by protection or enclosure of components, geometric shape or choice of materials, which have reduced adhesion.

In the absence of project specific requirements for the accumulation of snow and ice, the following additional mass to be considered.

— 0,5 t to 1,5 t per bogie;

NOTE The weight is based on experiences made in Sweden.

5.3.3 Anti-icing and de-icing

At winter conditions with snow on the line and/or in the air and the temperature in the range of approximately −10 °C or lower, snow will accumulate primarily in the running gear and at underframe components. This will reduce the possibility to inspect the condition of safety and operational critical parts/components. Build-up of snow and ice also will reduce the possibility for free movements of parts/components in the running gear and brake system, hence causing reduced running comfort and probability for reduced or lacking braking effort. The probability for defective parts/components and for derailment is at the same time increased.

A simple and quick manual removal of snow and ice at train ends should be possible. Good accessibility should be considered.

Preventive anti-icing using chemicals like Propylene Glycol is a method which helps prevent build-up of snow and ice as well as assists with easier removal.

Another method for removing accumulated snow and ice is by hot steam or water.

Methods are:

— thawing by storing inside heated depots or temporary shelters;

— use of high pressure hot water or steam: When de-icing with water, the pressure should not be more than 0,6 MPa.

The vehicle should not be exposed to sub-zero temperatures before it is dried out. The functionality of the components should not be reduced due to exposure by these methods. A comprehensive maintenance instruction (details of water direction, forces, temperature, etc.) should be prepared to allow for anti- and de-icing of these components without damage.

Instructions for de-icing should be described in the vehicle documentation in order to ensure intended functionality of the components.

5.4 Humidity related

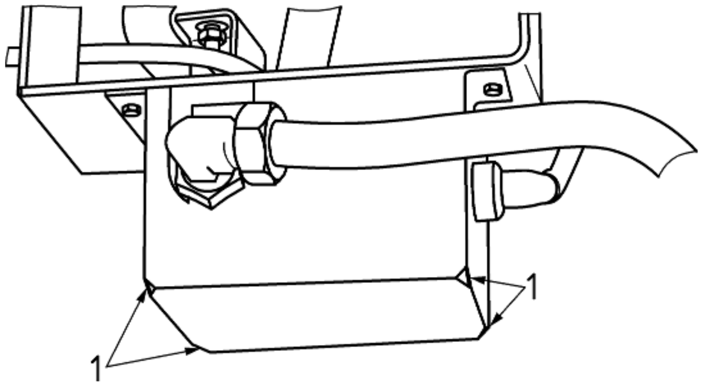
5.4.1 General

Humidity reduces the effectiveness of thermal insulation. Wet or frozen insulation adversely affects the performance of thermal insulation. Wet insulation also increases the risk of fungus growth and corrosion.

Humidity may cause condensation. Condensated water may cause frost action when freezing. Structure, components and protecting hoses should therefore be made hermetic or have drainage holes at the lowest position.

Recommended diameter of the drainage holes in structures is 15 mm to 25 mm to avoid clogging by dirt. For smaller parts/components the size of the holes should be regulated by the dimension of the components.

The holes should be accessible during maintenance for cleaning and checking they are not blocked. An example of drainage holes in a small protective box is shown in Figure 1.



Key

1 drainage holes in all four corners

Figure 1 — Drainage holes in a protective box

An example of frost action due to sucked-in and condensed humidity in a closed fully welded part is shown in Figure 2. Rupture shall show that frost action has damaged the welding and “openend” the construction by bending of the metal cover sheet.

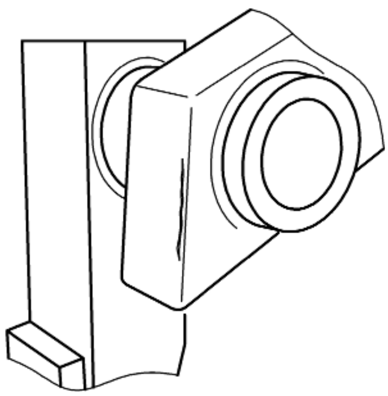


Figure 2 — Frost action in a closed beam without drainage

5.4.2 Test description

The vehicle should be soaked at temperatures < −10 °C over a minimum of 5 h with all systems in operation. Then the vehicle should be shunted into an environment with temperatures > +20 °C and dew point > +15°C. After an operation time of > 10 min the condensation effects of the windows and head lights (visibility) should be checked. The functional test should be followed by shunting the vehicle back into the winter environment (temperatures < −10 °C).

If required in the specification, this may be repeated several times to demonstrate freeze/thaw capability of the train or component.

After a minimum of 1 h, the correct functionality of each tested component should be checked according to a client check list. It should be checked if permissible water condensation or ice accumulations on critical components are within the limits given in the check list.

5.4.3 Evaluation criteria

The following pass criteria should be achieved:

— operability of the vehicle under condensation effects;

— no condensation on all operation relevant windows or screens that impairs use (e.g. wind screen, rear mirror) and signal lights;

— condensation within the limits on critical components (e.g. electrical boxes);

— correct operation of safety related equipment.

5.5 Thermal insulation

Thermal insulation should be fixed to the car body in such a way as to prevent cold bridges to the interior surface.

Thermal insulation that is not vapour tight should have a vapour barrier on the warm side to avoid condensation.

The insulation concept should avoid condensation on the interior side of the windows.

For the specification of thermal insulation different temperature levels within the train should be considered. Relevant data should be exchanged in the design process, e.g.:

— geometrical characteristics of sub-assemblies;

— location of the main heat emitting elements and their heat dissipation;

— thermal time profile;

— characteristics of the cooling system.

5.6 Mechanical fixations of inner structures to the car body, have to be thermally interrupted by insulating spacers to avoid thermal bridges. Collision with animals

Collisions with large animals like elks, reindeers, cows and horses may lead to critical damages to vehicles, if this scenario has not been taken into account in the design phase. A damaged train may cause blocking of tracks and be unavailable for operation over a long period due to repair.

After collisions with large animals, the train should be able to continue its journey at least to the next station or depot to make cleaning or necessary repairs in a depot.

Most critical damage occurs on electric and pneumatic connections. This kind of damage should be avoided. Large animals cause frequent accidents in Nordic countries with almost no structural damages on the load carrying structure of the vehicle.

NOTE 1 Examples for protection for electrical and pneumatic connections are given in Annex A.

Affected areas of vehicles should be designed to enable repair in a depot. Damaged parts should be easy to replace. An obstacle deflector or a snow plough helps to protect the bogie area.

NOTE 2 Generally, after collisions with large animals, the Nordic experience shows that cleaning is sufficient to keep the train in service if protection for exposed components exists. The height of large animals (withers height) is in the range of 0,7 m up to 2,1 m (such as wild boar - elks).

5.7 Condensation

5.7.1 General

The objective is to check the functionality of the vehicle after a rapid climate change (such as tunnel running with harsh winter conditions and warm humid tunnel conditions) either single or multiple events.

5.7.2 Recommendations

The vehicle should not be adversely affected by freeze/thaw conditions.

5.7.3 Test description

The vehicle should be soaked at temperatures < −10 °C over minimum 5 h with all systems in operation. Then the vehicle should be shunted into an environment with temperatures > +20 °C and dew point > +15 °C. After an operation time of > 10 min the condensation effects of the windows and signal lights (visibility) should be checked. The functional test should be followed by shunting the vehicle back into the winter environment (temperatures < −10 °C).

If required in the specification, this may be repeated several times to demonstrate freeze/thaw capability.

After a minimum of 1 h, the correct functionality of each relevant component should be checked according to the specification. It should be checked if permissible water condensation or ice accumulations on critical components are within the limits.

5.7.4 Evaluation criteria

The following pass criteria should be achieved:

— operability of the vehicle under condensation effects;

— no condensation on all relevant windows or screens that impairs use (e.g. wind screen, rear mirror, cameras) and signal lights;

— condensation within the limits on critical components (e.g. electrical boxes);

— correct operation of safety related equipment.

6 Design guidance for sub systems

6.1 Snow plough

6.1.1 General

This clause includes the guidance for the design of snow ploughs.

The environmental conditions in Table 3 are covered.

Table 3 — Snow plough

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Snow plough		X	X				

6.1.2 Design guidance

The objective of a snow plough is to remove snow in front of the train. It is not designed to handle hazards such as ice slides, landslides, rock falls and fallen trees.

The snow plough may be one or several separate components mounted on the vehicle body and/or on the bogie. A snow plough mounted on the vehicle body can be combined with the obstacle deflector which can be designed to function also as a snow plough. In this case, the snow plough should fulfil the requirements of EN 15227:2008+A1:2010, Clause 5, Table 3.

The vehicle should be designed to operate in the snow class selected for the vehicle which is defined in EN 50125-1. For class S2 and S3 operation is only possible using a snow plough.

Table 4 — Recommended design forces

Classes	Snow level above top of rail [mm]	Design force due to the snow level [kN]	Snow plough functionality mandatory	Test mandatory
S1	0 – 250	not applicable [a]	No	No
S2	250 – 400	300 [b]	Yes	Yes
S3	400 – 800 [c]	600	Yes	Yes

[a] Obstacle deflector according to EN 15227:2008+A1:2010 is also enough for removing snow.

[b] The forces can be reduced to 200 kN for maximum speed of 120 km/h. By increasing the speed limit up to 180 km/h, the forces for the snow plough should be 600 kN.

[c] For snow levels above 800 mm, the performance of the snow plough is reduced.

Table 4 lists recommended design loads which have proven experiences for speeds of up to 140 km/h. The forces listed are for the higher snow level within the class. For other train speeds and snow levels the forces should be determined. The forces should be applied in longitudinal direction uniformly over the surface of the plough. The surface considered is the plough surface projected in the longitudinal direction.

