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Railway Applications — Running time calculation for timetabling —

Part 1: Requirements

Applications ferroviaires — Calcul des temps de parcours pour la construction des horaires —

Partie 1: Exigences

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 3, *Operations & Services*.

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

The purpose of this document is to help many railway-related organizations around the world, regardless of their experience, to calculate accurate train running time between stations for all types of trains, helping to improve the punctuality of railways around the world.

Improving railway punctuality can increase the competitiveness of railway transportation against other modes of transportation such as planes, buses and cars. More customers using railway means more income for railway infrastructure managers, railway operators and related organizations. It also means promotion of national economic growth, increased social efficiency, and use of environmentally friendly energy leading to increased global sustainability. Overall, increased use of railway leads to an improvement of "Quality of Life (QoL)" for customers.

This document describes the requirements necessary to accurately calculate shortest running time when setting up the daily and yearly timetables by clarifying the parameters to be considered.

In addition, this document shows the appropriateness of calculation by verifying the response observed on the calculated shortest running time when the parameter values are changed.

The verification will make it possible to easily confirm that shortest running time is reasonably calculated using the parameters specified in this document.

By calculating shortest running time based on this document, railway-related organizations around the world can promote punctuality and increase network capacity for train operations.

In addition to this document, further documents will complete the standard series of railway timetabling. All parts together form a specific and comprehensive guideline for railway timetabling. Figure 1 shows a map of the target of our working group. It involves important elements of railway timetabling to be standardized in the future.

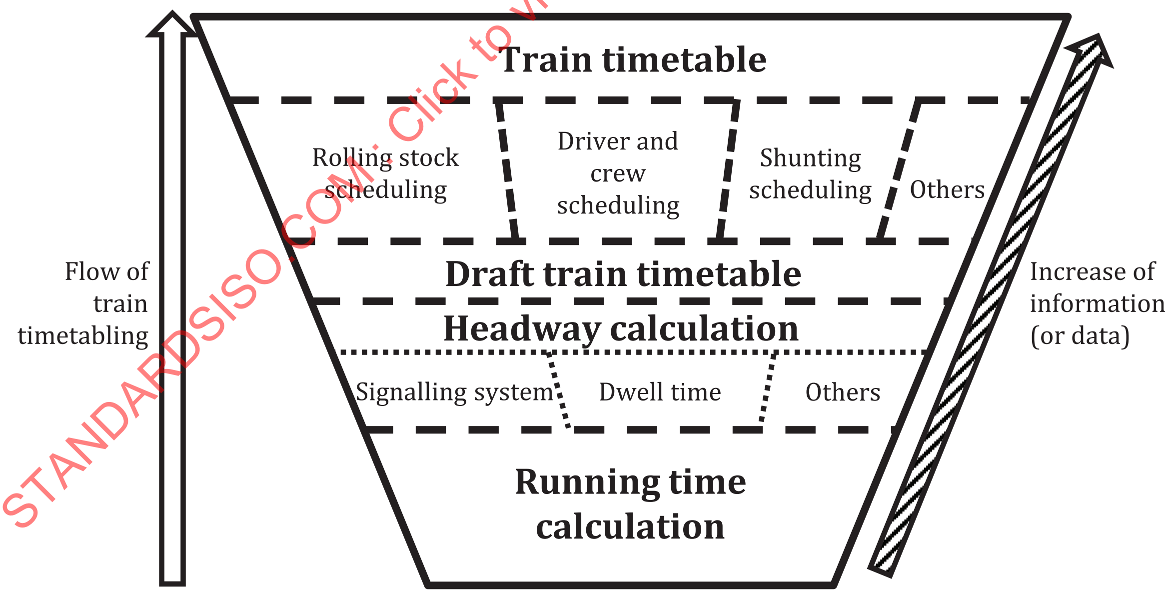

Figure 1 — Roadmap of our working group

Railway Applications — Running time calculation for timetabling —

Part 1: Requirements

1 Scope

In order to create punctual timetables, it is necessary to accurately calculate and plan out many values, such as running time between stations, headway between trains, train scheduling, rolling stock scheduling, driver and crew scheduling, operation scheduling in stations and depots and capacity of the line/infrastructure.

Among these values, shortest running time between stations must be calculated first, as this is the basis of timetabling.

