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

Part 2: Thermal comfort

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

Partie 2: Confort thermique

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Foreword

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

Thermal comfort is the condition that expresses satisfaction with the thermal environment. This is mostly reached, if the heat generated by the human metabolism is allowed to dissipate in every part of the human body in order to maintain thermal equilibrium with the surroundings. Since the heat generated by the human metabolism is individual, the satisfaction with the thermal comfort condition is also individual.

The main factors that influence thermal comfort locally at every part of the human body are physical activity, clothing insulation, air temperature, mean radiant temperature, air velocity and relative humidity. A satisfying thermal equilibrium can be reached in various combinations of the mentioned factors. Therefore, it is not possible to specify an independent optimum of a single factor, like air temperature, mean radiant temperature, air velocity or relative humidity.

ISO 7730 presents methods for predicting the general thermal sensation and degree of thermal satisfaction of people exposed to moderate thermal environments in buildings.

The thermal comfort sensation in railway vehicles is in addition strongly affected by temporary factors.

Passengers enter the vehicle coming from an environment with a different thermal condition and with an individual physical activity level. Thermal comfort sensation is then temporary depending on the thermal equilibrium and comfort sensation generated in the environment where they are coming from. In hot weather conditions, passengers who travel just for some minutes in an urban train typically prefer lower temperatures and higher air velocities than passengers who travel for some hours in a long-distance train. Further, whether passengers adapt their clothing during their stay in the vehicle is of additional influence.

The thermal comfort which can be offered is also affected by temporary factors. The interaction of the vehicle with the environment influences the thermal condition in the occupied areas in a dynamic way. Door openings in train stations, rapidly changing outside weather conditions, rapidly changing degree of occupation cannot be balanced promptly by the installed HVAC system.

The mentioned combinations of air temperature, mean radiant temperature, air velocity and relative humidity are furthermore limited by the high grade of occupation, high air volume exchange rate, short distance between passenger and surrounding surfaces and other technical constraints of a railway vehicle.

This document takes into account these special conditions in railway vehicles. It deals with the influence of the exterior climatic condition on the dimensioning of the HVAC system, the air quality, and the measurement methods in order to achieve adequate thermal comfort. This document also considers specific areas in railway vehicles, such as sanitary rooms, entrance areas and galleries.

This document describes the parameters and requirements in general which should be taken into account when designing and testing an HVAC-system for railway vehicles. This document also describes guidelines to specify conditions, performance values and the comfort parameter measurement methods, but does not specify detailed pass and fail criteria for comfort requirements or any other technical property of the railway vehicles.

These specifications are designed to be considered together with the national/regional standards, which take into account different preferences, local weather and operational conditions.

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

Part 2: Thermal comfort

1 Scope

This document specifies a general approach for achieving thermal comfort for passenger compartments or saloons of railway vehicles (single level or double-decker) such as main line, regional/suburban and urban vehicles used in public transportation services.

This document also describes guidelines to specify conditions, performance values and the comfort parameter measurement methods for compartments, saloons and local annexes.

This document does not apply to the thermal comfort of the cab driver.

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*

3 Terms and definitions

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

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

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

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

4 Category of passenger railway vehicles

4.1 General

For the needs of this document, passenger railway vehicles are categorized into three types that consider average passenger travel time and average time between station stops next to each other. The following subclauses, 4.2, 4.3 and 4.4, are helpful for choosing the category.

NOTE The ability to achieve thermal comfort is influenced by the type of train. It is not practicable to take a level of thermal comfort of one vehicle category and apply it to a different vehicle category. For example, it is generally not feasible to provide the higher level of thermal comfort of a main line train in an urban train.

4.2 Category 1 (e.g. main line, intercity, long-distance, high speed)

Passenger railway vehicles are typically used in long-distance transit services between major cities and/or regions of a country and sometimes across several countries. They have toilets and often have

food service facilities, such as a dining car or a restaurant car. Passenger railway vehicles travelling overnight also sometimes have sleeping cars. Passenger coach interiors are typically fitted with comfortably spaced and configured seating and separated by interior doors from the vestibule. The average passenger travel time is typically more than 30 minutes and the average time between consecutive station stops is typically 15 to 30 minutes or more.

4.3 Category 2 (e.g. suburban, commuter, regional)

Passenger railway vehicles are typically used in medium-distance transit services between cities and suburban areas or between smaller communities along the line or at the outer rim of a suburban belt. Passenger coach interiors are normally equipped with high-density seating with proportionately limited space for standing passengers. The average passenger travel time is typically more than 20 minutes and the average time between consecutive station stops is typically 5 to 10 minutes.

4.4 Category 3 (e.g. urban, LRV, tram, metro/subway)

Passenger railway vehicles are typically used in high-density urban passenger transportation services. Passenger coach interiors are normally equipped with limited seating with a proportionately large space for standing passengers. The average passenger travel time is typically less than 20 minutes and the average time between consecutive station stops is typically 1 to 5 minutes.

5 Design conditions

5.1 General

Exterior/interior boundary conditions, under which the comfort parameters shall be achieved, shall be specified as the design conditions in the technical specification.

Since exterior/interior design conditions depend on local climatological conditions, this document does not give specific values for exterior/interior design conditions. It is recommended to use values taken from relevant national/regional standards, literature or existing meteorological data. In case such values are not available, this document provides recommended values that can be applied in general.

