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Ansvarig enhet
Expertstöd Teknik

Fordon - krav på strömavtagare

Krav på strömavtagare och interaktionen mellan strömavtagaren och kontaktledningen

Innehållsförteckning

Förord / Syfte

Denna standard BVS 543.330 är framtagen i samarbete mellan banverket i Sverige, Jernbaneverket i Norge och Banförvaltningscentralen i Finland inom NES-arbetet (Nordiskt elsamarbete). Standarden sammanställer olika krav på strömavtagare och strömavtagarinteraktion med kontaktledningen för att fordon ska kunna erhålla spårmedgivanden.
Dokumentet vänder sig till operatörer och fordonstillverkare som önskar spårmedgivande för ett fordon eller en fordonstyp för att få trafikera Banverkets spåranläggningar.
Denna tekniska systemstandard (BVS) ersätter BVS 543.330 från 2007-01-31.
Förändringsförslag som berör denna BVS ska ställas till ”Leveransdivision Anläggning”.

1 Omfattning

Denna standard (BVS 543.330 version 3) sammanställer alla krav som Banverket ställer på fordon med strömavtagare. Kraven ställs på strömavtagaren samt strömavtagar-/kontaktledningsinteraktionen.
De norska och finska krav som finns i denna standard är enbart med som information, samt för att underlätta för operatörer och tillverkare att få godkännande i både Norge, Finland och Sverige.
Kraven i denna standard finns i bilagan, vilken är ett gemensamt dokument för Jernbaneverket, RHK och Banverket.
Dokumentet riktar sig till trafikoperatörer och fordonstillverkare som önskar spårmedgivande för att få trafikera Banverkets spåranläggningar med ett fordon eller en fordonstyp.

2 Referenser

2.1 Bindande referenser

[1] NES TS01-Technical specification: Approval of new trains - Pantographs and pantograph-/overhead contact line interaction

3 Definitioner och förkortningar

Definitioner enligt refererade standarder i referens [1].

4 Ansvar

Ej relevant för detta dokument.

5 Krav på strömavtagare

Alla krav på strömavtagare och strömavtagning finns beskrivna i referens [1]. Där finns även beskrivningar av de prov som en fordonstyp måste genomgå för att erhålla ett spårmedgivande vad gäller strömavtagning. Till grund för kraven ligger befintliga europastandarder, främst EN 50 206-1, EN 50 367 och EN 50 317.
Referens [1] innehåller dessutom bilagor som beskriver kontaktledningssystemen, befintliga strömavtagare samt andra förhållanden som är av intresse för att kunna få en fordonstyp att klara de krav som ställs.

6 Bilagor

NES TS01-Technical specification: Approval of new trains - Pantographs and pantograph-/overhead contact line interaction

NES	TECHNICAL SPECIFICATION	TS 01
NORDIC ELECTRIC POWER CO-OPERATION	FROM THE NES GROUP	PAGES: 35 ENCLOSURES: 1 DATE: 19.04.2007 SECOND VERSION

Approval of new trains

Pantographs and pantograph-overhead contact line interaction

1 SCOPE

Existing and new standards regarding different aspects of compatibility between vehicles and electrical infrastructure do not cover all issues, especially those issues which are specific for Finland, Norway and Sweden. This has been experienced in different acceptance processes of new vehicles.

The objective for this project was to compile all relevant pantograph and pantograph - overhead contact line interaction requirements in a report in order to simplify the acceptance process for new rolling stock in Finland, Norway and Sweden and to cover all possible compatibility aspects. This report deals with requirements regarding pantographs and the interaction between pantographs and overhead contact lines.

The aim of this report is to give a common Nordic model for approving electric powered trains equipped with pantographs for overhead contact lines in Finland, Norway and Sweden.

The report consists of information on how to achieve this.

The first part describes which type tests must be performed on pantograph and vehicle.

The second part describes the measurement of interaction between pantograph and overhead contact lines in various train/pantograph configurations.

Further on there are references on how and what to do, based on international norms with acceptance criteria.

Approval is given for a specific train traffic configuration even though type test might be done in a test stand.

The results from the measurements must prove to be in accordance with the demands given in this document.

The document is first and foremost based on the standards EN 50 317, EN 50 206 and EN 50 367. This does not imply that other standards are obsolete.

The document concentrates on the specific national conditions that are valid for Finland, Norway or Sweden and topics that are not completely covered by the standards mentioned above.

The requirements in this document are valid for:

- first time use of rolling stock or reintroduction of rolling stock that have been considered out of use permanently
- rolling stock that is going to be introduced on sections of track not included in current acceptance
- changes in rolling stock usage not in compliance with current acceptance
- modifications of rolling stock in a way that may affect the compliance with the current acceptance.

This means that the requirements in this document are valid for new electric traction vehicle and old used vehicles that have not been used in normal operation in Finland, Norway or Sweden before. An old vehicle used in one of the countries is, however, not automatically accepted in the other countries, due to differences in older requirements.

The requirements in this document can however be discussed when applied on imported old vehicles.

The intension is to harmonize the requirements and tests as much as possible. The aim is that when a vehicle is tested to be accepted in one country, fulfilment of a requirement shall also be valid in another country if that country has the same requirement. This is especially valid for Norway and Sweden, which have very similar power supply systems.

A summary of how and for which rolling stock the requirements are valid is given in Table 1 below.

Rolling stock	**New**	**Existing**
Domestic (only for use in either Norway, Sweden or Finland)	All requirements are mandatory.	Already accepted. For any rebuilds or modifications all requirements are still mandatory, however some test in 7.4, 7.6 and 7.7 can be omitted after approval from the infrastructure manager.
Foreign (vehicles for cross border operation or used vehicles from other countries)	All requirements are mandatory. Some test in 7.6.3 and 7.7 can be omitted after approval from the infrastructure manager.	All requirements are mandatory. Some test in 7.4, 7.6.2, 7.6.3 and 7.7 can be omitted after approval from the infrastructure manager.

Table 1 Requirements for new and existing rolling stock.