This document describes parameters as the requirements for shortest running time calculation that enable railway infrastructure managers, railway operators and related organizations to calculate accurate running time at the stage of setting up a feasible and punctual daily and annual timetable.

In addition, this document shows the appropriateness of calculation by verifying the response observed on the calculated shortest running time when the parameter values are changed.

This document excludes running time calculation used for purposes other than timetabling.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1 General

3.1.1
running time
amount of time, on a defined path on the infrastructure, for the head of a train to pass from one stopping point or passing point to another without making any stops in between

3.1.2
shortest running time
running time (3.1.1) when a train is driven in the quickest way while complying with predetermined operating restrictions

3.1.3
position
distance from a specific reference point on a defined path on the infrastructure

3.1.4
stopping point
point where a train stops or starts

3.1.5
passing point
point where you need to know the passing time of a train

3.1.6
train scheduling
defining a set of fixed times for a train in a timetable using the information on train performance and characteristics, route, infrastructure characteristics and restrictions, requested departure and arrival time, commercial and/or technical stops and buffer times

3.1.7
timetabling
defining a set of train schedules for a railway system to provide a service considering conditions such as the interaction between trains, infrastructure capacity, rolling stock, personnel, stations and depots scheduling, shunting, commercial requirements, etc. according to its validity period or application

3.2 Infrastructure

3.2.1
gradient resistance force
force derived from track gradient

[SOURCE: IEC 60050-811, 811-05-06]

3.2.2
curve resistance force
force derived from additional resistance in curves

3.2.3
tunnel resistance force
force derived from additional air resistance in tunnels

3.3 Rolling stock

3.3.1
mass
total of the gross load hauled and mass of motor vehicles which haul it

Note 1 to entry: Mass is the same as total gross load.

[SOURCE: IEC 60050-811, 811-03-09]

3.3.2
running resistance force
resistance to motion of a vehicle or train

3.3.3
tractive force
force in direction of travel exerted by traction motors, engines or other means of propulsion

4 Purpose and range of running time calculation

In the timetabling process, after defining the train route, it is mandatory to know how much time it would take to complete its entire journey. Running time of a train from origin to destination would be the sum of the shortest running time between each adjacent stopping points and passing points on route, stopping time at each intermediate stopping point, and buffer time. Therefore, this document focuses on shortest running time calculation between two adjacent stopping points or passing points on a defined train route (i.e. the starting point and ending point of calculation) as it is the minimum unit of calculation. The speed is not to be zero between the two points; any point where the train stops is to be defined as a stopping point.

5 Requirements of shortest running time calculation

5.1 General

In general, shortest running time is calculated by the flow shown in Figure 2. First, calculation parameters are prepared based on the train route. Using these parameters, shortest running time is calculated based on the basic principles of physics. The hatched area in Figure 2 shows the requirements of this document.

In order to establish a method to calculate shortest running time accurately, it is important to select, prepare and consider all parameters that may have a significant influence on the shortest running time. For this reason, the dominant parameters in shortest running time calculation are selected as shown in 5.2, 5.3 and 5.4.

All of the selected parameters shall be applied to the calculation method (refer to Figure 2 and Table 1). The usage of additional parameters is allowed but not in the scope of this document. Furthermore, the calculation method shall be verified to confirm the appropriate application of the parameters (see Clause 6). This document does not intend to specify the calculation method itself.