The design should avoid any contact of a collapsing snow plough with the track and the running gear.

The type of suspension and position of the snow plough should be considered. The plough may not exceed the permitted rolling stock gauge taking bogie and vehicle body movements into account.

In order not to exceed the permitted wheel unloading when clearing snow the snow plough should generate a resulting downwards force to the traction vehicle's front end. Hence the snow should be cut from the underside and thrown upwards and to the side. Snow should not be thrown upwards to or over the wind screen.

Snow plough shapes with proven performance are described in Annex B.

6.1.3 Proposal for evaluation

6.1.3.1 Test description

These on-track-tests should be carried out according to the following test scenarios:

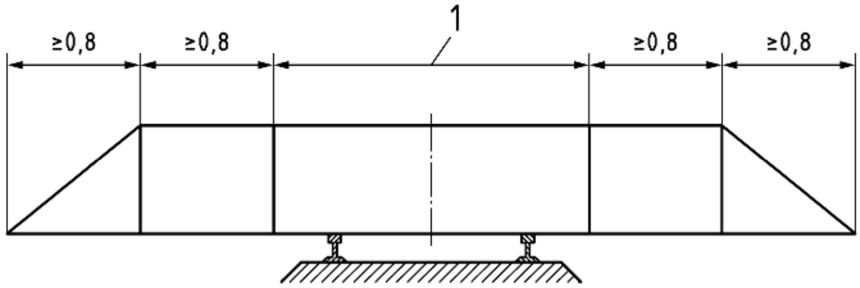
— a drift with a continuous horizontal top surface at the maximum height above the top of the rail according to the snow class (Figure 3);

— a drift with a top surface declining from a height equal to the maximum height according to the snow class at half vehicle width to one side of the track centre line to 0,0 m at half vehicle width to the other side of the centre line (Figure 4).

The heights should be measured from top of the rail, and the length of the drifts should be at least 20 m.

The height of the snow drifts should continue horizontally at least 0,8 m from the bodyside. If it is practically necessary to limit the drift's width the side wall of the drift should not be steeper than 45°.

Dimensions in metres



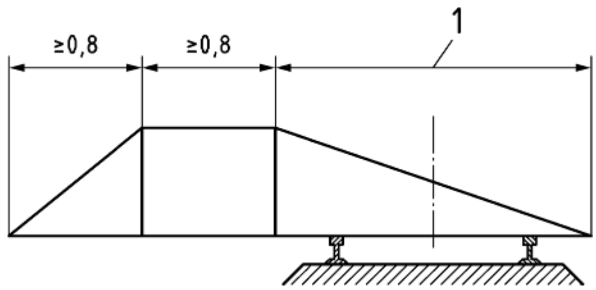
NOTE Top of the drift = maximum height according to snow class.

Key

1 vehicle width

Figure 3 — Test scenario 1: Laterally level snow drift – for verification of wheel un-loading

Dimensions in metres



NOTE Top of the drift = maximum height according to snow class.

Key

1 vehicle width

Figure 4 — Test scenario 2: Laterally sloping snow drift – for verification of Y/Q-forces

The test vehicle's first bogie should be instrumented with the aim to measure the change in wheel loads. If the vehicle has a two-axle bogie both axles should be instrumented. If the bogie is a three-axle the first and the third axle should be instrumented.

The snow density should be recorded before each test run and should be between 300 kg/m^3 and 400 kg/m^3.

The test vehicle should run into the drift with an initial speed of 40 km/h, and thereafter repeatedly run into the same and reshaped drift at step-wise (steps of no more than 10 km/h are recommended) higher speeds while calculating the wheel unloadings before the next step. From these calculations, the speed limit at which a minimum allowable wheel load remains should be set by subtracting 10 km/h as a safety margin. The maximum permitted speed when running through areas where snow drifts may occur should be set to the maximum speed while still obtaining permitted wheel unloadings.

When running through test shaped drifts with low and medium consistency of snow the vehicle should be able to run continuously without getting stuck in the snow. Sufficient traction power and axle load will therefore also be of importance.

6.1.3.2 Evaluation criteria

The following pass criteria should be achieved:

— the permitted wheel unloading should not be exceeded;

— the visibility for the driver should be ensured during the test;

— the train should not get stuck;

— no damage should occur.

6.2 Bogie and running gear

6.2.1 General

This clause includes the guidance for the design of bogies and running gear.

The environmental conditions in Table 5 are covered.

Table 5 — Bogie and running gear

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Bogie and running gear	X	X	X	X	X	X	X

Bogies, coupler and its ancillary equipment, roof and under frame are areas which are exposed to snow and ice accumulation. A measurement of thickness or weight of snow and ice layers is difficult to perform in service to get limit values.

The design of the train has a major impact on the amount of snow accumulation resulting in additional weight. Design should be chosen in such a way that accumulation can be avoided. This can be achieved by protection or enclosure of components, geometric shape or choice of materials, which have reduced adhesion.

6.2.2 Winter conditions

Snow and ice can accumulate either around the bogie and running gear or ingress through fortuitous air paths ingress into equipment. Snow under running conditions can accumulate on the vehicle. It is then compressed by vehicle movements and turns into ice due to variation in temperature. This may damage components where movements become restricted.

This can affect safety, running stability and brake function.

6.2.3 Summer conditions

The temperature of bogie and running gear components can be up to 40 °C above the external temperature at stand-still condition. This can affect grease in axle boxes and rubber components.

6.2.4 Design guidance

6.2.4.1 General on component level

6.2.4.1.1 General

Where the primary suspension relies on elastomeric components for the running stability, the extremes of temperature and its effects on dynamic properties should be considered in the design.

Air hose movements should be minimized, e.g. by placement near the bogie pivot.

6.2.4.1.2 Cold requirements

The masses due to accumulation of ice should be considered during the design of the vehicle and bogies.

At the design stage, it is recommended to analyse the aerodynamics in the vehicle's underframe to minimize snow pick-up on the bogie and the running gear.

Design measures may be necessary to prevent snow or ice accumulation that blocks suspension travel and compromises running stability. This may include using bellows to cover the spring components.

If linkages for secondary suspension airbags require protection from snow/ice the use of protection, e.g. rubber bellows, is recommended.

Air pipes should be protected to prevent damage. They should not be installed adjacent to moving parts in order to prevent damage by e.g. ice build-up, ice lumps or ballast pick-up.

Build-up of snow and ice on critical areas between moving parts, e.g. levelling valve, levers, hoses and cables should be prevented by e.g. rubber bellows, skirts, spoilers or by heating. Sharp features can be used to break the ice when the parts are moving towards each other.

Visual inspections during operation under winter conditions should be made together with follow-up for checking build-up of snow and ice on critical areas. In these inspections special attention should be paid to free movement of the parts which are important for safety and operability.

Where snow or ice accumulates in the bogie and running gear, operational or maintenance de-icing should be considered. The bogie and running gear and associated equipment should be designed to withstand the required de-icing operations. For general information, see 5.3.3.

6.2.4.1.3 Hot requirements

Where high temperatures occur, it is recommended to analyse the aerodynamics in the vehicle's underframe to ensure air movement around the axle boxes for cooling reasons. In addition enhanced maintenance may be required to ensure acceptable lubrication.

For elastomeric components the extremes of temperature including the effects of hot ballast and other hot sources should be assessed in the material selection to ensure optimised properties.

6.2.4.2 Bogie frame

Flat horizontal surfaces should be avoided for preventing build-up of snow and ice. Additional surface treatments of the frame may be considered to help prevent the build-up of snow and ice. Additional covers made of e.g. plastic can be put on critical surfaces.

Effects of condensation should be taken into account (see 5.7).

6.2.4.3 Wheels, axles and brake discs

Water in cracks in the rim surface of wheels may cause crack propagation. Wheel slide/slip protection systems should be installed. Preventive re-profiling should be considered to remove small damage and avoid their growth.

6.2.4.4 Axle boxes

When selecting the appropriate grease properties the operating temperature of the bearing should be considered taking into account the cooling effect during operation of the train in winter and from convection and hot ballast effect in summer.

The grease and re-greasing intervals should be selected taking into account the above mentioned environmental conditions.

To withstand the de-icing methods as defined in 5.3.3, the sealing of axle box backing ring should be designed and tested to prevent ingress of water or contaminants, for example by using a contacting seal on the outside.

6.2.4.5 Gear box

To withstand the de-icing methods as defined in 5.3.3, the sealing of the gearbox should be designed and tested to prevent the water or contaminant ingress for example by using a contacting seal.

6.2.4.6 Suspension components

The selection of materials should be such as to minimize the variation of suspension characteristics across the temperature range.

When air springs are used, it is recommended to equip them with integrated emergency springs because external emergency springs can be blocked by the build-up of snow.

6.3 Brake components integrated in bogie

6.3.1 General

This clause includes specific environmental guidance for the design of brakes.

The environmental conditions in Table 6 are covered.

Table 6 — Brakes

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Brakes	X	X	X		X	X	X

6.3.2 Design guidance

Winter conditions may cause significant reduction of braking performance. The braking performance under these conditions should be validated.

In order to avoid or to reduce a degradation of the brake performance, several design options should be considered:

— magnetic track brakes;

— magnetic track brakes with heated magnets;

— brake cylinders of bogies intended for use in T2 temperature class should have improved drainage if this is required by the design on the cylinders;

— brake cylinders should be protected against damage by flying ice;

— de-icing brake.

The de-icing brake (snow brake) is a function installed to automatically or manually apply a low level braking force to the discs or wheels preventing the build-up of ice or snow in the braking system. This may be a timed function or automatically applied prior to each braking operation to enable the activation of the friction brake for a limited time. The duration of an interval between applications should be determined by operational experience and in the specification.

