# TECHNICAL REPORT

# Power supply, OCL Design S20 and S25
# Verification of conformity with TSIs

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**Verification of conformity with TSIs**
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# 1 INTRODUCTION

The Norwegian National Railway Administration has ownership of the OCL designs S20 and S25. This document shows how these fulfil all necessary requirements in ENE TSI 1301/2014 in order to put an EC certificate for both S20 and S25. The first operates with speeds including 200 km/h, while the latter with speeds including 250 km/h. The nominal voltage and frequency is 15 kV RMS and 16 ⅔ Hz. The accepted pantograph profiles in Norway are given in EN 50367:2012 Annex B2, Figure B5 and Annex A2, Figure A7[1]. Nominal current rating is 600 A and 800 A for S20 and S25 respectively. For further characteristics see appendix N. [2] In Germany, the equivalent OCL systems Re200 and Re250 are certified.

## 1.1 Module CA

The EC type examination is done in compliance with 6.1.2 in ENE TSI 1301/2014, [3] specifically : “In the case of products placed on the market before the publication of relevant TSIs, the type is considered to have been approved and therefore EC type examination (module CB) is not necessary, provided that the manufacturer demonstrates that tests and verification of interoperability constituents have been considered successful for previous applications under comparable conditions and are in conformity with the requirements of this TSI. In this case these assessments shall remain valid in the new application.” [3] The OCL systems have been in place since the 1990. [4] Furthermore, The Norwegian National Railway Administration also wishes to give a thorough investigation, and thus the application module used is CA, not CH. Where technical regulations are referred to in the text, these are of The Norwegian National Rail Administration. According to the ENE TSI chapter 5, points 4.2.5, 4.2.9 and 4.2.11-14 of chapter 4 will be documented, which cover the required documentation laid out in 2010/713/EU module CA. Hence, the points 2-4 of the CA module for conformity assessment of interoperability constituent will be fulfilled[5].

## 1.2 Structure of this document

This document is divided into the five points necessary for EC certification. Each point again starts with stating the criteria for the point being fulfilled, and covers four aspects where relevant; design, maintenance and operation. According to 2010/713/EU module CA; *‘The technical documentation shall specify the applicable requirements and cover, as far as relevant for the assessment, the design, manufacture, maintenance and operation of the interoperability constituent.’* Thus, not all points are covered by all four aspects. However, point 4.2.12 requires measurement, by point 6.1.4.1 of this ENE TSI, of contact wire uplift and contact force, and hence such measurements are supplied.

## 1.3 About the four aspects of criteria for approval

Each point under consideration starts with laying down the criteria for each point to be qualified as met, and explicitly states which four aspects are relevant.

### 1.3.1 Design

This section covers the relevant design aspects of S20 and S25. Table B.1 in Appendix B of this ENE TSI instructs that all points below shall be handled in a design review. Such review is described in chapter 3 of the general technical requirements in book 540, and stipulates that a design review to be conducted according to FEF 2006 and EN50119:2009, by qualified personnel. [6-8]

### 1.3.2 Manufacture

This section covers the relevant manufacturing aspects of S20 and S25. All control tests mentioned in this chapter are performed after building, extending or upgrading contact lines.

### 1.3.3 Maintenance

As laid out in chapter 4, clause 4 of general technical requirements of book 542, there are generic maintenance routines, so to control that technical regulations are met. These cover control points 4.2.9 [3] and 4.2.11-12. See appendix L. Furthermore, in the case of error or damage on the OCL, a report must be issued. The template for this report can be viewed in the appendix M. In general, FEF 2006 dictates that electrical installations shall be operated and maintained to preserve its intended function without being a danger to life, health or material goods. [7] Moreover, a risk assessment should be the foundation of any design decision and documented for possible scrutiny. [7]

### 1.3.4 Operation

This section covers the relevant operational aspects of S20 and S25, meaning relevant tests and measurements. Table B.1 in Appendix B of this TSI instructs that point 4.2.12 to be verified with test measurements, while sub-point 6.1.4.1 (3) (d) describes that the test for point 4.2.12 shall be performed for worst case arrangements in regard to pantograph spacing.
4.2.5 Current capacity, DC systems, trains at standstill
(1) - (3) Not relevant for AC systems.

## 1.4 4.2.9 Geometry of OCL

(2) There needs to exist technical regulation dictating pantograph's head geometry and head length. Secondly, this needs to be in accordance with LOC&PAS TSI point 4.2.8.2.9.2. [9]

(3) Technical regulation concerning lateral deviation of contact wire height under cross-wind need to be highlighted.

Aspects covered: design.

### 1.4.1 Design

(4) Point 7.2.3 needs to be taken into account in this sub-point. Here, the most relevant notions are sub-points 7.3.2.1 c) and 7.3.2.2 c), where the first sub-point is fulfilled through this certification. The latter is covered by clause 2.2 of the OCL systems specifications in book 540, which dictates that EN 50367:2012, Annex A2, Figure A7 and a pantograph head length of 1950 mm shall be accommodated for. [10]

(5) Furthermore, the contact wire height and its lateral deviation under cross-wind are highlighted as important for interoperability, and are taken into account by fulfilling the sub-points 4.2.9.1-2. Additionally, clause 4.2.3 of the general technical requirements in book 540 demands that the OCL to be designed for 30 m/s and even 37 m/s for areas exposed to high winds. [11]

## 1.5 4.2.9.1 Contact wire height

(1) - (2) Technical regulation need to comply with table 4.2.9.1 on contact wire heights. In order to further ensure this compliance, control tests after manufacture and regular maintenance routines to verify the contact wire heights are in order.

(3) There needs to be technical regulation concerning contact wire height at level crossings.

(4) Not relevant.

Aspects covered: design, manufacture and maintenance.

### 1.5.1 Design

(1) - (2) The nominal contact wire height of 5600 mm for speeds up to 200 km/h and 5300 mm for higher speeds and are given in clause 4.2.5 of the general technical requirements in book 540. [12] These regulations are in accordance with the permissible data of table 4.2.9.1 and EN 50119:2009. In addition, 50119:2009 is adopted as technical regulation (NEK 900:2014 which is a part of national electro technical norms) in Norway, and thus the constraint for minimum contact wire height in table 4.2.9.1 is satisfied. [13]

(5) There are also national rules for the contact wire height at level crossings. [14]

(6) Not relevant.

### 1.5.2 Manufacture

(1) - (3) According to clause 6.2.1 of the general technical requirements in book 541, a dynamic control with a test car drive is required to measure the contact wire height. [15] After such data is gathered, it must be evaluated and necessary measures will be conducted, ensuring values are within tolerance limits. [16] Such limits can be studied in appendix A.

(4) Not relevant.

### 1.5.3 Maintenance

(1) - (2) Covered by generic maintenance routines. See introduction for explanation of maintenance under 'About the four aspects of criteria for approval'. The tolerance for contact wire heights can be studied in Table 1:

| Design | Maximum height [mm] | Minimum height [mm] |
|---|---|---|
| S20 | 5600 ± 20 | 5050 ± 20 |
| S25 | 5300 ± 30 | 5300 ± 30 |

**Table 1 Tolerances for contact wire height [16]**

(3) - (4) Not relevant.

## 1.6 4.2.9.2 Maximum lateral deviation

(1) - (2) Technical regulation need to comply with table 4.2.9.2 on maximum lateral deviation. Maintenance routines will be needed to ensure this in practice.

(3) Not relevant

Aspects covered: design, manufacture and maintenance.

### 1.6.1 Design

(1) - (2) The maximum lateral deviation is 550 mm according to clause 2.1 of the OCL systems specifications in book 540, and is in compliance with table 4.2.9.2. [17]

(3) Not relevant

### 1.6.2 Manufacture

(1) - (2) In order to calculate maximum lateral deviation, the tool given in appendix C is used.

(3) Not relevant

### 1.6.3 Maintenance

(1) - (2) Covered by generic maintenance routines, through control of stagger. See introduction for explanation of maintenance under “About the four aspects of criteria for approval”. The tolerance for the stagger is ±30 mm of the plant documentation at the mast, and within c-measure at mid span. [18]

(3) Not relevant

## 1.7 4.2.11 Mean contact force

(1) This point contains informative text, and induces no specific requirements.

(2) There needs to be technical regulation complying with Table 6 in EN50367:2012.

(3) There needs to be maintenance routines to control high and low values of contact force.

(4) Technical regulation is necessary for the contact forces as function of speed up to 320 km/h. Over 320 km/h need to comply with 6.1.3 in ENE TSI.

Aspects covered: design, manufacture, maintenance and operation.

### 1.7.1 Design

(1) - (3) Clause 2.2 of the OCL systems specifications in book 540 adopts EN 50367 Table 6 to indicate $F_m$, thus this point is covered in technical regulations. [10] The static contact force in Norway is 55 N, which causes larger variations than the more conventional 70 N. This is due to older OCL designs in Norway having been designed for 55 N, while vehicles operate between multiple systems. S20 and S25 have been operated with 55 N since 1990, and there have only been exclusively positive experiences. Both S20 and S25 are designed for 70 N, and thus pose no conflict with interoperability.

(4) S20 and S25 operate at maximum speeds of 200 km/h and 250 km/h respectively. The curves for speeds up to 320 km/h accordingly clause 4.2.11 (4) and EN 50367:2012 Table 6 can be studied in Figure 1.

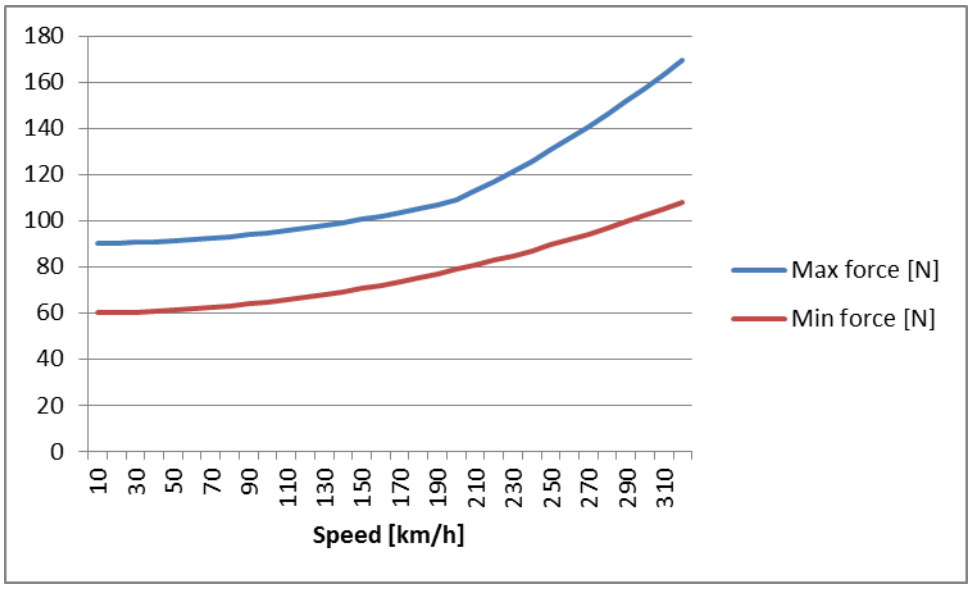


**Figure 1 Force vs. speed**

### 1.7.2 Manufacture

(1) - (2) Not relevant.

(3) According to clause 6.2.2 of the general technical requirements in book 541, a dynamic control with a test car drive is required to measure the contact force. [15] After such data is gathered, it must be evaluated and necessary measures will be conducted, ensuring values are within tolerance limits. During the dynamic control, the test car will operate at +10% of maximal line speed.

(4) Not relevant

### 1.7.3 Maintenance

(1) - (2) Covered by generic maintenance routines. See introduction for explanation of maintenance under “About the four aspects of criteria for approval”. The consequences of the contact forces being higher than 230 N or lower than 0, is that line speed must be halved. [19]

(3) In a control of the pantograph, static contact force is set to 200 N at 5-7 km/h as to ensure that all components can handle the mechanical strain. [20, 21]

(4) Not relevant.

### 1.7.4 Operation

(1) - (2) In Figure 2 and Figure 3 one can observe the contact force as a function of distance for the section Tønsberg - Barkåker on the Vestfold line, with both S20 and S25. Both graphs clearly show that even though the data are not always within the boundaries, the measurements still follow the tendency marked out by the $F_{m,max}$ and $F_{m,min}$ functions of Table 6 in EN50367:2012. For more data and analysis see appendix D and E.

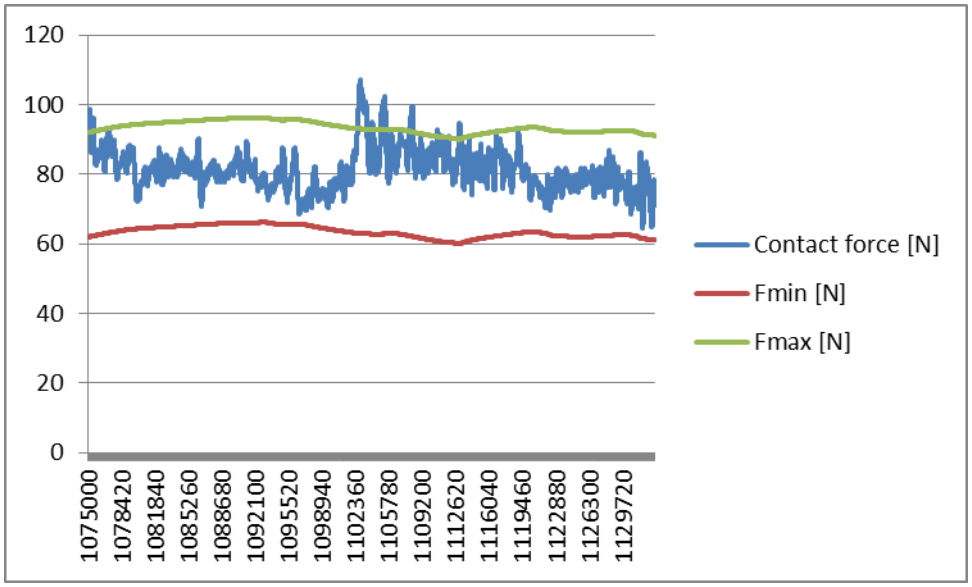


**Figure 2 The line sections ‘right track’ Barkåker – Tønsberg, Measurements with 70 N static force 23rd of March 2015**

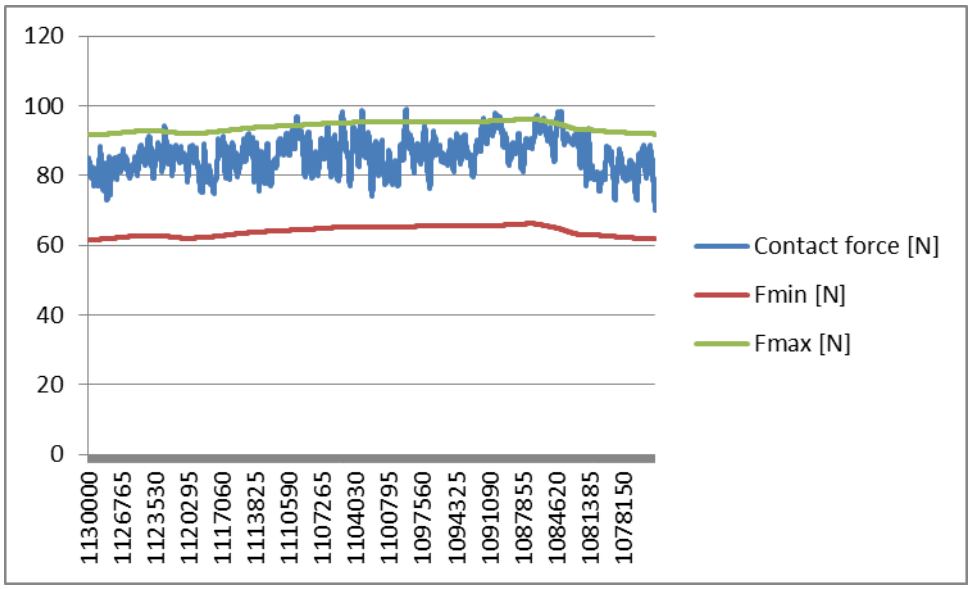


**Figure 3 The line sections 'left track' Tønsberg – Barkåker, Measurements with 70 N static force 23rd of March 2015**

(4) In order to study the capability of the same test site to sustain the upper design limit, the areas where the contact force was more than 3 N where reviewed to see if this effected the stagger or created hard points. This analysis can be studied in appendix F. Overall one sees that the OCL is capable of sustaining the upper design limit.