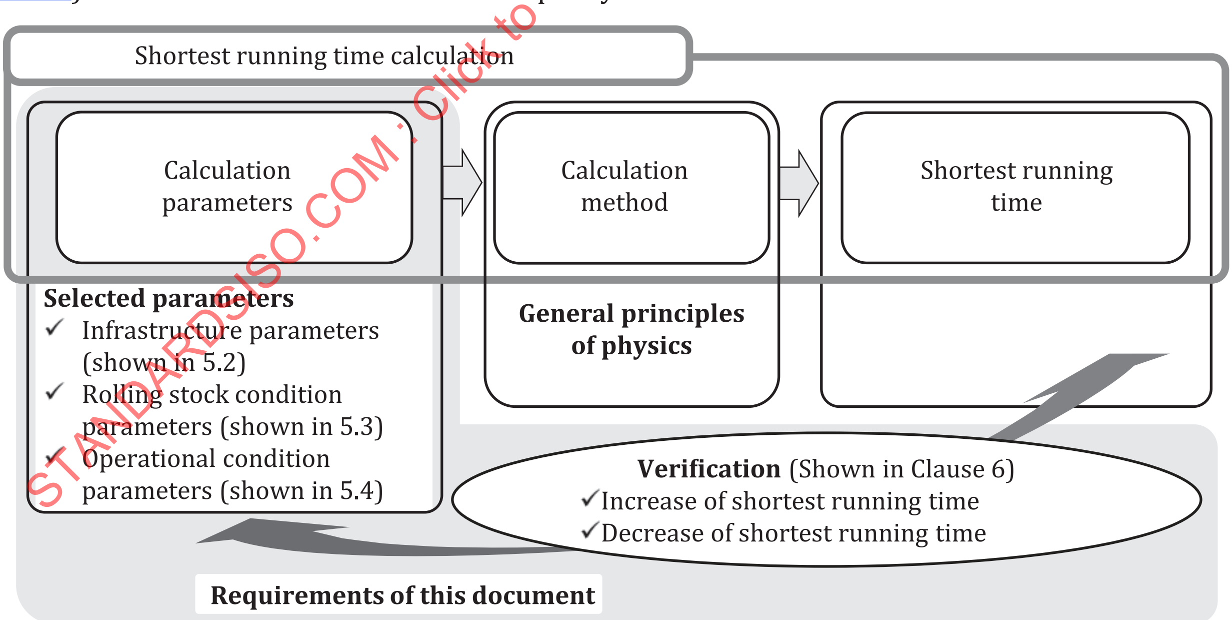

Figure 2 — Requirements of this document

Table 1 — Summarization of parameters

No.	Classification	Parameter (Subclause)		Unit
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point	m
			Ending point	
2		Gradient (5.2.3)	Gradient	‰
			Position	m
3		Allowed maximum speed (5.2.4)	Speed	km/h
			Position	m
4		Speed limits from infrastructure conditions (5.2.5)	Speed	km/h
			Position	m
5	Rolling stock condition parameters	Mass (5.3.2)		kg
6		Maximum operational speed of rolling stock (5.3.3)		km/h
7		Train length (5.3.4)		m
8		Unit running resistance force (5.3.5)		N/kg
9		Tractive force (5.3.6)		N
10		Braking deceleration (5.3.7)		m/s^2
11	Operational condition parameters	Stopping / passing (5.4.2)	Starting point	-
			Ending point	-
12		Maximum speed on operational condition (5.4.3)		km/h

5.2 Infrastructure parameters

5.2.1 General

Running time is affected by infrastructure-derived parameters such as gradients and speed limits which are all connected to position on the track. As infrastructure conditions change along the track, each parameter presented in this section can be determined in accordance with position, which is defined as the distance from the starting point of the calculation. The essential parameters deriving from infrastructure conditions are specified below.

5.2.2 Range of calculation

On a defined train route, the position of the starting point and ending point of calculation, expressed in [m], shall be defined.

5.2.3 Gradient

The gradient of the track, expressed in [‰], and the positions of its changing points, expressed in [m], shall be defined.

5.2.4 Allowed maximum speed

The allowed maximum speed of the infrastructure, expressed in [km/h], and the positions of its changing points, expressed in [m], shall be defined.

5.2.5 Speed limits from infrastructure conditions

Speed limits, expressed in [km/h], and its position and length, expressed in [m], shall be defined accordingly.

5.2.6 Other

Position of following track features, expressed in [m], should be defined: tunnels, curves, neutral sections, switches, etc.

5.3 Rolling stock condition parameters

5.3.1 General

Running time is affected by rolling-stock-derived parameters such as train mass, maximum speed and train length, etc. The essential parameters deriving from rolling stock conditions are specified below.

5.3.2 Mass

The mass of the train, expressed in [kg], shall be defined. The effect of inertia should be considered.

5.3.3 Maximum operational speed of rolling stock

The maximum operational speed of the rolling stock, expressed in [km/h], shall be defined.

5.3.4 Train length

The length of the train, expressed in [m], shall be defined.

5.3.5 Unit running resistance force

The unit running resistance force of the train, expressed in [N/kg], shall be defined.

Running resistance may differ according to the rolling stock type and track features.