Additional testing specified in the specifications may be necessary for severe winter conditions e.g. sufficient also for lines with long and steep gradients.

A continuous automatic activation may result in higher wear of the braking equipment. Therefore, a time limitation of the automatic activation of the snow brake function may be considered.

It is recommended to test the brake components at the lowest specified temperature.

6.3.3 Proposal for evaluation

6.3.3.1 General

The tests only include the general functions of brake application and release and extended stopping distance due to winter conditions affecting the brake system. In calculation of the braking performance, the additional mass due to accumulated snow and ice as indicated in 5.3.2 should be considered.

6.3.3.2 Test description

6.3.3.2.1 Static test with ice

The brake should be tested at an external temperature of (−15 ± 5) °C (holding time at least 3 h to ensure that ice build-up is of the correct type, i.e. hard ice). It should be ensured that the components to be tested have adopted the external temperature (surface temperature measurement).

The brake should be checked for proper functioning (brake application and release) in “dry” condition prior to testing.

Subsequently, a layer of ice should be applied on the moveable components (brake rigging, brake cylinder) using e.g. a manual sprinkler. This can be achieved by spraying water on the components at 10 min intervals. The ice should be allowed to harden for 30 min prior to testing. The thickness of the ice layer should be 3 mm to 5 mm. The brakes are engaged and released from the driver’s cab. The proper functioning of the mechanical parts can be assessed by visual inspection and by monitoring the applied brake force.

This test should be repeated with the parking brake in the engaged position. After icing, the parking brake system should be released to test the function of remote and manual release.

This test is designed to simulate vehicle operation under snow conditions with subsequent melting of the snow (during station stops or brake actuation) and subsequent refreezing.

6.3.3.2.2 Dynamic test with dry snow

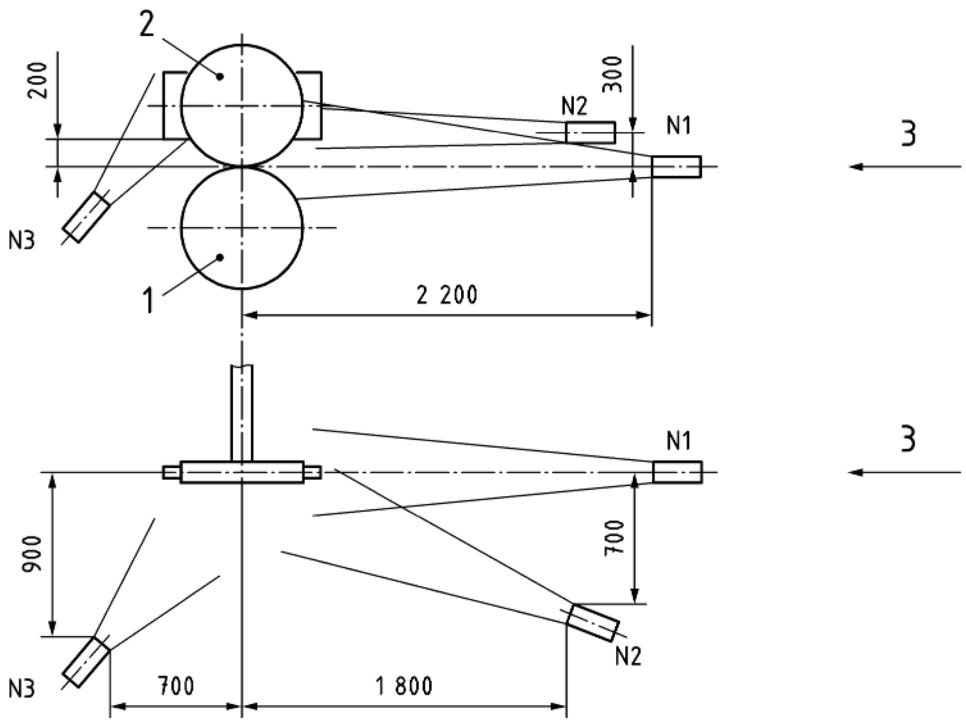
The test is designed to demonstrate the proper functioning of mechanical components such as brake rods, brake cylinders, brake valves etc. under snow conditions, including snow that melts due to brake heating and subsequently refreezes (snow/ice mixture), and the impact of snow on braking performance in terms of stopping distance (increase in stopping distance).

The vehicle should be positioned on the roller rig.

The mechanical components should be checked for proper functioning at an external temperature of −10 °C without snow. The stopping distance should be determined under this condition (at least 3 × braking to standstill).

Subsequently, dry snow should be sprayed onto both the mechanical components and the brake linings at various angles for approximately 30 min using snow nozzles with the roller rig in operation (for an example see Figure 5 with a water flow rate of (50 ± 5) l/h for nozzle N1 and N_2 and a water flow rate of (30 ± 5) l/h for nozzle N3). The subsequent braking/rolling/braking cycle is designed to lead to the desired snow/ice effect. In order to provide comparable conditions for determining the stopping distance, the vehicle should continue to roll until the temperatures of the brake linings, discs and wheels have fallen below 0 °C before the vehicle is braked to standstill again. Snow should be continuously applied throughout the cycle.

Dimensions in millimetres



Key

N1 to N3 snow nozzles 1 to 3

1 roller rig

2 wheel

3 wind direction

Figure 5 — Test on roller rig

This simulation is designed to simulate operation under snow conditions with snow entrainment and resulting snow accumulation in the area of the braking system. The wheel rotation represents the vehicle speed. The wind speed is simulated with approx. 10 km/h.

NOTE For operational reasons (freezing time of the snow simulation) the wind speed is simulated at a minimum.

6.3.3.2.3 On track test

For extreme temperature (high or low) and extreme snow conditions the whole train should be subject to an extended on-track test to verify the brake system on the train operates within the environment. The test duration and timing should be detailed in the specification together with acceptable bands of temperature, falling snow or precipitation.

NOTE It is possible that the recommended environmental conditions are not available within the project timescale.

6.3.3.3 Evaluation criteria

6.3.3.3.1 Static test

The following pass criteria should be achieved:

— the mechanical components move;

— the brake pad/block should be in full contact with the disc/wheel surface;

— brake pressures and pad/block forces should be in the defined range.

6.3.3.3.2 Dynamic test

The following pass criteria should be achieved:

— brakes engage and apply a braking torque;

— increase in stopping distances should be in the defined range.

6.4 Compressed air

6.4.1 General

This clause includes the guidance to ensure the quality of compressed air.

The environmental conditions in Table 7 are covered.

Table 7 — Compressed air

System/ component	Ice	Dry snow	Wet snow	Rain	Humidit y	High temperature	Low temperature
Compressed air					X	X	X

6.4.2 Design guidance

Humidity in compressed air should be avoided. There should be a margin between dew point and outside temperature. Suitable purity classes according ISO 8573-1 should be selected.

Test methods for measurement of humidity are described in ISO 8573-3.

The dew point, e.g. −40 °C in winter conditions should be considered in the design. Frequency of compressor use, i.e. warm-up for compressed air, should be taken into account.

Any automatic drain valve system should be fitted with appropriate insulation and heating systems to ensure correct operation in extreme environments.

Air drying devices should be integrated in the compressed air system. Regular measurement of the dew point may be required, e.g. automatic dew point measurement device and/or measurement during maintenance activities.

Compressed air in maintenance workshops should have the same quality as required by the train or unit.

6.5 Sanding equipment

6.5.1 General

This clause includes the guidance for the design of sanding equipment.

The environmental conditions in Table 8 are covered.

Table 8 — Sanding equipment

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Sanding equipment	X	X	X	X	X		X

6.5.2 Design guidance

For winter conditions, sand boxes should be equipped with appropriate means to ensure pourability of the sand and should have a specific design of the nozzle and delivery hoses to prevent clogging. A heating system should be used in the area of nozzle to prevent the obstruction by ice or snow. The cap of the sand box should prevent rain or flush water from ingress.

The characteristics of the sand should be defined in the specification. This specification should include the following:

— humidity of the sand;

— size distribution of the sand;

— density of the sand;

— chemical composition.

The flow rate for the sand should be specified.

6.5.3 Proposal for evaluation

6.5.3.1 Test description

The test of the sanding equipment should be carried out as follows:

a) This test simulates operation under the conditions listed in Table 8. The proper functioning of the sanding unit should be tested at cycles of external temperature of (−15 ± 5) °C during 2 h, (+5 ± 2) °C during 2 h, (−15 ± 5) °C during 2 h and at a speed of 80 km/h by measuring the amount of sand delivered per time unit and that the sand is deposited on the rail close to the wheel/rail contact point.

   For every cycle of temperature the functioning of the sanding unit should be testing every 30 min.

   The sander heating unit (if fitted) should be permanently turned on.

b) Then the train should operate in snowy conditions at external temperature of (−5 ± 5) °C and at a speed of 80 km/h for 30 min. The sanding system should be tested 10 min after the train has stopped by measuring the amount of sand delivered per time unit, and that the sand is deposited on the rail close to the wheel/rail contact point. The sander heating unit (if fitted) should be permanently turned on.

6.5.3.2 Evaluation criteria

The system should function properly and should deliver the specified minimum deposition rate of sand at the specified location.

6.6 Suspension level control system

6.6.1 General

This clause includes the guidance for the design of level control systems.

The environmental conditions in Table 9 are covered.

Table 9 — Level control system

System/ component	Ice	Dry snow	Wet snow	Rain	Humidit y	High temperature	Low temperature
Level control system	X	X	X				

6.6.2 Design guidance

In the design of the levelling system the ingress and packing of snow and ice should be taken into account to prevent mechanical failure. This can be realized by height monitoring, over-height protection, operating linkage protection or other means to ensure operation.