2 REFERENCES

[1]	NES I05	Prestudy for overhead contact line and pantograph operations in the Nordic countries.
[2]	NES I06	Europantograph and free space for pantographs in the Nordic countries.
[3]	EN 50206-1:1998	Railway applications – Rolling Stock – Pantographs - Characteristics and tests - Part 1: Pantographs for main line vehicles.
[4]	EN 50317:2001	Railway applications – Current collection systems – requirements for and validations of measurements of the dynamic interaction between pantographs and overhead contact line.
[5]	EN 50318:2001	Railway applications – Current collection systems – Validation of simulation of the dynamic interaction between pantograph and overhead contact line.
[6]	EN 50367:2006	Railway applications – Current collection systems – Technical criteria for the interaction between pantograph and overhead line (to achieve free access).
[7]	EN 12499:2003	International cathodic protection of metallic structures.
[8]	BVS 543.35020	Systembeskrivning ST 7.1/7.1 - Banverket
[9]	BVS 543.35050	Systembeskrivning SYT 7.0/9.8 - Banverket
[10]	BVS 543.35080	Systembeskrivning SYT 15/15 - Banverket
[11]	BVF 504	Spårgående fordon, typmedgivande, spårmedgivande och dispens - Banverket
[12]	SJF 400.7	Normalsektionsföreskrifter för dimensionering av järnvägsfordon och laster på dessa - SJ
[13]	JD 590	Infrastrukturens egenskaper - Jernbaneverket
[14]	BVF 586.20:1998	Fritt utrymme utmed banan - Banverket
[15]	BVF 999.19:2002	Förbud mot strömavtagare på A-fordon och K-fordon
[16]	EN 50405:2006	Railway applications - Current collection systems - Pantographs, testing methods for carbon contact strips

3 DEFINITIONS

A.D.D	Automatic dropping device
Europantograph	1600 mm wide pantograph defined in EN 50367:2006
Stiff overhead contact line system	Overhead contact line system with low elasticity for vertical forces
Soft overhead contact line system	Overhead contact line system with high elasticity for vertical forces
v	Train speed in [km/h]

4 INFORMATION ON OVERHEAD CONTACT LINE SYSTEMS AND PANTOGRAPHS FOR APPROVAL OF NEW TRAINS

4.1 General

This chapter gives a short introduction to the different overhead contact line systems in the Nordic countries and also an overview of the most used pantographs currently in service.

4.2 Overhead contact lines characteristics

4.2.1 Characteristics

The different overhead contact line systems in the Nordic countries are given in NES I05 [1]. The different systems used for testing according to the requirements in this report are given in Table 2.

Country	Name	Stitch wire	Tensile force messenger wire (kN)	Tensile force of contact wire(kN)	Maximum allowed speed (km/h)	Reference
Finland	SR without stitch wire	NO	9,8	9,8	140	NES I05 [1]
Finland	SR 70	YES	9,8	9,8	160	NES I05 [1]
Finland	SR 220	YES	12,5	12,5	220	NES I05 [1]
Norway	Tabell 54	NO	6,13	4,9	130	NES I05 [1]
Norway	System 20A	YES	10	10	200	NES I05 [1]
Norway	System 25	YES	15	15	250	NES I05 [1]
Sweden	ST 7,1/7,1	NO	7,1	7,1	140	NES I05 and BVS 543.35020 [8]
Sweden	SYT 7,0/9,8	YES	7	9,8	200	NES I05 and BVS 543.35050 [9]
Sweden	SYT 15/15	YES	15	15	250	NES I05 and BVS 543.35080 [10]

Table 2 Overhead contact line systems for testing.

4.2.2 Use of Europantograph on existing lines

The use of Europantograph in Sweden, Denmark and Norway is investigated in NES I06 [2]. Today, and for many years ahead, the Europantograph is not applicable in Sweden, Norway and Finland because of the design of most of the existing overhead contact lines.

4.3 Pantographs

4.3.1 Pantographs in service

Table 3 shows which pantographs that are in use and are approved in each country.

Pantograph tests according to 7.4 for approved pantographs don't have to be performed again unless there are modifications made that effect the pantograph's functionality.

Pantograph name	**Countries**		
	Finland	Norway	Sweden
DSA 200			X
DSA 350 S	X		
LLXJ 235 LLXJA 135			X
LSFC 201 LSFC 202		X	X
LSFC 204		X	X
SB 10		X	X
SIEMENS type 6			X
WBL 85 WBL 88		X	X
8WLO 120			X

Table 3 Approved pantographs.

The material for contact strips is plain carbon and shall confirm to prEN 50405:2006 [16].

4.3.2 Specific information for Finland

The overhead contact lines in Finland are designed for a 1950 mm wide pantograph.
For more information on the pantograph profile: EN 50367:2006, Appendix B, Figure B.3 [6].

4.3.3 Specific information for Norway

The overhead contact lines in Norway are designed for a 1800 mm wide pantograph. Some lines or part of lines are also approved for 1950 mm wide pantograph. The lines approved for 1950 mm wide pantograph in Norway are given in JD 590 [13].

For more information on the pantograph profile: EN 50367:2006, Appendix B, Figure B.6 [6].

4.3.4 Specific information for Sweden

The overhead contact lines in Sweden are designed for an 1800 mm wide pantograph. For traffic across the Öresund Bridge into Sweden, 1 950 mm pantographs are permitted. A and K vehicles can not be fitted with a pantograph, see BVF 999.19 [15].

For more information on the pantograph profile: EN 50367:2006, Appendix B, Figure B.6 [6].

For more information on approved pantographs on existing rolling stock in Sweden, see Table 4

Fordonstyp / Strömavtagarmodell	X50-X54	X40	X31K/X32K	X20	X11-X14	X10	X3	X2/X2K/X2NK	X1	Rm	Rc	Ra	Ma	IORE	El 16	El 15	El 13	EG	Dm3	Da	Bm68
DSA 200			■																		
LLXJ 235										■	■										
LLXJA 135				■								■	■						■	■	
LSFC 201/202					■	■			■	■	■										
LSFC 204					■						■										
SB 10						■			■						■						
SIEMENS typ 6											■										
WBL 85/88	■	■					■	■			■	■		■	■						
8WLO 120																		■			

Table 4 Approved pantographs on existing rolling stock in Sweden.

5 OVERHEAD CONTACT LINE SYSTEMS FOR TESTING

5.1 General

A system for testing shall be able to withstand the forces from the pantograph and guarantee good dynamic behavior of the pantograph. Table 5 describes the systems that shall be used for testing. The systems for each speed interval are equivalent. This means that a test made on one system for a given speed interval, automatically is accepted in all of the countries for the same speed interval.

If the maximum test speed is 140 km/h or lower, a soft system without stitch wire shall be used. For a test with speed up to 200 km/h a soft system with stitch wire shall be used. Speeds over 200 km/h shall be tested on a hard system with stitch wire.

	Speed interval		
Country for testing	v ≤140 km/h	140 < v ≤ 200	200 < v ≤ 250
Finland	ktl utan Y-lina	SR 70	SR 220
Norway	System 35MS	System 20A	System 25
Sweden	ST 7.1/7.1	SYT 7.0/9.8	SYT 15/15

Table 5 Speed intervals for testing of overhead contact line systems.