(5) Not relevant.

## 1.8 4.2.12 Dynamic behaviour and quality of current collection

(1) There needs to exist similar regulation to table 4.2.12, in terms of standard deviation in contact force and percentage of arching.

(2) Show through simulation and measurement that the space for steady arm uplift is $1.5*S_0$.

(3) By finding that technical regulation conforms to both table 4 in EN 50119:2009 and the statement that $F_{max}$ is within the range of $F_m$ plus three standard deviations this point can be confirmed. Furthermore there needs to be data that supports this last claim. As mentioned in 4.2.11, there needs to be maintenance routines to control high and low values of contact force.

Aspects covered: design, manufacture, maintenance and operation.

### 1.8.1 Design [3]

(1) According to FEF 2006, electrical installations shall not cause danger due to arcing. [7]

(2) NEK900:2014 has adopted EN 50119:2009, including clause 5.10.2, which covers all the considerations of this sub-point. Furthermore, $S_0$ has been simulated in the software "Sicat Candrop", along with the space for steady arm uplift, which verifies that $1.5*S_0$ is available for uplift. [3] See appendix G. Drawing E-7394 in appendix H also instructs on how to achieve this in practice.

(3) NEK900:2014 has adopted EN 50119:2009, cover most concerns in this sub-point. Explicitly, these are maximum forces on rigid components and permissible values of contact force. Moreover, maximum force should usually be in the range of $F_m$ plus three standard deviations.

This is fulfilled by technical regulations specifying 99.7% of all values lying within $F_m \pm 3*\sigma_{max}$. [22]

### 1.8.2 Manufacture

(1) Table 4.2.12 requires a maximum percentage of arcing (at the minimum duration of 5 ms), which clause 3.3 of general technical requirements in book 541 is in agreement with. [23] Explicitly, it states that the percentage of arcing with duration longer than 5 ms at speeds over and under 250 km/h should not be more than 0.2 % and 0.1 % respectively.

(2) - (3) Not relevant.

### 1.8.3 Maintenance

(1) - (2) Not relevant.

(2) Covered by generic maintenance routines. See introduction for explanation of maintenance under "About the four aspects of criteria for approval". The space for steady arm uplift should be larger than 200 mm, otherwise maintenance shall be performed. [24]

### 1.8.4 Operation

(1) Not relevant.

(2) In Table 2, one can study the results of measurement for space for uplift under various forces.

| Force [N] | Space for uplift [mm] |
|---|---|
| 0 | 110 |
| 50 | 100 |
| 110 | 80 |
| 150 | 65 |

**Table 2 Measurement of steady arm space uplift at Gardermoen 7th of May 2015**

This means that the space for steady arm uplift is 110 mm, while $S_0$ measured is to be 30 mm, and is well within the requirements of this point. [NOTE 1] More study of uplift is to be found in appendix K, though not a worst case pantograph arrangement.

(3) For study of contact forces see appendix J. The results are in accordance with this sub-point, but are not for worst case pantograph arrangement. To study results from measurements at the section of Kambo - Vestby with worst case pantograph arrangement see appendix I, which show that contact force values are within tolerance limits

NOTE 1: Maximum speed on this line is 210 km/h, and thus $F_{max}$ at this speed is 111 N

## 1.9 4.2.13 Pantograph spacing for overhead contact line design

There needs to exist technical regulation that is in accordance with the pantograph spacing's laid out in table 4.2.13.

Aspects covered: design.

### 1.9.1 Design

The tested performance of S20 and S25 are given in Table 3 below.

| Train speed [km/h] | Minimum distance [m] for Design S20, Type B and $C_2$ | Minimum distance [m] for Design S20, Type A and $C_1$ | Minimum distance [m] for Design S25 |
|---|---|---|---|

| | | | |
|---|---|---|---|
| $v \geq 250$ | - | - | 200 |
| $160 < v < 250$ | - | 200 | 73 |
| $120 < v \leq 160$ | 200 | 73 | 25 |
| $80 < v \leq 120$ | 25 | 25 | 25 |
| $v \leq 80$ | 25 | 25 | 25 |

**Table 3 Performance by OCL system [2]**

S20 B lies outside the accepted region of the TSI in the 5th row of Table 2, since this piece of regulation also applies for older OCL systems in Norway. However, EN 50367:2012 has been adopted into Norwegian technical regulations, which means that this point is guaranteed by table 8 in the same standard.

## 1.10 4.2.14 Contact wire material

Find technical regulation that is in accordance with the contact wire material specified in LOC&PAS TSI point 4.2.8.2.9.2. [9]

Aspects covered: design.

### 1.10.1 Design

The general technical requirements of book 540 have adopted EN50149:2012, and thus complies with the requirements of this point. [13, 25]

### 1.10.2 Manufacture

According to EN 50149 clause 5.1, which is a part of Norwegian technical regulations, the "manufacturer shall submit a certificate to confirm the material composition is in accordance with Annex B or the requirements agreed between purchaser and manufacturer". Thus, the contact wire material is verified before use, in addition to being examined according to clause 5.2 of the same standard.

# 2 CONCLUSION

To conclude, S20 and S25 have been in operation in Norway since 1990, with singlehandedly positive experiences. The OCL design of S20 and S25 have despite the design being operated in Norway with a lower static contact force of 55 N than are conventional in the European railways using 70 N. Table 3 which differs slightly with ENE TSI also poses no problems with interoperability. The OCL systems are of high quality and should thus be certified, as all the criteria's in this ENE TSI are met.

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13. Jernbaneverket. *TRV 540/4 - Relevante normer og standarder*. 2015 09/03/2015 [cited 2015 29/05]; Available from: https://trv.jbv.no/wiki/Kontaktledning/Prosjektering/Generelle_tekniske_krav/Relevante_normer_og_standarder.
14. Jernbaneverket. *TRV 540/4 - Næreføringer og kryssinger*. 2015 05/03/2015 [cited 2015 29/05]; Available from: https://trv.jbv.no/wiki/Kontaktledning/Prosjektering/Generelle_tekniske_krav#N.C3.A6rf.C3.B8ringer_og_kryssinger.

15. Jernbaneverket. *TRV 541/4 - Dynamisk kontroll, målevognskjøring*. 2015 05/03/2015 [cited 2015 29/05]; Available from: https://trv.jbv.no/wiki/Kontaktledning/Bygging/Generelle_tekniske_krav#Dynamisk_kontroll.2C_m.C3.A5levognskj.C3.B8ring.
16. Jernbaneverket. *TRV 542/5 - Vertikal kontakttrådhøyde*. 2015 05/03/2015 [cited 2015 29/05]; Available from: https://trv.jbv.no/wiki/Kontaktledning/Vedlikehold/Kontaktledning#Vertikal_kontakttr.C3.A5dh.C3.B8yde.
17. Jernbaneverket. *TRV 540/5 - Vindutblåsning*. 2015 04/03/2015 [cited 2015 29/05]; Available from: https://trv.jbv.no/wiki/Kontaktledning/Prosjektering/Kontaktledningssystemer#Vindutbl.C3.A5sning.
18. Jernbaneverket. *TRV 542/5 - Horisontal posisjon (sikksakk) av kontakttråden*. 2015 05/03/2015 [cited 2015 29/05]; Available from: https://trv.jbv.no/wiki/Kontaktledning/Vedlikehold/Kontaktledning#Horisontal_posisjon_.28sikksakk.29_av_kontakttr.C3.A5den.
19. Jernbaneverket. *TRV 542/5 - Krefter mellom strømavtaker og kontakttråd*. 2015 05/03/2015 [cited 2015 29/05]; Available from: https://trv.jbv.no/wiki/Kontaktledning/Vedlikehold/Kontaktledning#Krefter_mellom_str.C3.B8mavtaker_og_kontakttr.C3.A5d.
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21. Jernbaneverket. *TRV 542/5 - Dynamisk isolasjonsavstand*. 2015 05/03/2051 [cited 2015 29/05]; Available from: https://trv.jbv.no/wiki/Kontaktledning/Vedlikehold/Kontaktledning#Dynamisk_isolasjonsavstand.
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25. CENELEC, *EN 50149 - Railway applications - Fixed installations - Electric traction - Copper and copper alloy grooved contact wires.* 2012, European Committee for Electrotechnical Standardization: Brussels. p. 35.

# 4 APPENDIX A – MAXIMUM AND MINIMUM STATIC CONTACT WIRE HEIGHT

Maximum and minimum static contact wire height

| OCL Design | Maximum height [mm] | Minimum height [mm] |
|---|---|---|
| S20 | 5600 ± 20 | 5050 ± 20 |
| S25 | 5300 ± 30 | 5300 ± 30 |

# 5 APPENDIX B – LATERAL DEVIATION CURVE FOR OCL

Lateral deviation curve for OCL.

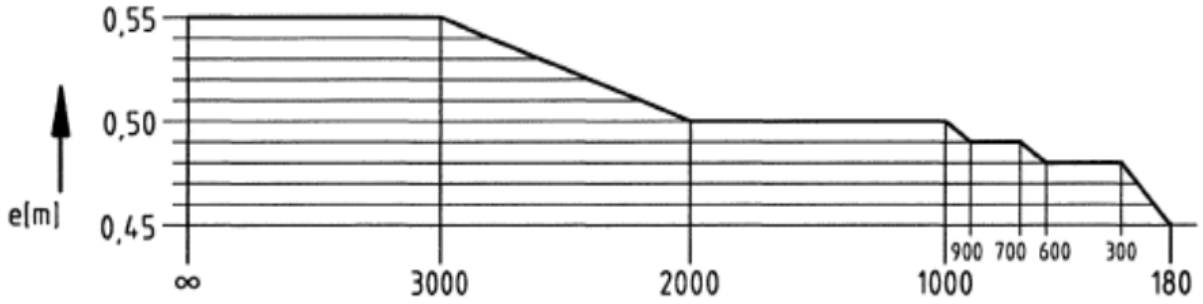


**Figure 4 Lateral deviation curve: Deviation vs. radii**

# 6 APPENDIX C – TOOL TO CALCULATE LATERAL DEVIATION ACCORDING TO THE OCL DESIGN

Tool to calculate lateral deviation according to the OCL design

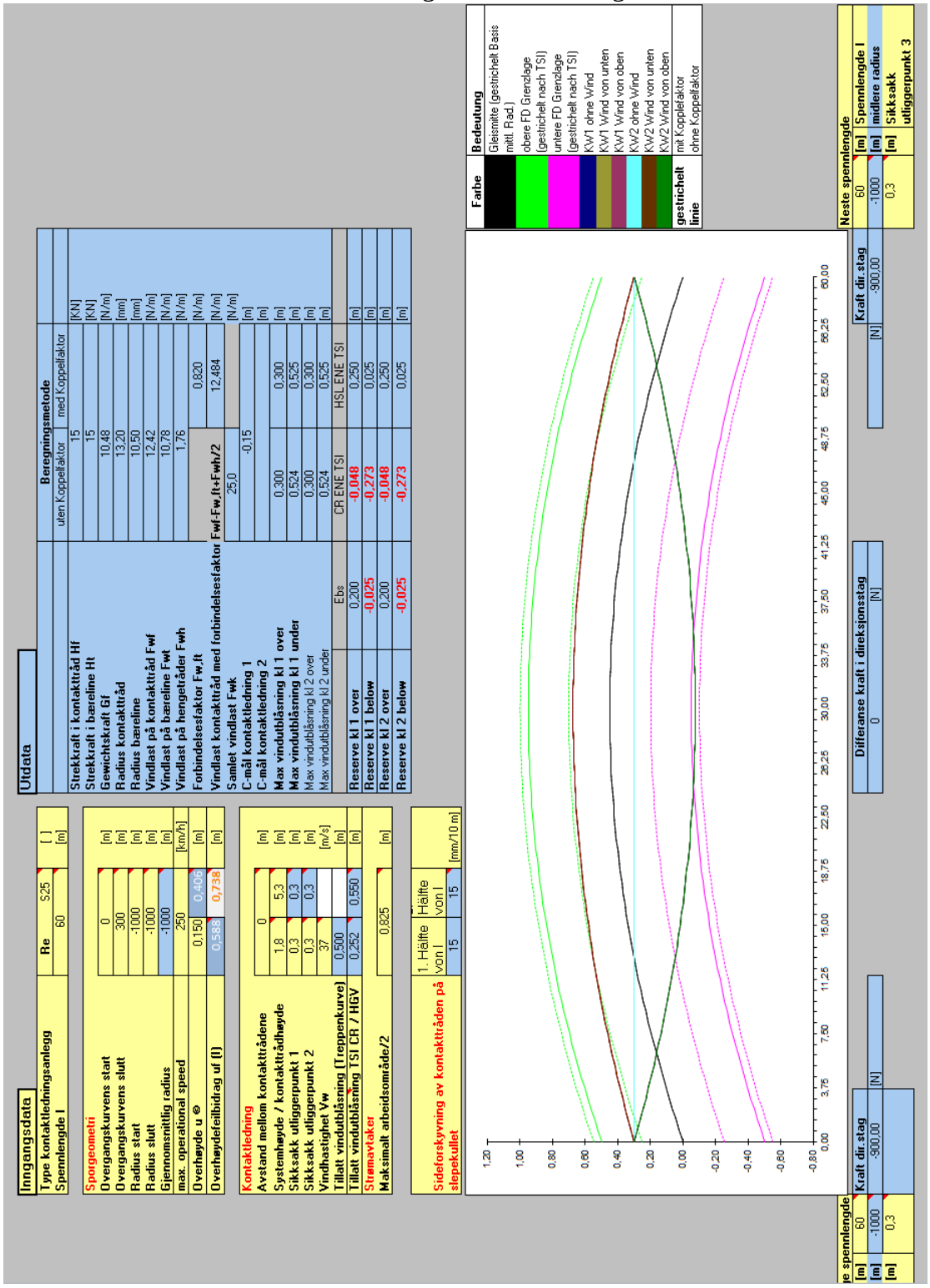


**Figure 5 Calculation tool for lateral deviation OCL designs**

# 7 APPENDIX D – STATISTICAL ANALYSIS OF MEASUREMENTS ON LINE SECTION TØNSBERG - BARKÅKER ON THE VESTFOLD LINE PERFORMED 23RD OF MARCH 2015

