



# Manuál pro projektování VRT ve stupni DÚR

**High-Speed Railways Design Guide  
for the Planning Permit Level**

**December 2019**

**English version**

---

# Table of contents

## List of abbreviations

- 1 Introduction
  - 1.1 Sources and inputs for this Guide
    - 1.1.1 Expert workshops between SŽDC and SNCF
  - 1.2 Requirements for high-speed railways
    - 1.2.1 General requirements
    - 1.2.2 Operating requirements
    - 1.2.3 Quality of civil work
  - 1.3 Objectives
  - 1.4 Area of application
  - 1.5 Exemptions from recommended values and solutions
  - 1.6 Design values
    - 1.6.1 Maximum and minimum values
    - 1.6.2 Recommended values
    - 1.6.3 Exceptional and/or limit values
- 2 Alignment
  - 2.1 Route proposal – horizontal layout
    - 2.1.1 K-coefficient
    - 2.1.2 Curves
    - 2.1.3 Transition curves
    - 2.1.4 Lengths of curve elements
    - 2.1.5 Superelevation
  - 2.2 Alignment proposal – track gradients
    - 2.2.1 Special rules for rolling stock
  - 2.3 Space arrangement
    - 2.3.1 Track spacing
    - 2.3.2 Clear profile and minimum distance to artificial structures
  - 2.4 Connecting HS lines with conventional lines
    - 2.4.1 Track speed in HS line connection to conventional lines
    - 2.4.2 Design parameters
    - 2.4.3 Minimum length of connecting track
- 3 Railway superstructure
  - 3.1 Railway sleepers
  - 3.2 Turnouts
  - 3.3 Expansion and shrinking equipment
  - 3.4 Track bed
  - 3.5 Ballastless track
- 4 Subgrade
  - 4.1 General earth work requirements
  - 4.2 Surveys
  - 4.3 Track formation

- 4.3.1 Subgrade gradient transition
- 4.4 Proposal of structural layers
- 4.5 Earth plain
- 4.6 Subgrade stability
- 4.7 Subgrade in an embankment
- 4.8 Subgrade in a cut
- 4.9 Subgrade on the ground
- 4.10 Transition of subgrade from embankment to cut
- 4.11 Transition from subgrade to structures
- 4.12 Protection of subgrade slopes
- 4.13 Subgrade in contact with water courses and areas
- 5 Drainage
  - 5.1 General requirements
  - 5.2 Longitudinal drainage
  - 5.2 Drainage types
    - 5.3.1 Unpaved ditches
    - 5.3.2 Paved ditches
    - 5.3.3 Infiltration channels and collecting pipes
    - 5.3.4 Ditch wall
    - 5.3.5 Top ditches and infiltration channels
    - 5.3.6 Drainage ribs
    - 5.3.7 Slides, steps and cascades
    - 5.3.8 Infiltration and evaporation structures
    - 5.3.9 Longitudinal ditches placed in tubes – road culverts
    - 5.3.10 Retention tanks
- 6 Bridges
  - 6.1 Space arrangement on HS bridge
    - 6.1.1 Illustrative sample cross sections
  - 6.2 Calculations and loadings
  - 6.3 Choosing the expansion and shrinking system
    - 6.3.1 Expansion and shrinking systems for bridges without expansion joints
    - 6.3.2 Expansion and shrinking systems for bridges with expansion joints
  - 6.4 Bridge structure for HS
    - 6.4.1 General principles
    - 6.4.2 Space arrangement under bridge structures (more stringent requirements of ČSN 73 6201)
    - 6.4.3 Bridge structures over water courses (more stringent requirements of ČSN 73 6201)
  - 6.5 Culverts
  - 6.6 Bridges with small span 2–10 m
  - 6.7 Bridges with small span 12–10 m
  - 6.8 Bridges with medium bridging length 20–40 m
  - 6.9 Bridges with big bridging length 20–40 m
  - 6.10 Overpasses, footbridges and ecoducts
- 7 Tunnels

