EUROPEAN UNION AGENCY FOR RAILWAYS

COVID-19 INFORMATION BULLETIN

VENTILATION IN RAILWAY VEHICLES

Sept. 2020

Introduction

On 21 July 2020, the European Union Agency for Railways (ERA) and the European Centre for Disease Prevention and Control (ECDC) published the COVID-19 Rail Protocol, which provides operational guidelines for the resumption of railway operations in Europe after the COVID-19 pandemic lockdown. This protocol complements measures taken by the European Commission to support Member States in re-launching mobility and tourism across Europe. We strongly recommend consulting the COVID-19 Rail Protocol before reading this Information Bulletin, as it contains complementary information.

ERA's COVID-19 Information Bulletins provide detailed non-binding information to safeguard the health and safety of passengers, transport workers and staff, and to re-establish trust in rail services.

The present Bulletin focuses on ventilation systems for railway vehicles, providing non-binding guidance on the optimal system settings and on related operational procedures and maintenance measures. ECDC contributed where appropriate.

ERA provides expertise to support the efforts of European railway companies to reduce the risk of spreading COVID-19, and facilitates the international exchange of COVID-19 relevant information, experience and best practice.

General advice

Railway undertakings, infrastructure managers, other railway stakeholders and National Safety Authorities (NSAs) - if this is in their national mandate -, taking into account the information in this bulletin, should coordinate their actions with the relevant national, regional or local public health authorities in order to effectively mitigate risk while complying with national requirements.

To efficiently reduce the risk of spread of the COVID-19 virus, it is essential that passengers and staff adopt appropriate behaviour such as physical distancing, respiratory etiquette, use of face masks and frequent hand hygiene. We have described this in the joint ERA/ECDC COVID-19 Rail Protocol. This Information Bulletin does not replace the protocol but complements it with additional recommendations on ventilation systems.

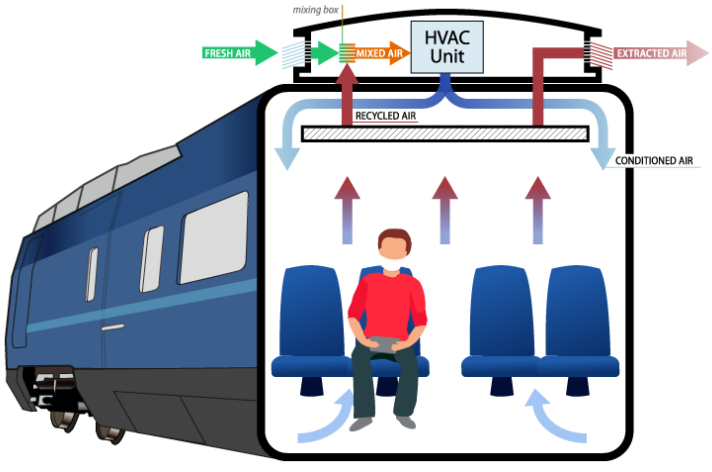

Fig.1: Typical situation in a passenger vehicle

Ventilation & air distribution systems

The current Technical Specifications for Interoperability for locomotives and passenger rolling stock [(1)] (TSI LOC&PAS) impose a maximum CO_2 level of 5000 parts per million (ppm) inside the vehicle's passenger area, but they do not impose any specific measures to prevent the spread of micro-organisms. Railway vehicles are already designed to allow optimal ventilation. Adapting some aspects of the train design, ensuring its proper maintenance and influencing certain settings may contribute to further reduce the risk of spreading of the COVID-19 virus. Where applicable, railway staff should be clearly instructed about specific settings as mentioned below.

Main ventilation concepts in railway vehicles

Various concepts of air distribution systems exist in the rail vehicle fleet today:

- Natural ventilation: Windows or transoms that can be opened;
- Forced air ventilation systems, sometimes with air refresher devices;
- Air conditioning (Heating, Ventilation, and Air Conditioning - HVAC) systems with various air circulation layouts depending on the type of vehicle, e.g. single deck or double deck, applying partial re-circulation of passenger compartment air.

Similar systems manage the air distribution in the driver's cab, either dedicated to that cab alone or shared with passenger air treatment units.

The majority of ventilation systems in rolling stock do not generate direct airflow towards the travellers but conditioned air is led indirectly into the passenger compartment from the ceiling along the walls, thereby reducing the risk of spreading droplets from one traveller to another (Fig 1).

In the rare case of a train equipped with individual ventilation nozzles the EASA ECDC COVID-19 Aviation Health Safety Protocol recommends that individual air-supply nozzles for passengers should be turned off. The same recommendation applies to railways.