Statistical analysis of measurements on line section Tønsberg - Barkåker on the Vestfold line performed 23rd of March 2015.

| Location | Static contact force [N] | From km | To km | $F_{max}$ [N] | $F_{min}$ [N] | $F_m$ [N] | Standard deviation [σ] | Mean speed [km/h] |
|---|---|---|---|---|---|---|---|---|
| Barkåker – Tønsberg | 55 | 107.500 | 113.000 | 80.2 | 50.1 | 61.8 | 5.5 | 116.4 |
| Tønsberg – Barkåker | 55 | 113.000 | 107.500 | 79.6 | 43.9 | 60.4 | 5.0 | 74.8 |
| Barkåker – Tønsberg | 70 | 107.500 | 113.000 | 107.2 | 68.5 | 81.7 | 6.0 | 83.4 |
| Tønsberg - Barkåker | 70 | 113.000 | 107.500 | 99.1 | 70.0 | 85.9 | 5.1 | 90.6 |

**Table 4 Results from measurement test on line section Tønsberg – Barkåker on the 23rd of March 2015**

Technical regulations stipulate the distribution of contact forces:

| Range | Percentage of data within range |
|---|---|
| $F_m \pm 3 * \sigma$ | 99.7 |
| $F_m \pm 2 * \sigma$ | 95.5 |
| $F_m \pm \sigma$ | 68.3 |

**Table 5 Distribution of forces according to technical regulation [22]**

σ is the value of $F_{m,max}$ times 0.2, as laid down in the same technical regulation. In table 4 σ' is used, which is half the value of σ. Since that the measurements still comply with Table 5, The National Railway Administration may consider reducing σ for S20 and S25 for their next revision of technical regulations. Overall the results are in agreement with TSI ENE requirements.

| Location | Static contact force [N] | Range | Percentage of data within range |
|---|---|---|---|
| Barkåker - Tønsberg | 55 | $F_m \pm 3 * \sigma$ | 100 |
| | | $F_m \pm 2 * \sigma$ | 100 |
| | | $F_m \pm \sigma$ | 98.71 |
| Tønsberg – Barkåker | 55 | $F_m \pm 3 * \sigma$ | 100 |
| | | $F_m \pm 2 * \sigma$ | 100 |
| | | $F_m \pm \sigma$ | 98.98 |
| Barkåker – Tønsberg | 70 | $F_m \pm 3 * \sigma$ | 100 |
| | | $F_m \pm 2 * \sigma$ | 100 |
| | | $F_m \pm \sigma$ | 99.52 |

| | | | |
|---|---|---|---|
| Tønsberg - Barkåker | 70 | $F_m \pm 3 * \sigma$ | 100 |
| | | $F_m \pm 2 * \sigma$ | 100 |
| | | $F_m \pm \sigma$ | 100 |

**Table 6 Ranges and their percentages with σ**

| Location | Static contact force [N] | Range | Percentage of data within range |
|---|---|---|---|
| Barkåker - Tønsberg | 70 | $F_m \pm 3 * \sigma$ | 100 |
| | | $F_m \pm 2 * \sigma$ | 98.91 |
| | | $F_m \pm \sigma$ | 88.83 |
| Tønsberg – Barkåker | 70 | $F_m \pm 3 * \sigma$ | 100 |
| | | $F_m \pm 2 * \sigma$ | 100 |
| | | $F_m \pm \sigma$ | 93.42 |
| Barkåker – Tønsberg | 55 | $F_m \pm 3 * \sigma$ | 100 |
| | | $F_m \pm 2 * \sigma$ | 98.69 |
| | | $F_m \pm \sigma$ | 85.93 |
| Tønsberg - Barkåker | 55 | $F_m \pm 3 * \sigma$ | 100 |
| | | $F_m \pm 2 * \sigma$ | 99.16 |
| | | $F_m \pm \sigma$ | 93.68 |

**Table 7 Ranges and their percentage with σ'**

Force sum distribution graph

# 8 APPENDIX E – CONTACT FORCE VS. DISTANCE

Figures 1-3 show that contact forces follow the tendencies of the $F_m$ as a function of speed given in technical regulations. [22]

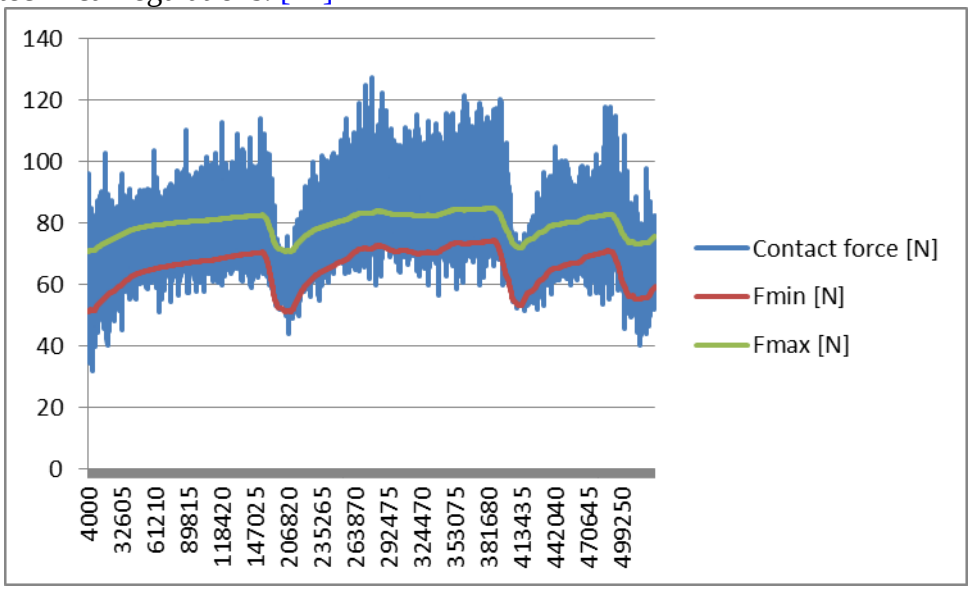


**Figure 6 Oslo – Eidsvoll 2014 Contact force vs. distance**

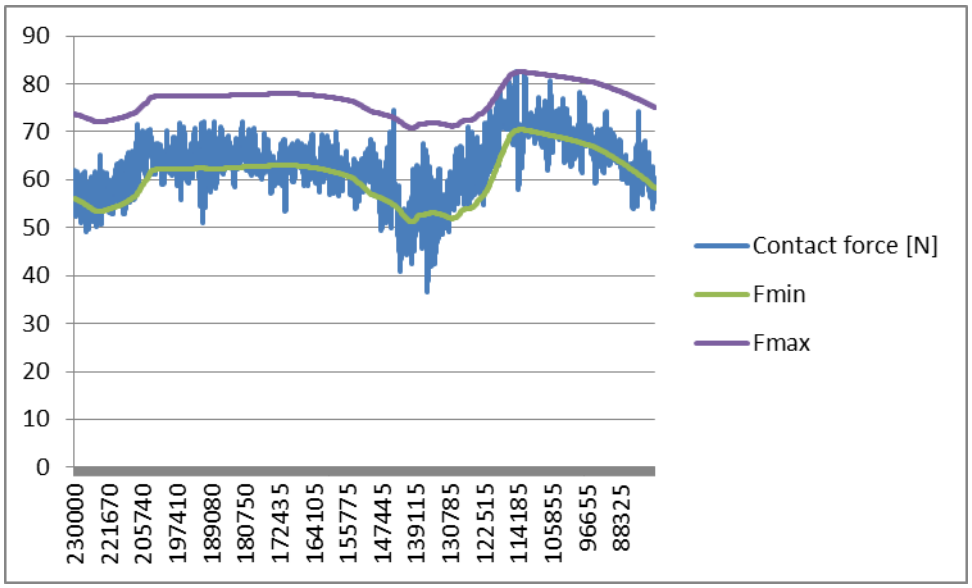


**Figure 7 Oslo – Drammen 2014 Contact force vs. distance**

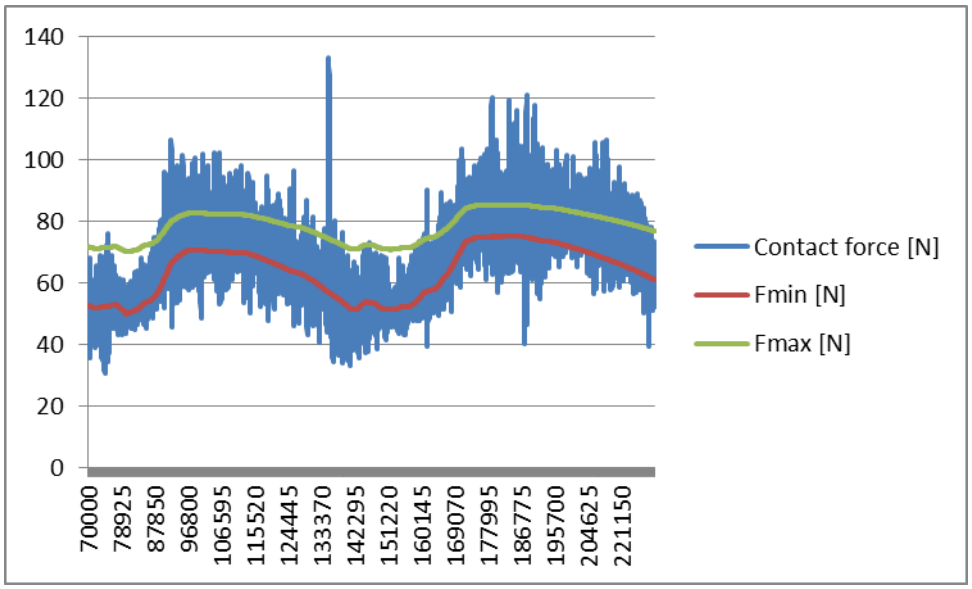


**Figure 8 Drammen – Oslo 2014 Contact force vs. distance**

# 9 APPENDIX F – ANALYSIS OF STAGGER AND HARD POINTS FOR LARGE CONTACT FORCES

**Line section: Barkåker – Tønsberg 70 N**

| Km for contact force + 3 N larger than $F_{m,max}$ |
|---|
| 107.5000 – 107.5185 |
| 107.5480 – 107.5550 |
| 110.2665 – 110.3560 |
| 110.5025 – 111.3090 |

**Table 8 Barkåker – Tønsberg km for contact force**

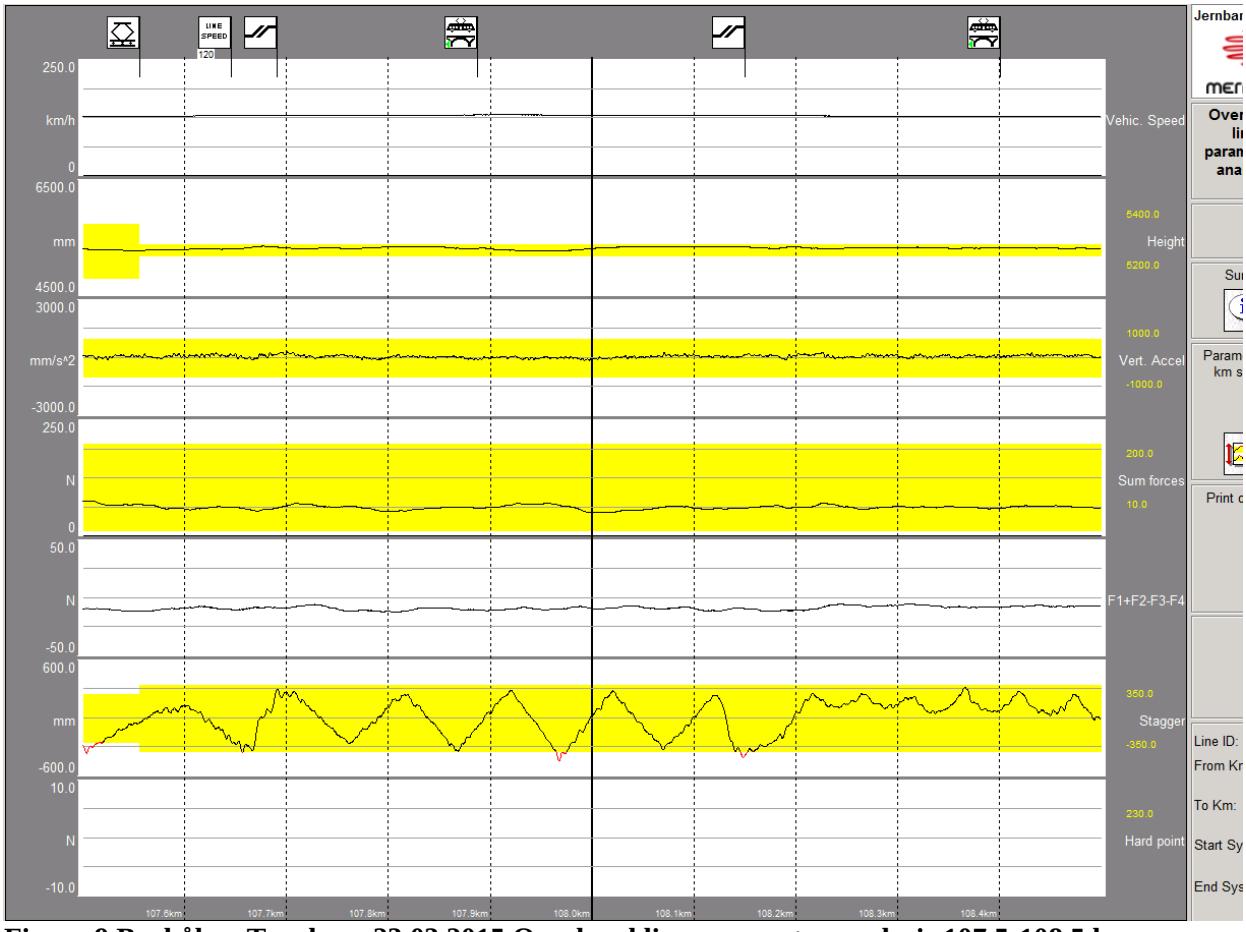


**Figure 9 Barkåker-Tønsberg 23.03.2015 Overhead line parameter analysis 107.5-108.5 km**

One can observe that around 107.5 km where the high contact forces occur there is a slightly larger value for the stagger than allowed. No hard points.