- 7.1 Safety in tunnels
  - 7.2 Adjacent track sections
  - 7.3 Examples of tunnel profiles
- 8 Stations for HS
  - 8.1 Directions concept in the station
  - 8.2 Platforms
  - 8.3 Trap roads
  - 8.4 Types of control points
    - 8.4.1 Track crossovers and junctions
    - 8.4.2 Stations for passenger transport where trains stop on a regular basis
    - 8.4.3 Stations for passenger transport for emergency train stopping
    - 8.4.4 Maintenance tracks
    - 8.4.5 Maintenance tracks for parking passenger trains
- 9 Maintenance base
  - 9.1 Standby centre
  - 9.2 Fully equipped centre
  - 9.3 Locations and distances between maintenance centres
- 10 Block signalling
  - 10.1 Outdoor elements
    - 10.1.1 Signals
    - 10.1.2 Turnouts
    - 10.1.3 Train detection systems
    - 10.1.4 Balises
    - 10.1.5 Cabling and wiring
    - 10.1.6 Ancillary signal boxes and signalling for work in tracks
    - 10.1.7 Detectors
  - 10.2 Indoor equipment
    - 10.2.1 Signal boxes
    - 10.2.2 Remote control
    - 10.2.3 Radio block centres
  - 10.3 Connecting HS lines with conventional lines
  - 10.4 Utility structures for safety systems
- 11 Communication systems
  - 11.1 Cabling and wiring
    - 11.1.1 Fibre-optic cabling
    - 11.1.2 Metallic cabling
  - 11.2 Transmission system
  - 11.3 GSM-R
    - 11.3.1 BTS
    - 11.3.2 Power supply
  - 11.4 Utility structure
  - 11.5 Tunnels
- 12 Power supply system
  - 12.1 Power supply system for track consumption
    - 12.1.1 Technical and economic principles of the power supply system

- 12.1.2 Sizing the output of the system
- 12.1.3 Requirements of the electric power provider
- 12.1.4 Coordination and insulation
- 12.1.5 Overvoltage protection
- 12.1.6 Recovery
- 12.1.7 Basic electric parameters of high-voltage systems
- 12.1.8 Environment, work conditions
- 12.1.9 Voltage systems
- 12.1.10 Protection against electric shock of live parts
- 12.1.11 Protection against electric shock of non-energised parts
- 12.1.12 Operating conditions and reliability
- 12.1.13 System resistance to short circuit
- 12.1.14 Technical solution concept
- 12.2 Power supply system of non-traction power
- 12.3 Lighting
- 12.4 Turnout heating systems
- 12.5 Device for remote power disconnecter
- 13 Traction line
  - 13.1 Assumptions and requirements for the traction system design
  - 13.2 Traction system for  $V \leq 350$  km/h
    - 13.2.1 Traction line parameters
    - 13.2.2 Structural arrangement of the traction line
  - 13.3 Theoretical calculation of traction line behaviour
    - 13.3.1 Flexibility and uneven flexibility
    - 13.3.2 Wave propagation speed
    - 13.3.3 Reflection coefficient
    - 13.3.4 Doppler coefficient and amplification factor
- 14 Accessibility of HS systems and equipment
  - 14.1 Access road
  - 14.2 Pedestrian access
  - 14.3 Working areas
    - 14.3.1 Working areas in control points
    - 14.3.2 Working areas for GSM-R equipment
    - 14.3.3 Working areas for hot bearing detectors
    - 14.3.4 Working areas for power supply stations
    - 14.3.5 Working area for switches
    - 14.3.6 Working area for transformers
  - 14.4 Widening the railway sub-structure plain by the noise protection wall
  - 14.5 Lateral embankments
    - 14.5.1 HS line on an embankment or on the ground – type 1
    - 14.5.2 HS line on an embankment or on the ground – type 2
    - 14.5.3 HS line in a cut
  - 14.6 Working areas for turnouts installation
  - 14.7 Entrance areas for maintenance
    - 14.7.1 Entrance area for heavy building and maintenance machinery