All the air inside the rolling stock is usually renewed at least every ten minutes depending on the type of train, which limits accumulation or stagnation of infectious droplets in the train cars. The relative contributions of aerosol and fomite transmission routes for SARS-CoV-2 infection and the spread of the COVID-19 pandemic have not yet been determined. Aerosols are diluted with increasing distance from the source but may be concentrated in confined, poorly ventilated spaces.

Droplet infection is the main route of transmission, however, the World Health Organization (WHO) recently acknowledged the importance of potential airborne transmission of aerosols containing SARS-CoV-2 [(2)].

Because of this possibility there is consensus among experts that it is better to keep ventilation systems 'on' to evacuate potentially harmful aerosols. Switching off ventilation systems may keep those aerosols in the passenger compartment.

It is recommended to switch on the ventilation as soon as possible before the passengers enter, to keep the ventilation working between two trips and as much as possible at the end of the service day.

Natural ventilation (doors, windows, transoms)

Even though highly recommended, the efficiency of natural ventilation is dependent on:

- Speed and direction of the vehicle
- Landscape (tunnel, mountains, flatlands, etc.)
- External wind and its direction.

It is not easy to predict the airflow from natural ventilation as well as the effect of other ventilation systems when combined with natural ventilation. However, as natural ventilation is very likely to reduce the concentration of aerosols that could potentially carry the virus, we recommend to use natural ventilation as much as possible, for example by opening the access doors during train stops in stations as well as in the terminal station between two trips to accelerate air renewal inside the vehicle.

We recommend to use natural ventilation as much as possible during train stops. Natural ventilation should be used also during travel time, particularly in instances of overcrowding, when operational limitations inhibit sufficient physical distancing. e.g. high density of passengers standing.

Air re-circulation inside passenger vehicles

In many trains Heating, Ventilation, and Air Conditioning (HVAC) systems are operating using both fresh outside air and recycled air. Up to 90% of the total ventilated volume of air can be recycled air. This is either a fixed ratio or automatically adjusted by HVAC regulation.

Air recycling is often used to:

- Lower the energy consumption,
- Increase passenger comfort (airflow from the cooling unit is dry and cold) - mixed air offers better comfort.

Maximising the ratio of fresh air can be achieved by different means such as:

- Settings in the ventilation / HVAC control panel,
- Physical reduction of the recycled air intake,
- Disconnecting CO2 sensors and setting HVAC to recovery mode.

[(1)] TSI LOC&PAS; [(2)] WHO; [(3)] Legionellosis; [(4)] WHO

Current automated climate control systems may require software adjustments to increase the amount of fresh air. These changes should be performed as soon as feasible by the train operator, taking into account the heterogeneity and number of vehicles/fleets.

Forcing the fresh air intake to a maximum may lead to some issues, such as:

- Lower performance of the system: the temperature might not reach the expected values, especially in extreme weather conditions (low or high external temperature, high humidity) or with high passenger density;
- Slight overpressure inside the compartment may delay the closing of the doors. (Not causing any safety issue once closed);
- Overpressure while entering tunnels and during crossing of two trains possibly causing ear discomfort.

That is why we recommend to test and verify the behaviour of the ventilation / HVAC unit as well as the level of performance with maximum fresh air intake and to ask the manufacturer of the system for advice. Manufacturers can provide guidance on the best settings to be applied. In addition, railway staff should be clearly instructed about specific settings to be applied.

We recommend to maximise the percentage of fresh air inside the vehicle and to minimise the amount of recycled air.

Air distribution through ducts (forced air & HVAC systems)

Air outlets and inlets are usually not placed all along the vehicle but in specific areas optimally directing the airflow throughout the passenger compartment. In most cases inlets are placed along the windows and not directly in the direction of the passengers.

Movements of passengers and staff can change the airflow in the vehicle, for example when entering and exiting the train, or walking to the toilets. As mentioned in the COVID-19 Rail Protocol those movements should be limited, if possible. Read the Protocol to learn more about our recommendations concerning passenger behaviour during travels and usage of face masks.

In order to remove any particles that could have accumulated inside the duct network, ducts have been made accessible for cleaning following the lessons learned from Legionellosis outbreaks in early 2002[3][4]. Specific cleaning procedures exist for recently built rolling stock, while for older rolling stock procedures may still need to be developed.

Please refer to the manufacturer's guidelines for frequency and procedure to clean the air distribution ducts and outlets of the HVAC.

Air Filtration (forced air & HVAC systems).

In many air-distribution systems, both outside air and recycled air are filtered with the aim to limit dust concentration in the compartment and in the system itself. HVAC units are designed to perform with a defined filtering class. Filters generally installed on rolling stock are designed to block dust, which means 40 to 60% of the particles of 10 micrometres (µm). Filtration efficiency depends on airflow, air pressure and speed. Passive filter efficiency has a direct impact on air pressure and comfort.