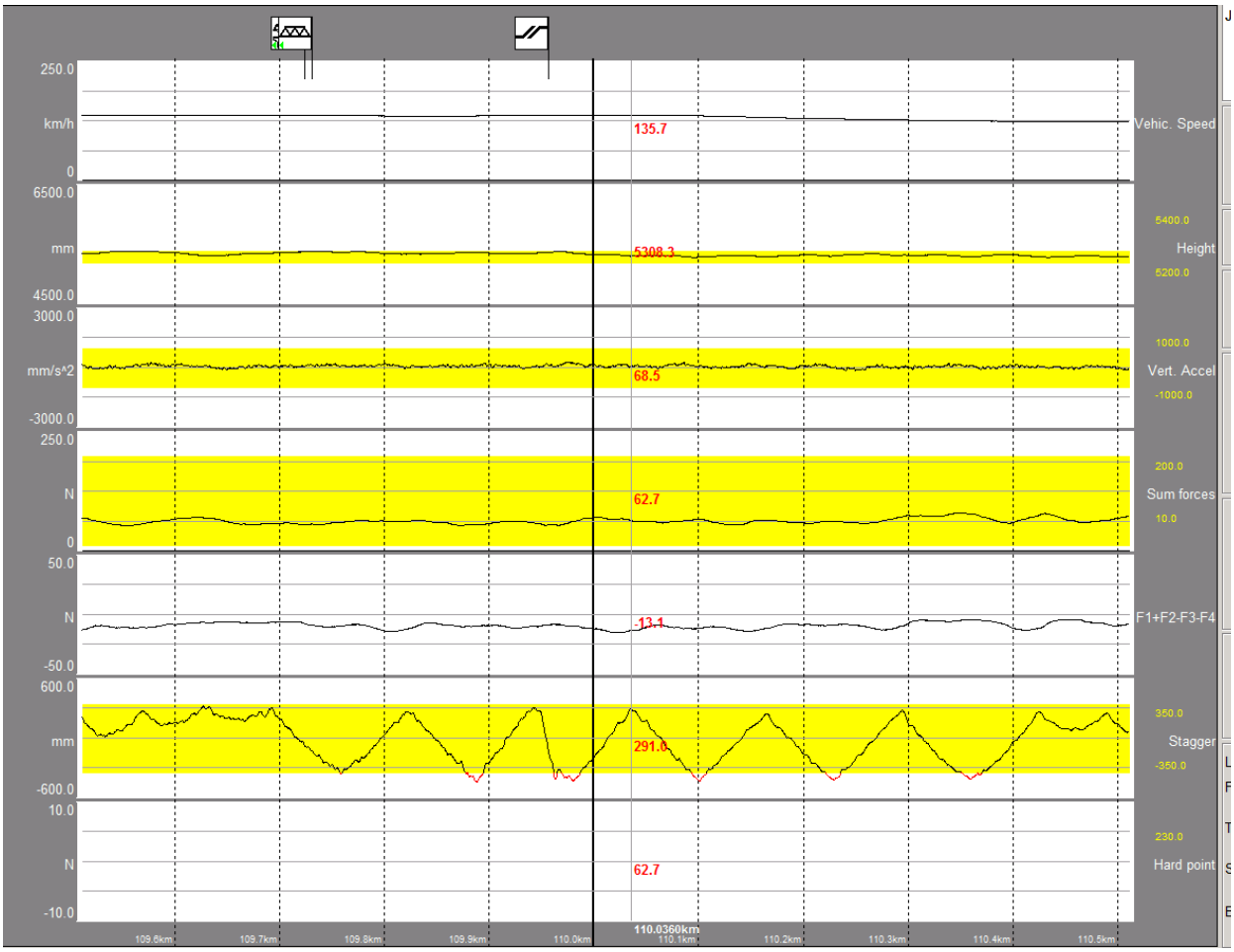


**Figure 10 Barkåker-Tønsberg 23.03.2015 Overhead line parameter analysis 109.5-110.5 km**

One can observe that around 110.2665 km where the high contact forces occur there is a slightly larger value for the stagger than allowed. No hard points.

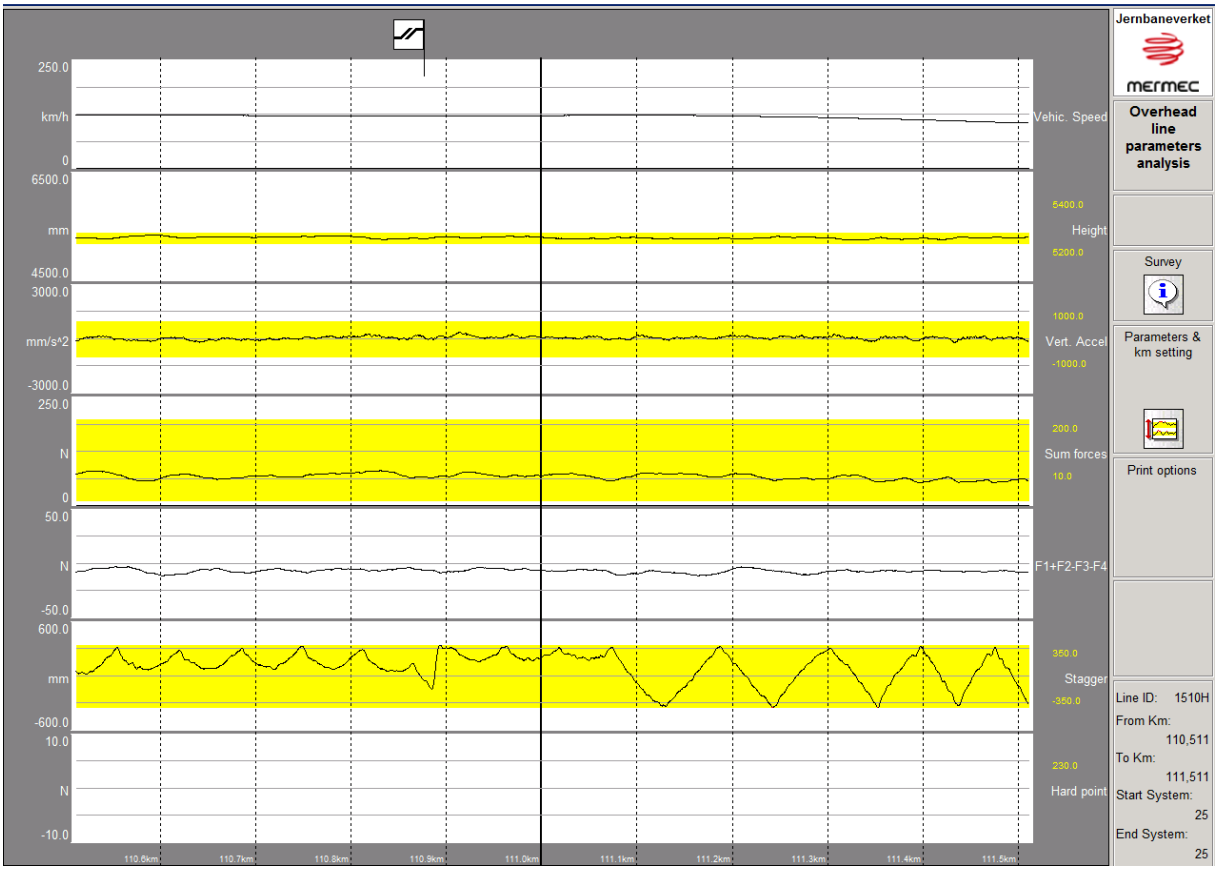


**Figure 11 Barkåker-Tønsberg 23.03.2015 Overhead line parameter analysis 110.5-111.5 km**

One can observe that around 110.5 km where the high contact forces occur there are no abnormal values concerning neither stagger nor hard points.

## Line section: Tønsberg – Barkåker 70 N

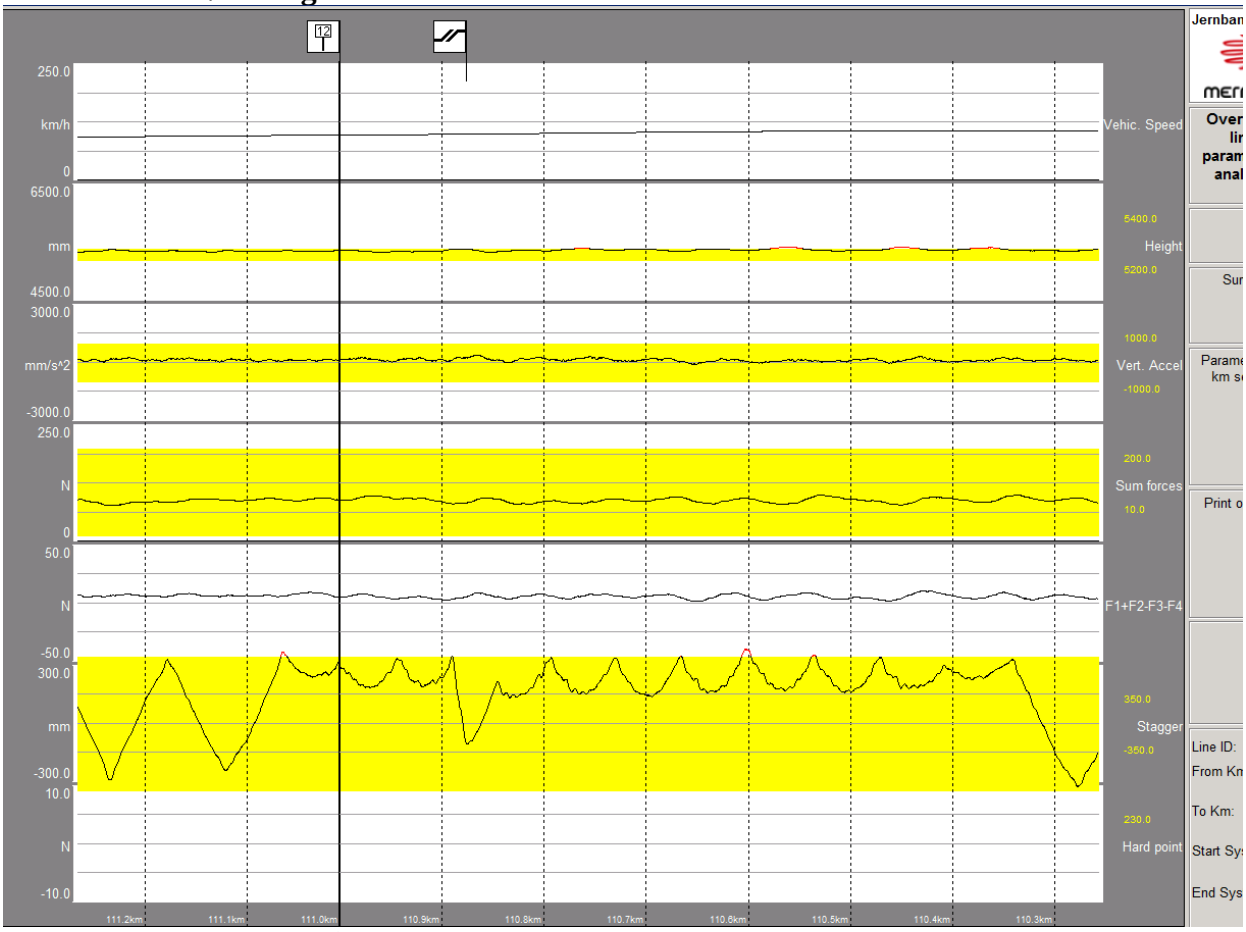


**Figure 12 Tønsberg- Barkåker 23.03.2015 Overhead line parameter analysis 111.5-110.5 km**

One can observe that around 110,5 and 110,3 km where the high contact forces occur there are no abnormal values concerning neither stagger nor hard points.

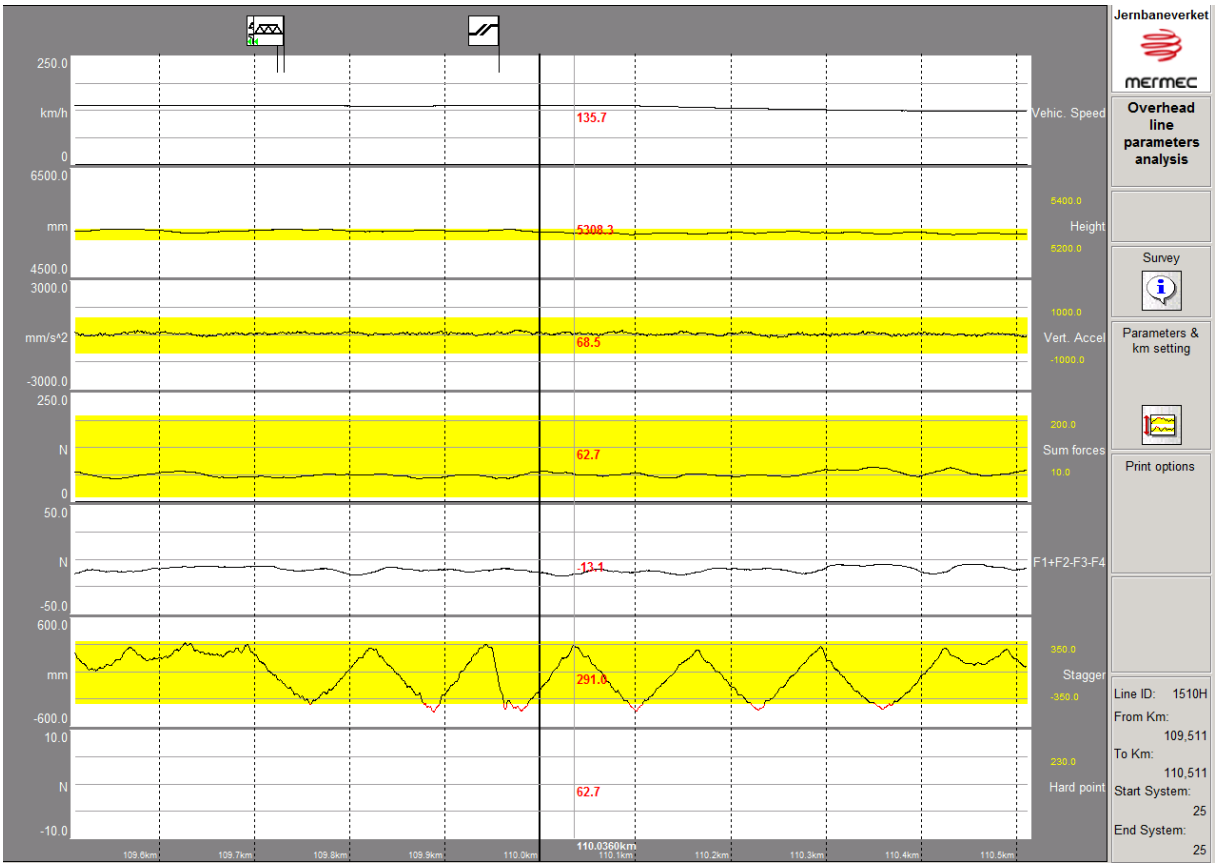


**Figure 13 Tønsberg- Barkåker 23.03.2015 Overhead line parameter analysis 110.5-109.5 km**

One can observe that around 109.9 km where the high contact forces occur there are no abnormal values concerning neither stagger nor hard points.

