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ROLLING STROCK FOR NORDIC CLIMATE CONDITIONS

ŽELEZNIČNÉ KOĽAJOVÉ VOZIDLÁ PRE SEVERSKÉ KLIMATICKÉ PODMIENKY

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1 INTRODUCTION

This document gives a short summary of rolling stock that have been developed and are in service in Finland.

It also describes specific requirements that have to be taken into account in engineering rolling stock for Nordic conditions and examples about measures done to meet the requirements.

2 TRAMS

Skoda Transtech has supplied 70 Forcity Smart Artic X34 trams to Helsinki since 2013. The trams have been operating in winter conditions in Helsinki since that. In addition Helsinki Artic trams have been delivered to Tampere (***fig. 1***). In addition there is ongoing project to deliver longer X54 trams to Helsinki.

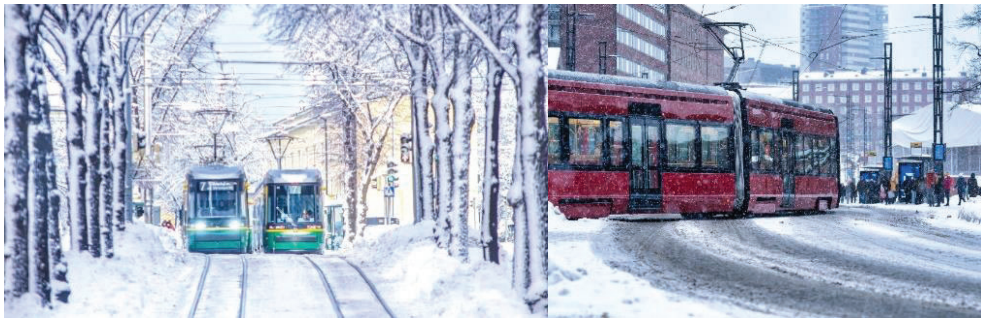

Fig. 1 *Helsinki and Tampere Smart Artic X34 tram*
Obr. 1 *Smart Artic X34 električka v Helsinkách a v Tampere*

3 DOUBLE DECK COACHES

The double deck coaches have been in service from 1998. At the moment about 300 coaches have been delivered to VR Group. The double deck coach family consists of different coach types like for example passenger coach, sleeping coach, restaurant coach, steering coach etc. (***fig. 2***)

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Fig. 2 *Train with double deck coaches*
Obr. 2 *Vlak s poschodovými vozňami*

4 SPECIFIC REQUIREMENTS FOR NORDIC COUNTRIES

The specific requirements for rolling stock for Nordic conditions are summarized below:

- Ambient temperature -40°C (T2).
- More severe 'snow, ice and hail' conditions:
  - Snowdrift covering track.
  - Powder snow.
  - Temperature gradient, temperature and humidity variations combined effect with low temperature.
- Recommendations of CEN/TR 16251 (railway applications. Environmental conditions. Design guidance for rolling stock).
- And some national specific requirements and limitations.

5 EXPERIENCES OF USE

5.1 Accumulating of snow

The Nordic countries like Sweden and Finland are very long countries starting from south by the seaside and ending up to north. In practice this means that rolling stock face big variation in weather conditions during every day.

In winter time in Helsinki area there can be +temperature and wet conditions. And in the same day in north (like Rovaniemi) there the temperature can be below -20°C and powder snow conditions.

When the train travels in north in powder snow conditions, all surfaces collect layer of powder snow. Then the same train is runs south and the accumulated snow turns wet, but not necessary melt away. And next time the train goes up to north, the partly melted snow turns to solid ice. And more new snow is accumulated on surfaces.

And this circle goes around. After several trips between south and north, more and more snow is accumulated on structures and turns to strong ice.

5.2 Powder snow

Powder snow on track and surfaces penetrates though all openings and gaps which means that the phenomena should be either prevented or all systems should be engineered so that they permit it.

5.3 Low operation temperature

The low operation of -40°C means that special care has to be taken into account when choosing the materials in the rolling stock.

5.4 Braking performance

The friction between wheel and rail can be reduced in winter conditions and this shall be taken into account braking performance.