The mechanism should be robust to withstand additional forces caused by packing of snow and ice.

Levelling valve of the air springs should be placed near the bogie pivot to minimize the effects of snow and ice build-up on the levelling valve mechanism. The valve and the levelling valve mechanism should be protected, e.g. by a box or rubber bellow.

6.6.3 Proposal for evaluation

6.6.3.1 Test description

The proper function of the system should be demonstrated for ice and snow packing.

The system pressure should be recorded before and after each change in the settings. The spring system (bellows etc.) should be additionally subject to a visual and acoustic inspection in order to detect leakages in the system.

6.6.3.2 Evaluation criteria

Vehicle body should return to the nominal height after inflation of air spring and from lifted position within the defined tolerance.

It is recommended to use the same pressure drop tolerances as used for testing of the brake system.

6.7 Tilting system

6.7.1 General

This clause includes the guidance for the design of tilting systems.

The environmental conditions in Table 10 are covered.

Table 10 — Tilting system

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Tilting system	X	X	X				X

6.7.2 Design guidance

In the design of the tilting system ingress and packing of snow and ice should be taken into account. This may take the form of tilt or force monitoring, over-tilt protection, operating mechanism protection or other means to ensure operation.

The system should be designed to allow monitoring of the tilt forces by pressure or current measurement during operation.

Any tilting equipment below the under-frame should be subjected to the temperature class extremes, and operate correctly.

The space around the moving tilt mechanism is affected by the effects of snow and ice ingress. Careful design studies are recommended for the space around moving parts including protective curtains, barriers or boots to limit the effect of snow ingress.

6.7.3 Proposal for evaluation

6.7.3.1 Test description

The tilting system should be tested at the extreme temperatures required by the specification. This should include tilt control in all extreme positions, all movements and the operation of any over tilt protection.

The tests should be carried out at the lowest/highest temperature of the related temperature classes. If the vehicle is equipped with a pantograph, the pantograph should be in the lifted position. Subsequently the vehicle should be tilted in both directions up to the maximum designed tilt angle. This process should be repeated several times (minimum of 5 cycles or track simulation). This procedure is designed to simulate regular on-track operation.

If applicable, the following should be measured during the tests:

— the oil temperature and pressure in the hydraulic cylinder (bogie system);

— currents in electric actuators;

— tilt angles and tilt rates for maximum tilt.

The proper functioning of the pantograph tilting compensating system (if applicable) should be tested.

All moveable components should be visually inspected for malfunctions (oil leakage, cracks in connection elements, etc.).

Simulated testing for snow packing may be specified. This should be defined in the specification, if required.

6.7.3.2 Evaluation criteria

The vehicle should tilt in both directions and the maximum tilt angle should be achieved at the designed tilt rate.

The pantograph should reach its foreseen positions.

6.8 Flange lubrication system

6.8.1 General

This clause includes the guidance for the design of flange lubrication systems.

The environmental conditions in Table 11 are covered.

Table 11 — Flange lubrication system

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Flange lubrication system						X	X

6.8.2 Design guidance

The filling opening should be placed so that accessibility is not affected by snow and ice accumulation.

6.9 Windscreen

6.9.1 General

This clause includes the guidance for the design of the view ahead.

The environmental conditions in Table 12 are covered.

Table 12 — Windscreen

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Windscreen	X		X	X	X		X

6.9.2 Design guidance

De-icing, cleaning and de-misting are depending on the interaction between the windscreen heater/ wiper/washer and cab HVAC system.

It is recommended that the windscreen should be equipped with de-icing, de-misting and external cleaning means, under control of the driver. The location, type and quality of windscreen cleaning and clearance devices should ensure that the driver is able to maintain a clear external view.

The windscreen wiper's parking position should be within the heated area of the windscreen.

6.9.3 Proposal for evaluation

6.9.3.1 Test description

6.9.3.1.1 Ice

The windscreen of the vehicle should be covered with an ice layer of approximately 2 mm at an external temperature of (−15 ± 5) °C. The driver's cab should be not in operation during that time. This procedure is designed to simulate a shutdown vehicle parked outside in freezing rain.

Once the last water film has been applied, the ice should be allowed to harden for at least 10 min prior to the commencement of the functional test.

The windscreen heater and cab HVAC system should be switched on and the defrosting progress should be monitored and documented until the visibility area of the windscreen is completely free of ice and for at least every 10 min. The test is complete once the visibility area of the windscreen should be completely free of ice.

At the end of the defrosting process, the windscreen wiper should be activated to remove the water film.

6.9.3.1.2 Wet snow

The test should be carried out as follows:

a) The first part of the test is designed to simulate a parked vehicle in falling snow. This test checks whether the windscreen wiper is able to remove the accumulated snow from the windscreen (heavy wet snow). The test also checks whether snow accumulates at the windscreen edges or on the windscreen wiper. The windscreen of the vehicle should be covered with wet snow at an external temperature of (−5 ± 5) °C and a wind speed up to 15 km/h. The wet snow should accumulate evenly on the windscreen; the snow layer should be (30 ± 5) mm thick. The driver's cab should be either in standby mode or regular parking mode, the windscreen heater should be switched off in any case. The test should be carried out with the wipers switched on. If problems occur, the windscreen heater can be switched on to support snow removal or the snow can be removed mechanically as far as possible.

b) The second part of the test is designed to examine real operation on the track during falling snow. The train should operate in snowy conditions at an external temperature of (−5 ± 5) °C and at a train speed of at least 80 km/h for 1 h. The driver‘s cab should be in "normal mode" (air conditioning unit switched on, operating instructions for the given weather conditions (should be observed). This test is designed to check whether the windscreen wiper lifts off from the windscreen and to detect potential malfunctions.

A distinction should be made between tests with the windscreen heater turned on and off.

6.9.3.1.3 Rain

This test checks whether the windscreen wiper is able to remove the water film in the area of the windscreen in continuous rain without streaks so as to ensure sufficient visibility for the driver. The cab HVAC system should be in operation during the whole test. All settings of the wiper should be tested separately and with increasing driving speeds.

This test should be carried out at temperatures above the freezing point.

6.9.3.1.4 Condensation test

The cab HVAC system should be switched on and should keep the mean interior temperature according to EN 14813-1 constant for at least 1 h. The external temperature should be (+20 ± 2) °C and the minimum outside relative humidity should be 80 %. During this time, the windscreen and windows of the driver's cab should be checked for fogging. If condensation occurs, corrective measures (windscreen heater, fan speeds, adjustment of ventilation nozzles at the window) should be tested and the time recorded until full visibility is reached.

6.9.3.2 Evaluation criteria

6.9.3.2.1 Ice

The defroster should ensure that an evenly spread ice layer (approximately 2 mm) can be removed from the windscreen using the windscreen wiper (≤60 wipes per minute).

6.9.3.2.2 Wet snow

The following criteria should be fulfilled:

— there is no ice and snow build-up in the area of the windscreen wiped during operation that could affect the function of the windscreen wiper, the windscreen washer or the driver's visibility;

— wiper removes snow layer;

— the area of the windscreen wiped permits full visibility to the driver;

— no snow accumulates in the area wiped;

— the windscreen should not fog up when exposed to snow.

6.9.3.2.3 Rain

The following criteria should be fulfilled:

— the area of the windscreen wiped permits full visibility to the driver;

— the wiper does not lift off;

— the windscreen should not fog up when exposed to rain.

6.10 Side mirrors/cameras

6.10.1 General

This clause includes the guidance for the design of side mirrors/cameras.

The environmental conditions in Table 13 are covered.

Table 13 — Side mirrors/cameras

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Side mirrors/ cameras	X				X		X

6.10.2 Design guidance

Mirrors and camera housings may be equipped with heating and vision clearance devices to maintain driver vision capability after stabling and during operation.

6.10.3 Proposal for evaluation

6.10.3.1 Test description

Side mirrors and cameras can be tested as separate subsystems with a small, representative ambient temperatures of the vehicle body.

Two test scenarios are described below:

a) Train preparation test

The side mirrors / cameras should be cooled to at least −20 °C and cold soaked for a minimum of 10 min. Water should then be applied to the exterior surface, including any operating pivot, until an ice coating of 2 mm is achieved.

The system should then be powered up and the side mirror / camera should then be deployed and any demisting/de-icing device powered up. The visual capability of the device should be assessed and the elapsed time to achieve the specified visual capability recorded.

b) Train operation test

With the side mirror / camera under test, a series of simulated or on-track tests at (−15 ± 2) °C (on-track tolerance ± 5 °C) should be performed to subject the side mirror / camera to snow and freezing rain, accelerating to operational speeds (between 50 % and 100 % rated maximum speed) for a period of 10 min and then slowing to a halt, and deploying the side mirror / camera. The visual capability of the device should be assessed after 20 s. This test should be repeated 4 times to simulate operational stopping patterns.

6.10.3.2 Evaluation criteria

The time should be recorded and compared with the defined time in the specification until the side mirror / camera achieves specified visual capability:

a) after deployment in the train preparation test. A preparation time of maximum 60 min is recommended;

b) after deployment in the selected train operation test(s). A setup time of maximum 20 s is recommended.

The defined times may vary depending on operational profiles and vehicle types.

6.11 Lights

6.11.1 General

This clause includes the guidance for the design of lights.

The environmental conditions in Table 14 are covered.

Table 14 — Lights

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Lights	X		X				X

6.11.2 Design guidance

Snow and ice accumulation and condensation on the head, marker and tail lights, reducing the signalling effect should be avoided. Snow and ice accumulation is typically caused by snow and ice rain or/and whirling snow, drawn from the ground.