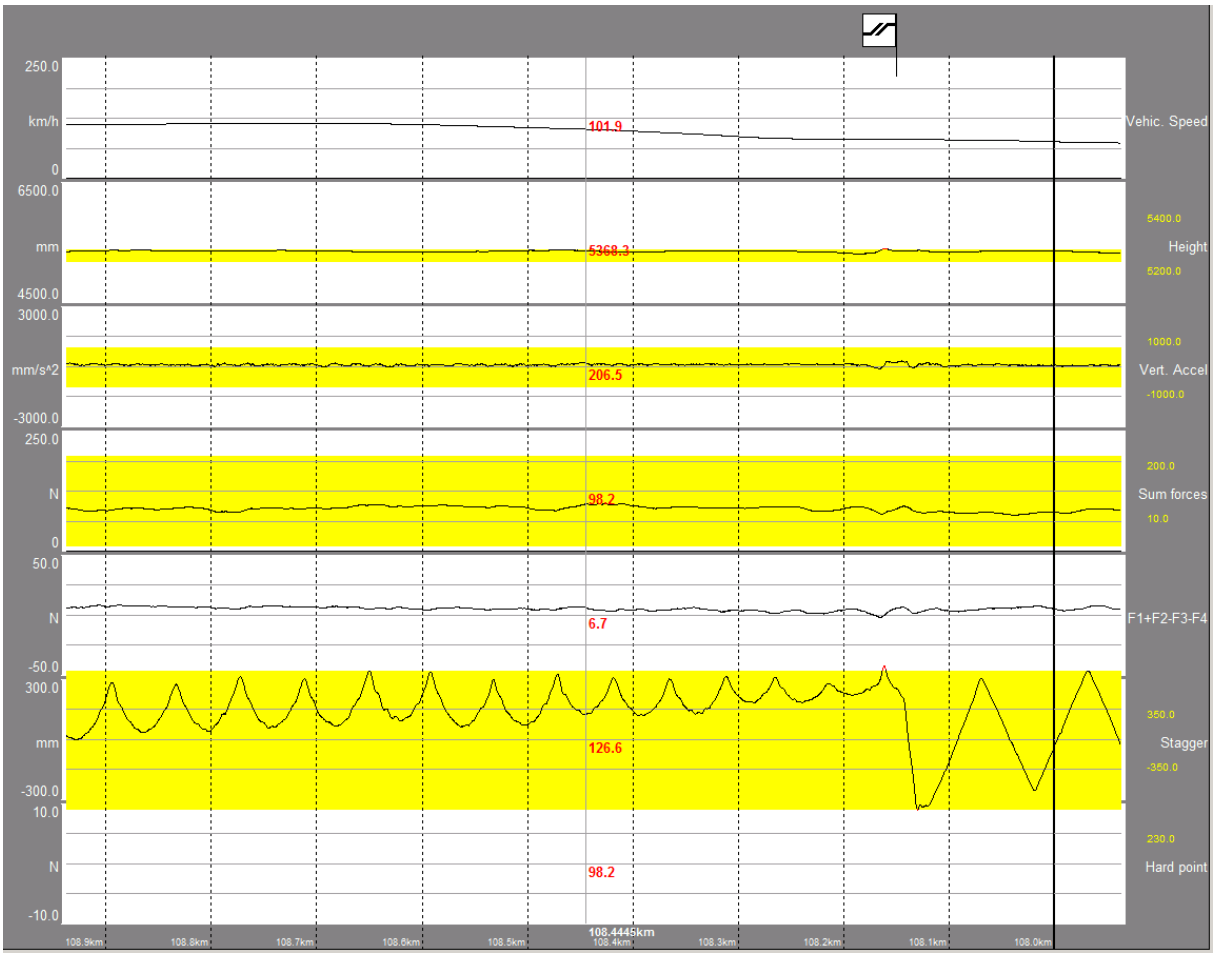


**Figure 14 Tønsberg- Barkåker 23.03.2015 Overhead line parameter analysis 108.9-108.0 km**

One can observe that around 108.4 km where the high contact forces occur there are no abnormal values concerning neither stagger nor hard points.

# 10 APPENDIX G – STEADY ARM FREE UPLIFT (NNRA – S20 AND S25)

Steady arm free uplift

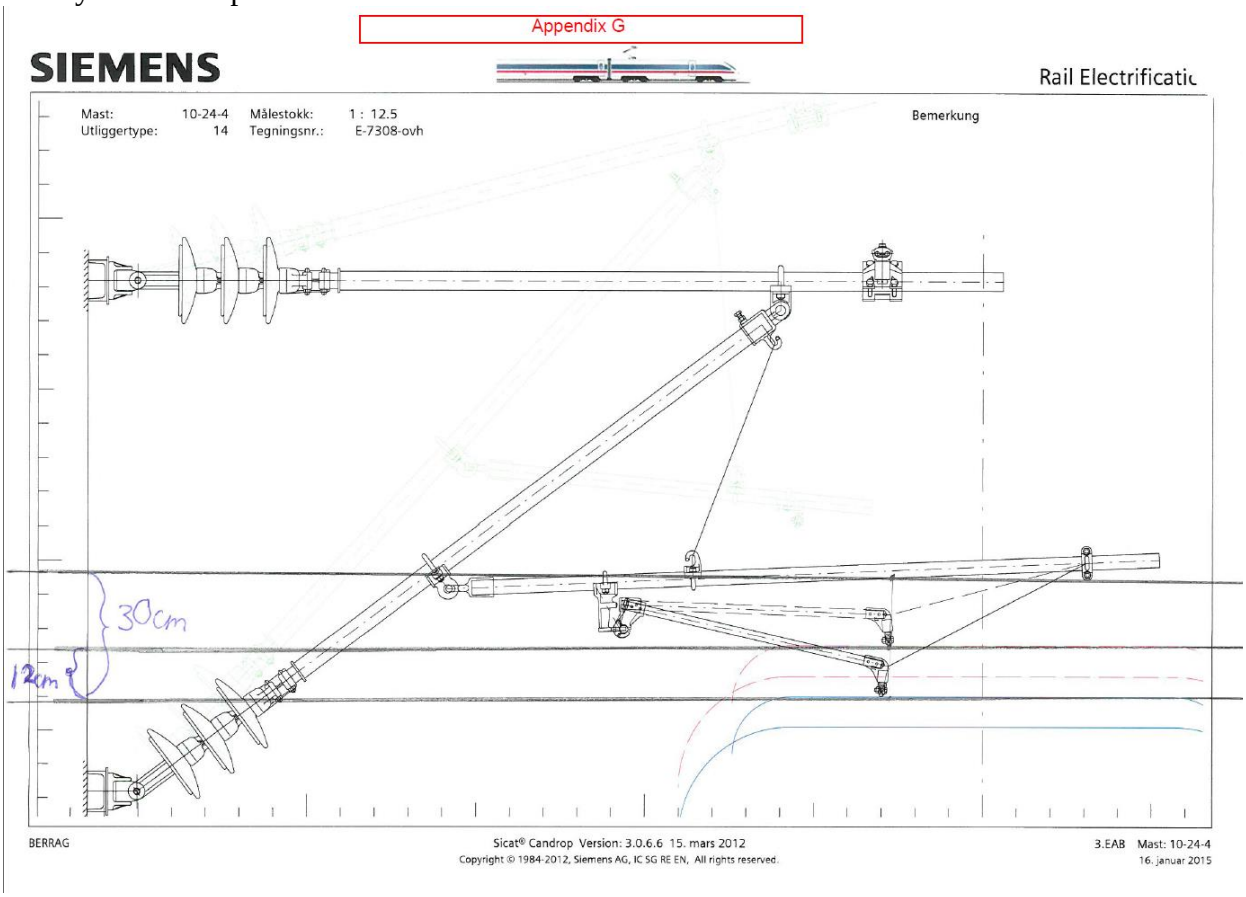


**Figure 15 Space available for uplift of steady arm in S20 (120 mm) – Based on drawing EK.707308-000**

# 11 APPENDIX H – ADJUSTMENT OF STEADY ARM (ACQUISITION)

Adjustment of steady arm (Acquisition)

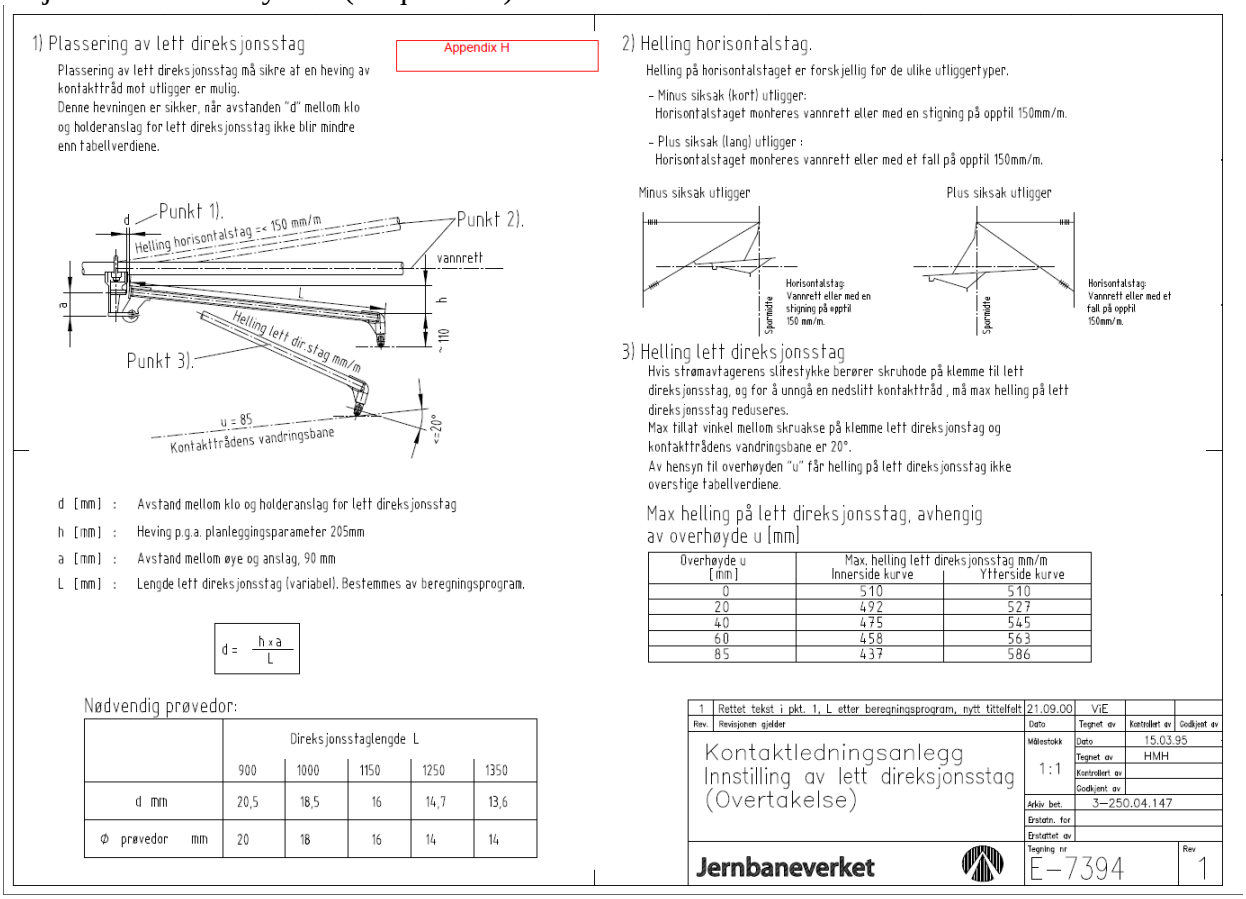


**Figure 16 Adjustment of steady arm in S20 by acquisition – Drawing EK.707394-000**

# 12 APPENDIX I – TYPE TESTING OF PANTOGRAPH WBL85 ON TRAIN BM 69

Report 200111NSB from Schunk Nordiska - Type testing of pantograph WBL85. For TRAIN BM 69, NSB Norway

| Schunk Nordiska | BM 69-TRAIN NSB | | | Report 200111NSB |
|---|---|---|---|---|
| Responsible department. | Take over department. | Revision. | Doc.-Type. | File no. |
| Schunk Nordiska AB | NSB | A- | | |
| Prepared. | Checked. | Approved. | Language. | Page. |
| Bertil Eriksson 02-03-28 | | 02-03-27 | EN | 1 / 28 |
| Valid for. | Derived from. | Replaces. | Classify no. | File. |
| NSB | | | | REPORT200111NSB |

# Type testing of pantograph WBL85

# For TRAIN BM 69 ,NSB Norway

| Schunk Nordiska | BM 69-TRAIN NSB | Report 200111NSB |
|---|---|---|

| Responsible department. | Take over department. | Revision. | Doc.-type. | File no. |
|---|---|---|---|---|
| Schunk Nordiska AB | NSB | A- | | |
| **Prepared.** | **Checked.** | **Approved.** | **Language.** | **Page.** |
| Bertil Eriksson 02-03-28 | | 02-03-27 | EN | 2 / 28 |
| **Valid for.** | **Derived from.** | **Replaces.** | **Classify no.** | **File.** |
| NSB | | | | REPORT200111NSB |

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| Schunk Nordiska | Revision. | Language. En | Page. 3 / 28 | Report 200111NSB |
|---|---|---|---|---|

# 1 Type test

## *1.1 Test number*

Function test of the pantograph WBL85 on the train "BM69".

