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Introduction

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 19659-4

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

Part 4: Design parameters, 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, éléments de test et
d'inspection pour l'unité de conditionnement d'air*

ICS: 45.060.01

ISO/TC 269/SC 2

Secretariat: **AFNOR**

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2025-02-17

This document is circulated as received from the committee secretariat.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 269, *Railway applications*, Subcommittee SC 2, *Rolling Stock*.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Since the 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 compliance with the contractual 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, we have no common international standard for the validation of a HVAC unit,

Generally, existing national and regional HVAC unit standards are for air-conditioning systems in buildings and 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, test and inspection items for the HVAC unit

1 Scope

This document covers the following as a guideline:

- the design parameters to be provided to the HVAC unit manufacturer by the rolling stock manufacturer (“Customer”) and the railway operator,
- the test/inspection items, requirements and methods used by the HVAC unit manufacturer to verify that the HVAC unit complies 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 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*

3 Terms, definitions and abbreviations

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 Abbreviations

CMM	Coordinate Measuring Machine
DB	Dry Bulb
FEM	Finite Element Method
FFT	Fast Fourier Transform
FST	Fire, Smoke and Toxicity
GWP	Global Warming Potential
HF	High Frequency
PTU	Portable Testing Unit
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 contractual technical specification so that the HVAC unit manufacturer can design and build the HVAC unit to meet the customers requirements.

These shall meet the local laws and legislation 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:

- Type of the railway vehicle (high speed, commuter, Cat. 1, Cat. 2, Cat. 3 in ISO 19659-2);
- 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);
- Number of the HVAC units per railway vehicle.

4.2.2 Air flow requirements

4.2.2.1 Air Volume Flow Rates

The following items 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 defined in ISO 19659-2 or local standard
- Number of passengers (Normal/Maximum)

NOTE In case free cooling mode is required, fresh air volume flow rate could be higher. Free cooling mode is defined in ISO 19659-1.

b) Supply Air Volume Flow Rate based on following heat gains:

- Heat transfer (including glazing)
- Heat emission from person defined in ISO 19659-2
- Fresh air / outside air (defined in ISO 19659-1) (ventilation)
- Passenger door cycling air infiltration
- Solar radiation (glazing and opaque surfaces) defined in ISO 19659-2
- Heat emission of supply fans/motors and other equipment defined in ISO 19659-2
- Lighting and Miscellaneous internal heat gains defined 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

4.2.2.2 Back pressure at air interfaces

The following items 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/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/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

4.2.2.3 Air flow distribution

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

4.2.3 Cooling/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 / or 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.

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 following design parameters in [4.2.3.1](#) 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/sensible cooling capacity) or supply air condition (in combination with supply air volume flow rate from [4.2.2](#)). If different cooling capacity will be required for pre-cooling mode, degraded mode, free cooling mode or other condition, cooling capacity and condition 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 reheat conditions to control inside maximum humidity level
- f) Filter condition (clean/dirty), e.g. 20 % of surface covered, 10 % reduction in air volume flow rate
- g) Heat exchangers condition (clean/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

In addition, the following information shall be provided:

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

4.2.3.3 Heating performance requirements (electric heater type)

The following design parameters in [4.2.3.1](#) 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 different heating capacity will be required for pre-heating mode, degraded mode, or other condition, heating capacity and condition 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/dirty)

- f) Maximum allowable duct temperature

In addition, the following information shall be provided:

- 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 exist

4.2.3.4 Heating performance requirements (heat pump type)

The following design parameters in [4.2.3.1](#) shall be provided:

- a) Exterior condition (air temperature and relative humidity)

— Design point, maximum operating point, minimum operating point

NOTE 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 1 Heating capacity may be provided by other equipment such as electric heater installed under passenger seat. Heating capacity for design parameter of HVAC unit should be specified as capacity required for HVAC unit only.

NOTE 2 If different heating capacity will be required for pre-heating mode, degraded mode, or other condition, heating capacity and condition 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/dirty)

- f) Maximum allowable duct temperature

- g) Heat exchangers condition (clean/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

In addition, the following information shall be provided:

- 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 exist

4.2.4 Electric/Electronic requirements

4.2.4.1 General

The scope of this section 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/ electronic devices do not malfunction e.g., by other on train electronic/electrical equipment or hand-held radio-transmitters.

The requirements of IEC 62236-3-2 or other equivalent standard shall be fulfilled when the HVAC unit is operating.

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 information shall be provided:

- nominal and rated voltage,
- minimum and maximum voltage during a specific time interval,
- D.C. 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,

4.2.4.3.2 Supply by a static converter or an independently driven generator/alternator

For equipment supplied from a static converter or a rotating set, the following information 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.