5.2 Exterior design conditions

5.2.1 Parameters

The values for the parameters — temperature and corresponding relative humidity, solar radiation, altitude, train speed — shall be specified based on actual conditions throughout the service route and should be described in the technical specification or the relevant national/regional standard.

In 5.2.2 to 5.2.5, recommendations are given that specify the exterior design conditions.

5.2.2 Temperature and corresponding relative humidity

Table 1 gives typical climatic design conditions for summer and Table 2 gives typical climatic design conditions for winter. For winter, relative humidity is not relevant and therefore, not considered. After extensive research, various climatic design conditions are collected, but not exhaustively. The collected conditions are grouped into 11 climatic conditions for summer and 7 climatic conditions for winter, covering most of the climatic design conditions worldwide.

The climatic design conditions for summer and winter can be selected from Table 1 and Table 2. Projects with particular local conditions could require the definition of a design point other than recommended in Table 1 and Table 2.

Table 1 — Typical climatic design conditions for summer

Climatic design condition	Exterior design temperature °C	Relative humidity %	Enthalpy (standard condition) kJ/kg	Relevant zone (example)	Relevant document (example)
TS1	28	45	55,3	North Europe	EN 13129 EN 14750
		(50)	(58,4)	(China)	(GB/T 33193.1)
TS2	32	50	70,5	Central Europe	—
TS3	33	69	89,7	Japan	JIS E 6603
				Malaysia Vietnam	—
TS4	35	50	80,8	Central Europe	EN 13129 EN 14750
TS5	35	60	90,2	Argentina Thailand Russia	—
				China	GB/T 33193.1
TS6	35	65	94,9	Brazil China Middle East	—
TS7	35	75	104,5	Brazil India Indonesia Singapore Thailand	—
TS8	40	40	88,3	South Europe	EN 13129 EN 14750
		(46)	(95,8)	(China)	(GB/T 33193.1)
TS9	40	60	113,4	Singapore Venezuela	—
TS10	45	10	60,6	Middle East	—
TS11	45	30	92,2	India USA	—

Table 2 — Typical climatic design conditions for winter

Climatic design condition	Exterior design temperature °C	Relevant zone (example)	Relevant document (example)
TW1	−40	China	GB/T 33193.1
		North Europe	EN 13129 EN 14750
		Russia	—
TW2	−30	USA	—

Table 2 *(continued)*

Climatic design condition	Exterior design temperature °C	Relevant zone (example)	Relevant document (example)
TW3	−25	China	GB/T 33193.1
TW4	−20	Argentina	—
		Central Europe	EN 13129 EN 14750
TW5	−10	China	GB/T 33193.1
		South Europe	EN 13129 EN 14750
TW6	0	Argentina Brazil	—
		Japan	JIS E 6603
TW7	5	Brazil India	—

NOTE 1 The "ASHRAE Handbook — Fundamentals" is a reference source of local climatological conditions, usable for selecting the appropriate design conditions.

NOTE 2 Annex A introduces exterior design temperature and corresponding relative humidity given in national/regional standards of Japan, China and Europe, and design conditions recommended in the ASHRAE Guideline.

5.2.3 Solar radiation

The solar load shall be specified for summer only. It could be taken from national/regional standards, literature or existing meteorological data.

The "ASHRAE Handbook — Fundamentals" recommends calculating the solar load under the condition of 21 July at 4:00 pm local standard time. This is because:

— July is typically the hottest month in the northern hemisphere, and

— 4:00 pm local standard time is typically the time of day when the combination of total solar irradiance and ambient temperature results in the greatest cooling gain.

If no values are available, a solar load of 700 W/m^2 at an angle of 30 degrees to the horizontal is recommended.

5.2.4 Altitude

Altitude throughout the service route shall be considered. If the difference in altitude between the testing location and the actual operating location is larger than 1 000 m, the reduction of cooling capacity shall be taken into account.

5.2.5 Train speed

The maximum operational train speed shall be considered for winter condition. Zero train speed shall be considered for summer condition.

5.3 Extreme exterior conditions

Extreme conditions should be specified in the technical specification to ensure the function of the system and to prevent an oversized HVAC system design. If not specified in the technical specification or national/regional standard, the following recommended values apply.

The function of the HVAC system installation shall be maintained up to extreme exterior temperatures: 5 K below the exterior design temperature for winter and 5 K above the exterior design temperature for summer. However, it should be recognized that thermal comfort parameters may not be achieved.

5.4 Interior design conditions

5.4.1 Internal heat gains

The following internal heat gains shall be taken into account during summer:

— electrical cubicles;

— electrical devices;

— catering equipment;

— number of persons (passengers/train staff; heat load per person);

— fresh air volume flow rate.

For winter, only the fresh air volume flow rate shall be considered, except in cases where national standards or technical specifications allow consideration of the heat emission of persons and related fresh air volume flow rate. In such cases, the most critical operational case shall be considered for the design (occupation and related fresh air volume flow rate).

The passenger heat load shall be assessed on the basis of an even distribution under a given number of passengers (e.g. over the seats/standing).

These conditions shall be specified in the technical specification.

5.4.2 Temperature and corresponding relative humidity

The values of Table 3 and Table 4 for the selected climatic design conditions according to 5.2.2, are given as recommendations to specify temperature and corresponding relative humidity. For winter condition, relative humidity is not relevant and therefore, not considered.

