Assessment of railway vehicles interaction with Swedish railway infrastructure
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1 Introduction

Transportstyrelsen [the Swedish Transport Agency] regulations on authorisation of subsystems in railways, etc. (TSFS 2010:116) contain provisions on the procedure for authorisation of railway vehicles. In accordance with the regulations for authorisation, Transportstyrelsen requests documentation certifying that the railway vehicle conforms to Swedish railway infrastructure in terms of safety. Transportstyrelsen requires the assessment to be carried out by an independent competent party. Transportstyrelsen has issued guidelines on the regulations for authorisation entitled “Guidelines for authorisation”. However, they contain no guidance regarding the documentation needed for certifying safe interaction between railway vehicle and Swedish railway infrastructure.

These guidelines therefore contain a compilation of documents containing requirements applying to or which may apply to railway vehicles and their conformity with Swedish railway infrastructure. This compilation should be regarded as a guide to how the requirements for conformity between railway vehicles and infrastructure may be fulfilled and then certified in the authorisation process. There may also be other technical solutions for ensuring compliance with the requirement that the railway vehicle must conform to railway infrastructure in terms of safety. The applicant can do this by, for example, submitting a risk analysis to Transportstyrelsen.

The certification submitted to Transportstyrelsen must contain a statement of whether or not the vehicle fulfils the relevant requirements and a list of documents forming the basis for the review. If the vehicle does not fulfil relevant requirements, any deviations must be described. The reviewer should, if possible, also propose restrictions to the vehicle to enable it to be operated in a safe manner. An assignment may include one or more of the requirement areas established for the type of vehicle in question and several different independent reviewers may therefore be engaged. Foreign authorisation may be accepted as certification – the authorisation must then clearly state that the requirement areas in question have been fulfilled.

When a vehicle which has been authorised in Sweden is upgraded or renewed, the review of that vehicle need only include the modified functions and their interfaces. A assessment need not be carried out after repairs or maintenance work. The applicant must submit a description of the modification along with the application for authorisation to Transportstyrelsen. Transportstyrelsen then decides which requirement areas are to be reviewed.

These guidelines do not include documents relating to the Danish part of the infrastructure managed by Øresundsbro Konsortiet. Reviews relating to connections between Danish and Swedish train radio, connections between Danish and Swedish ATCs, tunnel conditions and other specifically Danish conditions are carried out by the Danish authorities that issue authorisation.
for the Danish part of the infrastructure managed by Øresundsbro Konsortiet.

2 Abbreviations

ATC2 The Swedish/Norwegian Automatic Train Control system
ETCS European Train Control System (Joint European train control system intended to replace ATC2)
GSM-R Digital mobile telephone network adapted for railways
SS-EN Swedish and European standard
STM Specific Transmission Module (used along with ETCS in operation of tracks with ATC-2)
TDOK Document from Trafikverket
TSI Technical Specifications for Interoperability
TSI CCS TSI Control, Command and Signalling
TSI WAG TSI Freight wagons
TSI Loc&Pas TSI Locomotives and passenger vehicles
3 Locomotives and multiple-units

3.1 Detectability in terms of signal safety

The vehicle must comply with the applicable parts of TSI CCS Appendix A index 77 [1] (ERA/ERTMS/033281), and the following requirements.

1. If the distance between two of the vehicle’s axles exceed 17.5 m, the vehicle can’t be operated without restrictions.
2. If the distance between the vehicle’s first and last axle is less than 4.5 m, the vehicle can’t be operated without restrictions.
3. If a vehicle, with a buffer overhang exceeding 2.5 m, has a maximum total curve geometric displacement ($\Delta y$) that is larger than allowed distance from centre of the track, $x$, the vehicle can’t be operated without restrictions. If the requirement isn’t fulfilled the vehicle can’t be put in the end of a train.

$\Delta y$ and $x$ are calculated according to formulas below (see also reference [2]):

$$x = \frac{188.01}{\cos(\arccos(\frac{188.01}{191.93}) - \frac{n - 2.5}{190})} - 190$$

$$\Delta y = \Delta i + kp = \frac{4n(r+n) - p^2}{8 \times 190} + kp$$

- $x$ Maximum allowed distance from centre of the track [m]
- $\Delta y$ Total curve geometric displacement (calculates for $n=2.5$ to $n=b_n$) [m]
- $\Delta i$ Curve geometric displacement (the difference between the lateral position of the vehicle and the track centre line in a curve) [m]
- $kp$ Construction gauge (half the width of a vehicle) [m]
- $r$ Inner wheelbase (single axle running gear)/Pivot distance (vehicle with bogie) [m]
- $n$ Distance to closest axle/pivot (calculates from 2.5 to buffer overhang) [m]
- $p$ Wheelbase of the bogie (=0 at single axle running gear) [m]

