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Railway applications — Heating, ventilation and air conditioning systems for rolling stock —

Part 4:
Design parameters, and test and inspection items for the HVAC unit

Applications ferroviaires — Systèmes de chauffage, ventilation et climatisation pour le matériel roulant —

Partie 4: Paramètres de conception et éléments d'essai et d'inspection pour l'unité HVAC

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Foreword

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A list of all parts in the ISO 19659 series can be found on the ISO website.

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Introduction

Since the heating, ventilation and air conditioning (HVAC) unit is one of the main components of the HVAC system, its quality and performance is a key issue to improve thermal comfort and energy efficiency for rolling stock.

The purpose is:

— to develop a common International Standard for the validation of a HVAC unit,

— to establish methodologies and requirements on a component basis to demonstrate conformity with the technical specifications of the HVAC unit,

— to establish a clear scope of responsibility in case performance issues occur after mounting the HVAC unit on the rolling stock.

The justification is:

— currently, there is no common International Standard for the validation of a HVAC unit;

— generally, existing national and regional HVAC unit standards are designed for air-conditioning systems in buildings; there only a few standards for rolling stock;

— therefore, there is a need to unify the methodologies of the HVAC unit standards into one single document;

— this will not affect any existing national or regional standard.

Railway applications — Heating, ventilation and air conditioning systems for rolling stock —

Part 4: Design parameters, and test and inspection items for the HVAC unit

1 Scope

This document specifies requirements and guidelines for:

- the design parameters to be provided to the heating, ventilation and air conditioning (HVAC) unit manufacturer by the rolling stock manufacturer ("Customer") and the railway operator,
- the test and inspection items, requirements and methods used by the HVAC unit manufacturer to verify that the HVAC unit conforms with the design parameters.

This document is applicable to HVAC units for the passenger area and driver's cabs in urban (metro, tramway), suburban, regional and main line vehicles.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3743-1, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for small movable sources in reverberant fields — Part 1: Comparison method for a hard-walled test room*

ISO 3743-2, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms*

ISO 3744, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

ISO 3745, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic rooms and hemi-anechoic rooms*

ISO 3746, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

ISO 3747, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering/survey methods for use in situ in a reverberant environment*

ISO 9614-2, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning*

ISO 19659-1, *Railway applications — Heating, ventilation and air conditioning systems for rolling stock — Part 1: Terms and definitions*

ISO 19659-2, *Railway applications — Heating, ventilation and air conditioning systems for rolling stock — Part 2: Thermal comfort*

ISO 19659-3, *Railway applications — Heating, ventilation and air conditioning systems for rolling stock — Part 3: Energy efficiency*

IEC 60077-1, *Railway applications — Electric equipment for rolling stock — Part 1: General service conditions and general rules*

IEC 60077-2, *Railway applications — Electric equipment for rolling stock — Part 2: Electrotechnical components — General rules*

IEC 61373, *Railway applications — Rolling stock equipment — Shock and vibration tests*

IEC 62236-3-2, *Railway applications — Electromagnetic compatibility — Part 3-2: Rolling stock — Apparatus*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19659-1 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.2 Abbreviated terms

For the purposes of this document, the abbreviated terms given in ISO 19659-1 and the following apply.

AC	Alternating current
CMM	Coordinate measuring machine
DB	Dry bulb
DC	Direct current
EMC	Electromagnetic compatibility
FEM	Finite element method
FFT	Fast Fourier transform
FST	Fire, smoke and toxicity
GWP	Global warming potential
HF	High frequency
HVAC	Heating, ventilation and air conditioning
LED	Light emitting diode
PTC	Positive temperature coefficient
PTU	Portable testing unit
RMS	Root mean square

RPM	Revolutions per minute
TCMS	Train control monitor system
VOC	Volatile organic compounds
WB	Wet bulb

4 Prerequisites (design parameters) for the HVAC unit

4.1 General

The design parameters shall be clearly specified in the technical specification so that the HVAC unit manufacturer can design and build the HVAC unit to meet the customers' requirements.