Lights should work as defined in the standard EN 15153-1 under all environmental conditions for which the vehicle is specified.

Snow and ice accumulation is mainly influenced by the airflow on the positions of the lights. The positioning of the lights near stagnation points and recirculation areas should be avoided.

Accumulation of snow and ice can also be prevented or removed by the heat of the light itself, additional heating or mechanical cleaning. Additionally, attention should be given to melting water coming from the windscreen if the lights are situated directly below the windscreen.

6.11.3 Proposal for evaluation

6.11.3.1 Test description

The test for the function of the lights should be carried out as follows:

a) the first part of the test is designed to simulate a parked vehicle in falling snow. The lights and the whole cab should be switched off. The wet snow should accumulate evenly on the lights at an external temperature of (−5 ± 5) °C. Once the snow layer is (30 ± 5) mm thick, the cab and the lights should be switched on;

b) the second part of the test examines real operation on the track (or its simulation in a test centre) during falling snow. The train should operate in snowy conditions at external temperature of (−5 ± 5) °C and at a train speed of 80 km/h for 60 min. The driver‘s cab should be in “normal mode” and all potential settings for the lighting are in operation (e.g. heating);

c) the third part of the test is designed to simulate a parked vehicle under ice conditions. The lights and the whole cab should be switched off. The ice layer should accumulate evenly on the lights at an external temperature of (−15 ± 5) °C. Once the ice layer is (2 ± 0,5) mm thick, the cab and the lights should be switched on.

6.11.3.2 Evaluation criteria

The validation criteria are based on the amount of snow on the crucial surface of the lights. The crucial surface is defined as the light emitting area projected horizontally in the direction of travel.

The following pass criteria should be achieved:

a) for the first part of the test: after 60 min of operation of the lights at least 80 % of the crucial surface of the lights should be free of snow;

b) for the second part of the test: after the test, at least 80 % of the crucial surface of the lights should be kept free of snow and ice;

c) For the third part of the test: after 10 min of operation of the lights and any heating, at least 80 % of the crucial surface of the lights should be kept free of snow and ice.

6.12 Horns

6.12.1 General

This clause includes the guidance for the design of horns.

The environmental conditions in Table 15 are covered.

Table 15 — Horns

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Horns	X	X	X				X

6.12.2 Design guidance

Snow and ice accumulation on and in the horn reducing the sound pressure level such as to impede its warning capability should be avoided. Low temperatures should not affect the function either.

Horns should work as defined in the standard EN 15153-2 under all environmental conditions for which the vehicle is specified.

The function of the horn in snowy conditions depends on the positioning (how much snow enters the horn) and the horns ability to withstand snow. The positioning of the horns near stagnation points and recirculation areas should be avoided.

Low temperatures can cause condensation and ice accumulation as well as leakages in the compressed air system. Therefore, a sufficiently low dew point should be ensured and components materials suitable for the temperatures should be selected.

Possible solutions could be:

— bi-directional horns operated from the opposite driver's cab;

— horn opening protection;

— the combination of bi-directional and horns with covered openings.

A test is described in EN 15153-2.

6.13 Doors

6.13.1 General

This clause includes the guidance for the design of the doors. In addition, sand from platform gritting brought to the steps sticking to shoes etc. should be considered.

The environmental conditions in Table 16 are covered.

Table 16 — Doors

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Doors	X	X	X	X	X		X

6.13.2 Design guidance

The entrance doors for passengers should work in accordance with EN 14752 under winter conditions. Other doors (for example drivers cab doors, gangway doors, etc.) should work accordingly under these conditions and should be tested in accordance to EN 14752, if no other relevant standards are applicable.

6.13.3 Proposal for evaluation

6.13.3.1 Test at low temperature

The tests should be carried out at the minimum temperature according to the temperature class. The HVAC system of the passenger area should be switched on.

The automatic doorway of one door should be checked by the external "door opening button". The door closing mechanism should be activated automatically by the train control system. The entrapment protection device should be tested by positioning a test piece with its long edge vertically between the two door leaves. If the door does not reverse, the withdrawal force should be measured.

If there is a failure in cases of adaptive door control, the door should be opened and closed several times and the test should be repeated after a time.

At another door the emergency unlocking system should be checked from the outside.

6.13.3.2 Test with ice

The tests should be carried out at external temperatures of at least −20 °C. The HVAC system of the passenger area should be switched on. An ice layer should be applied on the entire surface of the vehicle doors using a manual sprinkler. This is achieved by applying water at 10 min intervals. The thickness of the ice layer should be approximately 1 mm to 2 mm. Once the last water film has been applied, the ice should be allowed to harden for 10 min. This procedure is designed to simulate freezing rain.

One door should be opened by the emergency unlocking systems, the other one manually by the external "door opening button". The door closing mechanism should be activated automatically by the train control system. The entrapment protection device should be tested by positioning a test piece with its long edge vertically between the two door leaves as described in 5.2.1.4 of EN 14752:2015. If the door does not reverse, the withdrawal force should be measured using a spring balance.

6.13.3.3 Test with dry snow

The tests should be carried out at external temperatures of at least −15 °C. The HVAC system of the passenger area should be switched on. Snow should be applied on the door by snow nozzles for at least 30 min. The dry snow should fly along the door at wind speeds of 15 km/h to 30 km/h. Additional tests at higher speeds may be required in the specification for non-pressure sealed doors.

This test simulates the operation under conditions with whirling snow.

After that, checks for ingress of snow and the functional test of the door should be carried out.

6.13.3.4 Evaluation criteria

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 < 150 N;

— the emergency unlocking system is fully functional;

— no entering of snow (water, ice) behind the door.

6.14 Moveable steps

6.14.1 General

The environmental conditions in Table 17 are covered.

Table 17 — Moveable steps

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Moveable steps	X	X	X	X	X		X

6.14.2 Design guidance

The moveable steps should work in accordance with EN 14752 under winter conditions. In addition sand from platform gritting brought to the steps sticking to shoes etc. should be regarded.

6.14.3 Proposal for evaluation

6.14.3.1 Test at low temperature

Exposed moveable steps and the independent hatches protecting them should be subject to the testing below.

The tests should be carried out at the minimum temperature according to the temperature class. The HVAC system of the passenger area should be switched on.

The step should be extended by pushing the external “door opening button“ and retracted automatically by the train control system. The entrapment protection system is tested as described in 5.2.14 of EN 14752. The step should reverse.

The test should be carried out at two passenger doors at different locations.

6.14.3.2 Test with wet snow

The tests should be carried out at an external temperature of at least −15 °C. A snow layer of approximately 20 mm (wet snow) should be applied to the retracted step in the downwind direction. Subsequently the step and the entrapment protection system should be tested. The HVAC system of the passenger area should be switched on.

Subsequently, the extended step should be covered with snow. This procedure is designed to simulate wet snow adhering to the step and compacted by boarding passengers. The step should be retracted and then tested again for proper functioning after approximately 20 min.

The test should be carried out at two passenger doors at different locations.

6.14.3.3 Test with ice

The tests should be carried out at an external temperature of -20 °C (or colder). The HVAC system of the passenger area should be switched on. The step should be covered with an ice layer by applying water at 10 min intervals.

The thickness of the ice layer should be approximately 1 mm to 2 mm. Once the last water film has been applied, the ice should be allowed to harden for 10 min. This procedure is designed to simulate freezing rain.

Subsequently, the step and the entrapment protection system should be tested.

The test should be carried out at two passenger doors at different locations.

6.14.3.4 Evaluation criteria

The following pass criteria should be achieved:

— the step extends and retracts completely;

— the step detects an obstacle and reverses. Peak force on contact should not exceed 300 N;

— the step should not move when the door is fully open.

6.15 Pantograph

6.15.1 General

This clause includes the guidance for the design of pantographs.

The environmental conditions in Table 18 are covered.

Table 18 — Pantograph

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Pantograph	X		X				X

6.15.2 Design guidance

During the vehicle start-up phase, it should be ensured that the pantograph can be raised for operation, even when it is covered by snow. Low temperatures and moisture should not affect the air quality. Air dryers are recommended.

If the pantograph rests on buffers when lowered, the shape of these buffers should be such that the contact area is small in order to minimize freezing of the pantograph to the buffer. A conical shape is recommended.

During operation snow and ice accumulation on the pantograph and its surrounding area should be avoided.

Frost on the contact wire causes arcing between contact wire and pantograph which can damage the contact strip, its carrier and fixings. A pantograph head that is designed to endure such arcing should be used.

It may be required by specification to add an automatic dropping device in order to limit damage to the contact wire and to the pantograph. At low temperatures, the automatic dropping device particularly could cause air leaks that could prevent the pantograph from rising.

6.15.3 Proposal for evaluation

6.15.3.1 Test description

6.15.3.1.1 Static tests

The raising and lowering of the pantograph should be tested in accordance with EN 50206-1 under the following additional scenarios:

a) (−7 ± 5) °C with a snow layer of approximately 20 mm thickness on the pantograph;

b) (−20 ± 5) °C with an ice layer of approximately 2 mm thickness on the pantograph. This procedure is designed to simulate a parked vehicle in freezing rain. Once the last water film has been applied, the ice should be allowed to harden for at least 10 min.

During the tests, it should be checked that any external air compression supply and any heat sources in the vicinity are switched off. Only the vehicle’s own air compressor should be used.

6.15.3.1.2 Dynamic test

For the verification of the pantograph's properties under low temperature or when it is covered with snow and ice, visual inspections and follow-up for checking build-up of snow and ice on the pantograph should be made as part of the operation procedure.

The functionality and integrity of the parts of the pantograph should be checked by the normal maintenance and operational procedures.

6.15.3.2 Evaluation criteria

Acceptance criteria are defined in EN 50206-1.