5.2 Tests in Finland

Tests for the speed interval < 140 km/h shall be performed between Seinäjoki and Tampere.

Tests for the speed interval > 140 km/h shall be performed between Kerava and Lahti.

Other locations than the above mentioned can be discussed with RHK.

5.3 Tests in Norway

Tests for the speed interval < 140 km/h shall be performed between Drammen and Kongsberg.

Tests for the speed interval < 140 km/h to 200 km/h shall be performed between Ski and Moss.

Tests for the speed interval > 200 km/h shall be performed between Lillestrøm and Gardermoen.

Other locations than the above mentioned can be discussed with Jernbaneverket.

5.4 Tests in Sweden

Tests for the speed interval < 140 km/h shall be performed between Mora and Garsås.

Tests for the speed interval < 140 km/h to 200 km/h shall be performed between Skövde and Töreboda.

Tests for the speed interval > 200 km/h shall be performed between Västerås and Enköping.

Other locations than the above mentioned can be discussed with Banverket.

6 PRE-REQUIREMENTS FOR LINE TESTS

6.1 General

This clause describes the tests which have to be done before the pantograph tests on the overhead contact line can take place. Most of the demands are country specific and may include tests of signaling system, brake system, track forces etc.

In general the following two demands are valid for all countries:

- you must have permission to drive on the track before testing starts
- you must have an approval from the power supply owner before testing starts.

Testing normally starts with a dialog with the operator to produce a test plan. Most common is though to do brake and pantograph speed step up test early, if it is a new vehicle.

6.2 Finland

Before starting pantograph tests in Finland there must be an approval from the Finnish Railway Agency and also a compatibility declaration from the Finnish Rail Administration (RHK).

6.3 Norway

Before starting pantograph tests in Norway there must be an approval from the Norwegian Railway Inspectorate and also a compatibility declaration from the Norwegian National Rail Administration (JBV).

6.4 Sweden

Before starting pantograph tests in Sweden there must be a track admittance. How to apply for this is described in BVF 504 [11].

7 APPROVAL TESTS

7.1 Test overview

The following tests are required:

- a test that shows that the geometry of the pantograph's profile is inside of the free space as specified in 7.3
- pantograph tests as specified in 7.4
- test of pantograph on the vehicle as specified in 7.5
- dynamic tests as specified in 7.6
- winter tests as specified in 7.7.

The tests have to be performed in this specific order if not agreed on otherwise.

7.2 Overview of nation specific tests

A test made in one country normally does not have to be made again in another country.

7.2.1 Finland

The following tests made according to the Norwegian or Swedish requirements have to be verified with the Finnish requirements:

- Test 7.3.1
- Test 7.4.4
- Test 7.4.7.1
- Test 7.5.1
- Test 7.5.2
- Test 7.6.3

7.2.2 Norway

The following tests made according to Finnish requirements have to be verified with the Norwegian requirements:

- Test 7.3.1
- Test 7.4.4
- Test 7.4.7.1
- Test 7.5.1
- Test 7.5.2
- Test 7.6.3

The following tests made according to the Swedish requirements have to be verified with the Norwegian requirements:

- Test 7.3.1
- Test 7.5.1

7.2.3 Sweden

The following tests made according to Finnish requirements have to be verified with the Swedish requirements:

- Test 7.3.1
- Test 7.4.4
- Test 7.4.7.1
- Test 7.5.1
- Test 7.5.2

- Test 7.6.3

The following tests made according to Norwegian requirements have to be verified with the Swedish requirements:

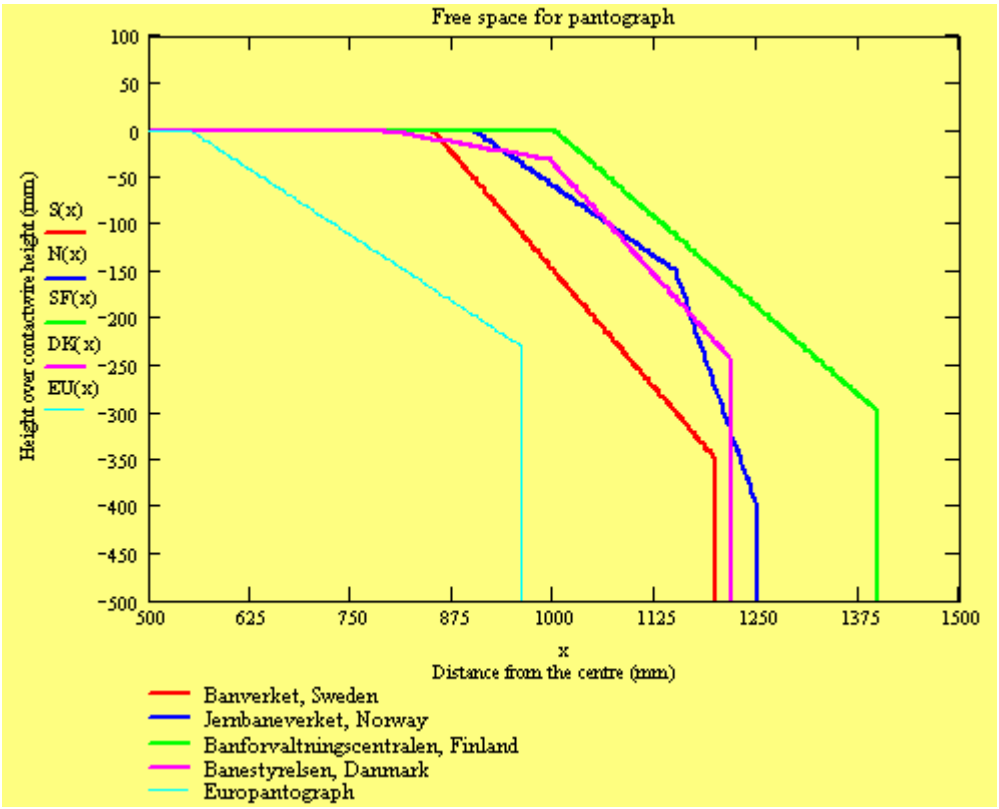
- Test 7.3.1
- Test 7.5.2

7.3 Geometry of the pantograph's free space

7.3.1 Free space for pantograph

7.3.1.1 INFORMATION

The infrastructure is designed in such a way that it gives the operating pantographs a free space. This space is referred to the centre of the track. Figure 1 shows the different free spaces for pantographs[1] for the Nordic countries. The free space for the Europantograph is also shown in the figure. It is important that the pantograph stays within the free space for pantographs in order to avoid hitting solid objects. The operator has to prove that the pantograph always is inside the free space.