Resistance has different sources. Speed dependency shall be considered.

NOTE It is allowed to combine different resistance forces and apply empiric values.

5.3.6 Tractive force

The tractive force, expressed in [N], shall be defined as a function of speed.

5.3.7 Braking deceleration

The deceleration when braking, expressed in [m/s^2], shall be defined.

NOTE Braking deceleration could depend on speed range and e.g. each section, train type.

5.4 Operational condition parameters

5.4.1 General

Running time is affected by operational-condition-derived parameters, such as whether a stop is made or not at the ends of the calculation section. The essential parameters deriving from operational conditions are specified below.

5.4.2 Stopping / passing

For the starting point and ending point of calculation (5.2.2), whether it is a stopping point or passing point shall be defined respectively. When the starting point is defined as a passing point, train speed at the point shall also be defined.

5.4.3 Maximum speed on operational condition

If any part of the track is intentionally operated below speed limits defined in 5.2.4, 5.2.5 and 5.3.3, the maximum operational speed, expressed in [km/h], shall be defined accordingly.

EXAMPLE If a train does not have the least required brake percentage, additional speed limits may apply.

6 Verification of the influence of the parameters in the shortest running time calculation

It is important to confirm the appropriate use of the parameters presented in 5.2, 5.3, and 5.4. The confirmation can be done by the method shown in this clause, observing and verifying the response of the calculated shortest running time when each corresponding parameter value is changed.

First, calculate the shortest running time using the parameter set shown in Table 2. The result is used as the reference value. Next, repeat the shortest running time calculation by using the parameter sets shown in Table 3 to Table 14 and compare each result with the reference value. The increase / decrease of each result shall follow Table 15.

NOTE 1 In Table 3 to Table 14, each parameter value presented in 5.2, 5.3 and 5.4 is changed one at a time to verify the appropriate use of the parameter.

NOTE 2 For verification, constant value of braking deceleration is used.

— Table 3 Range of calculation is changed.
— Table 4 Gradient is changed.
— Table 5 Allowed maximum speed is changed.
— Table 6 Speed limits from infrastructure conditions is changed.
— Table 7 Mass is changed.
— Table 8 Maximum operational speed of rolling stock is changed.
— Table 9 Train length is changed.
— Table 10 Unit running resistance force is changed.
— Table 11 Tractive force is changed.
— Table 12 Braking deceleration is changed.
— Table 13 Stopping/passing is changed.
— Table 14 Maximum speed on operational condition is changed.