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 according to IEC 60850 or other equivalent standard.

The following information 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.

4.2.4.4 Other design parameters

- dielectric test voltages for rated insulation voltage,
- electrical insulation resistance,
- maximum impedance / minimum cross section of catenary line earthing (for roof-mounted equipment with catenary line).

4.2.5 Control requirements

The HVAC unit shall be provided with a microprocessor-based control to control the elements of the HVAC unit / system according to the required operation as specified by the contractual technical specification.

The HVAC unit will typically communicate with the TCMS and other components over communication bus and/or digital and/or analogue inputs and outputs.

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,
- overheat protection device with manual reset, independent from other protections, to interrupt the power supply,
- Electrical heater with intrinsic overtemperature protection (e.g. PTC heaters).

The HVAC unit shall be provided with protection functions to prevent excessively high or low pressures in the refrigerating circuit. These can include:

- high pressure switch,
- low pressure switch,
- pressure relief devices.

The required behaviour of the HVAC unit in case of fire inside and in case of fire outside of the train shall be specified.

When a protection function is activated, this should give feedback to the HVAC controller and/or to the TCMS.

Depending on the required functions, the HVAC unit may also comprise of following elements (not exhaustive):

a) sensor/switch:

- temperature sensor / switch (air),
- humidity sensor (air),
- CO₂ sensor (air),
- VOC (Volatile organic compounds) sensor (air),
- differential pressure sensor / switch (air),
- smoke sensor / switch (air),
- pressure sensor / switch (refrigerating circuit),

b) damper

c) valve

d) relay

e) contactor

f) circuit breaker

g) fuse

h) voltage/phase sequence/over current detection

i) motor

j) converter/inverter/transformer

- k) hard wired external signal e.g., interior temperature setting selector

In case the microprocessor-based control is unavailable, it is recommended to have a back-up solution with a degraded temperature control, while maintaining the above-mentioned protection functions.

In case a certain functionality is required when a power supply is unavailable, this functionality shall be specified.

4.2.6 Structure requirements

The following design parameters shall be provided:

- a) to mount the HVAC unit correctly and firmly, and to minimise vibration:
- fixation method (to secure the HVAC unit to the vehicle),
 - mechanical interference from other systems on the train and / or of the infrastructure on the service route,
 - interface information (mechanical, electrical, maintenance),
 - critical dimensions,
 - allowable weight.
- b) to avoid incorrect air flows through the HVAC unit:
- information about local pressures at air in- and outlets, which might produce reverse air flow due to aerodynamic effects,
 - limits regarding leakages and maximum/minimum outside pressure to be considered (air tightness applicable to operation on high speed lines with tunnels).

Example

maximum leakage factor at static gauge pressure 400 Pa

$$\rightarrow f_{\max} = 1,32 \times 10^{-3} \text{ m}^3/\text{m}^2\text{s}.$$

- c) to avoid water ingress into the car interior:
- rain amount,
 - rainfall duration,
 - car washing water amount, angle and pressure,
 - washing duration,
 - maximum acceleration, inclination and cant for condensate drainage,
 - conditions (temperature, relative humidity and running time) to check that there is no condensate carry over.

4.2.7 Strength requirements

The following design parameters shall be provided:

- a) lifting information and limitation
- b) shock and vibration test (relevant standard: IEC 61373 or other specified standards) to be applied
- c) proof and fatigue load cases for FEM calculations, including number of cycles for the latter

- d) concentrated load on covers, frames, etc. (for example, maximum weight of the maintenance personnel, in case the maintenance personnel are required to travel from one end of the car to the other.)

The stress impact by other systems on the train and / or by the infrastructure around the train shall be specified and considered.

NOTE For example, maximum pressure variation around the railway vehicle which is generated when running into a tunnel and/or passing by an oncoming railway vehicle.

4.2.8 Component requirements

The following design parameters shall be provided:

- a) to select suitable materials and parts:
- the local regulations and standards for fire, smoke and toxicity,
 - specification for materials and parts and relevant standards if exist,
 - filter class according to ISO 16890-1 and design conditions (dust level, filter grade/life).
- b) manufacture information and notices:
- marking / labelling [model number, rated cooling capacity, rated heating capacity, rated voltage/frequency, refrigerant (name/charge amount), weight, manufacturing date/serial number/manufacturer, etc.],
 - warning labels and safety signs (language, etc.).
- c) characteristics of the pressurized air (if applicable) in case of pneumatic dampers:
- nominal, minimal and maximal pressure,
 - dry / lubricated.