TDOK 2014:0776 [3] shows how the requirement on electrical resistance between the rolling surfaces on opposite wheels in a wheelset is measured by a measuring voltage between 1.8 VDC and 2.0 VDC (open voltage).
3.2 Interaction with train detection systems

Vehicles with ETCS installations must fulfil TSI CCS [1] and for vehicles with ATC2 there is guideline in Transportstyrelsen guidelines “ATC installations in vehicles” [4]. (No guidelines for installation of STM have yet been produced by Transportstyrelsen.)

3.3 The infrastructure scanning for railway vehicles

If the vehicle has no onboard hot axle box detection, the vehicle chassis and running gear must be designed according to the requirements in TDOK 2014:0690 [5].

TSI Loc&Pas ch. 7.3.2.3 [21].

3.4 Communication between the railway vehicle and traffic management

The vehicle must fulfil TSI CCS [1] and Transportstyrelsen guidelines “GSM-R installations in vehicles” [6].

3.5 Dynamic interaction with the track

Vehicles must comply with the relevant safety limits values in SS-EN 14363 [7] and ERA/TD/2012-17/int [21]. Other measured values must be reported. For axle loads over 22.5 tonnes to 35 tonnes there are requirements in a draft regulation [8].

TSI Loc&Pas ch. 4.2.3.4 [21].

3.6 Dynamic and static profile

The vehicle profile must comply with the requirements for dynamic profile SEa or SEc in SS-EN 15273-2 [11] or static profile A or C in TDOK 2015:0143 [10]. For vehicles with profile G1, GA, GB or GC according to SS-EN 15273-2 [11] the following apply.

- G1, GA, GB are housed in Swedish profile SEa.
- GC is housed in Swedish profile SEc.

Specifically for infrastructure managed by Øresundsbro Konsortiet
The vehicle profile must comply with the requirements for GC profiles in SS-EN 15273-2 [11]. Vehicles with Swedish profile A or SEa fulfils that requirement.
3.7 Electromagnetic compatibility with the environment excluding energy

The vehicle must comply with SS-EN 50121-3-1 [12], SS-EN 50500 [12] and SS-EN 62311 [12]. Additional requirements for vehicles with pantographs are to be found in chapter 3.8. Vehicles without pantograph shall fulfil requirements for protection against electric shock according to SS-EN 50153 [13].

3.8 Current collection and interaction with the infrastructure energy system


Specifically for infrastructure managed by Øresundsbro Konsortiet

The vehicle must also comply with requirements in chapter 8 in Trafikstyrelsens "Bekendtgørelse om køretøjers tekniske kompatibilitet med jernbanenettet", no. 1127 [17]).

Safe switching between Danish and Swedish energy systems shall be proven.

3.9 Towing, lifting/rescue

It must be possible to tow the vehicle with another vehicle equipped with draw gear and buffers in accordance with SS-EN 15566 [18]. Vehicles not equipped with draw gear and buffers in accordance with SS-EN 15566 [18] must carry an emergency coupler to enable them to be towed.

The following information shall be given to Transportstyrelsen:
- Weight of emergency coupler [kg].
- Estimated time and conditions for mounting of emergency coupler [min].
- Maximum speed and the conditions that apply when towing the rescue coupler [km/h]. Recommended lowest speed is 30 km/h.
- Ability to connect to the brake systems main pipe.

There shall be instructions for towing and rescuing of the vehicle.
4 Passenger coaches

4.1 Detectability in terms of signal safety

The vehicle must comply with the applicable parts of TSI CCS Appendix A index 77 [1] (ERA/ERTMS/033281), and the following requirements.

1. If the distance between two of the vehicle’s axles exceed 17.5 m, the vehicle can’t be operated without restrictions.

2. If the distance between the vehicle’s first and last axle is less than 4.5 m, the vehicle can’t be operated without restrictions.

3. If a vehicle, with a buffer overhang exceeding 2.5 m, has a maximum total curve geometric displacement ($\Delta y$) that is larger than allowed distance from centre of the track, $x$, the vehicle can’t be operated without restrictions. If the requirement isn’t fulfilled the vehicle can’t be put in the end of a train.