Table 2 — Parameter set (Reference value)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
1	Infrastructure parameters	Range of calculation (5.2.2)	Ending point		m	12 000		
2	Infrastructure parameters	Gradient (5.2.3)	Gradient		‰	0		
2	Infrastructure parameters	Gradient (5.2.3)	Position	from	m	0		
2	Infrastructure parameters	Gradient (5.2.3)	Position	to	m	12 000		
3	Infrastructure parameters	Allowed maximum speed (5.2.4)	Speed		km/h	140		
3	Infrastructure parameters	Allowed maximum speed (5.2.4)	Position	from	m	0		
3	Infrastructure parameters	Allowed maximum speed (5.2.4)	Position	to	m	12 000		
4	Infrastructure parameters	Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
4	Infrastructure parameters	Speed limits from infrastructure conditions (5.2.5)	Position	from	m	0	5 000	7 000
4	Infrastructure parameters	Speed limits from infrastructure conditions (5.2.5)	Position	to	m	5 000	7 000	12 000
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1,2\times10^{5}$		
6	Rolling stock condition parameters	Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7	Rolling stock condition parameters	Train length (5.3.4)			m	80		
8	Rolling stock condition parameters	Unit running resistance force (5.3.5)			N/kg	$R=1,0\times10^{-2}+1,0\times10^{-4}\times V+1,0\times10^{-5}\times V^{2}$		
9	Rolling stock condition parameters	Tractive force (5.3.6)			N	$T=9,8\times10^{4}$ (0[km/h]≤V<40[km/h]) $T=-6,53\times10^{2}\times V+1,24\times10^{5}$ (40[km/h]≤V<100[km/h]) $T=-4,9\times10^{2}\times V+1,08\times10^{5}$ (100[km/h]≤V≤160[km/h])		
10	Rolling stock condition parameters	Braking deceleration (5.3.7)			m/s^2	$5,56\times10^{-1}$		
11	Operational condition parameters	Stopping / passing (5.4.2)	Starting point		-	Stopping point		
11	Operational condition parameters	Stopping / passing (5.4.2)	Ending point		-	Stopping point		
12	Operational condition parameters	Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 3 — Parameter set (Range of calculation is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	**Range of calculation (5.2.2)**	**Starting point**		**m**	**0**		
			Ending point			**13 000**		
2		Gradient (5.2.3)	Gradient		‰	0		
			Position	from	m	0		
				to		13 000		
3		Allowed maximum speed (5.2.4)	Speed		km/h	140		
			Position	from	m	0		
				to		13 000		
4		Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
			Position	from	m	0	5 000	7 000
				to		5 000	7 000	13 000
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1{,}2\times10^{5}$		
6		Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7		Train length (5.3.4)			m	80		
8		Unit running resistance force (5.3.5)			N/kg	$R=1{,}0\times10^{-2}+1{,}0\times10^{-4}\times V$ $+1{,}0\times10^{-5}\times V^{2}$		
9		Tractive force (5.3.6)			N	$T=9{,}8\times10^{4}$ (0[km/h]≤V<40[km/h]) $T=-6{,}53\times10^{2}\times V+1{,}24\times10^{5}$ (40[km/h] ≤V<100[km/h]) $T=-4{,}9\times10^{2}\times V+1{,}08\times10^{5}$ (100[km/h] ≤V≤160[km/h])		
10		Braking deceleration (5.3.7)			m/s²	$5{,}56\times10^{-1}$		
11	Operational condition parameters	Stopping / passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 4 — Parameter set (Gradient is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
			Ending point			12 000		
2		**Gradient (5.2.3)**	**Gradient**		**‰**	**20**	**0**	
			Position	**from**	**m**	**0**	**2 000**	
				to		**2 000**	**12 000**	
3		Allowed maximum speed (5.2.4)	Speed		km/h	140		
			Position	from	m	0		
				to		12 000		
4		Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
			Position	from	m	0	5 000	7 000
				to		5 000	7 000	12 000
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1{,}2\times10^{5}$		
6		Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7		Train length (5.3.4)			m	80		
8		Unit running resistance force (5.3.5)			N/kg	$R=1{,}0\times10^{-2}+1{,}0\times10^{-4}\times V+1{,}0\times10^{-5}\times V^{2}$		
9		Tractive force (5.3.6)			N	$T=9{,}8\times10^{4}$ (0[km/h]≤V<40[km/h]) $T=-6{,}53\times10^{2}\times V+1{,}24\times10^{5}$ (40[km/h]≤V<100[km/h]) $T=-4{,}9\times10^{2}\times V+1{,}08\times10^{5}$ (100[km/h]≤V≤160[km/h])		
10		Braking deceleration (5.3.7)			m/s^2	$5{,}56\times10^{-1}$		
11	Operational condition parameters	Stopping / passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 5 — Parameter set (Allowed maximum speed is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
			Ending point			12 000		
2		Gradient (5.2.3)	Gradient		‰	0		
			Position	from	m	0		
				to		12 000		
3		**Allowed maximum speed (5.2.4)**	**Speed**		**km/h**	**120**		
			Position	**from**	**m**	**0**		
				to		**12 000**		
4		Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
			Position	from	m	0	5 000	7 000
				to		5 000	7 000	12 000
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1,2 \times 10^{5}$		
6		Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7		Train length (5.3.4)			m	80		
8		Unit running resistance force (5.3.5)			N/kg	$R = 1,0 \times 10^{-2} + 1,0 \times 10^{-4} \times V + 1,0 \times 10^{-5} \times V^{2}$		
9		Tractive force (5.3.6)			N	$T = 9,8 \times 10^{4}$ (0[km/h] ≤V<40[km/h]) $T = -6,53 \times 10^{2} \times V + 1,24 \times 10^{5}$ (40[km/h] ≤V<100[km/h]) $T = -4,9 \times 10^{2} \times V + 1,08 \times 10^{5}$ (100[km/h] ≤V≤160[km/h])		
10		Braking deceleration (5.3.7)			m/s²	$5,56 \times 10^{-1}$		
11	Operational condition parameters	Stopping/passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 6 — Parameter set (Speed limits from infrastructure conditions is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
			Ending point			12 000		