4.2.9 Maintenance requirements

The following design parameters shall be provided to conduct the maintenance work smoothly and efficiently:

- category of maintenance (corrective maintenance, preventive maintenance, etc. in ISO 19659-1),
- maintenance interval,
- restriction (maintenance location, access to the parts e.g., outside / inside of the train etc., maintenance time, etc.),
- ergonomics (e.g. maximum weight of components for manual handling),
- access to the HVAC unit (e.g., outside / inside of the train etc.).

Maintenance time should be specified clearly e. g. maintenance starting condition (open/close conditions of covers, on the train or off the train, including / not including testing time), maintenance success criteria.

4.2.10 Environmental requirements

The following design parameters shall be provided with relevant standards if exist:

- a) to meet the natural environment around the respective region where the train is operating:
- air pollution, salt pollution, sulphur pollution, rainfall amount, snowfall accumulation, sand dust, etc.,
 - corrosion protection requirement.

- b) to reduce the global warming impact:
 - the local regulations and standards for the refrigerant (GWP).
- c) to be resistant against the cleaning agents

4.2.11 Noise and vibration requirements

The limits shall be provided in the technical specification for:

- a) exterior noise:
 - sound power level and/or sound pressure level.
- b) interior noise:
 - sound power level at return air, supply air and exhaust (if applicable) air interface,
 - sound power level at bottom of HVAC unit (if applicable).
 - transmission loss through the HVAC unit (from the fresh air intake opening to any opening at vehicle interior) (optional).
- c) Blocked forces at HVAC unit fixation points

4.3 Summary of design parameters

The design parameters from 4.2 are summarised in [Annex A](#), from [Table A.1](#) to [Table A.11](#). This table should be filled out and provided to the HVAC unit manufacturer.

5 Specification

5.1 General

The test/inspection items used to verify that the HVAC unit complies with the design parameters shall be agreed between the HVAC unit manufacturer and the customer.

This Clause gives an overview of the test/inspection items that should be included as good engineering practice in 5.2 and their classification into, “Type test” and/or “Routine test” in 5.3.

5.2 Test/inspection items and requirement specification by the HVAC unit manufacturer

5.2.1 Air volume flow rate and system pressure drop test

Air volume flow rates (fresh/return/supply, etc.) and pressures (inlet, outlet and other significant points inside the HVAC unit) are measured under the ambient air temperature, ambient static pressure, with only fans operating to verify conformance with the contractual technical specification.

Back pressure at the air interfaces as described in 4.2.2.2. are to be considered.

If applicable, the uniformity of air speed at supply air outlet(s) is measured to verify conformance with the required variation range in cooling and heating mode.

If applicable, reverse air flow due to aerodynamic effects (as defined in 4.2.6 b) shall be verified.

5.2.2 Cooling/Heating test

A cooling/heating test is conducted to verify the capacity of the HVAC unit according to the design criteria at the test conditions required by the contractual technical specification or ISO 19659-3.

After above tests, the total annual energy consumption and the total annual energy efficiency for the HVAC unit are calculated and verified (refer to ISO 19659-3).

If applicable, in cooling mode it shall be checked that no condensate would be generated on surfaces located outside the HVAC unit facing the vehicle interior under the test conditions.

If applicable, air temperature distribution at supply air outlet(s) is measured to verify conformance with the required variation range in cooling and heating mode.

5.2.3 Functional test

It shall be verified that:

- the software version installed on the HVAC controller unit is the latest one released (if applicable),
- all signals from HVAC unit to vehicle and vice versa correspond to the agreed interface,
- the outputs from the HVAC controller unit and/or other control and protection/safety devices produce the correct reaction of the switchgear and/ or components,
- the inputs to the HVAC controller unit correctly represent the status of the switchgear and/ or components.

5.2.4 Cooling/Heating operation and safety checks

A cooling/heating operation check is conducted to verify the HVAC unit operates correctly in both cooling and heating mode under the ambient conditions.

The correct operation of the safety switching devices for limiting the pressure, temperature and air flow respectively shall be verified.

The correct reading of the refrigerant pressure, temperature and air flow sensors shall be verified.

No unusual vibration, noise or odour shall be observed.

5.2.5 Noise test

5.2.5.1 Exterior noise

The sound power level and/or the sound pressure level outside of the HVAC unit shall be measured under the required test conditions to verify conformance with the contractual technical specification.

5.2.5.2 Interior noise

The sound power level at the return air, supply air and exhaust air (if applicable) shall be measured under the required test conditions to verify conformance with the contractual technical specification.