## *1.2 Conclusion*

### 1.2.1 General

Pantographs measuring was executed in single, 2 multiple and 3 multiple driving The test were performed on double track Vestby-Kambo on overhead line system 20 Kl wire 100" ris. The result is based on a chosen measure distance km 48-54 Vestby-Kambo and km 44-38 Kambo- Vestby on track Oslo S-Moss.

All type tests were measured on train No 69088 (3 coaches unit), for the multiple test train No 69033 (2 coaches unit) and train No 69067(3 coaches unit) where used.

The tests result for both driving direction for each train configuration is account.
The measure results for all train configurations are within the acceptance criteria for speed up to 130km/h.
From video monitoring can it verify that the pantograph visually function very well, no big different in current collection between the different train configuration and driving direction Open/Closed for the pantograph.

In Single train the total force is 73 N in Open and 76 N for Closed driving direction of the pantograph at the speed of 130 km/h.

When the measure pantograph is going first in multiple, the forces are nearly the same as single driving.

The conclusion is that the pantograph performs excellently with a aerofoil configuration as shown in Figure 1, i.e. with one aerofoil 1x300 mm active in closed knee directed and one aerofoil 1x150mm active in direction open knee.

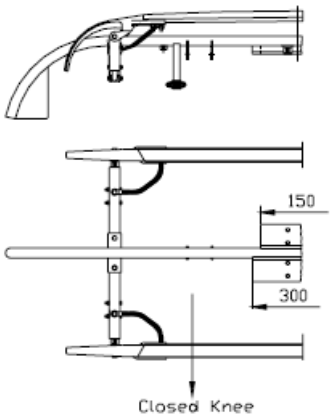



*Figure 1* Configuration of aerofoil

**Aerodynamic tests: OK**

In "Open" direction the force went up to 75N, and in "Closed" direction up to 83N see Table 1.
To decrease the total force aerofoil need to be added, one in each driving direction.
The finally adjustment of the dimensions of aerofoil was carried out during the dynamic test session.

Table 1 summarises the average forces for the aerodynamic test.

| Direction of Driving | Measure Name | Average F1 (N) | Average F2(N) | $F_{tot}$ Average (N) | Speed km/h | Remarks |
|---|---|---|---|---|---|---|
| | | | | | | |
| Open Knee | AO101 | 40 | 35 | 75 | 130 | No Aerofoil, Track Kambo-Vestby |
| | | | | | | |
| Closed Knee | AC101 | 40 | 43 | 83 | 130 | No Aerofoil, Track Vestby - Kambo |

*Table 1*, Summary of aerodynamic tests

**Dynamic tests:**

After test runs with several aerofoils configurations, the finally configurations will be.
One aerofoil of 300 mm width active in "Closed" running direction, and one 150 mm width active in "Open" direction.
This configuration gives good dynamic performance for running in either single or multiple units in speed up to 130 Km/h.
Table 2 bellows shows the measuring results for single unit, 2 and 3 multiple units.
To get an overview of the different train configurations seeFigure 2.

**Note:** Driving direction A = Kambo-Vestby , B =Kambo-Vestby.
Train-set Tp 69-88 were the measured vehicle and P1M stand for measure pantograph.

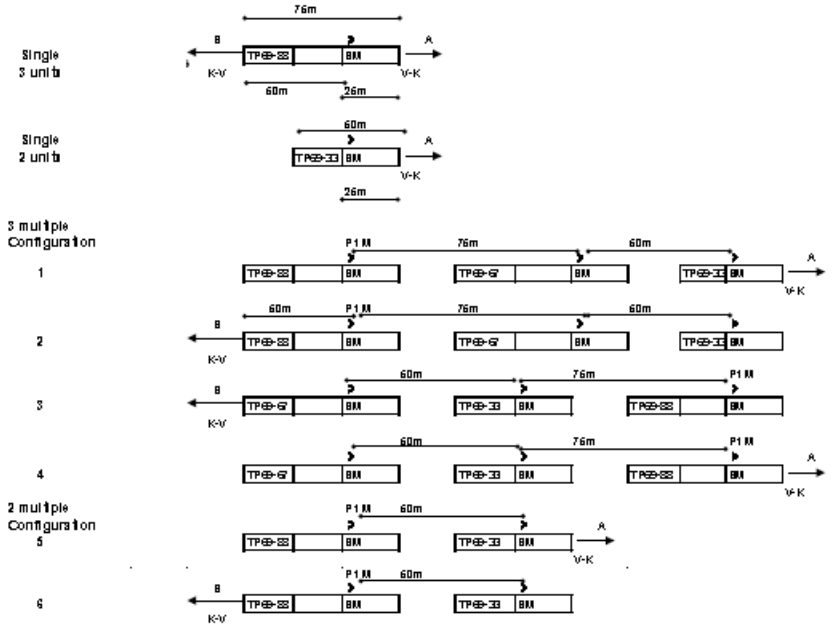



*Figure 2*, Train configuration for the tests

Table 2 summarises the statistics measure results for all the dynamic tests.

| Direction of driving | Track | Train configuration | Speed (km/h) | F1 (N) | F2 (N) | Average force (N) | Max force (N) | Min force (N) | STDAV (N) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|
| Open knee | B | | 128 | 39.1 | 33.9 | 73.0 | 104.4 | 45.1 | 8.9 | Single |
| Closed knee | A | | 128 | 36.8 | 39.1 | 75.9 | 113.6 | 42.9 | 10.2 | Single |
| Closed knee | A | 1 | 130 | 35.3 | 36.7 | 72.0 | 116.5 | 16.1 | 12.6 | *3Mult* |
| Open Knee | B | 2 | 127 | 38.8 | 35.5 | 74.3 | 105.9 | 40.6 | 9.5 | *3Mult* |
| Open knee | B | 3 | 133 | 38.1 | 35.6 | 73.6 | 109.2 | 41.8 | 10.0 | *3Mult* |
| Closed Knee | A | 4 | 130 | 37.7 | 39.7 | 77.8 | 116.1 | 41.8 | 10.8 | *3Mult* |
| Closed knee | A | 5 | 131 | 35.4 | 40.1 | 75.5 | 106.9 | 27.7 | 10.2 | 2 Mult |
| Open Knee | B | 6 | 126 | 39.0 | 34.5 | 73.6 | 104.3 | 48.2 | 8.6 | *2Mult* |

*Table 2*, Summary of dynamic tests

***NOTE.*** There is one place in the direction A and two places in direction B were the total force is to high, these places are related to the contact wire.

# 2 General

## 2.1 Introduction

*This test specification is a type test for NSB Norway on Vehicle BM 69.*

## 2.2 Aim of the test

The aim of the test was see if it was possible to more optimise the dynamic behaviour for the pantograph. And fulfils the requirements and it functions satisfactorily at maximum speeds (130km/h) for Single train and driving in Multiple 2 and 3.

## 2.3 Test norms

The tests are based on norms IEC 494-37 and EC 494-40.

## 2.4 *Measurement equipment*

The measuring system is a computer based system; all samplings and calculations are made simultaneously on the data acquisition board inside the computer, before the measured values are transferred to the computer the signals will be scaled and conditioned on the acquisition board.
All data are then transferred to the computer fore storage and printing. Figure 3 shows the measuring system in block form.
During the measuring a video camera are located on the roof of the vehicle, to record the behavior between overhead line and pantograph.
All data capture is carried out with a sampling frequency of 1000Hz, which is then averaged to 100Hz (even higher if necessary). The filter frequency is 20Hz.

The measure signals and other details are showed in Table 3,Table 4 andTable 5

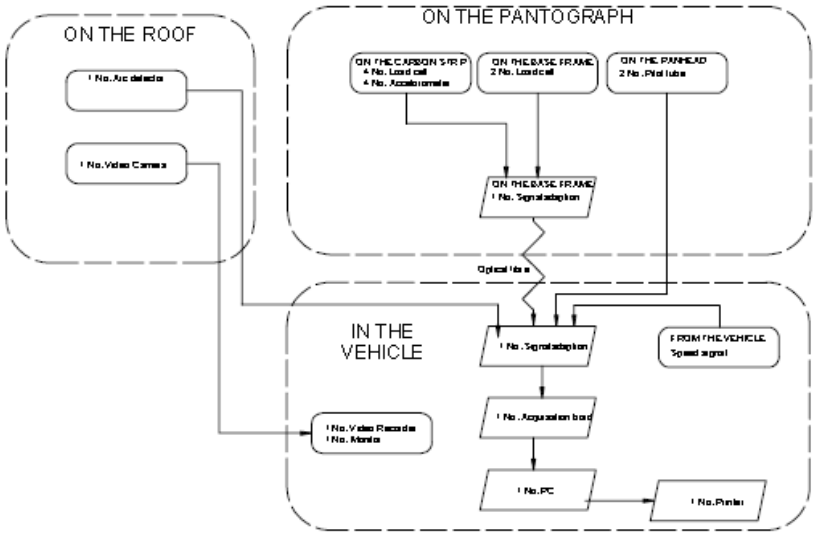



*Figure 3* , Block graph of measuring system

| Signal type | Name | | Range | Mounted |
|---|---|---|---|---|
| Force transducer 1 | Ft1 | ⇒ | Fmax=250N | On pantograph |
| Force transducer 2 | Ft2 | ⇒ | Fmax=250N | On pantograph |
| Force transducer 3 | Ft3 | ⇒ | Fmax=250N | On pantograph |
| Force transducer 4 | Ft4 | ⇒ | Fmax=250N | On pantograph |
| Accelerometer 1 | A1 | ⇒ | ±10 g | On pantograph |
| Accelerometer 2 | A2 | ⇒ | ±10 g | On pantograph |
| Accelerometer 3 | A3 | ⇒ | ±10 g | On pantograph |
| Accelerometer 4 | A4 | ⇒ | ±10 g | On pantograph |
| Wind speed 1 | Ws1 | ⇒ | Range 0-100 m/s | On pantograph |
| Force transducer 10 | Ft10 | ⇒ | Fmax=250N | On pantograph |
| Force transducer 11 | Ft11 | ⇒ | Fmax=250N | On pantograph |
| Wind speed 2 | Ws2 | ⇒ | Range 0-100 m/s | On pantograph |
| Height | H1 | ⇒ | Range 0-3 m | On pantograph |
| Electric arc | L1 | ⇒ | >1ms | On roof |
| Speed signal | Gs | ⇒ | Range 0-300 km/h, 0-10V DC | On train set |

*Table 3, Measurement signals*

| Type | Current consumption | Mounted |
|---|---|---|
| Battery 12V DC | 120mA | On pantograph |
| Battery 18-36V DC | 30A | On train set |
| Converter 18-36 DC V ⇒ AC 220 V | | On train set |

*Table 4, Current supply*

| Name | Type | Mounted |
|---|---|---|
| Signal adaptation | Schunk2000 | On train set |
| Measuring card, 16 channels | DAP 3000-212 | On train set |
| Optical transmitter/amplifier | Schunk SS2100 | On pantograph |
| Video | | On train set |
| Camera | | On roof |
| Monitor | | On train set |
| PC | Compaq Prolina | On train set |

*Table 5, Other equipment*

### 2.4.1 ATS, Aerodynamic measure equipment

In order to measure the aerodynamic contribution, the pantograph is tied down with two insulated wires. One end is fixed at the carbon strips and the other end in to the Force transducers, mounted on the pantograph base frame. See Figure 4 and Figure 5.

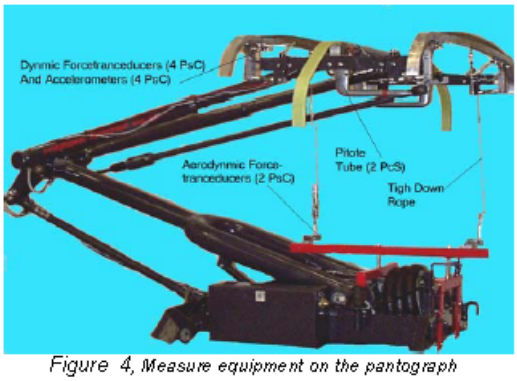



*Figure 4, Measure equipment on the pantograph*

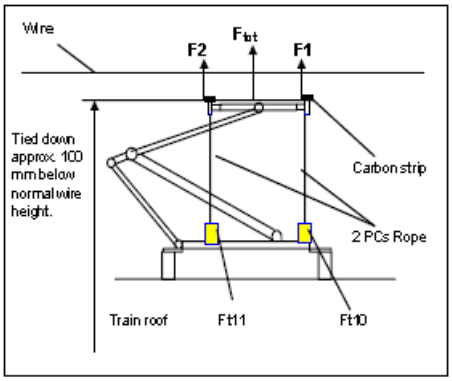



*Figure 5, Aerodynamic Measurement Equipment*

### 2.4.2 DTS, Dynamic measure equipment

The dynamic forces are measured with four Force transducers (Ft1-Ft4) and compensated by four accelerometers situated under the carbon strips, see Figure 6.
To overcome the potential difference between the pantograph and the roof (earth), the signals are fed through optic fibres from the pantograph to the vehicle. All other signals are opto-insulated to avoid interference.
All sensors on the pantograph apart from the pitot tubes are measured for voltage with a battery situated on the pantograph. The wind speed on the upper frame is measured with two pitot tubes mounted on each side of the upper frame mid tube. The measuring signals, current supply and other equipment are summarised in the tables on the next page.

To calculated the force for carbons strip 1 (F1) we use transducer Ft1± the value what we get out of accelerometer A1 + transducer Ft2± the value what we get out of accelerometer A2 The same calculation method is used for carbon strip2 (F2) except we use data from Ft3, A3, Ft4, A4.

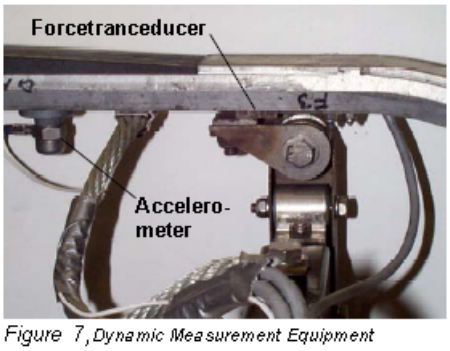



*Figure 7, Dynamic Measurement Equipment*

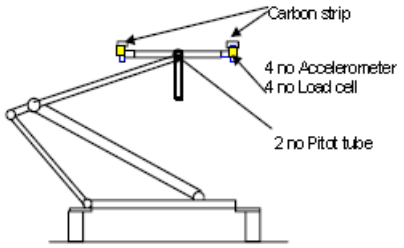



*Figure 6 Dynamic Measurement Equipment*

### 2.4.3 Compensation

All dynamic tests are compensated for the carbon strips:

- Aerodynamic.
- Mass.