- 14.7.2 Entrance area for light building and maintenance machinery
- 14.8 Working areas at big viaducts
- 15 Protection against persons and animals
  - 15.1 Fencing
  - 15.2 Fencing and accessibility of railway station premises
  - 15.3 Measures in the HS line connection to conventional lines
- 16 Contact between HS lines and roads
  - 16.1 Crossings with roads
  - 16.2 Parallel placement along motorways, category I roads and other roads with high traffic intensity
    - 16.2.1 Parallel placement on a single height level
    - 16.2.2 Parallel placement on different height levels
  - 16.3 Parallel placement along roads of higher significance
  - 16.4 Mutual glaring of road vehicles and rolling stock
- 17 HS lines and the surroundings
  - 17.1 The landscape
    - 17.1.1 Landscape fragmentation
  - 17.2 Noise protection measures
    - 17.2.1 Noise protection barriers
  - 17.3 Vegetation adjustments and tree fall protection
  - 17.4 Protection against atmospheric effects
    - 17.4.1 Lateral wind
    - 17.4.2 Snow, snow drifts and ice
- 18 Conclusion

# List of abbreviations

<b>B+R</b>	Zařízení nebo plocha pro bezpečné odložení jízdních kol u terminálu veřejné dopravy <i>Bike and Ride</i>
<b>CK MD</b>	Centrální komise Ministerstva dopravy ČR
<b>ČSN</b>	Česká technická norma
<b>DSP</b>	projektová dokumentace pro stavební povolení
<b>DÚR</b>	projektová dokumentace pro vydání územního rozhodnutí, resp. pro vydání rozhodnutí o umístění stavby
<b>EN</b>	Evropská norma
<b>ETCS</b>	Evropský vlakový zabezpečovací systém <i>European train control system</i>
<b>EU</b>	Evropská unie
<b>GPk</b>	geometrické parametry koleje
<b>GŘ</b>	generální ředitelství Správy železniční dopravní cesty, státní organizace
<b>GVD</b>	grafikon vlakové dopravy
<b>IZS</b>	integrovaný záchranný systém
<b>K+R</b>	Místo pro zastavení a vyložení nebo naložení cestujících u terminálu veřejné dopravy <i>Kiss and Ride</i>
<b>KDZ</b>	kolejové dilatační zařízení
<b>LGV</b>	vysokorychlostní trať SNCF <i>Ligne à Grande Vitesse</i>
<b>MD ČR</b>	Ministerstvo dopravy České republiky
<b>P+R</b>	Záchytné parkoviště pro osobní automobily u terminálu veřejné dopravy <i>Park and Ride</i>
<b>PHS</b>	protihluková stěna
<b>PJD</b>	pevná jízdní dráha
<b>PK</b>	pozemní komunikace
<b>PVRT</b>	Samostatné oddělení přípravy vysokorychlostních tratí SŽDC
<b>SIF</b>	schéma zařízení infrastruktury <i>Schéma des installations ferroviaires</i>
<b>SP</b>	studie proveditelnosti
<b>SNCF</b>	Národní společnost francouzských železnic <i>Société nationale des chemins de fer français</i>
<b>SŽDC</b>	Správa železniční dopravní cesty, státní organizace
<b>TEN-T</b>	Transevropská dopravní síť dle Nařízení Evropského parlamentu a Rady (EU) č. 1315/2013, o hlavních směrech Unie pro rozvoj transevropské dopravní sítě
<b>TGV</b>	vysokorychlostní vlak SNCF <i>Train à Grande Vitesse</i>
<b>TK</b>	temeno kolejnice
<b>TNŽ</b>	Technická norma železnic
<b>TSI</b>	Technické specifikace interoperability <i>Technical Specifications for Interoperability</i>
<b>TÚDC</b>	Technická ústředna dopravní cesty SŽDC
<b>UIC</b>	Mezinárodní železniční unie <i>Union Internationale des Chemins de fer</i>
<b>ÚP</b>	územní plán
<b>ÚTS</b>	územně-technická studie
<b>VRT</b>	vysokorychlostní trať
<b>ZÚR</b>	zásady územního rozvoje

# 1 Introduction

Based on **Regulation (EU) No. 1315/2013 of the European Parliament and of the Council on Union guidelines for the development of the trans-European transport network**, the Czech Republic committed to support the development of railway infrastructure by building new rail lines in the main directions of the TEN-T trans-European network corridors.