6.16 Automatic couplers

6.16.1 General

This clause includes the guidance for the design of automatic couplers.

The environmental conditions in Table 19 are covered.

Table 19 — Automatic couplers

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Automatic couplers	X	X	X				X

6.16.2 Design guidance

Coupling and uncoupling should function under extreme temperature and winter conditions. This applies in the same way for couplers with heaters and couplers with protective devices.

Under winter conditions it is recommended to add a cover for the coupler's head including the electric and air connectors used to avoid ingress of snow and dirt. In addition, a heating system for the coupler is recommended for use in temperature zone T2.

6.16.3 Proposal for evaluation

6.16.3.1 Test description

The objective of the tests is to demonstrate the proper functioning of the coupling and uncoupling under winter conditions. The general functions should be tested including mechanical, pneumatic and electrical coupling/uncoupling.

The following test description is valid for each climatic test condition. A mock-up with a mounted coupler or another train should be positioned behind the vehicle prior to the test. This second coupler should be supplied with compressed air and power and should be moved to the vehicle coupler at a speed of approximately 5 km/h until it engages. Once the coupling process is completed, the couplers should be tested for proper mechanical, pneumatic and electrical functioning. Finally, both couplings should be uncoupled and moved apart.

NOTE It is permitted to carry out the test with only two couplers and without a vehicle, if the in-service coupling conditions, the movement of the couplers, connections and functions including control and protective devices are representatively simulated at the test facility.

6.16.3.2 Test under dry conditions

Dry conditions at external temperatures of −7 °C and −20 °C with coupler heater switched on (vehicle powered up).

6.16.3.3 Test under ice conditions

Ice conditions at an external temperature of at least −20 °C. The coupler heater should be turned off (vehicle shut down). Both couplers should be covered with 2 mm to 3 mm of ice at an external temperature of at least −20 °C using a manual sprinkler. This procedure is designed to simulate freezing rain on the parked vehicle. Once the last water film has been applied, the ice should be allowed to harden for at least 10 min prior to commencement of the functional tests. The coupler heater should be turned on for the functional test (vehicle powered up). Subsequently the de-icing process at the coupling faces should be monitored for a period of approximately 30 min (at 5 min intervals);

6.16.3.4 Test under wet snow conditions

Under wet snow conditions, the coupler heater should be switched on (vehicle powered up). Both couplers should be covered with at least 5 cm wet snow at an external temperature of at least −7 °C. This is intended to simulate the front coupler of the running vehicle during heavy falling snow.

6.16.3.5 Test under dry snow conditions

Under dry snow conditions at an external temperature of at least −20 °C, the coupler heater should be switched on (vehicle powered up). At least one side of the coupler should be covered with at least 2 cm of dry snow at an external temperature of −20 °C. This simulation method is intended to simulate the snow entrained from the rail track, which is compressed during the coupling process and accumulates on the rear coupler.

6.16.3.6 Evaluation criteria

The following pass criteria should be achieved:

— mechanical coupling and uncoupling;

— leak-free compressed air connection;

— electrical coupling and uncoupling.

6.17 Cooling systems

6.17.1 General

This clause includes the guidance for the design of air intakes.

The environmental conditions in Table 20 are covered.

Table 20 — Cooling systems

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Cooling systems		X	X		X		X

6.17.2 Design guidance

Snow sucked in and subsequently melted should not create short circuits or other damage to systems and their equipment and water should be drained through appropriated drainage holes.

Technical systems and components with air intakes should not become clogged under winter conditions to the extent that the flow of fresh and exhaust air is affected unacceptably. For cooling equipment under snow conditions a maximum outside temperature of 5 °C should be considered. If necessary, technical systems and components should be monitored.

The flow of air can be ensured either by the design of the intakes or their arrangement. It may be assumed that snow is coming only from one direction at a time, i.e. from the top or from one side.

6.17.3 Proposal for evaluation

6.17.3.1 Test description

In order to simulate the normal line operation under dry snow conditions, tests onboard of the vehicle with dry snow should be carried out at an external temperature of (−15 ± 5) °C. The passenger areas should be in regulated mode and all devices and fans should be in operation. Snow should be applied to the roof or underframe areas, depending on the location of the vehicle's air intakes for approximately 30 min. The dry snow should pass the air intakes of the components at wind speeds of 15 km/h to 30 km/h. The components should be examined for proper functioning during snow application. Subsequently, the components should be inspected for snow ingress.

In order to simulate a parked vehicle during snow fall, wet snow should be applied to the area of the air intakes on the roof at an external temperature of at least −7 °C using snow nozzles for approximately 30 min. The thickness of the snow layer should be approximately 30 mm. It should be checked that heat sources in the vicinity are turned off. The compressed air and voltage supply should be connected prior to the tests.

Subsequently, the individual components should be put in operation and tested for proper functioning.

The tests should be continued until any potential overheating due to restricted air intake can be excluded.

The components behind the snow separator should subsequently be checked for snow (water) ingress, if required.

6.17.3.2 Evaluation criteria

The systems depending on the air intake capability should operate under normal mode. In places without drainage, there should be no snow or water.

For the proper working of cooling equipment under snow conditions a maximum outside temperature of 5 °C is considered.

6.18 Traction

6.18.1 General

This clause includes the guidance for the design of traction.

The environmental conditions in Table 21 are covered.

Table 21 — Traction

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Traction						X	

6.18.2 Design guidance

6.18.2.1 General

The objective is to demonstrate the proper functioning of the traction systems at the high temperature extremes. The temperature classes T3 and TX system calculations should be made considering 50 °C as the air temperature for cooling equipment placed on the roof.

Solar radiation of 1 120 W/m^2 should be considered. In both cases, calculations should consider a suitable safety coefficient in order to take into account a decrease of the cooling surface due to dust or any other causes.

In order to consider the hot ballast effect, all traction equipment attached to the underside of the vehicle frame should withstand 65 °C, (traction equipment, hydraulic transmission, traction control electronics, etc.).

Additional local temperature rises due to under vehicle heat sources should be considered.

Diesel motors should be able to start with no additional intervention after the vehicle has been parked for 48 h with motors switched off.

Input filter capacitors should work under TX conditions according to EN 50125-1.

6.18.2.2 Engine cooling system

6.18.2.2.1 Proposal for evaluation

The objective is to demonstrate the performance of the motor cooling systems of diesel-powered trains at high external temperatures and different loads such as maximum engine power and maximum braking power (retarder system).

The motor cooling system should not exceed the maximum permitted coolant temperature and not limit engine or retarder performance.

6.18.2.2.2 Test description

The tests examine the performance of the motor cooling system at high external temperatures and high heat loads. Vehicles especially with cooling systems designed for cooling both the engine and different ancillary units require tests should be carried out under realistic operating conditions in order to identify any air short circuits (heated exhaust air or exhaust gases are sucked back into the system) or determine the influence of airflow on cooling performance.

The vehicle should be positioned on the roller rig. The engine should be brought up to nominal power at an external temperature of > +30 °C to +60 °C and solar radiation. Realistic wind speed and load profiles can be set, depending on the project requirements. In order to simulate heat build-up during a station stop after full traction power operation, the train should be braked and subsequently accelerated again after the specified station stop time. The temperature curve in the underframe area should be measured during this time (at standstill).

The same procedure should be applied for the retarder system.

The performance limits of the roller rig should be observed during engine and retarder tests.

These simulation methods are designed to simulate uphill travel and braking as well as heat build-up in the underframe area during a station stop.

6.18.2.2.3 Evaluation criteria

The following pass criteria should be achieved:

— coolant temperature within permitted range;

— no restriction in engine output;

— air temperatures within permitted range;

— charge pressure ok.

6.19 Battery

6.19.1 General

This clause includes the guidance for the design of batteries.

The environmental conditions in Table 22 are covered.

Table 22 — Battery

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Battery							X

6.19.2 Design guidance

The battery system should be capable of:

— supplying the designated essential and emergency loads;

— powering devices required to prepare and start the vehicle or unit;

at the low temperature point of the designated temperature band (T2, TX) or at an agreed set point as defined by the specification. The capability should be demonstrated by test or by an optional test if required by the specification.

It should be ensured that the battery ventilation is not clogged under snow conditions.

6.20 Toilet and water systems

6.20.1 General

This clause includes the guidance of toilet and water systems with regards to avoiding damages caused by frozen water. The following design guidance and tests are supposed to cover just vehicles with automatic drainage systems.

The environmental conditions in Table 23 are covered.

Table 23 — Toilet and water systems

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
Toilet and water systems							X

6.20.2 Design guidance

In general, all devices in the water system are in danger of freezing. Therefore appropriate activities to prevent potential damages should be undertaken, e.g. by using insulation, heating and/or an automatic drainage system. Water piping should be installed without water pockets.

Depending on the technical solutions used, different verification methods for the anti-freezing properties of the toilet and water systems may be required:

— the entire system is located inside the vehicle, and hence not exposed to low temperature and wind speed;

A test for verifying of the anti-freezing properties should not be necessary.

— parts of the system are outside the vehicle, and hence exposed to low temperatures and wind speed. One solution of the automatic drainage function may be based on water temperature sensors in the system located at presupposed critical locations. Another solution may be based on a temperature sensor for the external air temperature in combination with monitoring of the existence of the power to the heating elements and a time delay relay. The choice of verification test used will be dependent on the type of automatic drainage system: For a system based on water temperature sensors, a stand-still test as in 6.20.3.2.1 should be sufficient, while an on-track or simulated on-track test as in 6.20.3.2.2 should be considered to encompass the cooling effect from the cold wind. Also, other technical solutions for automatic drainage systems are possible.