The carbon strips aerodynamic behaviour is measured whit tied down pantograph. In this measure the aerodynamic and dynamic measuring results are compared, the different between the results from aerodynamic Ft10 and dynamic F1 (F1 = Ft1+Ft2) gives the aerodynamic compensation factor for carbonstrip F1. And for carbonstrip 2 the different between the results from aerodynamic Ft11 dynamic F2 (F2 = Ft3+Ft4 ).

This compensation factor corrects the dynamic measure results directly in the measure program.

The force transducers results have influence of the carbon strip dynamic mass. The carbon strips mass is known, their acceleration is measure, and compensate by the calculation (F =m•a). The measuring programs continuous compensate measure results.

### 2.4.4 System check

The measure system force transducers, accelerometers etc. is assemble and calibrates initial at Schunk.

System checks on the field of force transducers, accelerometers etc. are preformed before every test day start and after test day completing.

### 2.4.5 Driving direction of the pantograph

Figure 8 explain the driving direction for the pantograph:

- "Open" knee
- "Closed" knee

**Other information:**

- F1 is the first carbon strip in open
- F2 is the second carbon strip in open.

This configuration (F1, F2) never changes in the measuring.
That means that the first carbon strip in closed direction is F2.

- WS 1 is the measured wind speed in open direction
- WS 2 is the measured wind speed in closed direction.

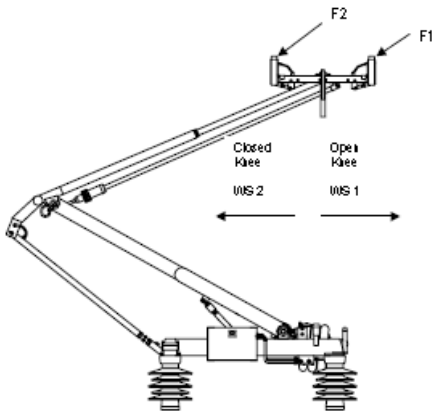



*Figure 8, driving direction*

### 2.4.6 How to read and understand the statistic results tables and graphs.

*(For example we shows measure file DCL 300, not from this test without from another of ours measuring we have done.)*

The statistic results are shows in Table 7, is an average values from five speed variations close to the maximum speed (table 6).

Table 6 shows this five speed variations, this table is included in the reports appendix fore each test.

| Speed (km/h) | Windspeed 1 (km/h) | Windspeed 2 (km/h) | F1 (N) | F2 (N) | $F_{lol}$ average (N) | MAX of $F_{lol}$ (N) | MIN of $F_{lol}$ (N) | Stdav of $F_{lol}$ (N) | Numbers of counts |
|---|---|---|---|---|---|---|---|---|---|
| 158.0 | 13.7 | 149.5 | 47.4 | 45.0 | 92.3 | 146.8 | 58.4 | 13.7 | 610.0 |
| 159.0 | 13.0 | 149.1 | 47.5 | 44.8 | 92.3 | 159.1 | 53.5 | 15.6 | 484.0 |
| 160.0 | 13.6 | 147.1 | 47.8 | 46.0 | 93.8 | 148.4 | 54.2 | 12.7 | 1955.0 |
| 161.0 | 11.9 | 145.5 | 47.8 | 45.9 | 93.7 | 133.7 | 57.2 | 11.7 | 2609.0 |
| 162.0 | 16.2 | 145.4 | 47.9 | 46.4 | 94.3 | 120.4 | 63.2 | 10.6 | 256.0 |

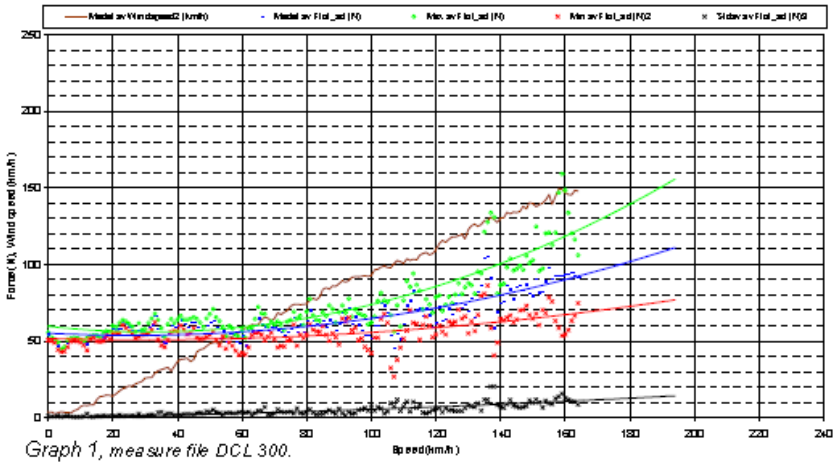
*Table 6, Measure results DCL 300*

| Medel Speed(km/h) | Average of Windspeed1 (km/h) | Average of Windspeed2 (km/h) | Average of F1_ad (N) | Average of F2_ad (N) | Average of Ftot_ad (N) | Max of Ftot_ad (N) | Min ofv FtotAD(N) | Stdav of FtotAD(N) |
|---|---|---|---|---|---|---|---|---|
| 160 km/h | | 147 km/h | 47.7 N | 45.6 N | 93.3 N | 141.7 N | 57.3 N | 12.8 N |

*Table 7,Average Measure results DCL 300 taken out from table 6.*

**The above results** Table 7 **is shown in tables of the report.**

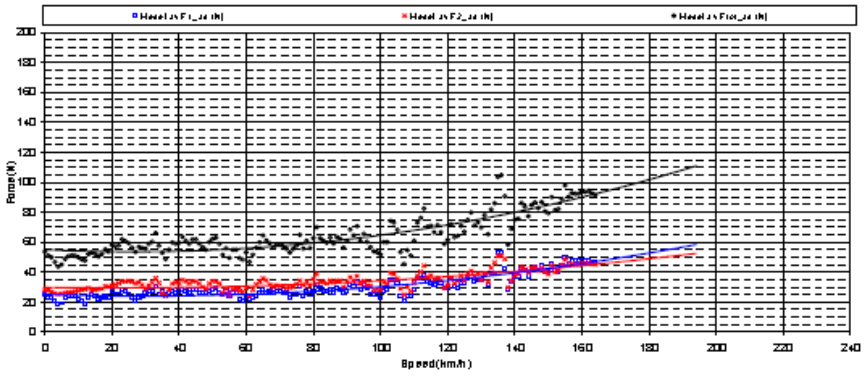
The measure files are also presented whit graphs in the report and appendix.




*Graph 1, measure file DCL 300.*

The Graph 1 shows $F_{tot}$ ,$F_{min}$ ,$F_{max}$ ,and STD ( average force as function of speed) . This graph shows also a trend curve (polynom), except for the wind speed curve.

The Graph 2 shows $F_{tot}$ ,F1 and F2 ( average force as function of speed) . This graph shows also a trend curve (polynom).




*Graph 2, shows force as a function of speed.*

# 3 Time and place

The tests were performed on the double track between Vestby-Kambo km48-54 and Kambo-Vestby km 44-38 in week 46, 2001.
During the test the weather condition was god and no consideration need to be taken.

# 4 Results

## *4.1 Static upwards pressure*

Prior to rolling tests a check was made of the pantographs up wards Force.

Using a spring balance the static up wards Force was checked at 5600 mm above rail upper edge. The up wards Force was set at 60 N.

## *4.2 Aerodynamic adjustment IEC 494-37*

### 4.2.1 Test method

The total average Force was measured, (the static Force plus the aerodynamic contribution cause by the airflow round the pantograph). The pantograph was raised during the test and tied down with two insulated wires to a height of 5400 mm over rail upper edge, approx. 200 mm below the normal contact wire system height of 5600 mm.
The train was propelled by a other train up to a maximum operating speed of 130 km/h, the measurement started and the train speed was lowered successively, slowly drawing to a complete halt.
This tests makes in both driving direction for the pantograph

### 4.2.2 Test runs

Total 4 test runs was carried out, See results in Table 8.
The finely aerofoil configuration of the pantograph (shown in Figure 1) was set in Dynamic test.

| Date | Test Runs | F1 (N) | F2 (N) | Plot (N) | Note | File Name | Configuration | Driving direction | |
|---|---|---|---|---|---|---|---|---|---|
| 2001-11-13 | | | | | The measure system adjustmet to 5.40m | | | | |
| 130 km/h | 1 | 39 | 44 | 83 | | AC100 | No Aerofil | CL | Vestby - Kambo |
| 130 km/h | 2 | 34 | 40 | 73 | | AC100 | No Aerofil | OP | Kambo-Vestby |
| 130 km/h | 3 | 40 | 43 | 83 | | AC 101 | No Aerofil | CL | Vestby - Kambo |
| 130 km/h | 4 | 40 | 35 | 75 | | AC101 | No Aerofil | OP | Kambo-Vestby |

*Table 8, Aerodynamic test runs*

### 4.2.3 Measuring equipment for test

See Chapter 2.4

### 4.2.4 Results of aerodynamic measurements

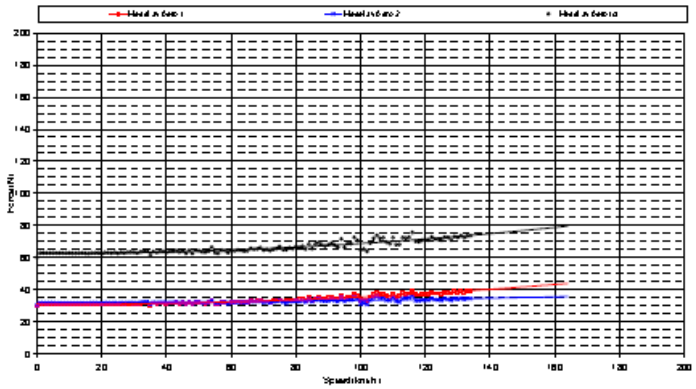
- Test results without aerofoil the average uplift of the pantograph was in open 75N and 83N in Closed direction (measure file A0101 and AC 101). Some aerofoil needs to decrease the forces.

| Direction of travel | Speed (km/h) | Average force as function of speed (N) | Measure file | Aerofoil |
|---|---|---|---|---|
| Open knee | 130 | 75 | AO101 | 0 |
| Closed knee | 130 | 83 | AC101 | 0 |

*Table 9,* Summary of aerodynamic results

Graph 3 test no AO101 shows the forces as function of train speed.

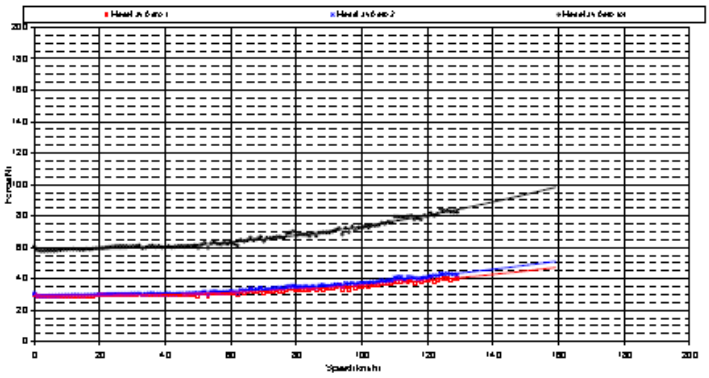
- No aerofoil .The measurements were carried out in the driving direction open knee.
- The upper curve shows total force $F_{tot}$(black), the middle curve shows the force on the front Carbon strip *F1* in the direction of driving (red) and the lower rear Carbon strip *F2* (blue). The speed is the speed of the train set



*Graph 3,* Force as a function of speed, direction of driving open knee

Graph 4 test no AC101 shows the forces as function of train speed.

- No aerofoil .The measurements were carried out in the direction of travel of open knee.
- The upper curve shows total force $F_{tot}$ (black), the middle curve shows the force on the front Carbon strip *F2* in the direction of driving (blue) and the lower rear Carbon strip *F1* (red). The speed is the speed of the train set



*Graph 4*, Force as a function of speed, direction of driving closed knee

### 4.2.5 Results of compensation measurements

The compensation measurements were made in aerodynamic tests. The results are given in Graph 5 and Graph 6.
Briefly put, the differences were not particularly large between open and closed driving direction of the pantograph.

In open direction the carbon strip (F1) is in principle neutral, and for carbon strip F2 show approx. 6 N to low in open direction.

And in closed direction the carbon strip F1 shows approx. 3 N to low and carbon strip F2 shows approx. 4 N to low.

The compensation figures below have been used to compensate for the aerodynamic effect of the carbon strips (All dynamic tests reported have been compensated).

***In open knee gives:***

$$F_1 = (-1.0 \cdot 10^{-5} \cdot v^2) + (4.1 \cdot 10^{-3} \cdot v)$$

Explanation ($F_1$ is the front Carbon strip in the direction of travel, $v$ is the speed. The dynamic sensors show approx. 0.5N too little at 130 km/h).

$$F_2 = (-3.0 \cdot 10^{-4} \cdot v^2) + (8.5 \cdot 10^{-3} \cdot v)$$

Explanation ($F_2$ is the rear Carbon strip in the direction of travel, $v$ is the speed. The dynamic sensors show approx. 65N too little at 130 km/h)

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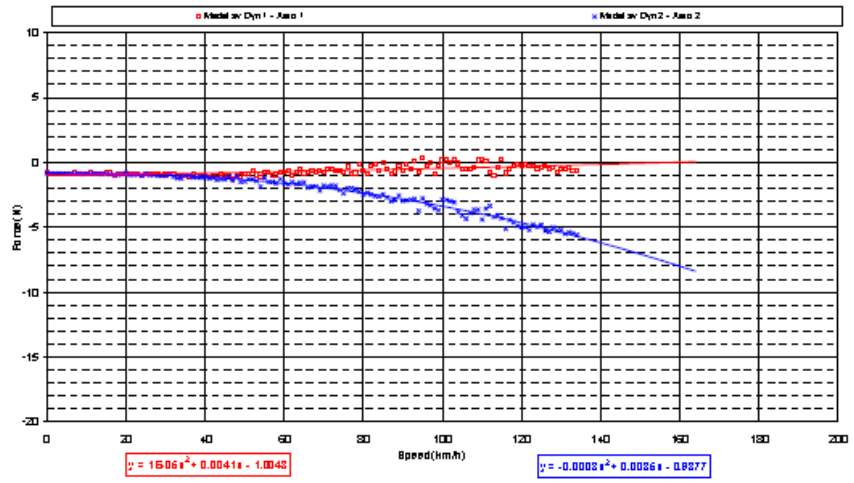
|---|---|---|---|---|




*Graph 5*, Comparison of compensation test run AC101 Force as a function of wind speed, direction of driving open knee.