This clause gives an overview of the design parameters that should be specified as good engineering practice including the parameters to calculate the total annual energy consumption and the total annual energy efficiency of the HVAC unit. The latter is important, as in most cases, after the traction system, the HVAC system is the second largest power consumer on the train.

4.2 Design parameters to be provided to the HVAC unit manufacturer

4.2.1 HVAC unit installation requirements

As a minimum, the following design parameters shall be provided:

— the type of the railway vehicle (high speed, commuter, Cat. 1, Cat. 2, Cat. 3 in ISO 19659-2),

— the type of the HVAC unit (compact, split in ISO 19659-1),

— HVAC unit location (roof mounted, roof embedded, ceiling mounted, on floor mounted, under floor mounted in ISO 19659-1),

— the number of the HVAC units per railway vehicle.

These design parameters are summarized in Table A.1.

4.2.2 Air flow requirements

4.2.2.1 Air volume flow rates

The following design parameters shall be considered for air flow requirements:

a) fresh air volume flow rate:

— fresh air volume flow rate per person depending on operating conditions as specified in relevant national or regional standard or in its absence ISO 19659-2,

— number of passengers (normal and maximum);

NOTE In case the free cooling mode is required, the fresh air volume flow rate can be higher. The free cooling mode is specified in ISO 19659-1.

b) supply air volume flow rate based on following heat gains:

— heat transfer (including glazing),

— heat emission from person specified in ISO 19659-2,

— fresh air (specified in ISO 19659-1) (ventilation),

— passenger door cycling air infiltration,

— solar radiation (glazing and opaque surfaces) specified in ISO 19659-2,

— heat emission of supply fans and other equipment specified in ISO 19659-2,

— lighting and miscellaneous internal heat gains specified in ISO 19659-2;

c) return air volume flow rate;

d) exhaust air volume flow rate: air volume flow rate required to be exhausted from technical cabinets, WCs, galleys, etc. and to compensate the fresh air volume rates to maintain the required vehicle inside pressure;

e) infiltration air volume flow rate.

These design parameters are summarized in Table A.2.

4.2.2.2 Back pressure at air interfaces

The following design parameters shall be considered for back pressure at air interfaces:

a) fresh air inlet back pressure:

— pressure loss through the ducts,

— type and efficiency of air filters in 4.2.8,

— filter condition (clean or dirty),

— external contamination,

— drip or mist separator,

— dampers action,

— back pressure due to train speed, especially in case of a high-speed train,

— back pressure due to other equipment;

b) supply air outlet back pressure:

— pressure loss through the ducts,

— dampers action,

— mechanical parts friction,

— diffusers,

— vehicle internal pressure;

c) return air inlet back pressure:

— pressure loss through the ducts,

— type and efficiency of air filters in 4.2.8,

— filter condition (clean or dirty),

— internal contamination,

— dampers action,

— vehicle internal pressure;

d) exhaust air back pressure, if applicable:

— pressure loss through the ducts,

— back pressure due to train speed, especially in case of a high-speed train,

— back pressure due to other equipment,

— dampers action,

— vehicle internal pressure.

These design parameters are summarized in Table A.2.

4.2.2.3 Air flow distribution

Air flow distribution (uniformity of air speed, temperature) at the supply air flow outlet(s), shall be considered.

The design parameter is summarized in Table A.2.

4.2.3 Cooling and heating performance requirements

4.2.3.1 Common requirements

The design conditions shall be specified as described in ISO 19659-2:

a) exterior design conditions:

— temperature and corresponding relative humidity,

— solar radiation,

— altitude,

— train speed;

b) extreme exterior conditions;

c) fresh air volume flow rate;

d) interior design conditions;

— temperature and maximum corresponding relative humidity,

— latent and sensible loads.

The thermal impact of other systems on the train and of the infrastructure on the HVAC system shall be specified and taken into account.

NOTE Other systems are, for example, braking resistors, battery cooling system and traction converter. An example for the infrastructure would be recycling of expelled air due to tunnel or station platform.

The maximum total annual energy consumption and maximum power consumption of the HVAC unit should be specified.