In 2017 the **Czech government issued decree No. 389 on the fast connections development scheme in the Czech Republic** for the construction of new high-speed rail lines, modernisation of significant existing lines, procurement of corresponding rolling stock and creation of a new operating concept, particularly for long-distance passenger railway transport.

SŽDC, as the railway infrastructure manager, was authorised – based on the documents mentioned above – with the construction of new high-speed rail lines. One of the steps in this task is to adopt the regulations and standards for the design, construction and operation of railways with speeds over 160 km/h. This adaptation is however a long process, so this document shall bridge the transition period, defining the technical and operating requirements for high-speed rail lines in the Fast railway connections system and allowing continuous preparations of different projects on the level of Due Diligence, Feasibility Study and the Planning Permit.

This **High-speed railways design guide for the planning permit level** (hereafter only the "**Guide**") is the result of cooperation between SŽDC and SNFC International that started in April and has been lasting until December 2019 based on the Services Agreement signed by the top management of these two organisations. As part of this cooperation, SŽDC made work trips, organised numerous workshops, held continuous consultations and accessed documents of this most experienced high-speed infrastructure manager in Europe to obtain high-speed railways know-how. Their concept (the TGV and LGV lines) is very close to that of the Fast connections and/or high-speed network in the Czech Republic.

This Guide was then written by SŽDC experts who adopted the proven French solutions to the conditions of the Czech railways and the local legal environment.

The aim of this Guide is to introduce the comprehensive requirements of the investor (i.e. SŽDC) to planning permit design contractors for HS pilot sections in the Czech Republic. These requirements involve the design, scope and principles of different solutions to HS systems and sub-systems based on proven French solutions arising from more than 40 years of experience of SNFC with and shall be applied in the Czech environment. This Guide shall therefore allow civil engineers and designers prepare the planning permit design in accordance with the requirements of act No. 183/2006 coll. of the Building Act, its implementing decrees and other regulations that are binding on the national and European level (particularly TSI) and give them the chance of designing a system that will be optimised in terms of design, economical execution, operating costs and maintenance options and that will be environmentally friendly and negotiable with the state administration, self-governments and the public.

**The concept and scope of this guide correspond with the requirements of Appendix No. 3 "Planning permit design scope and contents" to decree. No. 499/2006 coll. on civil design documentation.**

Given the importance and the European reach of the project, this document is also available in the English language and can be used by foreign designers expected to participate in public tenders for the contractor for the planning permit design.

## 1.1 Sources and inputs for this Guide

This Guide was prepared by the High-Speed Rail Lines Preparation Department (PVRT) of the Track Modernisation Unit of SŽDC general direction and is based on these inputs:



- **Cooperation between SŽDC and SNCF** from April 2019 until December 2019 based on the Services Agreement made between SŽDC and SNCF International, the aim of which was to create this Guide based on excursions, lectures, expert workshops (see below), inputs and consultations with experts from SNCF that has been developing, preparing, designing, operating, maintaining and servicing its own high-speed railways system for more than 40 years.
- **Référentiel Infrastructure – Référentiel Technique pour la réalisation des LGV** (and related regulations), which is a technical manual of SNCF containing the basic requirements, civil and technical solutions of the French HS system.
- **Requirements and remarks of expert units of SŽDC** – mostly of the track modernisation unit of the general direction, sub-units of the track operability unit of the general direction and the technical railways maintenance unit of the general direction.
- **Technical Operations Study – Technical HS solutions** prepared between 2015 and 2017 and approved by the Central Commission of the Ministry of Transport in October 2017.