Note 1: The Swedish free space will increase in curves by: $U[mm] = \frac{21000}{R[m]}$

Note 2: The EPs free space will increase in curves and for higher contact wire height, EN 50367 [6].

Figure 1 Free space for pantograph.

[1] The spaces given in the figure are not exactly as some of them vary with contact wire height, radius and cant.

7.3.1.2 REQUIREMENTS

7.3.1.2.1 General

For calculations: All movements that influence the pantograph's position over the track shall be taken into account. Free space for pantographs is a dynamic profile. This means that it follows the uplift of the contact wire caused by the pantograph at all operating speeds.

7.3.1.2.2 Requirements for Sweden

At any time the pantograph shall be inside of the free space for pantograph. This shall be proved by calculation according to SJF 400.7 [12].

7.3.1.2.3 Requirements for Norway

The maximum pantograph displacement from the track centre line is 250 mm. The requirement for maximum pantograph displacement from the track centre line applies to a contact wire height of 5,60 m.

The maximum pantograph displacement from the track centre shall be documented by calculations according to Annex I, [prEN 15273:2006]. The calculations shall be made with a contact wire height of 5,60 meter for radii 275 meter, 3000 meter and for straight line.
The Norwegian National Rail Administration must approve calculations and tests for electrical rolling stock. With regards to the traction power supply, such calculations will only be relevant for the part of the rolling stock where a pantograph is mounted.

7.3.1.2.4 Requirements for Finland

At any time the pantograph shall be inside of the free space for pantograph. This shall be proved by calculation

7.3.1.3 VERIFICATION

7.3.1.3.1 Verification for Sweden

The operator must show that the pantograph always is inside the free space. This shall be done by calculations and may also be supplemented with video recordings.

7.3.1.3.2 Verification for Norway

The operator must show that the maximum pantograph displacement from the track centre line is less then 250 mm. This shall be done by calculations and may also be supplemented with video recordings.

7.3.1.3.3 Verification for Finland

The operator must show that the pantograph always is inside the free space. This shall be done by calculations and may also be supplemented with video recordings.

7.3.1.4 DOCUMENTATION

A report shall present results from calculations, and measurements if that is done, which show that the pantograph is inside the free space for all test lines in operating speed. For video recordings the picture must show the limits of the free space or the maximum allowed displacement.

7.4 Pantograph tests

7.4.1 Basic functions

7.4.1.1 INFORMATION

Basic functions include geometry, functions as raising and lowering the pantograph and other mechanical movements. Before starting other tests it must be secured that the pantograph will not damage the infrastructure.

7.4.1.2 REQUIREMENTS

All requirements can be found in EN 50206-1:1998 [3]. To get permission for a new pantograph, the following tests have to be done as type tests:

- General tests
    a) Visual inspection (7.4.2)
    b) Weighing (7.4.3)
    c) Collector head length (7.4.4)
    d) Collector head height (7.4.4)
    e) Collector head width (7.4.4)
    f) Head profile (7.4.4)
    g) Length of contact strips (7.4.4)
    h) Housed height (7.4.4)
    i) Maximum extension (7.4.4)
    j) Limited maximum extension (7.4.4)
    k) Electrical thickness (7.4.4)
    l) Distance between mounting points (7.4.4)
    m) Identification (7.4.5)
    n) Functional check of A.D.D (7.4.6)
- Operating tests 7.4.7
    a) Nominal static force
    b) Checking operation system
    c) Operating climatic test
- Endurance tests 7.4.8
    a) Raising/lowering operations
    b) Collector head suspension
    c) Transverse vibrations
- Transverse rigidity test 7.4.9
- Air tightness tests 7.4.10
    a) Operating device cylinder
    b) Tightness climatic test
- Measurements 7.4.11
    a) Degrees of freedom of collector head
    b) Housing force

To be allowed to take power through a raised pantograph when parked without driver the raised pantograph must be equipped with a pressure guard.

7.4.1.3 VERIFICATION

Verification shall be carried out according to EN 50206-1:1998, clause 6 [3].

7.4.1.4 DOCUMENTATION

A complete test report shall present all measurements, tests, results and conclusions.

7.4.2 Visual inspection

7.4.2.1 INFORMATION

This test is to check that the pantograph is completely assembled.

7.4.2.2 REQUIREMENTS

EN 50206-1:1998, clause 6.2.1 [3].

7.4.2.3 VERIFICATION

EN 50206-1:1998, clause 6.2.1 [3].

7.4.2.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.4.3 Weighing

7.4.3.1 INFORMATION

A test to check that the pantograph has the same mass as specified

7.4.3.2 REQUIREMENTS

EN 50206-1:1998, clause 6.2.2 [3].

7.4.3.3 VERIFICATION

EN 50206-1:1998, clause 6.2.2 [3].

7.4.3.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.4.4 Dimensions

7.4.4.1 INFORMATION

The dimensions of pantograph (including tolerances), as specified on the drawings shall be verified with appropriate measurement devices.

7.4.4.2 REQUIREMENTS

EN 50206-1:1998, clause 6.2.3[3].
The length of the carbon strips shall be $\geq$ 1,00 m.

Sweden: When pantograph is housed it must be fitted into load gauge according to BVF 586.20, profile A, B or C [14].

7.4.4.3 VERIFICATION

EN 50206-1:1998, clause 6.2.3 [3].

Finland: Head profile according to EN 50367:2006, Appendix B, Figure B.3 [6].
Sweden and Norway: Head profile according to EN 50367:2006, Appendix B, Figure B.6 [6].
Sweden: For international traffic over the bridge of Öresund (to Denmark) head profile according to EN 50367, Appendix B, figure B.3 [6].

7.4.4.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.4.5 Identification

7.4.5.1 INFORMATION

Here is defined the minimum labeling of the pantograph.

7.4.5.2 REQUIREMENTS

According to EN 50206-1:1998, clause 5 [3].

7.4.5.3 VERIFICATION

According to EN 50206-1:1998, clause 6.2.4 [3].

7.4.5.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.4.6 Automatic dropping of pantograph

7.4.6.1 INFORMATION

Automatic dropping device (A.D.D.) has the function of lowering the pantograph in case of injured carbon strip or collision with infrastructure.

7.4.6.2 REQUIREMENTS

The pantographs in Sweden, Finland and Norway shall be equipped with A.D.D. according to EN 50367:2006, clause 5.2 [6]. This demand is only applicable for new vehicles and vehicles that will be equipped with a new type of pantograph.

The A.D.D. shall not cause additional damage to the pantograph according to EN 50367:2006, clause 5.2 [6].

Requirements on the A.D.D are described in EN 50206-1:1998, clause 4.9 and 6.2.5 [3].
Before lowering the pantograph by A.D.D the vehicle's main circuit breaker shall open.