5.5 Big animals

In addition to temperature and snow conditions in Nordic countries, the design of the rolling stock, especially main line vehicles, shall be engineered to tolerate contracts with big animals like moose (or elks) and reindeers. The weight of grown up moose can be over 700 kg.

6 ENGINEERING PRINCIPLES

6.1 Bogie structures

All parts in bogie area collect snow and ice. ***fig. 3*** shows bogie of double deck coach with accumulated snow. Critical areas are:

- Flat surfaces, especially horizontal.
- Surfaces parallel to each other, snow packing.
- Cables and hoses, especially hanging hoses and cables shall be avoided.
- Moving and turning parts, secondary suspension components.

Fig. 3 *Example of snow accumulating in bogie area*
Obr. 3 *Príklad akumulácie snehu v oblasti podvozku*

Components and systems have to robust enough to take their space and break the accumulating ice.

Also, in winter time influence of ballast projection from track is increased because there are also ice blocks with stones that hit the underframe and body structure. This means that components shall be strong enough to take the loads or they shall be protected, loads or they shall be protected.

6.2 Design of roof area and underframe

The snow is accumulated especially on areas where air flow has turbulences and where snow has places to attach.

In practice this means that underframe and the roof area of the vehicles shall be as smooth as possible. It is preferred that all pipes and cables are routed inside of the vehicle instead of outside under the underframe. Also roof areas with roof boxes should be fully covered to minimize the snow accumulating.

Fig. 4 *Fully covered roof area of ForCity Smart ArtiOc X34 LRV in Helsinki*

Obr. 4 *Úplne zakrytá oblasť strechy ForCity Smart ArtOc X34 LRV v Helsinkách*

6.3 Air inlets

The air inlets shall be located and designed in a way that snowing and accumulating snow does not cause problems in operating the systems.

It is recommended to locate the systems that require air input (like HVAC units) on the roof area where snow accumulating is less than in the underframe.

Additionally, the air inputs shall be designed in a way that amount of snow and water penetrating in the systems is minimized. This includes:

- design of the input grille in a way that falling snow and rain flow outside of the vehicles
- shape of input chamber in a way that air flow speed is slowing down and particles like snow are not sucked inside the critical components
- realizing proper mean for leading water out of the systems

6.4 Due to accumulating snow Weight increase and ice

The accumulating snow increases with of the vehicle and that shall be taken into account in structural calculations and also in simulations related to running dynamics.

According to experience in Sweden, the recommendation is 500 – 1500 kg per bogie shall be counted.

6.5 Low operation temperature

Low operating ambient temperature sets special requirements for choice of materials. Special care shall be taken on:

- Steel materials with low transient temperature, impact resistance proved in -40°C
- Rubber materials in suspension (stops, air spring system)
  - The running safety and safety against derailment shall be proved also -40°C
- Cables and hoses suitable for -40°C

Properties in low temperature combined with EN45545-2 material requirements limit amount of capable suppliers

6.6 Braking performance

Braking performance in winter conditions is reduced. Thus the requirement is that rolling stock shall have supplementary braking system to cover the reduction of friction in wheel rail contact.

The requirement is typically solved with track brakes with heated magnets in 50% or in all bogies depending on vehicle speed range.

6.7 Condensation

Because of temperature and air moisture variations, the condensation shall be noticed seriously.

- The insulation of the vehicles shall be designed in a way that dew point is known and condensation is lead out of structures in controlled way.
- Other important area of condensation control are box structures.

6.7.1 Insulation and condense control

The design of insulation shall be done in a way that internal humidity shall not penetrate in insulation. That is typically realized by thin AL folio layer behind the paneling.

