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Technical Recommendation

Specification and verification of energy consumption for railway rolling stock

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Contents

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Foreword

The content of this document (TecRec 100:001) has been prepared as a result of the outcomes of the EU funded project RAILENERGY. The project partners involved were: Ansaldobreda, Alstom, Banverket, Bombardier, Corys, D'Appolonia, emkamatik, ENOTRAK, EUROLUM, FAV, Faiveley, IST, IZT, KTH, Nitel, Rail Cargo Austria, RFI, SAFT Batteries, SCIROIDEA, Siemens, TFK, Transrail, Transtechnik, Trenitalia, UIC, UNIFE and VUZ . The project partners have offered the deliverable from the RAILENERGY Work Package 2.2 to UIC and UNIFE for publication.

A TecRec is a UIC/UNIFE standard designed to be used within the European region. The primary field of application is the European rolling stock domain and all associated interfaces with other subsystems and is the preferred solution by both partners for, in particular:

- Product and interface standards such as standardisation of component interfaces
- Publication of results of common research programs or projects/studies undertaken by either UIC or UNIFE
- Acceleration of and better influence over the European standardisation process.

Pending the publication of a European standard, a TecRec will serve as a common comprehensive standard, approved by UIC and UNIFE and therefore recognised as a voluntary sector standard aimed at facilitating the interoperability of and at improving the competitiveness of the European railway system.

The general hierarchy within which a TecRec sits is, in order of prevalence:

- EN standards
- TecRecs
- UIC leaflets

The normative references related to this TecRec can be found in chapter 2 (Normative References) of this document.

TecRecs are managed by a joint UIC/UNIFE standards management group that meets on a regular basis to co-ordinate the process. TecRecs can be downloaded by UNIFE and UIC members from the two organisations web sites: www.uic.org and www.unife.org.

Introduction

This document is a voluntary standard, produced by UIC/UNIFE at the request of the rail sector. Individual companies may choose to mandate it through internal instructions/procedures or contract conditions.

Purpose of this document

— This document provides a voluntary standard on the *"Specification and verification of energy consumption for railway rolling stock"* for use by companies in the rail sector if they so choose.

— The document is set out in the same format than EN standards including, where appropriate, normative and informative annexes. This is so as to facilitate the interface with the ENs.

Application of this document

— These Standards are voluntary. Individual companies may however elect to mandate all or part of its use through company procedures or contract conditions. Where this is the case, the company concerned must specify the nature and extent of application.

— Specific compliance requirements and dates of application have therefore not been identified since these will be the subject of the internal procedures or contract conditions of the companies which choose to adopt this standard.

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Approval and authorisation of this document

— The content of this document was approved for publication by the UNIFE Technical Committee on 4 March 2010 and the UIC Technology and Research Platform on 15 January 2010.

1 Scope

This Technical Recommendation is applicable for the specification and verification of energy consumption of railway rolling stock. The criterion for the energy consumption of rolling stock, as set forth in the present document, is the total net energy consumed – either at pantograph or from the fuel tank – over a predefined service profile, which is either taken from the future operation of the train, or according to a standardised typical profile valid for the specific service category of trains. This will assure results directly comparable or representative for the real operation of the train.

The general purpose of this Technical Recommendation is to provide the framework that will enable to generate comparable energy performance values for trains and locomotives on a common basis and thereby support benchmarking and improvement of the energy efficiency of rail vehicles.

The purpose of this document is not to allow for comparison of energy consumption with other modes of transportation, or even for comparison between diesel and electric traction, as it only deals with the energy consumption of the vehicle itself. For the same reason this document is not suitable for the evaluation of the carbon foot print of the railways transportation system.

2 Normative references

The following referenced documents are indispensable for the application of this document. ENs are developed by CEN[1] or CENELEC[2] and are made available from their members.

NOTE 1: www.cen.eu

NOTE 2: www.cenelec.eu

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50163, *Railway applications – Supply voltages of traction systems*

EN 50215, *Railway applications – Rolling stock – Testing of rolling stock on completion of construction and before entry into service*

EN 50463:2007: *Railway applications – Energy measurement on board trains*

EN 590:2000: *Automotive fuels. Diesel. Requirements and test methods*

EN 13129-2: *Railway applications. Air conditioning for main line rolling stock. Comfort parameters*

EN 15663:2009: *Railway applications. Definition of vehicle reference masses*

3 Terms, definitions and abbreviations

For the purposes of this document, the following definitions apply.

NOTE: The definitions for rolling stock used in this document are either copies or directly inspired of the ones of the TSI locomotives and passenger carriages (draft 4.0) , for more precise understanding, the user of this document should refer to the TSI LOC-PAS

3.1
AC
Alternative Current

3.2
Auxiliaries
Equipment needed to operate the traction equipment, but not producing tractive or dynamic braking efforts themselves (e.g. cooling fans, oil and water pumps, and compressor).

NOTE: In the context of this Technical Recommendation, heating and / or air conditioning of the leading driver's cab is included in the auxiliaries.

3.3
Comfort systems
All equipment consuming energy, but neither belonging neither to the traction equipment nor to its auxiliaries, mainly in passenger cars: heating, air conditioning, toilets, information and entertainment systems, laptop supplies etc.

3.4 Consist
Group of vehicles coupled together

3.5
DC
Direct Current

3.6
DMU
Diesel Multiple Unit: a train of fixed consist powered by one or several diesel engines

3.7
Electric power supply
Generation and distribution of electric energy to the train: power stations, high voltage transmission lines, substations and their switchgear, catenary lines

3.8
EMU
Electric Multiple Unit: a train of fixed consist getting its traction power from an external electric power supply

3.9
HVAC
Heating, Ventilation and Air Conditioning

3.10
Infrastructure
Fixed installations of the railway system: tracks, power supply, signalling, communication etc.

3.11
Locomotive
Is a traction vehicle (or combination of several vehicles) that is not intended to carry a payload and has the ability to uncouple in normal operation from a train and to operate independently

3.12
Rolling stock
General term covering all railway vehicles or consist of vehicles with traction ability or not

3.13
Single-train simulation
Simulation of the run of one train over a part of infrastructure, without inclusion of effects of other trains

3.14
Total railway system simulation
Simulation of several trains over one or several parts of infrastructure (railway network), including effects of train performance, power supply characteristics, operational constraints (time table, conflicts between trains)

3.15
Traction equipment
Equipment directly needed to produce tractive or dynamic braking effort (e.g. transformer, converters, motors, gearboxes)

3.16
Traction unit
A railway vehicle with traction ability (it can be a locomotive, a shunter, a power car or a power head)

3.17
Train
An operational formation consisting of one or more motored or non-motored railway vehicles

3.18
Vehicle
The smallest part in a train (= a single vehicle) without any traction unit (freight wagons or passenger coaches)

4 General methodology

Energy is an integral quantity. This means that the cumulated energy is the decisive factor. On the other hand, realistic train operation always has to take place under the constraints of infrastructure and operational requirements. An important part is the defined timetable for the operation over a specified line. This Technical Recommendation incorporates these conditions into a so-called "service profile" for the train.

This Technical Recommendation is therefore not a direct specification of detailed operational profiles and driving styles. Instead the Technical Recommendation provides the framework for and allows freedom for the user to propose sound solutions integrating a given mix of energy efficient technologies and driving styles.

The specification and verification of energy consumption has to take into account these facts. The energy consumed over such a service profile shall be specified and verified as an input to life cycle cost (LCC) considerations. It can also serve as key documentation for the (future) environmental performance of the train. This requires a well defined and harmonised methodology for specification and verification of the energy consumption. The selected approach has two steps:

1) Simulation of the energy consumption of the train, for one or several specific train runs over a defined infrastructure under defined conditions.

2) Measurements for the verification of this simulation under the same conditions as the simulation within acceptable tolerances.