$\Delta y$ and $x$ are calculated according to formulas below (see also reference [2]):

$$ x = \frac{188.01}{\cos(\arccos\left(\frac{188.01}{191.93}\right) - \frac{n - 2.5}{190})} - 190 $$

$$ \Delta y = \Delta i + kp = \frac{4n(r+n) - p^2}{8 \times 190} + kp $$

- $x$ Maximum allowed distance from centre of the track [m]
- $\Delta y$ Total curve geometric displacement (calculates for $n=2.5$ to $n=b_n$) [m]
- $\Delta i$ Curve geometric displacement (the difference between the lateral position of the vehicle and the track centre line in a curve) [m]
- $kp$ Construction gauge (half the width of a vehicle) [m]
- $r$ Inner wheelbase (single axle running gear)/Pivot distance (vehicle with bogie) [m]
- $n$ Distance to closest axle/pivot (calculates from 2.5 to buffer overhang) [m]
- $p$ Wheelbase of the bogie (=0 at single axle running gear) [m]

TDOK 2014:0776 [3] shows how the requirement on electrical resistance between the rolling surfaces on opposite wheels in a wheelset is measured by a measuring voltage between 1.8 VDC and 2.0 VDC (open voltage).

4.2 The infrastructure scanning for defective railway vehicles

If the vehicle has no onboard hot axle box detection, the vehicle chassis and running gear must be designed according to the requirements in TDOK 2014:0690 [5].
4.3 Dynamic interaction with the track

Vehicles must comply with the relevant safety limits values in SS-EN 14363 [7] and ERA/TD/2012-17/INT [21]. Other measured values must be reported. For axle loads over 22.5 tonnes to 35 tonnes there are requirements in a draft regulation [8].

TSI Loc&Pas ch. 7.3.2.3 [21].

4.4 Dynamic and static profile

The vehicle profile must comply with the requirements for dynamic profile SEa or SEc in SS-EN 15273-2 [11] or static profile A or C in TDOK 2015:0143 [10]. For vehicles with profile G1, GA, GB or GC according to SS-EN 15273-2 [11] the following apply.
- G1, GA, GB are housed in Swedish profile SEa.
- GC is housed in Swedish profile SEc.

Specifically for infrastructure managed by Øresundsbro Konsortiet
The vehicle profile must comply with the requirements for GC profiles in SS-EN 15273-2 [11]. Vehicles with Swedish profile A or SEa fulfils that requirement.

TSI Loc&Pas ch. 4.2.3.1 [21].

4.5 Electromagnetic compatibility with the environment excluding energy

The vehicle must comply with SS-EN 50121-3-1 [12], SS-EN 50500 [12] and SS-EN 62311 [12].
The vehicle shall fulfil requirements for protection against electric shock according to SS-EN 50153 [13].

4.6 Towing, lifting/rescue

It must be possible to tow the vehicle with another vehicle equipped with draw gear and buffers in accordance with SS-EN 15566 [18]. Vehicles not equipped with draw gear and buffers in accordance with SS-EN 15566 [18] must carry an emergency coupler to enable them to be towed.
The following information shall be given to Transportstyrelsen:
- Weight of emergency coupler [kg].
- Estimated time and conditions for mounting of emergency coupler [min].
- Maximum speed and the conditions that apply when towing the rescue coupler [km/h]. Recommended lowest speed is 30 km/h.
- Ability to connect to the brake systems main pipe.

There shall be instructions for towing and rescuing of the vehicle.

TSI Loc&Pas ch. 4.2.12.5 och 4.2.12.6 [21].
5  Freight wagons

5.1  Detectability in terms of signal safety

The vehicle must comply with the applicable parts of TSI CCS Appendix A index 77 [1] (ERA/ERTMS/033281), and the following requirements.

1. If the distance between two of the vehicle’s axles exceed 17.5 m, the vehicle can’t be operated without restrictions.

2. If the distance between the vehicle’s first and last axle is less than 4.5 m, the vehicle can’t be operated without restrictions.

3. If a vehicle, with a buffer overhang exceeding 2.5 m, has a maximum total curve geometric displacement ($\Delta y$) that is larger than allowed distance from centre of the track, $x$, the vehicle can’t be operated without restrictions. If the requirement isn’t fulfilled the vehicle can’t be put in the end of a train.