6.20.3 Proposal for evaluation

6.20.3.1 General

In this clause, two tests are described.

The stand still test (see 6.20.3.2.1) describes the activation of the automatic drainage function with temperature sensors for the external air temperature in combination with monitoring of the existence of the power to the heating elements and a time delay relay.

The dynamic test (see 6.20.3.2.2) evaluates the activation of the automatic drainage function with water temperature sensors in water and toilet systems equipped with insulation and heating. If not, the automatic drainage system will detect too low water temperature (normally below +5 °C) and will activate the drainage. This test verifies that the function is as intended.

6.20.3.2 Test description

6.20.3.2.1 Stand still test

For automatic drainage systems with temperature sensors in external air, additional temperature sensors should be attached for monitoring of the water temperature at the presupposed most critical locations in the water and toilet systems during the test.

At least 5 h prior to the test, the water tanks should be filled with water of a temperature of < +15 °C. The vehicle should be connected to the power system. Each type of tank should be filled to 50 % of its capacity. To ensure that the whole system contains water in the pipes, the toilet flushing, water taps to the wash basins etc. should be operated before the commencement of the test.

The vehicle should be cold soaked for at least 5 h in an external temperature according to the lowest temperature of the chosen temperature class. The vehicle's power supply and the monitoring of the heating elements' power supply should be as normal, as also the time delay relay. The interior temperature should be according to the applicable air-conditioning standard of the vehicle type.

The heating elements' power monitoring and the time delay relay should be deactivated and the power to the heating elements turned off while monitoring the falling temperature in the water measured from the water sensors. If the drainage is not released the test should be interrupted at the latest if a sensor reaches + 1 °C.

6.20.3.2.2 Dynamic test

For automatic drainage systems with temperature sensors in the water, a wind speed according to 80 % of the vehicle's maximum speed should be applied for a 5 h test period. Regarding high speed trains, 60 % of the vehicle's maximum speed should be applied.

The test should be interrupted if the water system is in danger of freezing.

Once the freeze protection test has been completed, the installations should be re-checked for proper functioning. The functional test is followed by pre-heating and filling of water again. If the functional test has not been successful, it should be repeated at specific intervals (approximately 15 min) after pre-heating and release by the freeze protection system until the sanitary installations function properly.

An additional test should be recommended: testing that the drainage system releases when the power monitoring function detects no power to the heating elements after the time delay relay has ended.

6.20.3.3 Evaluation criteria

The following evaluation criteria should be achieved:

— the filling of water system is successful;

— the measured lowest water temperature should not be below +4 °C;

— the automatic draining is released when the first sensor detects too low water temperature, normally at ≤ +4 °C;

— the water system (WC and the wash basin) should be fully functional under normal mode (HVAC switched on) and after the freeze protection test;

— the sanitary installation should not show any signs of damage during and after the freeze protection test.

6.21 External cabinets, boxes for equipment, cables and connectors

6.21.1 General

This clause includes the guidance for the design of external cabinets and boxes for equipment, cables and connectors.

The environmental conditions in Table 24 are covered.

Table 24 — External cabinets, boxes for equipment, cables and connectors

System/ component	Ice	Dry snow	Wet snow	Rain	Humidity	High temperature	Low temperature
External cabinets, boxes for equipment, cables and connectors	X	X	X	X	X		

The aim of this guidance is to ensure the function in the conditions listed above.

6.21.2 Design guidance

For sensitive or electrical devices not being able to withstand the rough environmental conditions, equipment cabinets and boxes should be provided as a suitable protection against ingress of snow, ice and pollution. Necessary actions should be taken to avoid condensation and collected humidity.

Cabinets and boxes should be made airtight to prevent ingress of foreign particles. Cabinets should be fitted with drainage if condensation is possible and not acceptable. Thermal elongation should be taken into account so that the tightness of the cabinets and boxes does not suffer from this deformation.

In addition to EN 50155 and EN 60529 (IP-Code), the following solutions should be considered:

— cabinets and boxes which are equipped with heating or cooling should keep the temperature inside the cabinet within the required values;

— the over-pressurized air going out through the sealing of the connector boxes and cabinets. This air should be taken from a filtered air channel.

Between passenger coaches, there are several cables for electric power supply for trains and remote control and data. The connectors at the end of the cables should be stored in a cabinet when not in use. To prevent accumulation of snow and ice and additional cleaning work, it is recommended to install these connectors in a dedicated over-pressurized cabinet with sealed hatches. If these or similar solutions are not chosen, the sockets and plugs should be regularly cleaned from snow, ice and pollution to ensure correct connections.

Electrical cabinets should be exposed to water according to EN 14752 at least for the type test.

6.21.3 Proposal for evaluation

6.21.3.1 Test description

The train should operate in winter conditions at external temperature of (−5 ± 5) °C and a train speed of 80 km/h for 1 h (or its simulation in a test centre).

6.21.3.2 Evaluation criteria

The following pass criteria should be achieved:

The hatches and doors of cabinets and boxes for equipment, cables and connectors are opened after the test for inspection. There should be no harmful amount of water or snow inside the cabinet or box.

Annex A
(informative)