7.4.6.3 VERIFICATION

EN 50206-1:1998, clause 6.2.5 [3].

7.4.6.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.4.7 Operation tests

7.4.7.1 NOMINAL STATIC FORCE

7.4.7.1.1 Information

Test for measurement of the static force at ambient temperature.

7.4.7.1.2 Requirements

According to EN 50206-1:1998, clause 6.3.1 [3].

There must be a fixed value for the static force as reference for comparison of measurements and for assessment of typical values in output.

In Norway and Sweden, the static force shall be 55 N ± 10 %.

In Finland the static force shall be between 60-90 N according to EN 50367:2006 [6].

The chosen value shall be fixed and used for all other measurements required in the dynamic tests.

7.4.7.1.3 Verification

According to EN 50206-1:1998, clause 6.3.1 [3].

7.4.7.1.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.7.2 CHECKING OPERATION SYSTEM

7.4.7.2.1 Information

The pantograph shall be coupled to the whole operating system. The test shall be carried out at ambient temperature and at rated air supply pressure or rated voltage in case of electrical operating system. During and after the tests the pantographs shall operate satisfactorily.

7.4.7.2.2 Requirements

According to EN 50206-1:1998, clause 6.3.2 [3].

7.4.7.2.3 Verification

According to EN 50206-1:1998, clause 6.3.2 [3].

7.4.7.2.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.7.3 OPERATING CLIMATIC TEST

7.4.7.3.1 Information

The tests shall be carried out at the extremes of temperature and humidity that are specified for the vehicle as a whole. The above tests, at extremes of temperature shall also be carried out at the minimum and maximum values of air pressure or voltage specified in the customer specifications.

7.4.7.3.2 Requirements

According to EN 50206-1:1998, clause 6.3.3 [3].

7.4.7.3.3 Verification

According to EN 50206-1:1998, clause 6.3.3 [3].

7.4.7.3.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.8 Endurance tests

7.4.8.1 GENERAL

For pantographs which have no proven in-service reliability for at least two years on European railway network, the following endurance tests shall be carried out at ambient temperature.

7.4.8.2 RAISING/LOWERING OPERATIONS

7.4.8.2.1 Information

In this test the pantograph is submitted to a number of raising and lowering operations

7.4.8.2.2 Requirements

According to EN 50206-1:1998, clause 6.4.1 [3].

7.4.8.2.3 Verification

According to EN 50206-1:1998, clause 6.4.1 [3].

7.4.8.2.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.8.3 COLLECTOR HEAD SUSPENSION

7.4.8.3.1 Information

In this test the collector head shall be subjected to a number of consecutive cycles

7.4.8.3.2 Requirements

According to EN 50206-1:1998, clause 6.4.2 [3].

7.4.8.3.3 Verification

According to EN 50206-1:1998, clause 6.4.2 [3].

7.4.8.3.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.8.4 TRANSVERSE VIBRATIONS

7.4.8.4.1 Information

The pantograph fitted with a collector head which has the largest mass designed for that pantograph shall be installed with its insulators on a vibrating table producing sinusoidal vibrations the amplitude and the frequency of which shall be adjustable in the transverse direction. While this test is carried out, the frequency of the table shall be 10% lower than the transverse frequency of oscillation.

7.4.8.4.2 Requirements

According to EN 50206-1:1998, clause 6.4.3 [3].

7.4.8.4.3 Verification

According to EN 50206-1:1998, clause 6.4.3 [3].

7.4.8.4.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.9 Transverse rigidity test

7.4.9.1 INFORMATION

This test checks that the pantograph does not move too much when a transverse force is applied.

7.4.9.2 REQUIREMENTS

According to EN 50206-1:1998, clause 6.6 [3].

7.4.9.3 VERIFICATION

According to EN 50206-1:1998, clause 6.6 [3].

7.4.9.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.4.10 Air tightness tests

7.4.10.1 OPERATING DEVICE CYLINDER

7.4.10.1.1 Information

This test checks the sealing of the operating device's cylinder or air bellows.

7.4.10.1.2 Requirements

According to EN 50206-1:1998, clause 6.7.1 [3].

7.4.10.1.3 Verification

According to EN 50206-1:1998, clause 6.7.1 [3].

7.4.10.1.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.10.2 TIGHTNESS CLIMATIC TEST

7.4.10.2.1 Information

This test checks the sealing of the operating device's cylinder or air bellows at specified minimum and maximum temperature. The temperature range shall be the same as specified for the vehicle as a whole.

7.4.10.2.2 Requirements

According to EN 50206-1:1998, clause 6.7.2 [3].

7.4.10.2.3 Verification

According to EN 50206-1:1998, clause 6.7.2 [3].

7.4.10.2.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.11 Measurements

7.4.11.1 DEGREES OF FREEDOM OF COLLECTOR HEAD

7.4.11.1.1 Information

This test checks that the collector head degrees of freedom are as specified between customer and the supplier.

7.4.11.1.2 Requirements

According to EN 50206-1:1998 clause 6.8 [3].

7.4.11.1.3 Verification

According to EN 50206-1:1998 clause 6.8 [3].

7.4.11.1.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.11.2 HOUSING FORCE

7.4.11.2.1 Information

This test checks the pantograph's housing force.

7.4.11.2.2 Requirements

According to EN 50206-1:1998 clause 6.9[3].

7.4.11.2.3 Verification

According to EN 50206-1:1998 clause 6.9 [3].

7.4.11.2.4 Documentation

A report shall present all measurements, tests, results and conclusions.

7.4.12 Current at standstill

7.4.12.1 INFORMATION

The performance of the overhead contact line and pantograph interface shall be subject to the approval by the infrastructure manager.

7.4.12.2 REQUIREMENTS

According to EN 50367:2006 clause 7.1 [3], maximum current at standstill per pantograph is 80 A.

7.4.12.3 VERIFICATION

Check that the required power consumption at standstill is less than 80 A per active pantograph.

7.4.12.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.5 Geometrical tests for vehicle mounted pantographs

7.5.1 Working range

7.5.1.1 INFORMATION

The working range of the pantographs shall cover the existing contact wire heights.

7.5.1.2 REQUIREMENTS

Sweden: The working range should be between 4800 and 6100 mm.
Norway: The working range should be between 4600 and 6100 mm.
Finland: The working range should be between 5600 and 6700 mm.

7.5.1.3 VERIFICATION

Sweden: Check that the pantographs working range is between 4800 and 6100 mm.

Norway: Check that the pantographs working range is between 4600 and 6100 mm.
Finland: Check that the pantographs working range is between 5600 and 6700 mm.