Two different sorts of service profiles may be chosen:

Individual service profiles based on data from a real railway line, normally one or several lines out of the railway network where the train will be operated. This will be the choice for trains built for a specific railway line or network, or for operators that want to know the exact consumption of a standard train under their operational conditions. Definitions of all applicable input parameters are given in annex A of this Technical Recommendation.

Standardised, typical service profiles if applicable, for the following categories for passenger service:

- Suburban
- Regional
- Intercity (inter-regional)
- High speed

and for the following types of freight service:

- Mainline
- Shunting

Definitions of relevant values for the typical service profiles and their parameters are given in annex B of this Technical Recommendation. The standard service profiles are characterised by definitions of standard values for the identified service types being typical (i.e. representative) – yet not real – of the type of railway service. This means that it is not possible to validate these service profiles directly on real tracks and under realistic conditions unless some modifications are applied (e.g. modification of the distances for different speed restrictions). Consequently, these service profiles serve as basis for quantitative characteristics of the energy performance of the relevant rolling stock.

In order to keep different characteristics, requirement and procedures manageable, the energy consumption for the whole train is handled separately:

- Traction equipment and auxiliaries necessary for traction without comfort systems
- Only comfort systems (for stand still and parking mode)

The following sections show how to define the infrastructure (section 5) and the operational and environmental conditions (section 6) for both simulations and verification tests. The simulations are specified in section 7 and verification tests in section 8. Finally post processing of test results is described in section 9.

5 Infrastructure description

5.1 General

The infrastructure shall be defined by the characteristics as specified in the following paragraphs. All values shall be given as a function of the distance (running path of the train).

The targeted resolution of position for track parameter changes (gradient, speed limit, curve radius, tunnel cross section) in longitudinal direction is one meter.

5.2 Longitudinal profile

The longitudinal profile shall be defined by the following required parameters:

- total distance of selected route or reference track from selected origin station to selected destination station [km] (ID I01, this identification number refers to the infrastructure parameter 01 in annex A),

- height [m], as an absolute (above sea level) or relative value e.g. versus height of the start station (ID I02), or
- gradient [–], as difference in height divided by difference of distance in longitudinal direction (ID I03).
- In principal, ID I02 and ID I03 are equivalent. If the gradients are defined, it shall be checked that the integral of gradients along the track result in the correct difference of height between start and terminal station

5.3 Speed profile

The speed profile in [m/s] or [km/h] is defined by the required parameter: maximum speed profile at every location along the selected route or reference track (ID I04). The speed profile shall already include the following criteria:

- Maximum speed according to the capability of the track.
- Permanent speed reductions due to curves, according to the required capabilities of the specified train. Example: tilting trains may have a higher permitted speed in some sections along the route than other trains.
- Non-permanent speed reductions due to signalling, according to conditions during verification runs or service operation of the train. Example: speed restrictions imposed by the changeover between two tracks shall be either specially marked, or already be included in the speed profile.
- Rules for safe operation. Example: if the safety operation rules require the target speed to be reached already 100 m before a permanent speed restriction, this shall be included in the profile.

5.4 Curves

The following required parameter shall be specified for curve radii: Exact locations and radii of all curves along the selected route or reference track [m] (ID I05). Curves with a radius of more than 1000 m can be neglected, since they do not increase the running resistance of the train in practice.

5.5 Tunnels

The following parameters shall be specified for tunnels:

- exact locations and lengths [m] of all tunnels along the selected route or reference track (ID I06)
- exact locations and cross section areas [m^2] of all tunnels along the selected route or reference track (ID I07). Very short tunnels with a length of less than 20 meters can be neglected. The same is valid for road bridges over the railway.

5.6 Electric power supply system

In case of electric trains, the following characteristics of the electric power supply shall be defined by the required following parameters:

- nominal voltage (ID E01) and nominal frequency in case of AC (ID E02)

- mean voltage at the feeding point (e.g pantograph) during operation of the train (ID E03), according to experience (measurements) in existing infrastructures, or as a result of total system simulations (for new infrastructure). Note: the mean voltage at pantograph is normally not identical to the nominal voltage.

- position and length of neutral sections or phase separation sections (if applicable) along the selected route or reference track, which require the traction power to be cut. (ID E04).

The parameters used to characterise the electric power supply system are defined in table A-2 of annex A.

5.7 Diesel fuel oil specifications

In case of diesel trains, the characteristics of the diesel fuel oil shall be defined according to EN 590.

6 Operational requirements

6.1 General

Two main phases during operation of a train are considered here:

- Section 6.2. In service operation mode (train operation with passengers: from origin to destination station including stand stills on the way), including HVAC

- Section 6.3 Out of service mode (train operation without passengers: pre-heating/pre-cooling, cleaning and parking/hibernate).

6.2 In-service operation mode

This section is further divided into the following subsections:

6.2.1 Train and propulsion system

A single-train run shall be specified. The specification shall include the train and its mechanical losses, the propulsion chain (electric, diesel-electric or diesel-mechanic) and all auxiliaries which are essential to operate the propulsion chain including control circuits for traction and signalling. Heating and/or air conditioning of the leading driver's cab is considered as part of the traction auxiliaries (to simplify the process for locomotives and during testing).

6.2.2 Timetable

As the main concept of this Technical Recommendation is to define the energy consumption of a train for situations comparable to scheduled train operation, it is necessary to follow a given time table. The reduction in energy consumption by increasing travel times would be easily achievable, but this is not the goal here. The sensitivity of energy consumption versus travelling time is high. Therefore, the requirements on precision of the timetable are high as well.

The following required parameters shall be specified for the in-service operation mode:

- Stops/stations. The number and exact location of stations with planned stops (except departure and arrival station) (ID S01).

- Standstill time on the route. This is the total time elapsed for stopping times [s] at stations (wheels not in motion), during the run over the specified profile (ID S02). The train is fully operational, but e.g. with reduced auxiliary consumption (ventilation) and / or losses (traction converters blocked). These times are specified for simulation. If they are shorter or longer during verification test runs, a correction (post processing) is possible.Journey duration as total time elapsed (from wheels rolling at departure station to wheels stopped at arrival station) e.g. from time table (ID S03). The specification shall include the required time [s] between each start and stop, for a train run over the profile defined in section 5. During both simulation and verification, these times have to be hold with high precision (see subsequent section 7.2.2).

Journey durations and standstill times shall be specified as an integer number (whole number) of seconds.

6.2.3 Pay load

The gross mass, and therefore the load, of a train have a significant influence on its energy consumption. The mass of the train shall be specified as follows:

- Multiple units and passenger coaches, for the selected configuration: design mass [kg] in working order (i.e. dead mass, plus consumables, plus staff) plus normal operational payload or specified load conditions (see below). Terminology according to EN15663:2009.
- Locomotives: design mass in working order according to EN15663:2009
- A trailer consist as a load shall be homogeneous, i.e. shall consist of only one wagon or coach type with identical load in each . Preferred trailer vehicle types are single-deck or double-deck passenger coaches (for passenger trains), or unloaded or loaded freight wagons. Preferred types of freight wagons are Eanos (open high-board wagons), Sgnss (container wagons), Shimmns (coil twagons) or Zans (tank twagons). The following values must be specified for the trailer vehicles as a load:
  - Mass [kg]. For verification, the mass of the train shall be within +/- 2% of the mass specified for simulation.
  - Factor for rotating masses [-] or dynamic mass [kg]
  - Running resistance [kN] versus speed [m/s] or [km/h] over the whole speed range used for the simulation and / or test

  Note: These values are only supporting the calculation of parameter ID S05 and shall have been validated independently.
- Passenger load conditions: The total mass of passengers [kg] shall be specified according to the expected operation of the rolling stock (either as an average value or during specific peak / off-peak periods; parameter ID S05). For specific projects, it may be lower than the normal operational payload as specified in EN15663:2009. For operation over standard service profiles according to Annex B of this TecRec, the normal operational payload as defined in EN15663:2009 shall be used.