$\Delta y$ and $x$ are calculated according to formulas below (see also reference [2]):

$$x = \frac{188.01}{\cos(\arccos(\frac{188.01}{191.93}) - \frac{n - 2.5}{190})} - 190$$

$$\Delta y = \Delta i + kp = \frac{4n(r+n) - p^2}{8 \times 190} + kp$$

- $x$: Maximum allowed distance from centre of the track [m]
- $\Delta y$: Total curve geometric displacement (calculates for n=2.5 to n=bn) [m]
- $\Delta i$: Curve geometric displacement (the difference between the lateral position of the vehicle and the track centre line in a curve) [m]
- kp: Construction gauge (half the width of a vehicle) [m]
- r: Inner wheelbase (single axle running gear)/Pivot distance (vehicle with bogie) [m]
- n: Distance to closest axle/pivot (calculates from 2.5 to buffer overhang) [m]
- p: Wheelbase of the bogie (=0 at single axle running gear) [m]

TDOK 2014:0776 [3] shows how the requirement on electrical resistance between the rolling surfaces on opposite wheels in a wheelset is measured by a measuring voltage between 1.8 VDC and 2.0 VDC (open voltage).

5.2  The infrastructure scanning for defective railway vehicles

If the vehicle has no onboard hot axle box detection, the vehicle chassis and running gear must be designed according to the requirements in TDOK 2014:0690 [5].
**5.3 Dynamic interaction with the track**

Vehicles must comply with the relevant safety limits values in SS-EN 14363 [7], ERA/TD/2013-01/INT [22] and/or SS-EN 15687 [9]. Other measured values must be reported. For axle loads over 25 tonnes to 35 tonnes there are requirements in a draft regulation [8].

TSI WAG chap. 7.3.2.2 [22].

**5.4 Dynamic and static profile**

The vehicle profile must comply with the requirements for dynamic profile SEa or SEc in SS-EN 15273-2 [11] or static profile A or C in TDOK 2015:0143 [10]. For vehicles with profile G1, GA, GB or GC according to SS-EN 15273-2 [11] the following apply.
- G1, GA, GB are housed in Swedish profile SEa.
- GC is housed in Swedish profile SEc.

Specifically for infrastructure managed by Øresundsbro Konsortiet

The vehicle profile must comply with the requirements for GC profiles in SS-EN 15273-2 [11]. Vehicles with Swedish profile A or SEa fulfils that requirement.

TSI WAG chap. 4.2.3.5 [22].

**5.5 Electromagnetic compatibility with the environment excluding energy**

The vehicle must comply with SS-EN 50121-3-1 [12].

The vehicle shall fulfil requirements for protection against electric shock according to SS-EN 50153 [13].

**5.6 Towing, lifting/rescue**

It must be possible to tow the vehicle with another vehicle equipped with draw gear and buffers in accordance with SS-EN 15566 [18]. Vehicles not equipped with draw gear and buffers in accordance with SS-EN 15566 [18] must carry an emergency coupler to enable them to be towed.

The following information shall be given to Transportstyrelsen:
- Weight of emergency coupler [kg].
- Estimated time and conditions for mounting of emergency coupler [min].
- Maximum speed and the conditions that apply when towing the rescue coupler [km/h]. Recommended lowest speed is 30 km/h.
- Ability to connect to the brake systems main pipe.

There shall be instructions for towing and rescuing of the vehicle.
6 Vehicles for construction or maintenance

6.1 Detectability in terms of signal safety

The vehicle must comply with the applicable parts of TSI CCS Appendix A index 77 [1] (ERA/ERTMS/033281), and the following requirements.

1. If the distance between two of the vehicle’s axles exceed 17.5 m, the vehicle can’t be operated without restrictions.

2. If the distance between the vehicle’s first and last axle is less than 4.5 m, the vehicle can’t be operated without restrictions.

3. If a vehicle, with a buffer overhang exceeding 2.5 m, has a maximum total curve geometric displacement ($\Delta y$) that is larger than allowed distance from centre of the track, $x$, the vehicle can’t be operated without restrictions. If the requirement isn’t fulfilled the vehicle can’t be put in the end of a train.

$\Delta y$ and $x$ are calculated according to formulas below (see also reference [2]):

$$x = \frac{188.01}{\cos(\arccos(\frac{188.01}{191.93}) - \frac{n - 2.5}{190})} - 190$$

$$\Delta y = \Delta i + kp = \frac{4n(r+n) - p^2}{8 \times 190} + kp$$

TDOK 2014:0776 [3] shows how the requirement on electrical resistance between the rolling surfaces on opposite wheels in a wheelset is measured by a measuring voltage between 1.8 VDC and 2.0 VDC (open voltage).