7.5.1.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.5.2 Distances between pantographs

7.5.2.1 INFORMATION

A train can exist of more than one electrical unit, and can therefore have more than one pantograph working at the same time. Some pantograph distances however are not allowed. For example, when passing through neutral sections the distances between pantographs must be specified to avoid electrical overlap.

All pantograph distances, not mentioned in 7.5.2.2, are allowed as long as tests according to 7.6 are performed and verified.

For locomotives, test according to 7.6 will normally only be made for the locomotive and not for the train configuration the locomotive is working in. In case multiple pantograph operations are not tested, the general rules according to Table 6 will apply. Distances between 30 and 39 m between two operating pantograph's are not allowed due to neutral sections.

Pantograph distances (m)	**Maximum speed as a function of the number of pantographs.**	
	2 pantographs	*3 pantographs or more*
< 20	*)	*)
20 – 30	As for one pantograph but with a maximum speed of 160 km/h	As for one pantograph but with a maximum speed of 120 km/h
39 – 150	As for one pantograph	As for one pantograph but with a maximum speed of 140 km/h
150 – 400	As for one pantograph	As for one pantograph

) Special agreement.

Table 6 Allowed train speeds for locomotives. In case multiple pantograph operations are not tested.

7.5.2.2 REQUIREMENTS

The pantograph distances that are not allowed are mainly nation specific and mentioned in EN 50367:2006 Annex B [6], special national conditions.

The maximum overall pantograph distance is 400 m, according to EN 50367:2006 [6].

7.5.2.3 VERIFICATION

Check that allowed distances are inside allowed values.

7.5.2.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.5.3 Electrical connection between active pantographs

7.5.3.1 INFORMATION

No electrical connection between active pantographs is allowed.

7.5.3.2 REQUIREMENTS

According to EN 50367:2006 [6].

7.5.3.3 VERIFICATION

Check that no electrical connections exist between two active pantographs.

7.5.3.4 DOCUMENTATION

A report shall present all measurements, tests, results and conclusions.

7.6 Dynamic tests

7.6.1 General

All tests are to be made according to EN 50317:2001 [4].

According to EN 50317:2001 [4] dynamic interaction between contact line and pantograph can be measured by dynamic force measurements or by arc detection. This document describes only the force measurement, since arc detection is a method with lower reliability. It is for example impossible to use when temperature is near or below zero due to all arcs from hoar frost.

7.6.2 Speed step up

7.6.2.1 INFORMATION

Speed step up test shall be performed when the train will be used for speeds above 100 km/h. If other tests will be performed for speeds above 100 km/h before the complete dynamic contact force test is performed, it is necessary to perform this simple speed step up. If the first test for speeds above 100 km/h is a dynamic force test it is only necessary to do the speed step up while performing the contact force measurement. The test is made to check the pantograph initially before dynamic contact force tests are made at maximum speed. Maximum test speed for speed step up is 200 km/h. For speeds above 200 km/h dynamic tests are mandatory. Speed step up is performed to allow other tests (i.e. brake tests and ATC-tests) before the dynamic contact force tests are made.

7.6.2.2 REQUIREMENTS

Speed steps shall be performed on the same kind of overhead contact line systems as the rest of the tests. The overhead contact line system is chosen according to Table 2.

Speed step up is only required if the maximum test speed is above 100 km/h. First speed shall be 100 km/h and steps of 20 km/h up to maximum test speed.

7.6.2.3 VERIFICATION

A skilled person (test supervisor) shall perform the supervision of the pantograph's movements. This skilled person shall be a representative from or approved by the national rail administration in the country where the tests are being performed. A camera mounted on the roof of the vehicle can be used. The test supervisor shall after each speed step evaluate and decide if an approval to raise the speed to the next level can be given.

The pantograph's behavior is sufficient if the vertical movement of the pantographs head is absorbed by the springs between the head and the frame. The rising and lowering of the frame shall only be a result of the rising and lowering of contact wire height.

7.6.2.4 DOCUMENTATION

A test report including train configuration and pantograph configuration, speeds for each test run and comments of supervisor shall be written.

7.6.3 Contact Force

7.6.3.1 INFORMATION

The contact force is the vertical force applied by the pantograph to the overhead contact line. The contact force is the sum of forces for all contact points of one pantograph.
The mean contact force is the statistical mean value of the contact force between the pantograph and the overhead contact line. It includes the static force and the aerodynamic force developed from the aerodynamic influence caused by wind.

The aerodynamic force is a function of wind speed around the pantograph which again is a function of the actual train speed. Adjusting the aerodynamic force is a vital parameter for current collection quality.

7.6.3.2 REQUIREMENTS

Measurement shall be carried out according to EN 50317:2001 [4]. The maximum wind speed shall be less then 5 m/s. Two repetitive measurements in each pantograph direction shall be made on the same track.

The measurements shall be done on an overhead contact line and for the appropriate speed interval according to Table 5. The measurements hall be done for a single pantograph and if applicable even for multiple pantographs on an open line. The measurement shall be done for a single pantograph and, if demanded by the national rail administration, even for multiple

pantographs in a tunnel. In case of rolling stock with multiple pantographs, the pantograph with the calculated highest standard deviation of force shall be tested.
F_{mean} shall not differ more than 20 % depending of the direction of the train.
The distribution of the contact forces between the contact points of the two carbon strips shall not differ more than 20 %. This is calculated by dividing the largest value with the lowest value.

The measurement shall be conducted for the whole range of the operating train speed + 10 %.
The mean contact force should have a target value of $F_{mean} = F_{stat} + 0.00097*v^2$. For Norway and Sweden, the tolerance is ± 10 %.
The static force shall be according to 7.4.7.1.
The aerodynamic component is taken from EN 50367:2006 [6].
The standard deviation shall be less than 30 % of the target value of F_{mean}.
The mean contact force and the maximum and minimum contact forces are visualized in Figure 2 (Norway and Sweden) and Figure 3 (Finland).

The initial speed for measurements of contact force is the lesser value of 100 km/h or maximum operating speed minus 20 km/h. After the first measurement the speed can be increased in steps of 20 km/h up to maximum test speed.