5.2.5.3 Transmission loss through the HVAC unit (if applicable)

The transmission loss between the interior / exterior air inlet / outlets shall be measured to verify conformance with the contractual technical specification.

5.2.6 Blocked forces (if applicable)

The vibration generated by HVAC unit components like compressor/s and fan/s etc. in operation at the HVAC unit fixation points shall be measured under the required test conditions to verify conformance with the contractual technical specification.

5.2.7 Shock and vibration test

A shock and vibration test shall be conducted at the required test conditions required by the contractual technical specification.

FEM calculations should be performed for all defined proof and fatigue load cases to verify conformance with the contractual technical specification.

NOTE The test conditions to be applied should be sufficient to provide a reasonable degree of confidence that the equipment will survive the specified life under service conditions.

5.2.8 Water tightness test

5.2.8.1 Water tightness (rain and car washing)

A water tightness test shall be conducted (if applicable) to verify absence of water ingress from the outside into the designated dry areas, in particular any electrical connection box(es) and car interfaces.

NOTE 1 Car washing could use water pressure above normal falling rain that could compromise seals and gaskets.

NOTE 2 Water ingress through the mounting gasket between a car and the HVAC unit is not in the scope of this part of the standard because it is a car level test.

5.2.8.2 Condensate drainage

A drainage test of the condensate shall be conducted to verify it does not splash nor spill and drains as design intent, considering maximum acceleration, inclination and cant as required by the contractual technical specification.

For the consideration of maximum acceleration, inclination and cant, the verification can also be done by engineering judgement of static test results

5.2.8.3 Condensate carryover

A condensate carryover test shall be conducted to verify that all condensate from the evaporator coil shall remain inside the drain system (drainage, drain pan, etc.), no condensate shall spill from the drain system.

If the evaporator can be continuously monitored (e.g. by video), no dedicated test is necessary, and the compliance can be verified by observing the evaporator during the cooling tests

5.2.9 Air tightness test (if applicable)

An air tightness test shall be conducted at the required test conditions to verify that the air leakages of the pressure tight area remain within the contractual technical specification.

5.2.10 Air leakage test (if applicable)

An air leakage test for inside parts of the HVAC unit such as ducts, dampers shall be conducted at the required test conditions to verify that the air leakage of the inside part remains within the contractual technical specification.

5.2.11 Electrical insulation resistance and dielectric test

The integrity of all electrical insulation shall be proven by an insulation resistance test.

After completing this test, dielectric testing shall be used to verify the ability of all electrical insulation to withstand an applied AC voltage across the test points with no indication of insulation failure.

Finally, the electrical insulation resistance test shall be repeated.

5.2.12 Starting characteristics test**5.2.12.1 Starting characteristics for inrush current**

A starting characteristics test shall be conducted at the required test conditions to verify that the inrush current of the main components of the HVAC unit does not exceed the limits specified in the contractual technical specification.

If the inrush current of a component is already measured by the supplier, no dedicated test is necessary.

5.2.12.2 Starting characteristics for voltage variation (if applicable)

A starting characteristics test shall be conducted at the required test conditions as defined in the contractual technical specification.

5.2.13 Refrigerant leakage test

A refrigerant leakage test shall be conducted after connecting all the components of the refrigerating system to verify that no refrigerant leakage can be detected in the entire refrigeration system.

5.2.14 Mass and Centre of gravity measurement

The mass of completed HVAC unit shall be measured to verify the mass is equal or less than the specified value.

If required, the position of the centre of gravity in the X, Y plane shall be determined.

5.2.15 Visual, dimensional and constructional inspection

Visual, dimensional and constructional inspection shall be conducted to verify conformance with the contractual technical specification and the approved drawings.

5.2.16 Maintainability demonstration

Maintainability shall be demonstrated to verify conformance with the contractual technical specification.

NOTE Replacement of consumable parts, operation of special devices and cleaning belongs to this demonstration.

5.2.17 Marking / labelling inspection

A durable nameplate shall be firmly attached to the frame and in a location accessible for reading once the HVAC unit is installed on the vehicle. All warning labels and safety signs shall be in the correct location.

The information shall meet the contractual technical specification and/or applicable standards and/or local regulations.

General labelling of components shall be checked to verify conformance with the contractual technical specification and documentation, e.g. cables, connectors, sockets.

5.2.18 EMC test

The HVAC unit or its components shall be tested to verify conformance with the contractual technical specification and/or applicable standards and/or local regulations.

5.2.19 Specific materials and parts tests

Specific materials and parts tests shall be conducted to verify conformance when required by the contractual technical specification and/or applicable standards and/or local regulations.