These design parameters are summarized in Table A.3.

Based on the above and the car data, the information for the design and testing of the HVAC unit shall be derived.

4.2.3.2 Cooling performance requirements

The design parameters in 4.2.3.1 and the following design parameters shall be provided:

a) exterior condition (air temperature and relative humidity): design point, maximum operating point, minimum operating point;

b) mixed air condition or interior condition (air temperature and relative humidity): design point, maximum operating point, minimum operating point;

c) cooling capacity (total cooling capacity and sensible cooling capacity) or supply air condition (in combination with supply air volume flow rate from 4.2.2); if a different cooling capacity is required for pre-cooling mode, degraded mode, free cooling mode or other conditions, cooling capacity and conditions should be specified;

d) local air temperature (in case that they are different from exterior value)

- — fresh air inlet,
- — outdoor heat exchanger air inlet;

e) information if the system has reheating conditions to control inside maximum humidity level;

f) filter condition (clean or dirty), e.g. 20 % of surface covered, 10 % reduction in air volume flow rate, simulation of maximum acceptable pressure drop at nominal air volume flow rate;

g) heat exchangers condition (clean or dirty), e.g. 20 % of surface covered, 10 % reduction in air volume flow rate;

h) pressure drop caused by outside air flow speed or other factors affecting the total pressure drop of outdoor heat exchanger area in the HVAC unit;

i) additional operating point to calculate the total annual energy consumption for the HVAC unit, if any (refer to ISO 19659-3).

These design parameters are summarized in Table A.3.

4.2.3.3 Heating performance requirements (electric heater type)

The following design parameters in 4.2.3.1 and the following design parameters shall be provided:

a) exterior condition (air temperature): design point, maximum operating point;

b) mixed air condition or interior condition (air temperature): design point, maximum operating point;

c) heating capacity or supply air condition (in combination with supply air volume flow rate from 4.2.2); if a different heating capacity is required for pre-heating mode, degraded mode or other conditions, heating capacity and conditions should be specified;

NOTE Heating capacity can be provided by other equipment such as electric heater installed under passenger seat. The heating capacity for design of HVAC unit is the capacity required for HVAC unit only.

d) local air temperature (in case that they are different from exterior value): fresh air inlet;

e) filter condition (clean or dirty);

f) maximum allowable duct temperature;

g) additional operating point to calculate the total annual energy consumption for the HVAC unit, if any (refer to ISO 19659-3);

h) information about exhaust heat recovery system (system schematic, operation, etc.) to cooperate with the HVAC unit, if it exists.

These design parameters are summarized in Table A.3.

4.2.3.4 Heating performance requirements (heat pump type)

The following design parameters in 4.2.3.1 and the following design parameters shall be provided:

a) exterior condition (air temperature and relative humidity): design point, maximum operating point, minimum operating point;

NOTE 1 Relative humidity is only relevant for outdoor heat exchanger.

b) mixed air condition or interior condition (air temperature): design point, maximum operating point, minimum operating point;

c) heating capacity or supply air condition (in combination with supply air volume flow rate from 4.2.2);

NOTE 2 Heating capacity can be provided by other equipment such as electric heaters installed under passenger seats. The heating capacity to be provided as design parameter of HVAC unit is the capacity required for the HVAC unit only.

If a different heating capacity is required for pre-heating mode, degraded mode or other conditions, heating capacity and conditions should be specified.

d) local air temperature (in case that they are different from exterior value):

— fresh air inlet,

— outdoor heat exchanger air inlet;

e) filter condition (clean or dirty);

f) maximum allowable duct temperature;

g) heat exchangers condition (clean or dirty);

h) pressure drop caused by outside air flow speed or other factors affecting the total pressure drop of outdoor heat exchanger area in the HVAC unit;

i) additional operating point to calculate the total annual energy consumption for the HVAC unit, if any (refer to ISO 19659-3);

j) information about exhaust heat recovery system (system schematic, operation, etc.) to cooperate with the HVAC unit, if it exists.

These design parameters are summarized in Table A.3.