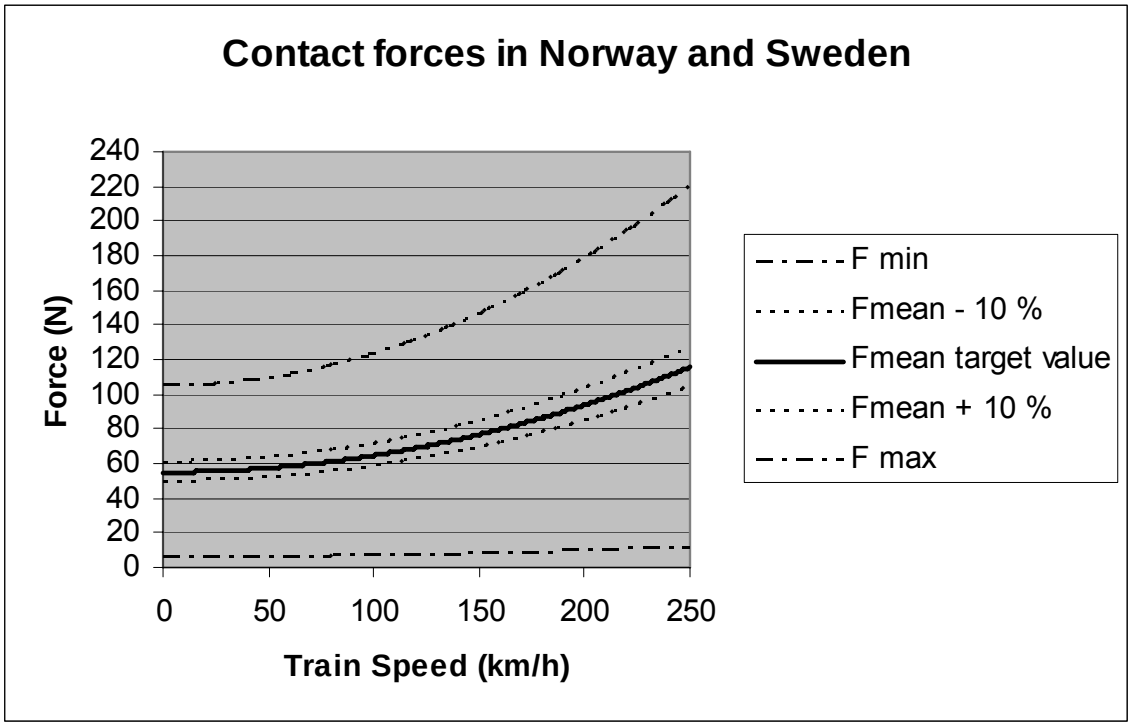


Figure 2 Contact forces in Norway and Sweden.

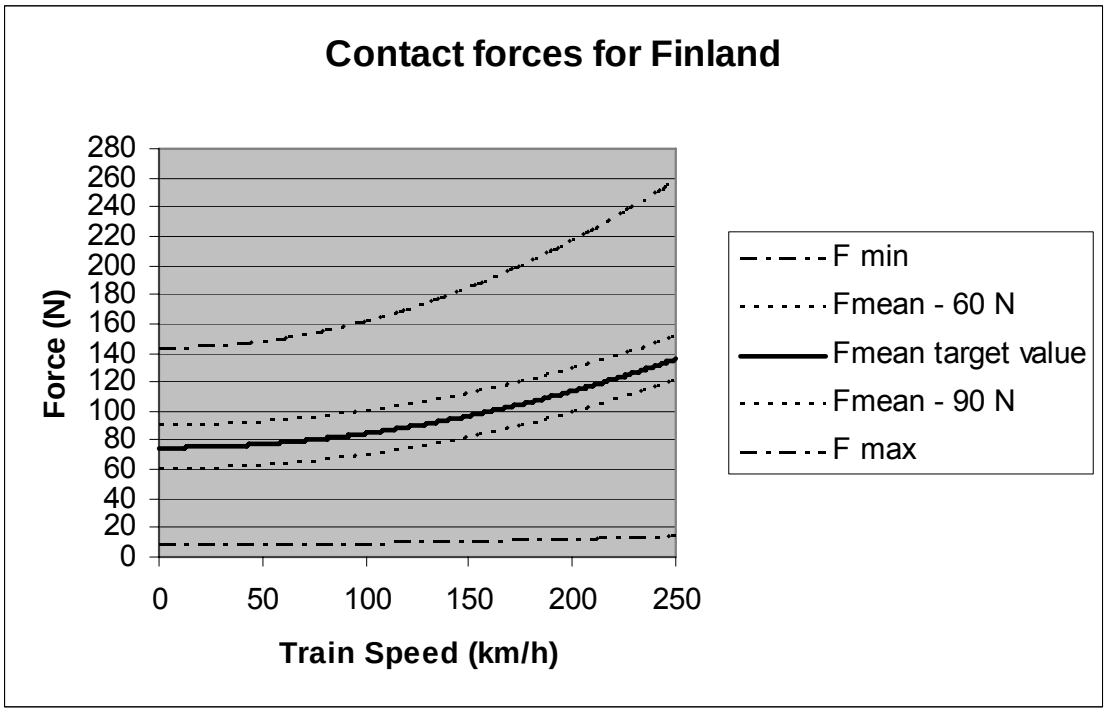


Figure 3 Contact forces in Finland.

7.6.3.3 VERIFICATION

A skilled person (test supervisor) shall perform the supervision of the pantograph's movements. This skilled person shall be a representative from or approved by the national rail administration in the country where the tests are being performed. A camera mounted on the roof of the vehicle can be used. The test supervisor shall after each speed step evaluate and decide if an approval to raise the speed to the next level can be given.

Check that F_{mean} does not differ more than 20 % depending of the direction of the train.
Check that the distribution of the contact forces between the contact points of the two carbon strips does not differ more than 20 %.
Check that the mean contact force is $F_{mean} = F_{stat} + 0.00097*v^2$, and inside of the tolerances.
Check that the standard deviation is less then 30 % of the target value of F_{mean}.

7.6.3.4 DOCUMENTATION

A report shall be written in accordance to EN 50317:2001: clause 5 [4].
A figure showing the mean contact force, the statistical maximum and minimum contact forces as defined in EN 50318:2001 [5] and the limits of contact force as a function of train speed.

There shall also be a description of the measurement procedure and instrument used. There shall be one figure for each pantograph that has been measured. There shall also be noted the weather condition, temperature and where the measurements took place.

7.6.4 Uplift measurement

7.6.4.1 INFORMATION

In addition to measuring contact forces between the pantograph and the contact wire it is also necessary to verify the uplift. There could be places where the limits for uplift are reached before the limits for the force.

7.6.4.2 REQUIREMENTS

Measurement shall be carried out according to EN 50317:2001 [4]. The overhead contact line systems and the speeds intervals used for measuring uplift are given in Table 5. The test shall be made 3 times in each direction of travel at the maximum test speed.

In case measurements are made on an overhead contact line system for speeds between 140 and 200 km/h according to Table 5, the maximum uplift at the support is $50 + 0{,}00175*v^2$. In case measurements are made on an overhead contact line system for another speed interval then according to Table 5, the maximum allowed uplift shall be discussed with the national rail administration. For multiple pantograph operation the requirements apply to all active pantographs. Worst pantograph configuration shall be according to 7.6.3.2.