6.2.4 Driving style

The driving style of the train driver is not specified by this Technical Recommendation. The driving style (i.e. acceleration or deceleration at each point of the trip) should be chosen as a way to minimise the energy consumption of the operating train while respecting the following conditions:

- Safe operation of the train, under the rules applicable for the foreseen operation of the train. If any such rules exist, they have to be specified together with the infrastructure and timetable information.

- The specified timetable (ID S01) has to be held. Normal (or extra) reserves in the timetable, with respect to the performance of the train operation should be used for energy efficient driving.

6.2.5 Regenerative braking

For electric trains, the regenerative brake (if available) shall be used as preferred braking system, within the constraints of capability of the brake, timetable, and applicable rules for safe operation of the train.

The calculation of the energy consumption shall be done as follows in cases where the electric traction equipment allows for regenerative braking

- For AC electrified railway systems: net energy at pantograph, i.e. fed back energy counted as negative without any other reduction factor than the one possibly imposed by the electric traction system itself (if for example a part of the braking energy is systematically consumed in resistors even in regenerative mode)

- For DC electrified railway systems, two calculations shall be made: the first one in the same conditions as for AC railway systems, the second one with the total braking energy consumed in the vehicle without any consideration of fed back energy. These two extremes correspond to fully regenerative and fully rheostatic braking respectively. The consumed and fed back energy at pantograph shall be identified separately for both AC and DC railway systems. It may depend on the individual project or economic rules in different countries how consumed and fed back energy is taken into account for life cycle cost (LCC) considerations.

The calculation of the energy consumption shall take into account the effect of any on-board energy saving systems, e.g the amount of braking energy stored in batteries or other devices for later use by traction or auxiliary systems or the possible use of the diesel engine losses for train heating.

6.2.6 Comfort functions (in-service)

The performance of comfort functions during in-service operation is specified in the following two required parameters:

- Comfort function duration in-service operation is defined as the duration for the total package of comfort functions in service operation: Heating, ventilation, air-condition, lighting, entertainment and info panels (during summer and winter) per 24 hours (ID S07) and measured in [hh:mm:ss], use total journey time/day unless specified otherwise,

- Comfort function profile for in service operation (load) is defined as the load profile for the total package of comfort functions in service operation: Heating, ventilation, air-condition, lighting, entertainment and info panels (during summer and winter) per 24 hours (ID S08) and measured in [% of nominal effect of comfort functions], use 80% unless specified otherwise.

6.3 Out of service mode

6.3.1 General

The out of service mode are periods [h/day] where the train is stationary in depot areas, without staff or passengers being on board. Power supply to the parked train is either via normal circuits from the electric catenary, via shore supply or via diesel engines running in the train. The duration of these periods are important data for the design of the train and for determination of life cycle costs (LCC), but it is not necessary to fully respect them for the purpose of verification when applying the present Technical Recommendation.

For parked trains, prEN 13129-2 shall be applied (pending publication of the EN). a: Heating mode: see Table 1, Zone II, 0 degree Celsius (page 7) b: Cooling mode: see Table 2, Zone II, 28 degrees Celsius (page 7) shall be used for the definition of environmental conditions. The out of service mode covers essentially three levels of parked trains:

6.3.2 Pre-heating and pre-cooling

Pre-heating and pre-cooling for preparation of trains before in-service operation is defined by the following two required indicators:

- Total average duration of the pre-heating or pre-cooling period (covering heating, ventilation, air-condition, lighting and other necessary auxiliaries) per 24 hours during summer and winter (ID P01) and measured in [hh:mm:ss], use 30 minutes/day unless specified otherwise,

- Load profile for the pre-heating or pre-cooling period (covering heating, ventilation, air-condition, lighting and other necessary auxiliaries) during summer and winter (ID P02) and measured in [% of nominal effect of comfort functions], use 80% unless specified otherwise.

6.3.3 Cleaning of trains

Cleaning of trains before or after in-service operation is defined by the following two required indicators:

- Total average duration of the cleaning period (covering heating, ventilation, air-condition, lighting and other necessary auxiliaries) per 24 hours during summer and winter (ID P03) and measured in [hh:mm:ss], use 1 hour/day unless specified otherwise,

- Load profile for the cleaning period (covering heating, ventilation, air-condition, lighting and other necessary auxiliaries) during summer and winter (ID P04) and measured in [% of nominal effect of comfort functions], use 30% unless specified otherwise.

6.3.4 Parking of trains (hibernating)

Parking of trains before or after in-service operation is defined by the following two required indicators:

- Total average duration of the parking/hibernating period (covering heating, ventilation, air-condition, lighting and other necessary auxiliaries) per 24 hours (during summer and winter) (ID P05) and measured in [hh:mm:ss], use remaining time [24h – operational hours - ½h preparation – 1h cleaning] unless specified otherwise,

- Load profile for the parking/hibernating period (covering heating, ventilation, air-condition, lighting and other necessary auxiliaries) (ID P06) and measured in [% of nominal effect of comfort functions], use 10% unless specified otherwise.

6.4 Environmental (ambient) conditions

The environmental conditions shall be specified (see also table A-5, annex A) under the following required conditions:

- Ambient temperature for energy consumption simulation without the comfort functions [deg C]; 15 degrees Celsius unless specified otherwise to consider specific geographical locations (ID A01). For comfort functions only (sections 6.2.6 and 6.3.2 -6.3.4) use 0, +15 and +30 degrees Celsius, unless specified otherwise,
- Humidity [Relative humidity %]; 50% all year round average humidity (ID A02),
- Intensity of sunlight [W/m2]: 0 W/m2, unless specified otherwise (ID A03),
- Average head wind: Simulation: 0 m/s (ID A04). Verification: actual wind speed lower than 5m/s.

Other relevant (optional) parameters and factors:

- Ambient air pressure (ID A05): Simulation (if relevant): international standard atmosphere 1013 hPa, unless otherwise specified (e.g. for mountain railways). Verification: uncontrolled. Special post processing / assessment if deviations between simulation and verification are claimed to originate from deviations in ambient air pressure,
- Minimum temperature, winter conditions (ID A06), measured in degrees Celsius,
- Humidity at winter conditions (ID A07), measured in relative humidity %,
- Maximum temperature summer conditions (ID A08), measured in degrees Celsius,
- Humidity at summer conditions (ID A09), measured in relative humidity %,
- Weather conditions: dry rails with good adhesion conditions, for both simulation and verification.

It shall be ensured that the train is in a thermally stable condition already when starting the simulation or verification runs, as starting with a too cold or too hot train would significantly affect the results (traction chain losses, auxiliary power).

7 Simulation

7.1 General

The simulation shall be based on the information provided in section 5 and 6. The simulation shall consider the two main phases during normal operation of a train: In service operation mode (train operation with passengers: from origin to destination station including stand stills on the way) and out of service mode (train operation without passengers: pre-heating/pre-cooling, cleaning and parking/hibernate).

7.2 In-service operation mode

7.2.1 Train and propulsion system

Single-train run simulations shall be performed. The simulation shall include the train and its mechanical losses, the propulsion chain (electric, diesel-electric or diesel-mechanic) and all auxiliaries which are essential to operate the propulsion chain including control circuits for traction and signalling. Heating and/or air conditioning of the leading driver's cab is considered as part of the traction auxiliaries (to simplify the process for locomotives and during testing).

The result of the simulation is the energy consumption [kWh or Kg of fuel oil] of the train, running over the infrastructure (section 5) under the operational conditions (section 6).

See also informative annex C for best practices of simulation tools.

7.2.2 Timetable

The following precision is required for simulation of the journey duration: +0/-N seconds for each section between two specified stops.