2		Gradient (5.2.3)	Gradient		‰	0		
			Position	from	m	0		
				to		12 000		
3		Allowed maximum speed (5.2.4)	Speed		km/h	140		
			Position	from	m	0		
				to		12 000		
4		**Speed limits from infrastructure conditions (5.2.5)**	**Speed**		**km/h**	**140**	**100**	**140**
			Position	**from**	**m**	**0**	**5 000**	**6 000**
				to		**5 000**	**6 000**	**12 000**
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1,2\times10^{5}$		
6		Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7		Train length (5.3.4)			m	80		
8		Unit running resistance force (5.3.5)			N/kg	$R=1,0\times10^{-2}+1,0\times10^{-4}\times V+1,0\times10^{-5}\times V^{2}$		
9		Tractive force (5.3.6)			N	$T=9,8\times10^{4}$ (0[km/h] ≤V<40[km/h]) $T=-6,53\times10^{2}\times V+1,24\times10^{5}$ (40[km/h] ≤V<100[km/h]) $T=-4,9\times10^{2}\times V+1,08\times10^{5}$ (100[km/h] ≤V≤160[km/h])		
10		Braking deceleration (5.3.7)			m/s²	$5,56\times10^{-1}$		
11	Operational condition parameters	Stopping/passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 7 — Parameter set (Mass is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
			Ending point			12 000		
2		Gradient (5.2.3)	Gradient		‰	0		
			Position	from	m	0		
				to		12 000		
3		Allowed maximum speed (5.2.4)	Speed		km/h	140		
			Position	from	m	0		
				to		12 000		
4		Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
			Position	from	m	0	5 000	7 000
				to		5 000	7 000	12 000
5	Rolling stock condition parameters	**Mass (5.3.2)**			**kg**	$\mathbf{2{,}4 \times 10^{5}}$		
6		Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7		Train length (5.3.4)			m	80		
8		Unit running resistance force (5.3.5)			N/kg	$R = 1{,}0 \times 10^{-2} + 1{,}0 \times 10^{-4} \times V + 1{,}0 \times 10^{-5} \times V^2$		
9		Tractive force (5.3.6)			N	$T = 9{,}8 \times 10^{4}$ (0[km/h] ≤V<40[km/h]) $T = -6{,}53 \times 10^{2} \times V + 1{,}24 \times 10^{5}$ (40[km/h]≤V<100[km/h]) $T = -4{,}9 \times 10^{2} \times V + 1{,}08 \times 10^{5}$ (100[km/h] ≤V≤160[km/h])		
10		Braking deceleration (5.3.7)			m/s²	$5{,}56 \times 10^{-1}$		
11	Operational condition parameters	Stopping/passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 8 — Parameter set (Maximum operational speed of rolling stock is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
			Ending point			12 000		
2		Gradient (5.2.3)	Gradient		‰	0		
			Position	from	m	0		
				to		12 000		
3		Allowed maximum speed (5.2.4)	Speed		km/h	140		
			Position	from	m	0		
				to		12 000		
4		Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
			Position	from	m	0	5 000	7 000
				to		5 000	7 000	12 000
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1,2 \times 10^5$		
6		**Maximum operational speed of rolling stock (5.3.3)**			**km/h**	**120**		
7		Train length (5.3.4)			m	80		
8		Unit running resistance force (5.3.5)			N/kg	$R = 1,0 \times 10^{-2} + 1,0 \times 10^{-4} \times V + 1,0 \times 10^{-5} \times V^2$		
9		Tractive force (5.3.6)			N	$T = 9,8 \times 10^4$ (0[km/h]≤V<40[km/h]) $T = -6,53 \times 10^2 \times V + 1,24 \times 10^5$ (40[km/h]≤V<100[km/h]) $T = -4,9 \times 10^2 \times V + 1,08 \times 10^5$ (100[km/h]≤V≤160[km/h])		
10		Braking deceleration (5.3.7)			m/s²	$5,56 \times 10^{-1}$		
11	Operational condition parameters	Stopping/passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 9 — Parameter set (Train length is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
			Ending point			12 000		
2		Gradient (5.2.3)	Gradient		‰	0		
			Position	from	m	0		
				to		12 000		
3		Allowed maximum speed (5.2.4)	Speed		km/h	140		
			Position	from	m	0		
				to		12 000		
4		Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
			Position	from	m	0	5 000	7 000
				to		5 000	7 000	12 000
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1,2\times10^{5}$		
6		Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7		**Train length (5.3.4)**			**m**	**160**		
8		Unit running resistance force (5.3.5)			N/kg	$R=1,0\times10^{-2}+1,0\times10^{-4}\times V+1,0\times10^{-5}\times V^{2}$		
9		Tractive force (5.3.6)			N	$T=9,8\times10^{4}$ (0[km/h]≤V<40[km/h]) $T=-6,53\times10^{2}\times V+1,24\times10^{5}$ (40[km/h]≤V<100[km/h]) $T=-4,9\times10^{2}\times V+1,08\times10^{5}$ (100[km/h]≤V≤160[km/h])		
10		Braking deceleration (5.3.7)			m/s²	$5,56\times10^{-1}$		
11	Operational condition parameters	Stopping/passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 10 — Parameter set (Unit running resistance force is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
			Ending point			12 000		
2		Gradient (5.2.3)	Gradient		‰	0		
			Position	from	m	0		
				to		12 000		
3		Allowed maximum speed (5.2.4)	Speed		km/h	140		
			Position	from	m	0		
				to		12 000		
4		Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
			Position	from	m	0	5 000	7 000
				to		5 000	7 000	12 000
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1,2 \times 10^{5}$		
6		Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7		Train length (5.3.4)			m	80		
8		**Unit running resistance force (5.3.5)**			**N/kg**	$\boldsymbol{R = 2,0 \times 10^{-2} + 2,0 \times 10^{-4} \times V + 2,0 \times 10^{-5} \times V^{2}}$		
9		Tractive force (5.3.6)			N	$T = 9,8 \times 10^{4}$ (0[km/h]≤V<40[km/h]) $T = -6,53 \times 10^{2} \times V + 1,24 \times 10^{5}$ (40[km/h]≤V<100[km/h]) $T = -4,9 \times 10^{2} \times V + 1,08 \times 10^{5}$ (100[km/h]≤V≤160[km/h])		
10		Braking deceleration (5.3.7)			m/s²	$5,56 \times 10^{-1}$		
11	Operational condition parameters	Stopping/passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton

Table 11 — Parameter set (Tractive force is changed)

No.	Classification	Parameter (Subclause)			Unit	Values of each parameter		
1	Infrastructure parameters	Range of calculation (5.2.2)	Starting point		m	0		
			Ending point			12 000		
2		Gradient (5.2.3)	Gradient		‰	0		
			Position	from	m	0		
				to		12 000		
3		Allowed maximum speed (5.2.4)	Speed		km/h	140		
			Position	from	m	0		
				to		12 000		
4		Speed limits from infrastructure conditions (5.2.5)	Speed		km/h	140	60	140
			Position	from	m	0	5 000	7 000
				to		5 000	7 000	12 000
5	Rolling stock condition parameters	Mass (5.3.2)			kg	$1{,}2 \times 10^{5}$		
6		Maximum operational speed of rolling stock (5.3.3)			km/h	140		
7		Train length (5.3.4)			m	80		
8		Unit running resistance force (5.3.5)			N/kg	$R = 1{,}0 \times 10^{-2} + 1{,}0 \times 10^{-4} \times V + 1{,}0 \times 10^{-5} \times V^{2}$		
9		**Tractive force (5.3.6)**			**N**	$\mathbf{T = 1{,}8 \times 10^{5}}$ **(0[km/h]≤*V*<40[km/h])** $\mathbf{T = -6{,}53 \times 10^{2} \times V + 1{,}44 \times 10^{5}}$ **(40[km/h]≤*V*≤160[km/h])**		
10		Braking deceleration (5.3.7)			m/s^2	$5{,}56 \times 10^{-1}$		
11	Operational condition parameters	Stopping/passing (5.4.2)	Starting point		-	Stopping point		
			Ending point		-	Stopping point		
12		Maximum speed on operational condition (5.4.3)			km/h	140		

Key

V: Train speed, expressed in kilometre per hour

T: Total tractive force of a train, expressed in newton