7.6.4.3 VERIFICATION

The operator shall measure the uplift of the contact wire. This can be done by passing an uplift measuring device mounted along the track. The measurement shall be done in maximum line speed. If the maximum line speed is higher than the maximum train speed, then use the maximum train speed.

7.6.4.4 DOCUMENTATION

A report shall present test results showing the measured uplift at maximum test speeds in both directions.

7.7 Winter tests

7.7.1 Operation

7.7.1.1 INFORMATION

The test checks the pantograph's mechanical function during operation in winter climate, including snow and temperatures below zero degrees Celsius.

7.7.1.2 REQUIREMENTS

The temperatures shall be below zero degrees Celsius. This test can be performed during other winter tests, e.g. while testing brakes.

A camera for supervision of the pantograph is needed and if necessary lamps for lighting and a skilled supervisor.

Speed steps shall be performed on the same kind of overhead contact line systems as the rest of the tests. The overhead contact line system is chosen according to
Table 2.

Speed step up is only required if the maximum test speed is above 100 km/h. First speed shall be 100 km/h or maximum operating speed minus 20 km/h. After the first test the speed can be increased in steps of 20 km/h up to maximum test speed.

7.7.1.3 VERIFICATION

A skilled person (test supervisor) shall perform the supervision of the pantograph's movements. This skilled person shall be a representative from or approved by the national rail administration in the country where the tests are being performed. A camera mounted on the roof of the vehicle can be used. The test supervisor shall after each speed step evaluate and decide if an approval to raise the speed to the next level can be given.

The pantograph's behavior is sufficient if the vertical movement of the pantographs head is absorbed by the springs between the head and the frame. The rising and lowering of the frame shall only be a result of the rising and lowering of contact wire height.

7.7.1.4 DOCUMENTATION

A test report including train configuration and pantograph configuration, speeds for each test run and comments of supervisor shall be written.

7.7.2 Icing

7.7.2.1 INFORMATION

The test is performed to check if the pantograph is accumulating ice and snow during operation.

7.7.2.2 REQUIREMENTS

The weather conditions shall be winter conditions which include drift of snow and temperatures below zero degrees Celsius. This test can be performed during other winter tests, e.g. while testing brakes. The vehicle shall be cooled down before start of the tests and shall be in normal operation for at least 5 hours.

7.7.2.3 VERIFICATION

When the vehicle is stopped the pantograph shall be investigated to see if ice and snow has been accumulated in a way that constrains the function of the pantograph.

7.7.2.4 DOCUMENTATION

Documentation is made by photos of the pantograph and a short description of possible problems during operation.

7.7.3 Automatic Dropping Device (A.D.D)

7.7.3.1 INFORMATION

The winter test shall prove the A.D.D. function in winter climate.

In case of use of A.D.D. built with air tube to the carbon strip and no test valve; demount the tube from the pantograph and put the end at the side of the roof with an air valve at the end.

7.7.3.2 REQUIREMENTS

The weather conditions shall be winter conditions which includes temperatures below zero degrees Celsius.

Requirements for the A.D.D are described in EN 50206-1:1998 clause 4.9 and 6.2.5 [3].

7.7.3.3 VERIFICATION

Simulate a damage and check if the ADD is functioning according to EN 50206-1:1998 clause 6.2.5 [3].

7.7.3.4 DOCUMENTATION

The test report shall include short information about the A.D.D. system and how the test was performed. Temperatures and timeframes shall be included. Times for lowering of pantograph shall be presented.

8 REVISION HISTORY

31-01-2007:	First version. Based on the NIM NES-R09 report with the same title as this document.
19-04-2007:	Second version. Bullet point 8, Revision history, created. Mostly editorial changes and corrections due to false numbering in some references. New rules added for Norway regarding the calculation of pantograph deviation, ref. 7.3.1.2.3.

Annex A – Items specified by national rail administrations

The table is based on EN 50206:1998, Annex F.

Name	Referens	Finland	Norway	Sweden
Characteristics of the railway equipment and infrastructure	EN 50206-1:1998 clause 3.3	4.2	4.2	4.2
Rated voltage	EN 50206-1:1998 clause 3.3.1	25 kV 50 Hz	15 kV 16,7 Hz	15 kV 16,7 Hz
Rated current at standstill	EN 50206-1:1998 clause 3.3.2	7.4.12	7.4.12	7.4.12
Maximum current vehicle at standstill	EN 50206-1:1998 clause 3.3.3	7.4.12	7.4.12	7.4.12
Static force	EN 50206-1:1998 clause 3.3.5	7.4.7.1	7.4.7.1	7.4.7.1
Total mean uplift force	EN 50206-1:1998 clause 3.3.7	7.6.3	7.6.3	7.6.3
Total contact force	EN 50206-1:1998 clause 3.3.8	7.6.3	7.6.3	7.6.3
Extension of pantograph	EN 50206-1:1998 clause 4.2	7.5.1	7.5.1	7.5.1
Collector head length	EN 50206-1:1998 clause 4.7.1	EN 50367 Annex B	EN 50367 Annex B	EN 50367 Annex B
Collector head profiles	EN 50206-1:1998 clause 4.7.3	EN 50367 Annex B	EN 50367 Annex B	EN 50367 Annex B
Contact strips	EN 50206-1:1998 clause 4.7.4	EN 50367 Annex B	EN 50367 Annex B	EN 50367 Annex B
A.D.D	EN 50206-1:1998 clause 4.9	7.4.6 and 7.7.3	7.4.6 and 7.7.3	7.4.6 and 7.7.3
Protection against corrosion	EN 50206-1:1998 clause 4.11	EN 12499 Class C3	EN 12499 Class C3	EN 12499 Class C3
Supplementary type tests	EN 50206-1:1998 clause 6.1.1	7	7	7
Investigation tests	EN 50206-1:1998 clause 6.1.3	no	no	no
Combined tests	EN 50206-1:1998 clause 6.1.4	7	7	7
Operating climatic tests	EN 50206-1:1998 clause 6.3.3	7.4.7.3	7.4.7.3	7.4.7.3
Vertical vibration tests	EN 50206-1:1998 clause 6.4.3.3	no	no	no
Tightness climatic tests	EN 50206-1:1998 clause 6.7.2	7.4.10	7.4.10	7.4.10
Field tests	EN 50206-1:1998 clause 6.13.3	no	no	no
Inspections	EN 50206-1:1998 clause 7	free	free	free
Maintenance	EN 50206-1:1998 clause 9	No extra demands	No extra demands	No extra demands