NOTE: N is every number of seconds or percent, i.e. travel times are always allowed to be shorter, both in simulation and during verification.

The following precision is required as reference for simulation of the journey duration: +/- 0 seconds (can be reached without extra effort). Verification: +/-5 seconds (without correction / post processing) or +100 / -50 % of each specified standstill interval (with correction / post processing of the measured energy). Larger differences during verification may affect the thermal behaviour of the train and shall be assessed individually.

7.2.3 Pay load

Simulation should be done according to specification in 6.2.3.

The simulation for passenger trains shall be done

- for "part A" profiles, i.e. profiles for a specific railway, with the specified load mass for passengers

- for "part B" profiles, i.e. synthetic profiles for the comparison of trains, for the normal operational payload as defined in EN15663:2009."

7.2.4 Driving style

Simulation should be done based on conditions specified in 6.2.4.

7.2.5 Regenerative braking

The simulation should be done based on conditions specified in 6.2.5.

7.2.6 Comfort functions (in-service)

Comfort systems shall be disregarded in the simulations of the train run, and shall be switched off during verification test runs. Note: heating and / or air conditioning of the leading drivers cab are considered not to be part of the comfort systems, but traction auxiliaries (section 7.2).

The energy consumption of comfort systems shall be calculated and verified separately, for the fully operational train. This shall be done for the specified ambient temperature, and two different train speeds: standstill, and maximum speed of the train.

The number of passengers shall be specified in accordance with the normal operating conditions of the EN 15663.

7.3 Out of service mode

The energy consumption per unit of time (i.e. power consumption) for a parked train shall be calculated and verified for the three ambient temperatures specified in section 6.4. The parameters used to calculate energy consumptions for parked trains are given in table A-5 of annex A.

For parked trains, prEN 13129-2 shall be applied (pending publication of the EN). Table a: Heating mode: see Table 1, Zone II, 0 degree C. (page 7) b: Cooling mode: see Table 2, Zone II, 28 degrees Celsius. (page 7) shall be used for the definition of environmental conditions. Verification shall be done for the power consumption, for the train in a thermally stable situation. The out of service mode covers essentially three levels of parked trains:

7.3.1 Pre-heating and pre-cooling

The simulation should be done based on conditions specified in 6.3.2. For a standard simulation (annex B) over 24 hours a value of 30 minutes shall be applied for all train types except suburban trains which shall use 1 hour (2 x 30 minutes) due to the two periods of peak/rush hours.

7.3.2 Cleaning of trains

The simulation should be done based on conditions specified in 6.3.3. For a standard simulation (annex B) over 24 hours a value of 60 minutes shall be applied for all train types.

7.3.3 Parking of trains (hibernating)

The simulation should be done based on conditions specified in 6.3.4. For a standard simulation (annex B) over 24 hours a value of 4 hours and 30 minutes shall be applied for all train types except suburban trains which shall use 4 hours straight.

7.4 Environmental (ambient) conditions

Simulation should be done according to specification in 6.4.

7.5 Documentation

The results of the calculations and simulations shall be documented in a report. The minimum requirements for the contents of the report are:

— Information about infrastructure and operational input data,

— Key data of the train: length, mass, number of driven and not driven axles, tractive effort versus speed diagram, maximum mechanical braking effort,

— Energy consumption [kWh or kg of fuel oil] of the traction equipment and auxiliaries, for the specified runs, separated into consumption during running and at standstill. Note that for DC railways, two values for the running phase shall be given (fully receptive and non-receptive power supply network during braking, see also section 6.2.5).

— Information about the use of on-board energy storage systems, energy management or other energy efficiency technologies,

— Power needs [kW or kg of fuel oil/ h] of the parked train defined in section 6.3.2 to 6.3.4,

— For preparation of the tests: profile of speed versus distance, and tractive / braking effort versus distance for the simulated driving style,

— In order to reach plausible results: separation of the cumulated energy into parts for potential energy (height difference), running resistance, mechanical brakes, traction chain losses plus auxiliaries, and braking resistor. Any onboard energy storage device should have the same energy content before and after the test.

8 Verification

The following sections only contain specific conditions which shall be considered during preparation and performance of the tests. All conditions already specified in the sections above apply as well, and are not repeated hereafter.

8.1 Infrastructure conditions

If the train run is specified for a real, existing railway line, this line shall be taken for the test. Infrastructure conditions must be identical to the specification (section 5).

If the infrastructure has been changed between the simulation and the tests (e.g. between the bid phase and commissioning phase), and if this results in more restrictive conditions for the train run (e.g. lower permitted speed), the simulations shall be repeated prior to the tests, in order not to punish the train design for changes in infrastructure. If the conditions are less restrictive, the original profile shall be followed.

If the train run is specified for a typical standard profile (normative annex B) tests shall be done on an infrastructure which has similar characteristics to as wide extent as possible, possibly by post-calculation if necessary. The simulations shall be repeated with the same simulation model for the train, but with the infrastructure used for the tests. Comparisons between simulation and measurement shall then be done on the basis of same infrastructure characteristics.

8.2 Operational conditions

The operational conditions are defined in sections 6.2 to 6.4, together with those for simulation 7.2 to 7.5.

8.3 Environmental conditions

The environmental conditions are also defined in section 6.4, together with those for simulation.

The following differences are allowed without further need for post processing of the results:

- Ambient temperature: +/- 5 degrees Celsius (for running, traction and auxiliary losses)
- Ambient temperature: +/-1 degrees Celsius (for comfort systems)

8.4 Measurement equipment

For electric trains, the energy consumption shall be measured with equipment (transducers, recorders) which is independent from the equipment of the train. Exception: the same voltage sensor as mounted on the train can be used, if it fulfils the accuracy requirements as defined below.

The accuracy of the whole measurement chain shall follow EN 50463.

Measurement options for diesel trains: diesel fuel oil flow meters or measurement of tanked fuel over the necessary number of test runs in order to achieve the accuracy. Measurements shall result in a total accuracy of within + / - 2% of fuel oil consumed.

8.5 Performance of tests

In addition to all requirements specified above (sections 5, 6, 7, 8.1 to 8.5), the test shall be performed according to the following rules:

- A test plan has to be defined prior to the tests. This plan especially contains:
  - The infrastructure conditions for the specific test,
  - The speed profiles versus distance, and a description on how to instruct the driver to follow these profiles,
- The train shall be in fully operational condition (e.g. no degraded modes in traction or auxiliaries) and in a controlled software status, with all parameters which are relevant for energy consumption being identical to those for later normal operation,
- The train shall have the same load as for the simulations,
- The operation of the train by the train driver shall be done in the same way as during scheduled operation later. Especially the blending between electric and mechanic brakes must correspond to this principle,
- The test shall be carried out three times in each direction, without significant disturbance of the specified speed versus distance profile (e.g. by red or warning signals),
- The travel times specified in the timetable must be strictly followed, with the precision as defined in section 7.2.2. Shorter travel times as specified are not restricted,
- Comfort systems are switched off during the verification test runs, and tested separately. Such tests can be done during other test runs under suitable conditions, or in specialised facilities like climatic chambers,
- Measurements with the parked train (including traction auxiliaries as far as relevant) shall be performed separately as well, under similar conditions like for the comfort systems.

8.6 Documentation

The results of the verification measurements shall be documented in a report. The minimum requirements for the contents of the report are:

- Key information about the train: vehicle number(s), software configurations. Mass of the train during the tests,
- Key information about infrastructure and operational input data where applicable,
- Description of the measurement equipment used,
- Energy measured for “in service” and “out of service” phases. Power consumption of comfort systems and for the parked train. For the train runs, consumed and fed back energy shall be given separately,
- For the test runs: speed and tractive / braking effort versus distance,
- Ambient and weather conditions during the tests,

— Any observations during the tests which might have an effect on the interpretation of the test results.