### 1.1.1 Expert workshops between SŽDC and SNCF

Below you can find the time line and a brief outline of expert workshops that took place between May and September 2019 mostly in Prague. The inputs for and outputs of these events are available (mostly in the French language).

- Study trip (13 to 24 May ; France)
  - Meeting the widest possible circle of stakeholders in SŽDC to learn how to operate HS railways in everyday practice (lectures, excursions).
- The Czech railway and legal environment (4 June ; France)
  - Making SNCF experts familiar with the Czech economic, railway and legal environment, with the current state of works on the preparation of the different HS routes and with the required detail level of this Guide.
- Bridges (25 June; Prague)
- Alignment (26 and 27 June; Prague)
- Railway sub-structure (11 July; Prague)
- HS lines and the surroundings – SIF railway systems scheme (17 July; Prague)
- Tunnels (18 July; Prague)
- Railway super-structure (30 and 31 July; Prague)
- Traction and power supply (23 August; Prague)
- Maintenance (27 to 29 August; France)
  - A workshop in France focused on the provision of operability and maintenance technology, held directly in SNCF maintenance sites and on sites where major work is under way on HS rail lines (done always during a regular night closure).
  - A link between the design of a new rail line designed for 100 years and its effective maintenance is considered to be the core issue in France.
- Communication systems (3 Sept; Prague)
- Safety systems (4 Sept; Prague)
- HS lines preparation and construction management + rolling stock interoperability (5 Sept; Prague)
- HS lines and the surroundings – Noise, the environment, parallel placement with roads, etc. (10 Sept; Prague)

## 1.2 Requirements for high-speed railways

### 1.2.1 General requirements

Certain restrictions to the HS railways system are laid down in related regulations (national or international), which brings corresponding design and sizing of certain civil structures that are dependent on them.

Other restrictions arising from the experience with the design, construction and operation of HS lines however often lead to more specific requirements regarding civil and technical solutions that are not defined in any regulations yet. Such specific requirements for the design

of high-speed rail lines are described in more detail in this Guide and are mostly based on the experience of SNCF experts and/or units SNCF Réseau and SNCF Mobilités.

These initial requirements include:

- contact between train wheels and rails must be preserved under all circumstances;
- the route shall be designed as a comfortable route due to static and dynamic stress on the structure and for high convenience of passengers,
- operation on the HS rail line must meet the highest reliability, quality and safety requirements and distances between trains must be correctly defined, so that required precision of the timetable can be reached.

### 1.2.2 Operating requirements

The HS rail line must meet very strict Reliability, Availability, Maintainability and Safety (RAMS) requirements.

Given the travel speeds and height at which the driver sits, the driver does not see far enough to be able to brake early on. On top of this, the train speed must be independent of weather (fog, snowfall, etc.). For these reasons, the signal system used on the conventional network cannot be used and rail lines and trains operated at speeds over 160 km/h must be equipped with the ETCS L2 safety system.

The driver cannot generally stop his/her train if an obstacle, reaching into the driving profile (falling rock or boulder, land slide, random object, vehicle, etc.) appears or if there is a defect on the railway super-structure (rail misalignment, rail fracture, etc.). These restrictions commit the designer to take all known risks that may affect the operating safety into account and take all necessary measures against such risks. These measures primarily involve the use of the ETCS L2 safety system, use of wind speed and snow sensors, or retaining systems against the fall of a vehicle onto the track. Given the nature of operation on HS rail lines, train stopping or a major speed reduction are only possible in very exceptional situations. These cases seriously compromise reliability in the HS timetable.

Regular and accurate connections on HS rail lines are extremely important for passengers. Any delay in HS operation has an immediate impact on connecting means of transport, on the turning of trains and causes major delays of connecting trains, with serious consequences particularly during the morning and afternoon peaks. This also translates into financial compensation claims from passengers and train operators.