6.2 Interaction with train detection systems

Vehicles with ETCS installations must fulfil TSI CCS [1] and for vehicles with ATC2 there is guideline in Transportstyrelsen guidelines “ATC installations in vehicles” [4]. (No guidelines for installation of STM have yet been produced by Transportstyrelsen.)
6.3 The infrastructure scanning for defective railway vehicles
If the vehicle has no onboard hot axle box detection, the vehicle chassis and running gear must be designed according to the requirements in TDOK 2014:0690 [5].

TSI Loc&Pas ch. 7.3.2.3 [21].

6.4 Communication between the railway vehicle and traffic management
The vehicle must fulfil TSI CCS [1] and Transportstyrelsen guidelines “GSM-R installations in vehicles” [6].

6.5 Dynamic interaction with the track
Vehicles must comply with the relevant safety limits values according to chapter 8 in SS-EN 14033-1 [20] and ERA/TD/2012-17/INT [21]. Other measured values must be reported.

TSI Loc&Pas ch. 4.2.3.4 [21].

6.6 Dynamic and static profile
The vehicle profile must comply with the requirements for dynamic profile SEa or SEc in SS-EN 15273-2 [11] or static profile A or C in TDOK 2015:0143 [10]. For vehicles with profile G1, GA, GB or GC according to SS-EN 15273-2 [11] the following apply.
- G1, GA, GB are housed in Swedish profile SEa.
- GC is housed in Swedish profile SEc.

Specifically for infrastructure managed by Øresundsbro Konsortiet
The vehicle profile must comply with the requirements for GC profiles in SS-EN 15273-2 [11]. Vehicles with Swedish profile A or SEa fulfills that requirement.

TSI Loc&Pas ch. 4.2.3.1 [21].
6.7 Electromagnetic compatibility with the environment excluding energy

The vehicle must comply with SS-EN 50121-3-1 [12], SS-EN 50500 [12] and SS-EN 62311 [12]. Additional requirements for vehicles with pantographs are to be found in chapter 6.8. Vehicles without pantograph shall fulfil requirements for protection against electric shock according to SS-EN 50153 [13].

6.8 Current collection and interaction with the infrastructure energy system

Requirements according to chapter 3.8.

6.9 Towing, lifting/rescue

It must be possible to tow the vehicle with another vehicle equipped with draw gear and buffers in accordance with SS-EN 15566 [18]. Vehicles not equipped with draw gear and buffers in accordance with SS-EN 15566 [18] must carry an emergency coupler to enable them to be towed.

The following information shall be given to Transportstyrelsen:
- Weight of emergency coupler [kg].
- Estimated time and conditions for mounting of emergency coupler [min].
- Maximum speed and the conditions that apply when towing the rescue coupler [km/h]. Recommended lowest speed is 30 km/h.
- Ability to connect to the brake systems main pipe.

There shall be instructions for towing and rescuing of the vehicle.

TSI Loc&Pas ch. 4.2.12.5 och 4.2.12.6 [21].
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7 References

[1] TSD Trafikstyrning och signalering (ERA/ERTMS/033281) *
[2] Utredning om kollisionsrisk mellan fordon i växlar på grund av långt buffertöverhäng i kombination med kort avstånd mellan hindersfrihetspunkt och isolerskarv, F08-13349/TR60 (2009-06-11)
[4] Transportstyrelsens vägledning ”ATC-installationer i fordon” *
[6] Transportstyrelsens vägledning ”GSM-R –installationer i fordon” *
[8] "Regulation on Running Dynamics Requirements for vehicles with an axle load higher than 25 tonnes and up to and including 35 tonnes" (2013-09-22)
• SS-EN 50500 ”Mätning av elektromagnetiska fält från elektriska och elektroniska apparater med avseende på exponering” (2008) www.sis.se
[14] TDOK 2014:0774 ”BVS 543.19300 - Elektriska krav på fordon med avseende på kompatibilitet med infrastrukturen och andra fordon” (2010-02-05)
[16] Bekendtgørelse om køretojers tekniske kompatibilitet med jernbananetet www.trafikstyrelsen.dk
[18] TSD WAG ”Rullande materiel – Godsvagnar” *
[20] Kommissionens förordning nr 1302/2014 om en teknisk specifikation för driftskompatibilitet avseende delsystemet Rullande materiel – Lok och passagerarfordon i Europeiska unionens järnvägssystem *
• ERA/TD/2012-17/INT
[21] Kommissionens förordning nr 321/2013 om teknisk specifikation för driftskompatibilitet avseende delsystemet Rullande materiel – godsvagnar i Europeiska unionens järnvägssystem *
• ERA/TD/2013-01/INT
* www.transportstyrelsen.se