9 Post processing

9.1 General

Ideally, no post processing of measured or simulated data is necessary. In this case, a final report, containing the comparison between simulation and measurement is issued, and the process is closed.

However, it might be difficult to fully control all conditions during tests in the real railway system, under the influence of other operations and weather conditions. Therefore, some post processing of the measurements, with or without repetition of simulations, can be tolerated, for the cases specified in the following sections.

9.2 Train data

For multiple units (passenger trains), no post processing due to deviations in train data (e.g. mass, running resistance, losses) is allowed. Differences in energy consumption, which originate from such deviations, clearly show a difference in design of the train, and will lead to a corresponding difference in energy consumption over the lifetime of the train.

For locomotives, deviations in the characteristics of the hauled train can be tolerated to some extent. This concerns mass and / or running resistance of the train. Post processing shall be tolerated for deviations up to +/-5 % of the mass or +/- 15% of running resistance of the train. In this case, the simulation shall be repeated with the modified characteristics of the train. The documentation shall give evidence that the model for the locomotive is completely unchanged for the repeated simulations.

9.3 Time and driving style

No post processing for deviations in travel times are allowed, except for extraordinary standstill times in freight services. The test shall be planned and carried out in a way that the tolerances specified in section 7.1.2 can be met. The reason for this is that the dependency between travel time and energy consumption is strongly non-linear, and very sensitive to some parameters such as use of braking system.

Standstill times can be corrected within the limits specified in section 7.2.2 without further detailed analysis. Larger corrections can be tolerated, if an analysis shows that the train is still in sufficiently steady state thermal conditions during the next running phase.

9.4 Environmental conditions

Post processing of results with respect to the ambient temperature outside of the range defined in section 8.3 shall be done by means of repetition of the simulations. In this case, the same temperature as during the tests is applied, with all other conditions unchanged. The documentation shall give evidence that the model for the train is completely unchanged for the repeated simulations. This post processing shall allow the tests to be performed during nearly any time of the year without delaying a project just for the reason of these tests.

Post processing for other environmental (wind, rail conditions) is not foreseen. Tests have to be planned and performed under conditions which are sufficiently identical to the specification.

9.5 Electric network characteristics

For both AC and DC networks, a correction due to a different mean value of the line voltage during the tests can be performed. In this case, the simulation shall be repeated with the identical model for the train, but the line voltage according to the values during the test. This voltage depends on the location and / or power of the train. The documentation shall give evidence that the model correctly represents changes in line voltage, but is completely unchanged otherwise for the repeated simulations.

For DC networks, the receptiveness of the network for regenerated energy can vary significantly. The tests shall be planned in such a way that full regenerative braking is applied. Differences during the tests would be seen from a higher line voltage than assumed for simulation, leading to a blending between regenerative and rheostatic brake. Such a situation may be different from location to location (distance from substation, energy consumed by other traffic).

Post processing of the measured data (correction by comparison of corresponding simulations) or the additional measurement of energy consumed by the braking resistor (during the test runs) can serve to prove that the tested train corresponds to the specification. Evidence shall be given that the post processing and / or comparison are correctly done. Note that for the simulation the energy values for operation under both fully receptive and non-receptive network shall be computed (section 6.2.5).

Annex A

(normative)

Definition of standard parameters

This Annex A identifies and defines all necessary parameters referred to in the main text of this Technical Recommendation. The parameters are describing railway operation and rolling stock and they are divided into the following clusters and presented with definitions and measurement units in the tables below:

— Table A-1 Infrastructure characteristics (I)

— Table A-2 Electric supply system characteristics (E)

— Table A-3 In service operation mode (S)

— Table A-4 Parked train service mode (P)

— Table A-5 Ambient conditions with seasonal changes (A)

Each parameter belongs to one category of either “required” or “optional”. In order to comply with this Technical Recommendation all parameters labelled “required” shall be applied and specified. Parameters labelled “optional” may be applied and specified upon decision by the user of this Technical Recommendation.

Table A.1 — Infrastructure characteristics (I)

ID	Parameter	Definition	Measurement unit	Category
I - Infrastructure characteristics				
I 01	Route length	Total distance of selected route or reference track from selected origin station to selected destination station	km	required
I 02	Altitude profile (height)	The total height profile in meters above sea level along the selected route or reference track	m	required
I 03	Altitude profile (gradient)	The gradient profile (slope) along the selected route or reference track	o/oo	required
I 04	Track speed profile	The maximum speed profile at every location along the selected route or reference track	km/h	required
I 05	Curve radius	The exact locations and radii of all curves along the selected route or reference track	m	required
I 06	Tunnel profile (length)	The exact locations and lengths of all tunnels along the selected route or reference track	km	required
I 07	Tunnel profile (cross section area)	The exact locations and cross section areas of all tunnels along the selected route or reference track	m2	required

Table A.2 — Electric supply system characteristics (E)

ID	Parameter	Definition	Measurement unit	Category
E - Electric supply system characteristics (not applicable for diesel traction)				
E 01	Nominal voltage	Choice of the different standard electrification systems (750 V DC, 1.5 kV DC, 3 kV DC, 15 kV AC, 1x25 kV AC, 2x25 kV AC)	Volts	required
E 02	Nominal frequency	Choice of the different standard electrification systems (DC, 16.7 Hz, 50 Hz)	Hz	required
E 03	Mean voltage at pantograph	Mean voltage measured at pantograph during operation of the train according to existing standard measurement protocol (EN 50163)	Volts	required
E 04	Neutral sections	The exact locations and lenghts of all neutral/phase separation sections along the selected route or reference track	m	required

Table A.3 — In service operation mode (S)

ID	Parameter	Definition	Measurement unit	Category
S - In-service operation mode				
S 01	Stops/stations	Number and exact location of stations with planned stops (except departure and arrival station)	Integer	required
S 02	Stand still time on the route	The total time elapsed for stopping time at stations (wheels not in motion)	hh:mm:ss	required
S 03	Journey duration	Total time elapsed (from wheels rolling at departure station to wheels stopped at arrival station) e.g. from time table	hh:mm:ss	required
S 04	Load conditions in passenger service (multiple units)	Total pay load of passengers e.g. average or all seats occupied (total weight of persons, average weight per person per service type)	tons	required
S 05	Load conditions in service (locomotives)	Total pay load (total weight hauled by locomotive): weight of wagons in service plus passengers according to S08	tons	required
S 06	Passenger load conditions - occupancy according to number of seats (or standing capacity if applicable)	Total passenger occupancy rate e.g. average or all seats occupied	%	required
S 07	Comfort function duration in-service operation	Duration for the total package of comfort functions in service operation: Heating, ventilation, Aircondition, lighting, entertainment and info panels (during summer and winter) per 24 hours	hh:mm:ss	required
S 08	Comfort function profile for in-service operation (load)	Cumulated load profile for the total package of comfort functions in service operation: Heating, ventilation, Aircondition, lighting, entertainment and info panels (during summer and winter) per 24 hours	% of nominal effect of comfort functions	required

Table A.4 — Parked train service mode (P)

ID	Parameter	Definition	Measurement unit	Category
P - Out of service mode (parking)				
P 01	Pre-heating and pre-cooling duration	Total average duration of the pre-heating or pre-cooling period before each "in service" period begins per 24 hours	hh:mm:ss	required
P 02	Pre-heating and pre-cooling load profile	Load profile for pre-heating or pre-cooling before each "in service" period	% of nominal effect of comfort functions	required
P 03	Cleaning period duration	Total average duration of the "cleaning mode" period per 24 hours	hh:mm:ss	required
P 04	Cleaning period load profile	Load profile for "cleaning mode" period	% of nominal effect of comfort functions	required
P 05	Parking period duration (hibernating)	Total average duration of the "parking mode" per 24 hours	hh:mm:ss	required
P 06	Parking period load profile (hibernating)	Load profile for "parking mode" period	% of nominal effect of comfort functions	required