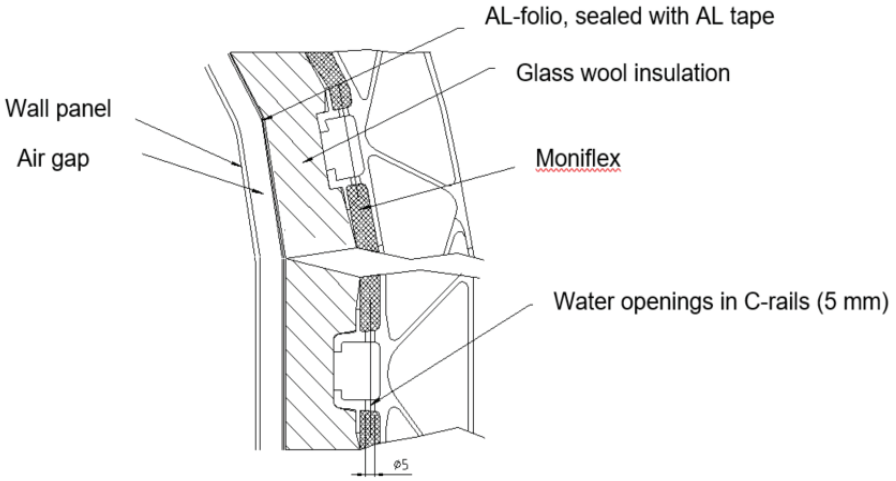

Fig. 5 *Example on side wall structure*
Obr. 5 *Príklad štruktúry bočnej steny*

In case there is a leakage in the moisture protection, it is possible that the moisture penetrates into the structure and creates condense water on the inner surface of metallic body structure. For those cases against the metallic structure there shall be materials that lead the water down the structures and do not get wet by themselves.

6.8 Body structure

Typically coach body structure consists of extruded AL profiles. In some extreme conditions condense water can be created also inside of the profiles. To prevent problems with this the AL-body structure should have openings where the water can be drained out of the profiles.

At the ends of the profiles there are cut outs where the water can drain out of each profile and downwards (see following figures). These cut outs are at every end of the profiles including at end walls, door frames and windows.

The condensed water can drain out of the bottom part of the body structure through the openings in the bottom of the car body.

Fig. 6 *Draining routes in window openings*
Obr. 6 *Odvodňovacie kanály v okenných otvoroch*

6.8.1 Box structures

If there is air leakage in box structure, this means that there shall also be condense water inside to structure. Then there is need for proper openings in the structure to allow ventilation and water to flow out.

Other possibility is to make the box structure pressure tight (hermetic) so that there cannot be any air exchange.

Typically this kind structures are side beams of the bogie frames.

6.8.2 Heating system

The heating system shall be powerful enough to keep temperatures inside the vehicles within acceptable levels. Systems shall be also powerful enough for fast up-heating in case the vehicles are not stored inside.

Floor heating guarantees good temperature control also on low heights in passenger area. But that is also important safety feature for avoiding slippery conditions especially in the access area of the vehicles.

6.8.3 Water system

The water system of the coaches shall engineered for winter conditions. All water outputs shall have heating to prevent freezing. Also, the equipment area where the water and waste water tanks are located needs to be heated.

In case the coach is left without external power, the coach shall be able to protect itself by freeze draining system. The system needs to be automatic and to be able to operate without external power supply.

Typically, the system starts with the control of temperature sensors which are located in the critical areas of the coach. After the system has started it empties fresh water tank and water pipes on track to prevent bigger problems that may take place in case the water in tanks or pipes get frozen.

6.9 Big animals

The design of front structure of rolling stock shall take into account collision with big animals. Main principles are:

- the metallic structure is strong enough to carry the loads from collision,
- the paneling structure of aerodynamic nose shall be realized by reasonable small and easy exchangeable panels to help easy and fast replacement.

6.10 Maintenance, snow and ice smelting

In Finland the rolling stock is typically taken inside the depot hall once per week for inspection and maintenance purposes. To be able to do any actions on the vehicles in the winter time the accumulated snow and ice need to be removed from the structures.

To make the process fast there are several means to speed up the smelting of the ice. VR Group uses high pressure water that is sprayed in underframe and bogie structure.

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Summary

The document gives a short summary of rolling stock that have been developed and used in service in Finland.

It also describes specific requirements that have to be taken into account in engineering rolling stock for Nordic conditions and examples about means that have been taken into account to meet the requirements.

Resumé

V príspevku je uvedený krátky prehľad železničných koľajových vozidiel, ktoré boli vyvinuté a používané v prevádzke vo Fínsku.

Opisuje tiež špecifické požiadavky, ktoré sa musia brať do úvahy pri konštrukcii koľajových vozidiel pre severské podmienky a uvádza príklady riešení, ktoré sa brali do úvahy na splnenie požiadaviek.