Examples of protection for electrical and pneumatic connections

Dimensions in millimetres

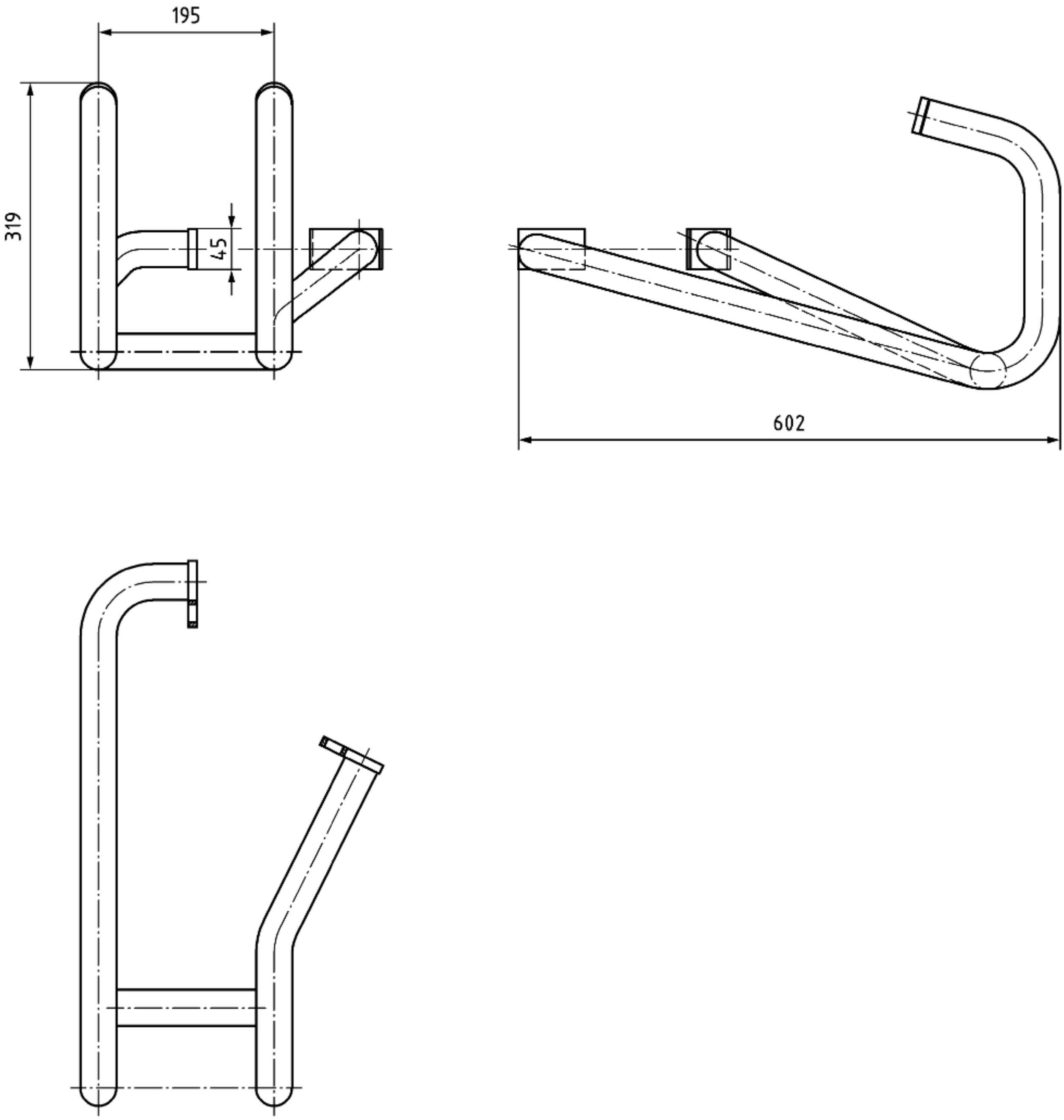


Figure A.1 — Example 1 of an electric coupling protection

Dimensions in millimetres

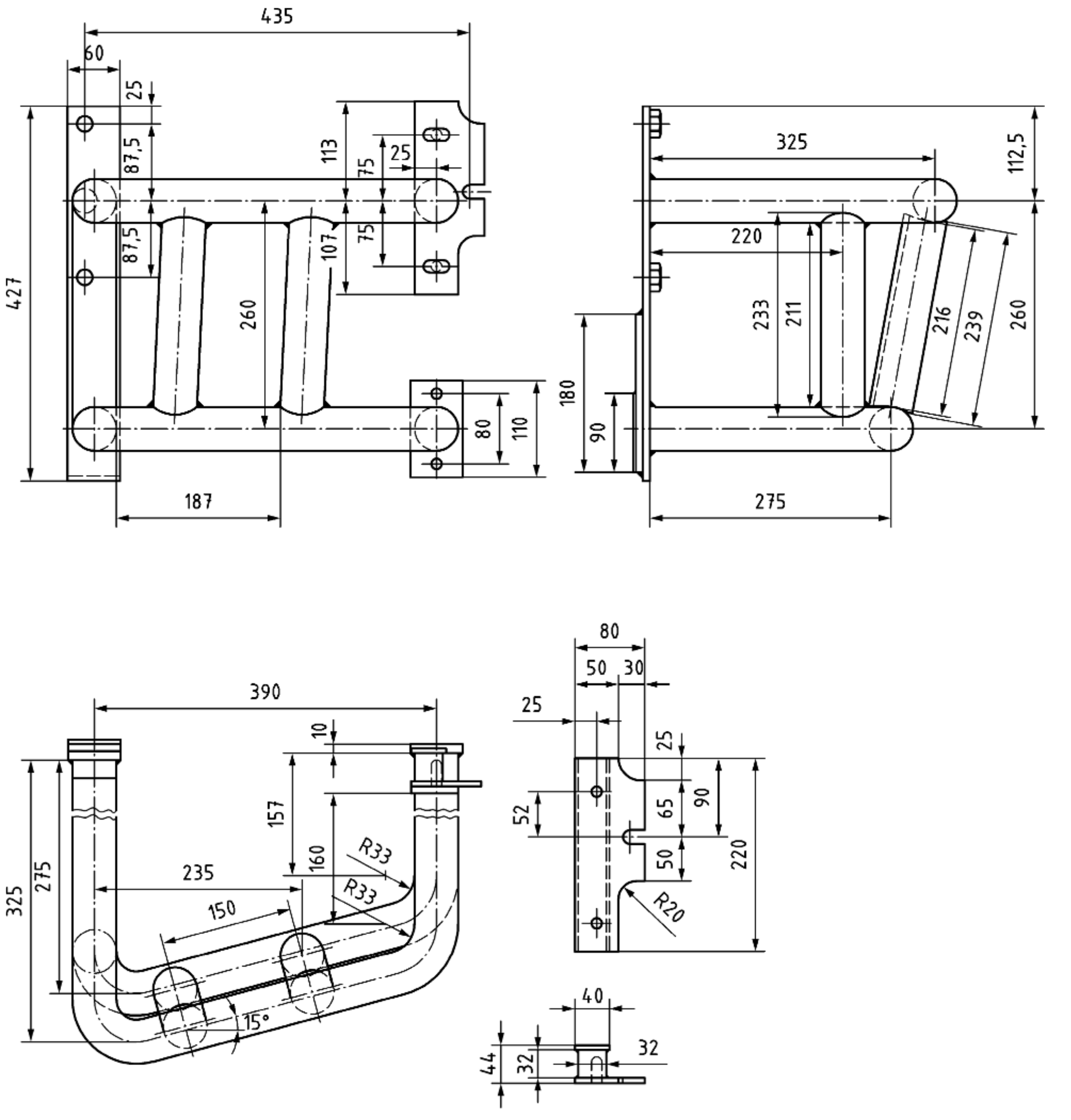


Figure A.2 — Example 2 of a pneumatic coupling protection

Annex B
(informative)

Examples for snow ploughs

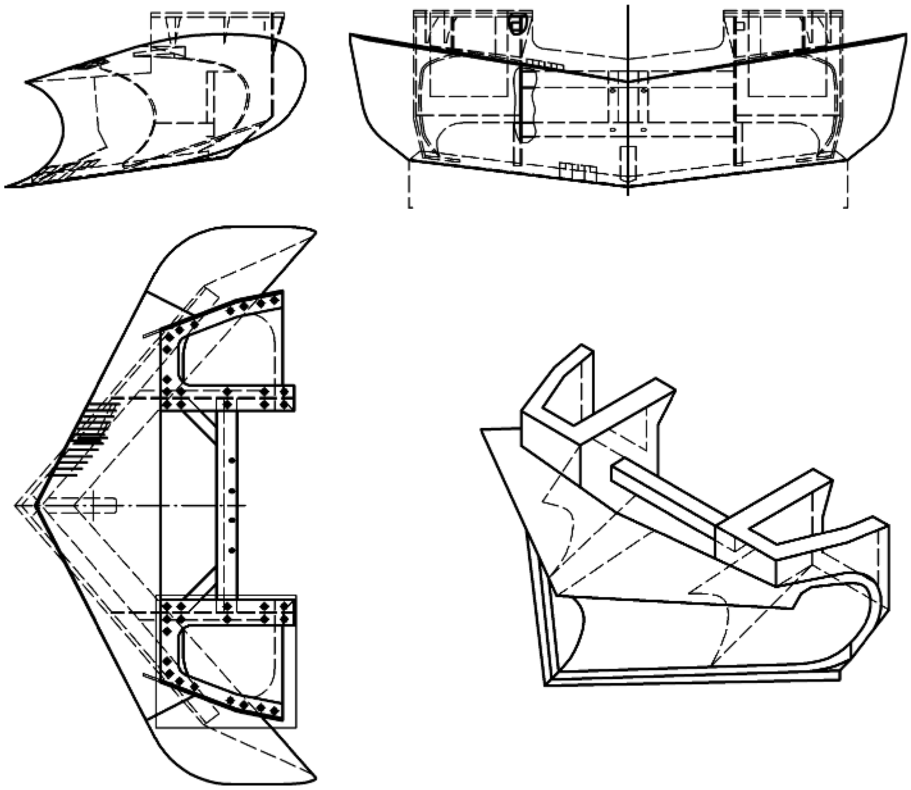


Figure B.1 — Example of a snow plough for locomotives

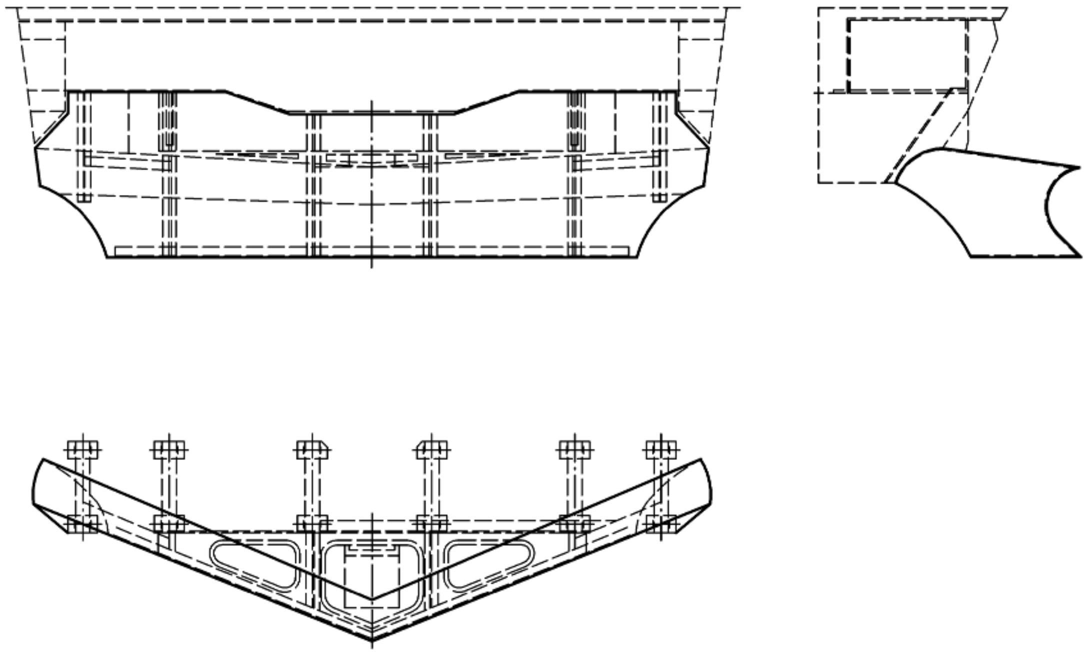


Figure B.2 — Example for snow plough for a multiple unit

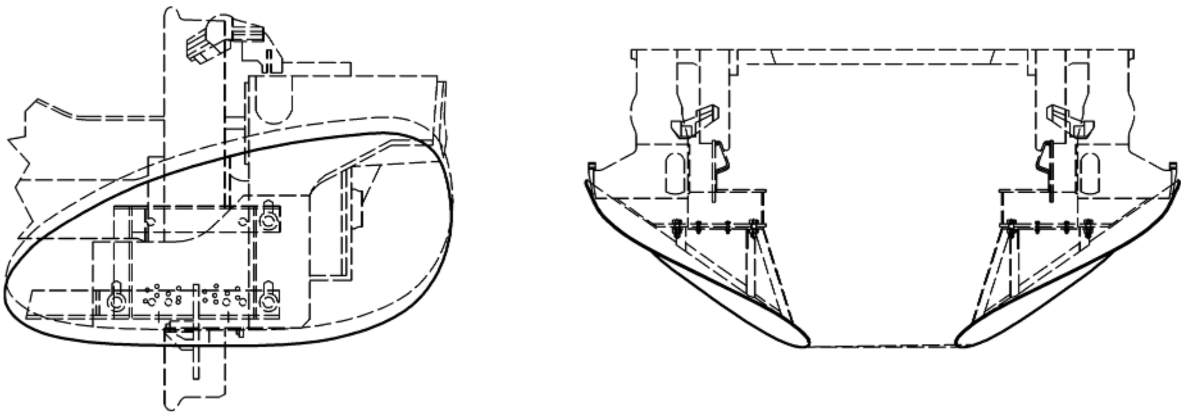


Figure B.3 — Example for a bogie mounted snow plough (multiple unit)

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