Table A.5 — Ambient conditions with seasonal changes (A)

ID	Parameter	Definition	Measurement unit	Category
P - Out of service mode (parking)				
P 01	Pre-heating and pre-cooling duration	Total average duration of the pre-heating or pre-cooling period before each "in service" period begins per 24 hours	hh:mm:ss	required
A - Ambient conditions (with seasonal changes)				
A 01	Temperature	All year round average temperature	degrees Celcius	required
A 02	Humidity	All year round average humidity	Relative humidity %	required
A 03	Sunlight	Intensity of sunlight	W/m2	required
A 04	Head wind	Average head wind conditions in service operation	m/s	required
A 05	Ambient air pressure	International standard atmosphere	hPa	Optional
A 06	Minimum temperature (winter conditions)	Winter minimum temperature	degrees Celcius	Optional
A 07	Humidity at winter conditions	Winter mean humidity	Relative humidity %	Optional
A 08	Maximum temperature (summer conditions)	Summer maximum temperature	degrees Celcius	Optional
A 09	Humidity at summer conditions	Summer mean humidity	Relative humidity %	Optional

Annex B

(normative)

Definition of standard values for service profiles

B.1 General remarks

The standard service profiles defined in the following sections are intended for the comparison of the energy consumption of trains, e.g. between the products of different manufacturers, under standardised conditions. Each profile consists of an infrastructure description (distances, speed limit) and a timetable. If only the infrastructure data is used, trains can be compared in view of their operational performance and energy consumption at shortest possible travel time. A comparison under equal operational conditions requires also the compliance with the given timetable requirements.

The profiles are defined in such a way that average values (e.g. route length, number of stops) correspond with typical values from table A-1 in the best possible way. For environmental conditions the values from table A-5 are applicable.

The profiles and corresponding requirements are valid for a complete train. For passenger traffic, this will normally be EMUs or DMUs, or a defined set of passenger coaches together with a locomotive. Therefore the running resistance of the coaches is part of the overall characteristics of the train. For freight trains, which are normally hauled by a locomotive, the parameters of a standard reference freight train are specified. The timetable requirements are independent from the length or mass of the train.

B.2 Suburban passenger traffic

The profile contains 10 intermediate stops, with different spacing between the station and different speed limits along the line. For each stop, the standstill time is defined. Otherwise, only the departure time at the first and the arrival time at the last station are defined and have to be carefully respected. Standstill times before departure at the first and after arrival at the last station shall be included in the evaluation of energy consumption, but are outside of the overall required journey time. Time reserves can be shifted from one to another section, as widely practiced for suburban traffic.

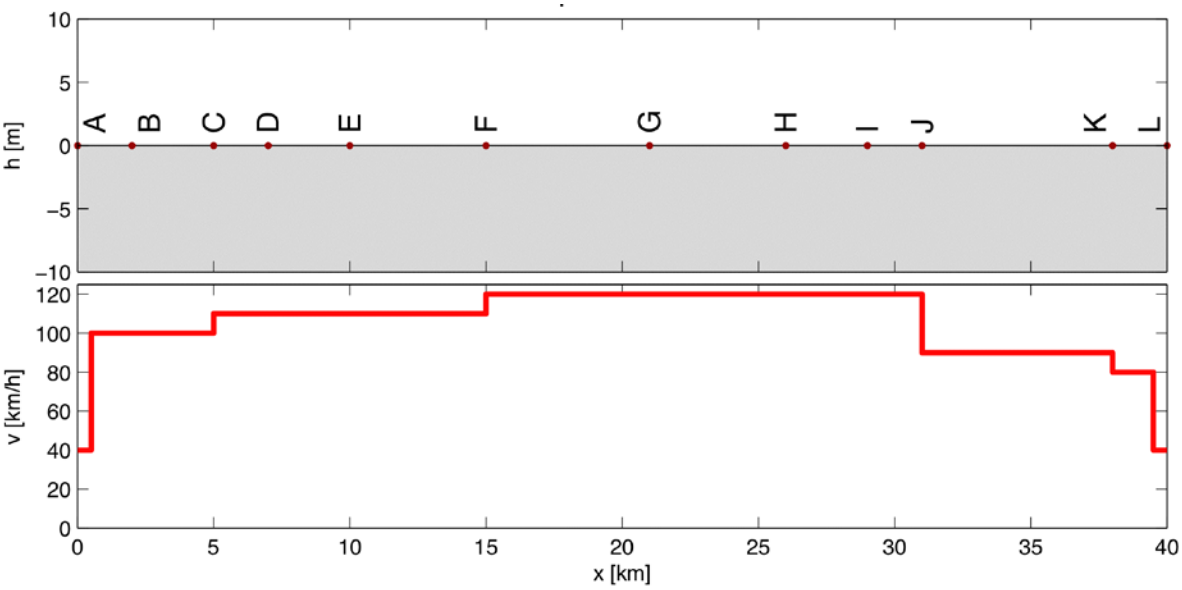

Figure B.1 — Standard profile SUBURBAN

Station	Km	Height	Speed limit	Arrival	Stop	Departure
Station A	0.000	0	40		1:00	0:00:00
	0.500	0	100			
Station B	2.000	0	100		1:00	
Station C	5.000	0	100		1:00	
Station D	7.000	0	110		1:00	
Station E	10.000	0	110		1:00	
Station F	15.000	0	120		1:00	
Station G	21.000	0	120		1:00	
Station H	26.000	0	120		1:00	
Station I	29.000	0	120		1:00	
Station J	31.000	0	90		1:00	
Station K	38.000	0	80		1:00	
	39.500	0	40			
Station L	40.000	0		0:40:00	1:00	

B.3 Regional passenger traffic

The profile is defined in the same way as for suburban passenger traffic. The timetable requirements have to be interpreted in the same way as specified there.

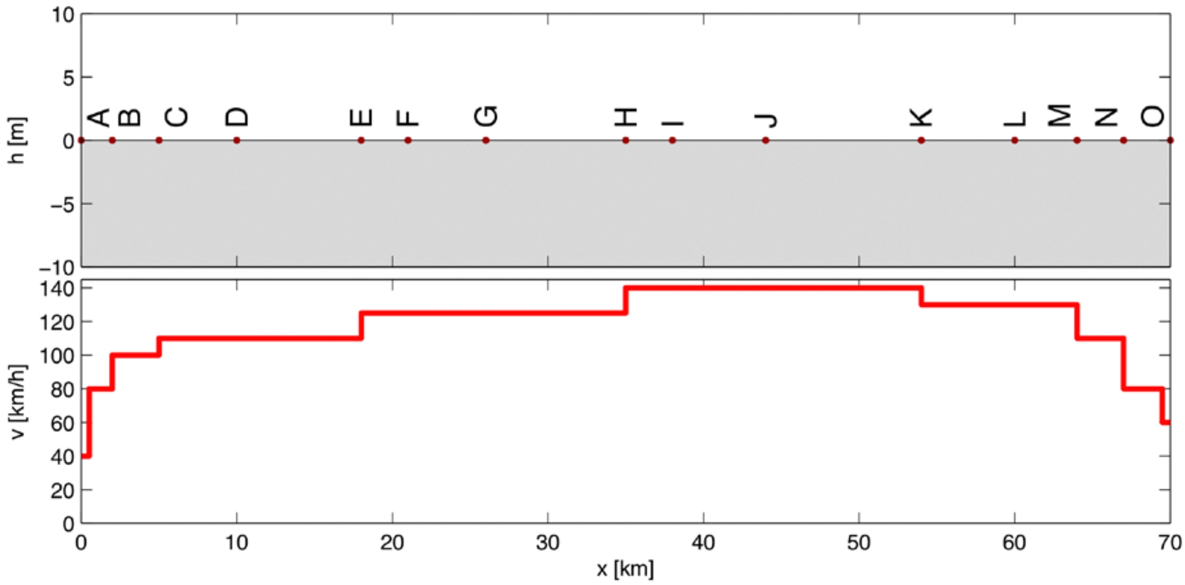

Figure B.2 — Standard profile REGIONAL

Station	km	Height	Speed limit	Arrival	Stop	Departure
Station A	0.000	0	40		2:00	0:00:00
	0.500	0	80			
Station B	2.000	0	100		1:00	
Station C	5.000	0	110		1:00	
Station D	10.000	0	110		1:00	
Station E	18.000	0	125		2:00	
Station F	21.000	0	125		1:00	
Station G	26.000	0	125		1:00	
Station H	35.000	0	140		2:00	
Station I	38.000	0	140		1:00	
Station J	44.000	0	140		1:00	
Station K	54.000	0	130		2:00	
Station L	60.000	0	130		1:00	