4.2.4 Electric and electronic requirements

4.2.4.1 General

Subclause 4.2.4 covers the use of on board electrical and electronic equipment inside the HVAC unit on rolling stock.

Electronic and electrical equipment inside the HVAC unit shall be designed and manufactured to meet the full performance specification requirement for the actual temperatures occurring at the location of the equipment concerned. The design shall take into account temperature rises within cubicles to ensure that the components do not exceed their specified temperature ratings.

4.2.4.2 Electronic requirement

4.2.4.2.1 General

Electrical machinery produces electromagnetic interference and therefore, it is important to reduce this as much as possible so that other sensitive electrical and electronic devices, for example, other on-train electronic and electrical equipment or hand-held radio-transmitters, do not malfunction.

The EMC test to be applied (e.g. IEC 62236-3-2 or another equivalent standard) shall be specified.

These design parameters are summarized in Table A.4.

4.2.4.2.2 Immunity requirements

The electronic components within the HVAC unit shall have immunity from specified fast transients, surges, electrostatic discharges and radio frequencies.

4.2.4.2.3 Emission requirements

The conducted and radiated disturbances generated by electronic components within the HVAC unit shall respect the specified emission limits.

4.2.4.3 Power supply

4.2.4.3.1 Supply from accumulator battery

For equipment supplied from a battery, the following design parameters shall be provided:

— nominal and rated voltage,

— minimum and maximum voltage during a specific time interval,

— DC ripple factor,

— interruptions of voltage to be taken into account (frequency and duration),

— allowable power consumption for the HVAC unit (normal, reduced power supply) under different conditions (e.g. design conditions, extreme conditions and emergency ventilation),

— allowable power consumption for the HVAC unit in operational points of operational point matrix for calculation total annual energy consumption.

These design parameters are summarized in Table A.4.

4.2.4.3.2 Supply by a static converter or an independently driven generator

For equipment supplied from a static converter or a rotating set, the following design parameters shall be provided:

— nominal and rated voltage,

— minimum and maximum voltage during a specific time interval,

— number of phases and availability of neutral line,

— fundamental frequency and tolerance,

— harmonics,

— maximum allowed imbalance,

— minimum allowed power factor,

— interruptions of voltage to be taken into account (frequency and duration),

— maximum inrush current,

— allowable real and apparent power consumption for the HVAC unit (normal, reduced power supply) under different conditions (e.g. design conditions, extreme conditions and emergency ventilation) in kW and kVA,

— allowable power consumption for the HVAC unit in operational points of operational point matrix for calculation total annual energy consumption.

These design parameters are summarized in Table A.4.

4.2.4.3.3 Supply with overhead line or third rail

For equipment for which the power supply is derived directly from the overhead line or third rail, power supply shall be in accordance with IEC 60850 or another equivalent standard.

The following design parameters shall be provided:

— nominal and rated voltage,

— minimum and maximum voltage during a specific time interval,

— interruptions of voltage to be taken into account (frequency and duration),

— allowable power consumption for the HVAC unit (normal, reduced power supply) under different conditions (e.g. design conditions, extreme conditions),

— allowable power consumption for the HVAC unit in operational points of operational point matrix for calculation total annual energy consumption.

These design parameters are summarized in Table A.4.

4.2.4.4 Other design parameters

Additionally, the following design parameters shall be provided:

— dielectric test voltages for rated insulation voltage,

— electrical insulation resistance,

— maximum impedance or minimum cross-section of catenary line earthing (for roof-mounted equipment with catenary line).

These design parameters are summarized in Table A.4.

4.2.5 Control requirements

The HVAC unit is typically provided with a microprocessor-based controller to control the elements of the HVAC system according to the required operation as specified by the technical specification.

The HVAC unit typically communicates with the TCMS and other components over either communication bus, digital or analogue inputs or outputs, or a combination of these.

The HVAC unit shall be provided with protection functions to prevent excessive temperatures. These can include:

— air flow sensing device or fan feedback signal,

— overheat protection device with automatic reset to interrupt the power supply,