Small operating reserves in travel times of trains, particularly during peaks, do not allow almost any operation disruptions. When calculating the travel time, penalties for trains slowing down on very short sections (due to maintenance) must be added. The speeds in such sections still remain relatively high (230 km/h, 160 km/h or 100 km/h).

Given the high attractiveness of HS trains and with work restrictions in the immediate vicinity of the tracks, maintenance work on HS lines are performed at night during a night closure. Minor day closures (closing of a part of the track) are intended for the most urgent repairs and inspections only. Availability and reliability of the reference speed on HS lines is the essential prerequisite for ensuring regular connections.

Regular connections on HS lines must be ensured under all circumstances, mostly in terms climate and weather (frost, very wet or very dry periods, rain, snowfall, wind, etc.), Restrictions (lower speed, detour) may be adopted only in very short periods of time if an exceptional phenomenon arises (very strong wind, heavy snowfall, earthquake, etc.).

### 1.2.3 Quality of civil work

All civil structures must be made in high quality to ensure safe operations, regular connections and high convenience for passengers on HS rail lines. As track maintenance and repairs can

only be done at night during the night break, any long-term intervention into the HS track is very challenging and costly. Therefore, the following principles must be followed:

- technical solutions enabling diagnostics, inspection and maintenance work without the need for operation restrictions on the HS rail line;
- **reliability and durability of all civil structures during their whole service life of 100 years**, i.e. the structures must be in operation for this period of time without any expected changes to safety coefficients and without any interventions except for routine maintenance (rails replacement, slope maintenance, drainage maintenance, coatings on metal structures, possible replacement of bridge bearings, etc.).

### 1.3 Objectives

This Guide shall optimise and technical and financial solution in all relevant areas. It defines the requirements for the design of HS civil structures, reflects the restrictions of the HS railway system for every type of civil structure and brings details about:

- the criteria to be met;
- the sizing principles meeting the above-mentioned general and operation requirements;
- typical and/or recommended solutions;
- exceptional solutions;
- forbidden solutions;
- special requirements connected with civil design and construction.

### 1.4 Area of application

**The requirements of this Guide apply on the territory of the Czech Republic for HS rail lines designated only for passenger trains with maximum loading 22.5 tonnes per axle (for speeds  $\leq 230$  km/h) and 18 tonnes per axle (for speeds  $> 230$  km/h).**

All vehicles operated on the HS rail lines must meet the TSI requirements.

Design speeds of less than and including 200 km/h (e.g. connecting rail lines) are speeds for conventional lines designed according to current applicable ČSN standards and SŽDC regulations.

### 1.5 Exemptions from recommended values and solutions

The application of values that are exceptionally allowed in the Guide and the use of exemptions from the solutions described must be approved by SŽDC – the High-Speed Rail Lines Preparation Department (PVRT) of the Track Modernisation Unit of SŽDC general direction.

### 1.6 Design values

The limit values recommended in this document comply with the EU interoperability directive and TSI.

#### 1.6.1 Maximum and minimum values

These are value are standard values that the civil engineer must comply with. They provide – from the top or from the bottom – the interval of recommended design values unless other restrictions of local limitations apply. These are the reference values that shall be complied with. The application of these values guarantees a comfortable ride and adequate costs of track maintenance.

#### 1.6.2 Recommended values

These values correspond with values used by civil engineers unless other restrictions apply.

### 1.6.3 Exceptional and/or limit values

These values represent extreme values and their application shall be rare. They must be limited only to specific places where standard values do not allow a relevant solution. This value must not be exceeded.

The application of exceptional values that may compromise travel convenience or maintenance conditions must be justified with serious reasons (not systematic issues). As a result, the following general restriction applies: an exceptional value regarding the direction or height proposal is permitted every 20 km provided these exceptional proposals do not overlap or and provided they are not adjacent up to 300 m.

**The application of exceptional values and solutions** is subject to chapter 1.5 Exemptions from recommended values and solutions. The possibility of keeping the design open for changes on the Building Permit Design level is an essential pre-condition of the use of exceptional values and solutions.