Station M	64.000	0	110		1:00	
Station N	67.000	0	80		1:00	
	69.500	0	60			
Station O	70.000	0		1:01:00	2:00	

B.4 Intercity passenger traffic

The profile consists of 9 sections and 8 intermediate stops with different speed limits. On one section, a maximum speed of 200 km/h can be reached. A speed reduction and reacceleration to a higher speed occurs on some sections. The stopping time is longer for some stations than for others.

The timetable requires the journey time to be hold not only for the total profile, but also for each individual section between two stations. The available journey time between the stations is shown in the last column of the timetable. Therefore, time reserves are not allowed to be shifted from one section to another, according to the normal practice in long distance traffic where connections with other trains have to be guaranteed.

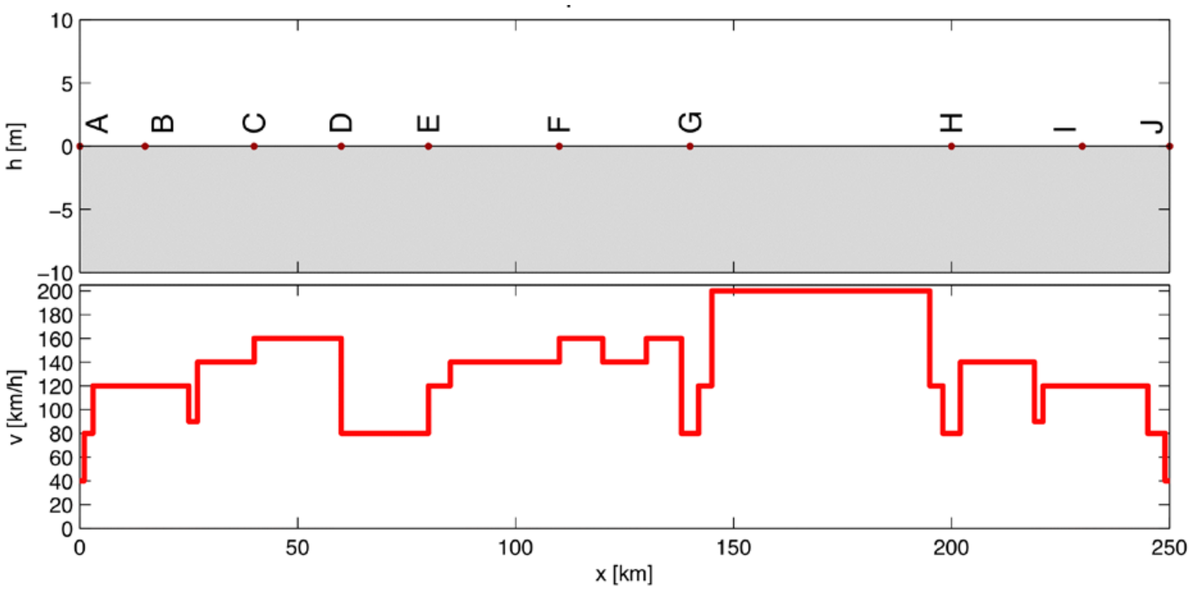

Figure B.3 — Standard profile INTERCITY

Station	km	Height	Speed limit	Arrival	Stop	Departure	Travel
Station A	0.000	0	40		3:00	0:00:00	
	1.000	0	80				
	3.000	0	120				
Station B	15.000	0	120	0:11:00	2:00	0:13:00	11:00

	25.000	0	90				
	27.000	0	140				
Station C	40.000	0	160	0:28:00	2:00	0:30:00	15:00
Station D	60.000	0	80	0:40:00	2:00	0:42:00	10:00
Station E	80.000	0	120	0:59:00	3:00	1:02:00	17:00
	85.000	0	140				
Station F	110.000	0	160	1:18:00	2:00	1:20:00	16:00
	120.000	0	140				
	130.000	0	160				
	138.000	0	80				
Station G	140.000	0	80	1:36:00	3:00	1:39:00	16:00
	142.000	0	120				
	145.000	0	200				
	195.000	0	120				
	198.000	0	80				
Station H	200.000	0	80	2:04:00	2:00	2:06:00	25:00
	202.000	0	140				
	219.000	0	90				
	221.000	0	120				
Station I	230.000	0	120	2:23:00	2:00	2:25:00	17:00
	245.000	0	80				
	249.000	0	40				
Station J	250.000	0	40	2:39:00	3:00		14:00

B.5 High-speed passenger traffic

The profile consists of a high speed line with a maximum speed of 300 km/h over half of the total route length, plus connecting upgraded lines (with 220 and 200 km/h) as well as a classical line between the departure station and the single intermediate stop. This takes into consideration that high speed trains very frequently run over classical lines to make connections into major cities. The timetable requirements have to be interpreted in an identical way as for intercity passenger traffic.

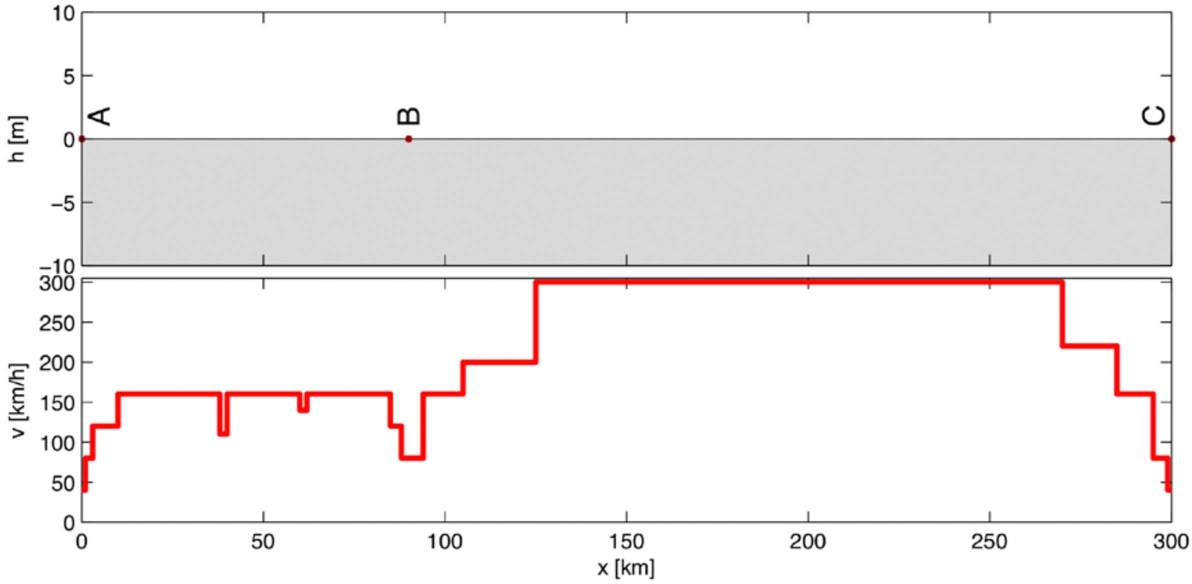

Figure B.4 — Standard profile HIGHSPEED

Station	km	Height	Speed limit	Arrival	Stop	Departure	Travel
Station A	0.000	0	40		3:00	0:00:00	
	1.000	0	80				
	3.000	0	120				
	10.000	0	160				
	38.000	0	110				
	40.000	0	160				
	60.000	0	140				
	62.000	0	160				
	85.000	0	120				
	88.000	0	80				
Station B	90.000	0	80	0:42:00	3:00	0:45:00	42:00
	94.000	0	160				