High-efficiency particulate air (HEPA) filters can retain aerosols containing SARS-CoV-2. To be able to filter properly, several parameters like air pressure and speed, or the effective surface of the filters have to reach specific values. HEPA filters need high air pressure and speed to function, and current ventilation systems in trains are not designed to generate such airflow. Upgrading the HVAC system to allow the use of HEPA filters is a significant operation that may entail:

- Upgrade of the fans,
- Changes in the duct network,
- Increase of energy consumption,
- Increase of noise level,
- Changes in the thermal comfort.

In addition, depending on the type of train (double deck or low floor trains) the upgrade may not be possible due to the lack of available space to install the upgraded HVAC system.

Alternative solutions to neutralise pathogens exist, like e.g. ultraviolet lights mounted in ducts, thermal exposition or ionised purifiers, however their efficiency against SARS-CoV-2 has not been sufficiently demonstrated yet in the railway environment. For more detailed information please refer to REHVA (Federation of European Heating, Ventilation and Air Conditioning Association) COVID-19 guidance document, August 3, 2020

By maximising the fresh air intake into vehicles, and depending on the external environment, the amount of particles to be filtered, coming from outside, increases. Extra maintenance may be needed to replace, clean or disinfect the filters. Manufacturers may help or provide guidance. During maintenance, the manufacturer's specified procedures have to be followed. The system has to be turned off and the maintenance personnel has to wear adequate protective equipment (gloves, facemask). The used filters have to be disposed in sealed bags.

Failure of the ventilation system

Every effort should be undertaken to minimise the duration of stay of passengers on-board a train without ventilation. In case of a main ventilation system failure, train staff shall use emergency ventilation (battery powered ventilation or natural ventilation) in order to decrease the concentration of

[1] TSI LOC&PAS; [2] WHO; [3] Legionellosis; [4] WHO

aerosols that might contain viruses. The trip shall be aborted as soon as possible and the passengers shall be evacuated from the train to the closest suitable and safe place.

The EASA ECDC COVID-19 Aviation Health Safety Protocol is giving a similar advice with a maximum duration of 30 minutes of ventilation failure before evacuation of passengers. TSI LOC&PAS [1] § 4.2.5.8. requires a minimum of 30 minutes emergency ventilation in case of main ventilation failure.

In the case of a train stopped on tracks outside a station and in order to ensure the safety of the passengers, it is highly recommended to:

- Keep the ventilation on and to open windows if possible;
- Provide general safety information to train passengers about the behaviour to adopt when the train is stopped on tracks (e.g.: not to use the emergency opening function of the doors to exit the train) and remind the passengers of specific measures (e.g. wearing masks and not moving through the train) to limit COVID-19 spreading;
- Provide updates about the rescue operations.

Summary of recommendations/mitigation measures:

- Evacuate passengers from a train without functioning ventilation system as soon as possible.
- Do not switch off the ventilation/air conditioning systems.
- If possible, operate the HVAC unit with 100% fresh (outside) air.
- Verify (with the manufacturer or by means of test) the behaviour of the units working with the advised 100% fresh air (from outside) and adapt the percentage of fresh air as well as the maintenance plan if needed.
- Open the windows / transoms to maximise fresh air in the vehicle, especially where other means of ventilation do not exist or if high passenger density cannot be avoided.
- Perform a specific analysis of the ventilation and air flows in long tunnels.
- Limit as much as possible the use of individual air supply nozzles (if available), unless it conflicts with the recommendations from the train manufacturer.
- Follow the advice of manufacturers for the maintenance of the HVAC system and the type of filter to be installed.

Acknowledgements

We would like to acknowledge the assistance of ECDC expert colleagues in formulating the text of this bulletin.

Note from the editors

This bulletin is the result of a fruitful collaborative effort among experts from the European Union Agency for Railways (ERA) and the European Centre for Disease Prevention and Control (ECDC) with contributions from the European Commission, National Safety Authorities and railway sector representatives. It reflects the current status of knowledge about the COVID-19 disease and its pandemic effect. It summarises preventive measures considered effective at the date of publication. While the herein proposed COVID-19 mitigating measures are not legally binding, they represent harmonising measures and may serve as reference for the European railway sector.

It is fully acknowledged that railway undertakings assume their legal responsibility in the context of national regulations, and may use the proposed measures at their own discretion and risk. For questions and feedback, please contact COVID-RAIL@era.europa.eu. We invite you to use this mailbox to also share your best practices and lessons learned with our team, enabling us to share those with the sector to the benefit of all.

Making the railway system work better for society.

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