	105.000	0	200				
	125.000	0	300				
	270.000	0	220				
	285.000	0	160				
	295.000	0	80				
	299.000	0	40				
Station C	300.000	0		1:47:00	3:00		62:00

B.6 Freight mainline

The profile over 300 km includes three planned stops plus two stops in front of red signals. Two third of the line is horizontal track whereas the middle part includes a mountain passage. This reflects the fact that long distance freight train operation includes railway lines with significant gradients in many countries, not only through the Alps. The gradients of the profile are selected in such a way that a four-axle locomotive can haul the same train as the reference train with average mass as specified below. Although locomotives and wagons of many freight trains may be capable to run faster than 100 km/h, the profile is limited to 100 km/h, which is the maximum speed for most loaded freight trains according to lines and wagons of Class D (22.5 t axle load).

Timetable requirements have to be interpreted in the same way as for intercity passenger traffic. Train and timetable are applicable for electric trains or fast freight DMUs only. Trains hauled by diesel locomotives can not hold the timetable for the mountain section, unless they have an uneconomically high number of locomotives.

The allowed maximum dynamic braking effort of a locomotive shall not exceed 150 kN. The same value is applicable for more than one locomotive at a concentrated position in the train. For trains with distributed power, higher total dynamic braking efforts are admissible. However, the longitudinal forces inside the train have to be limited and shall not exceed 150 kN at any position within the train.

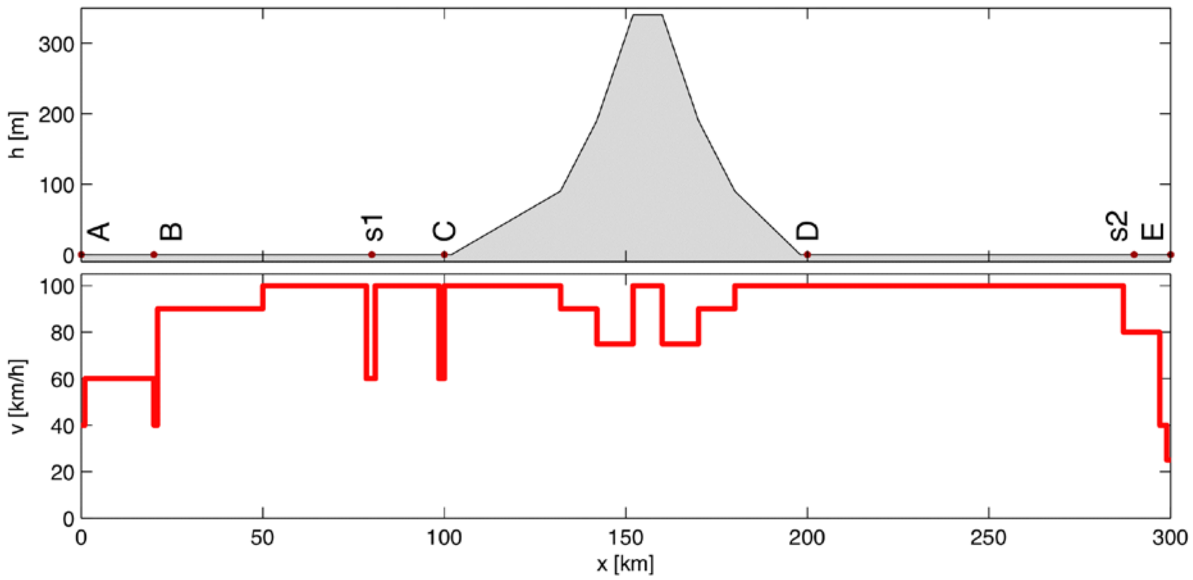

Figure B.5 — Standard profile FREIGHT Mainline

Station	Km	Height	Speed limit	Arrival	Stop	Departure	Travel
Station A	0.000	0	40		3:00	0:00:00	
	1.000	0	60				
	18.000	0	60				
Station B	20.000	0	40	0:24:00	2:00	0:26:00	24:00
	21.000	0	90				
	50.000	0	100				
	78.500	0	60				
Signal s1	80.000	0	60	1:12:00	1:00	1:13:00	46:00
	81.000	0	100				
	98.500	0	60				
Station C	100.000	0	100	1:29:00	5:00	1:34:00	16:00
	102.000	0	100				
	132.000	90	90				
	142.000	190	75				
	152.000	340	100				
	160.000	340	75				
	170.000	190	90				
	180.000	90	100				
	198.000	0	100				
Station D	200.000	0	100	2:51:00	5:00	2:56:00	77:00
	287.000	0	80				
Signal s2	290.000	0	80	3:59:00	1:00	4:00:00	63:00
	292.000	0	80				
	297.000	0	40				

	299.000	0	25				
Station E	300.000	0		4:13:00	3:00		13:00

Train data:

Wagon type	Zans (tank car)
Number of wagons	18
Tara mass of the train (without locomotive)	423 t
Relative load	50 %
Gross mass of the train (without locomotive)	1026 t
Length of the train (without locomotive)	306 m
Factor for rotating masses	1.04
Specific running resistance, constant term	1.05 N/Kn
Absolute running resistance, quadratic term	48.77 N / $(m/s)^2$
Available braking effort, service brake (without locomotive)	800 kN

This train intended to be hauled by one four-axle locomotive. For six-axle locomotives, a 50 % longer and heavier train shall be used. Note that the limits for longitudinal forces inside the train are not higher in this case.

Bibliography

UIC leaflet 345: Environmental specifications for new rolling stock (1st edition, June 2006)

UIC leaflet 330: Railway specific environmental performance indicators (1st edition, August 2008)

About UNIFE

UNIFE represents the European Rail Industry in Brussels since 1992. The Association gathers the Europe's leading large and medium-sized rail supply companies active in the design, manufacture, maintenance and refurbishment of rail transport systems, subsystems and related equipment. A further one thousand suppliers of railway equipment partake in UNIFE activities through national rail industry associations.

UNIFE members have an 80% market share in Europe and supply more than 50% of the worldwide production of rail equipment and services. UNIFE represents its members' interests at the level of both European and international institutions. On the technical side, UNIFE works on the setting of interoperability, developing standards and coordinates EU-funded research projects that aim at the technical harmonisation of railway systems. You can find more information on: www.unife.org

About UIC

The International Union of Railways (UIC) is the international professional association representing the rail sector. UIC currently counts 200 members across five continents. Its mandate is to promote the growth of rail transport across the world and to encourage and organise international cooperation between its members. UIC's technical departments draw their lead from the strategies defined by the members of its specialist forums and platforms, and steer or coordinate a total of circa 200 projects in the field of international cooperation, covering all aspects of rail activities: rail system technology, passenger and freight transport, research, safety and security, sustainable development and the development of skills and expertise.

A significant share of UIC's work consists of strengthening the coherence of the rail system as a whole and its international interoperability, as well as boosting the competitiveness of both passenger and freight transport services. The aim is to enable rail transport to meet current challenges of mobility and sustainable development as effectively as possible. You can find more information on: www.uic.org