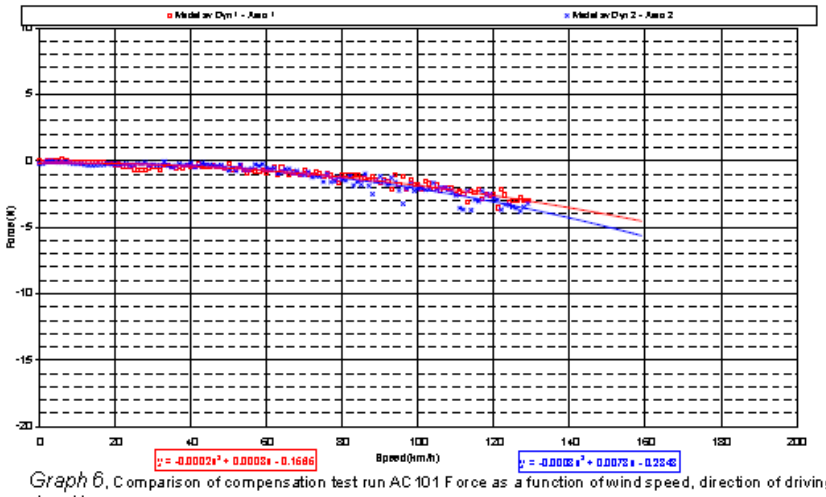
***In closed knee gives:***

$$F_1 = (-2.0 \cdot 10^{-4} \cdot v^2) + (8.0 \cdot 10^{-4} \cdot v)$$

Explanation ($F_1$ is the rear Carbon strip in the direction of travel, v is the speed. The dynamic sensors show approx. 3N too little at 130 km/h)

$$F_2 = (-3.0 \cdot 10^{-4} \cdot v^2) + (7.3 \cdot 10^{-3} \cdot v)$$

Explanation ($F_2$ is the front Carbon strip in the direction of travel, v is the speed. The dynamic sensors show approx. 4N too little at 130 km/h)




*Graph 6*, Comparison of compensation test run AC101 Force as a function of wind speed, direction of driving closed knee

## *4.3 Current collection test (dynamic tests) IEC 494-40*

### 4.3.1 Test method

The dynamic force between the pantograph and the overhead conductor is measured in speeds up to 130 km/h.
The test is run with an optimised pantograph, in both directions of driving. Under the whole test line the measured values collected continuously. All test results have been compensated. See 4.2.5.

### 4.3.2 Test runs Single

A total of 17 tests were performed, Table 10shows all the tests. And the final aerofoils configurations see test DCL 106 and DOP 106. The type test was carried out with an optimised pantograph. With one aerofoil 1x 300 mm directed in close knee and one aerofoil 1x150mm directed in open knee.

| Test no./ file no. | Direction of driving | Aero foil config. | Test track | Notes |
|---|---|---|---|---|
| DCL100 | Closed | 0 mm | Vestby- Kambo(Oslo s –Moss) | |
| DOP100 | Open | 0 mm | Kambo- Vestby(Oslo s –Moss) | |
| DCL101 | Closed | 1x200mm cl /1x110mm op | Vestby- Kambo(Oslo s –Moss) | |
| DOP101 | Open | 1x200mm cl 1x110mm op | Kambo-Vestby(Oslo s –Moss) | |
| DCL102 | Closed | 1x200mm cl /1x110mm op | Vestby- Kambo(Oslo s –Moss) | |
| DOP102 | Open | 1x200mm cl 1x110mm op | Kambo-Vestby(Oslo s –Moss) | |
| DOP103 | Open | 1x200mm cl 1x110mm op | Kambo-Vestby(Oslo s –Moss) | |
| DCL104 | Closed | 1x300mm cl /1x110mm op | Vestby- Kambo(Oslo s –Moss) | |
| DOP104 | Open | 1x300mm cl 1x110mm op | Kambo-Vestby(Oslo s –Moss) | |
| DCL105 | Closed | 1x300mm cl /1x110mm op | Vestby- Kambo(Oslo s –Moss) | |
| DOP105 | Open | 1x300mm cl 1x110mm op | Kambo-Vestby(Oslo s –Moss) | |
| DCL106 | Closed | 1x300mm cl /1x150mm op | Vestby- Kambo(Oslo s –Moss) | Final aero foil configuration |
| DOP106 | Open | 1x300mm cl 1x150mm op | Kambo-Vestby(Oslo s –Moss) | Final aero foil configuration |
| DCL107 | Closed | 1x300mm cl /1x150mm op | Vestby- Kambo(Oslo s –Moss) | Final aero foil configuration |
| DOP107 | Open | 1x300mm cl 1x150mm op | Kambo-Vestby(Oslo s –Moss) | Final aero foil configuration |
| DCL108 | Closed | 1x300mm cl /1x150mm op | Vestby- Kambo(Oslo s –Moss) | Final aero foil configuration |
| DOP108 | Open | 1x300mm cl 1x150mm op | Kambo-Vestby(Oslo s –Moss) | Final aero foil configuration |

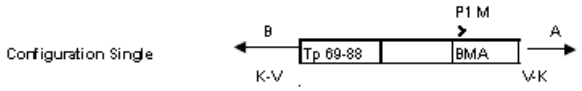
*Table 10*, Dynamic test runs

### 4.3.3 Measuring equipment for the test

See Chapter 2.4

### 4.3.4 Results of dynamic tests Single

Table 11 show all dynamic test results. The results were clearly satisfactory from the final aerofoils configuration from test DCL106 to DOP 108.




| FileName | Average Speed (km/h) | Average Windspeed 1 (km/h) | Average Windspeed 2 (km/h) | Average F1_ad (N) | Average F2_ad (N) | Average Ftot_ad (N) | Max of Ftot_ad (N) | Min of FtotAD (N) | Stdav of FtotAD (N) | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0mm in Closed + 0 in Open | | | | | |
| DCL100.xls | 129 km/h | | 109 km/h | 43.4 N | 48.3 N | 91.7 N | 122.2 N | 62.0 N | 9.5 N | *Vestby-Kambo Closed direction* |
| DOP100.xls | 128 km/h | 116 km/h | | 40.6 N | 34.1 N | 74.7 N | 105.7 N | 46.1 N | 9.0 N | *Kambo-Vestby ,Open direction* |
| New wing cfg | | | | | 200mm in Closed + 110 mm in Open | | | | | |
| DCL101.xls | 126 km/h | | 123 km/h | 40.8 N | 45.1 N | 85.9 N | 116.5 N | 52.3 N | 10.5 N | *Vestby-Kambo Closed direction* |
| DOP101.xls | 127 km/h | 112 km/h | | 38.3 N | 32.5 N | 70.8 N | 96.3 N | 43.1 N | 11.1 N | *Kambo-Vestby ,Open direction* |
| DCL102.xls | 127 km/h | | 113 km/h | 39.3 N | 43.1 N | 82.3 N | 122.0 N | 48.7 N | 10.7 N | *Vestby-Kambo Closed direction* |
| DOP102.xls | 129 km/h | 107 km/h | | 38.1 N | 32.9 N | 71.1 N | 99.6 N | 45.3 N | 8.1 N | *Kambo-Vestby ,Open direction* |
| DOP103.xls | 130 km/h | 112 km/h | | 38.9 N | 33.5 N | 72.4 N | 103.9 N | 44.1 N | 9.3 N | *Kambo-Vestby ,Open direction* |
| New wing cfg | | | | | 300mm in Closed + 110 mm in open | | | | | |
| DCL104.xls | 127 km/h | | 106 km/h | 35.3 N | 37.4 N | 72.6 N | 97.8 N | 42.3 N | 9.7 N | *Vestby-Kambo Closed direction* |
| DOP104.xls | 129 km/h | 120 km/h | | 41.4 N | 35.5 N | 76.9 N | 106.4 N | 49.8 N | 8.6 N | *Kambo-Vestby ,Open direction* |
| DCL105.xls | 127 km/h | | 109 km/h | 36.0 N | 37.6 N | 73.6 N | 112.0 N | 37.8 N | 10.9 N | *Vestby-Kambo Closed direction* |
| DOP105.xls | 128 km/h | 115 km/h | | 40.6 N | 34.7 N | 75.3 N | 101.2 N | 53.0 N | 7.3 N | *Kambo-Vestby ,Open direction* |
| New wing cfg | 300mm in Closed + 150 mm in open | | | | | | | | | |
| DCL106.xls | 128 km/h | | 105 km/h | 36.1 N | 38.4 N | 74.4 N | 106.9 N | 38.5 N | 10.2 N | *Vestby-Kambo Closed direction* |
| DCL107.xls | 128 km/h | | 107 km/h | 37.4 N | 39.6 N | 76.9 N | 119.0 N | 45.6 N | 10.3 N | *Vestby-Kambo Closed direction* |
| DCL108.xls | 128 km/h | | 107 km/h | 37.0 N | 39.5 N | 76.5 N | 114.8 N | 44.6 N | 10.2 N | *Vestby-Kambo Closed direction* |
| average | 128 km/h | | 107 km/h | 36.8 N | 39.1 N | 75.9 N | 113.6 N | 42.9 N | 10.2 N | |
| DOP106.xls | 128 km/h | 113 km/h | | 38.8 N | 33.7 N | 72.5 N | 101.1 N | 49.2 N | 8.6 N | *Kambo-Vestby ,Open direction* |
| DOP107.xls | 129 km/h | 114 km/h | | 38.9 N | 33.8 N | 72.7 N | 102.1 N | 41.3 N | 9.0 N | *Kambo-Vestby ,Open direction* |
| DOP108.xls | 128 km/h | 116 km/h | | 39.5 N | 34.3 N | 73.8 N | 109.9 N | 44.7 N | 9.2 N | *Kambo-Vestby ,Open direction* |
| average | 128 km/h | 115 km/h | | 39.1 N | 33.9 N | 73.0 N | 104.4 N | 45.1 N | 8.9 N | |

*Table 11*, Results of dynamic tests

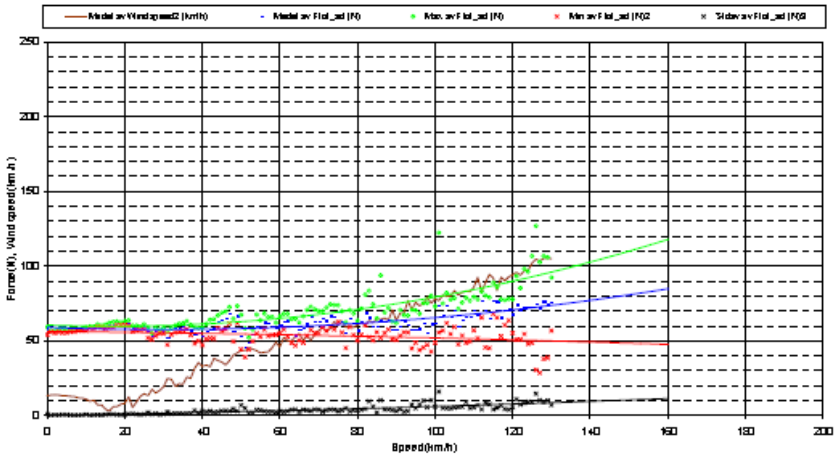
And Table 12 shows average value for closed driving direction from test DCL 106-DCL108 and for open driving direction from test DOP 106-108.

| Direction of driving | Speed (km/h) | F1 (N) | F2 (N) | Average force (N) | Average Max force (N) | Average Min force (N) | STD (N) |
|---|---|---|---|---|---|---|---|
| Closed knee | 128 | 36.8 | 39.1 | 75.9 | 113.6 | 42.9 | 10.2 |
| Open knee | 128 | 39.1 | 33.9 | 73.0 | 104.4 | 45.1 | 8.9 |

*Table 12* average DCL 106-108 and DOP 106-108

And in the diagram few force peaks over 120N in both directions of driving; the peaks come from contact wire system (not well adjusted). The standard deviation is also low about 9-10N, while the distribution between carbon strips is also entirely satisfactory.

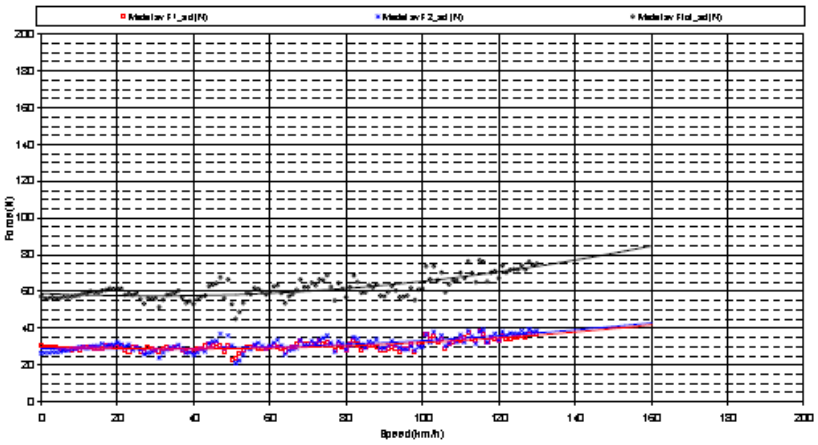
Graph 7, test DCL106, pantograph in closed knee, 1x300+1x150mm aerofoil.




*Graph 7*, Dynamic test run DCL106 Force as a function of speed, direction of driving closed knee

- The diagram shows the forces in function of train speed.
- *Maximum force* (green), *Average force* (blue), *minimum force* (red) *Standard deviation* (black) and wind speed (violet) as a function of speed

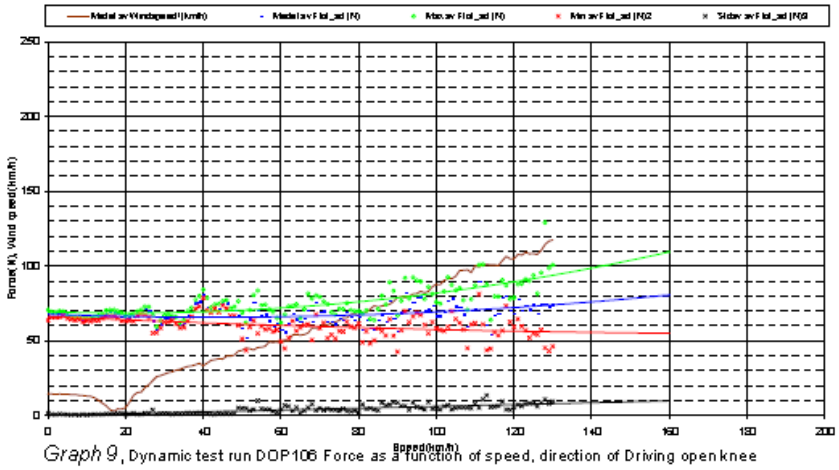
Graph 8, show test DCL106.




*Graph 8*, Dynamic test run DCL106 Force as a function of speed, direction of driving closed knee

- The diagram shows the Ftot (black).
- Distribution of forces between the carbon strips, *F1* (red) is the rear Carbon strip and *F2* (blue) is the front Carbon strip

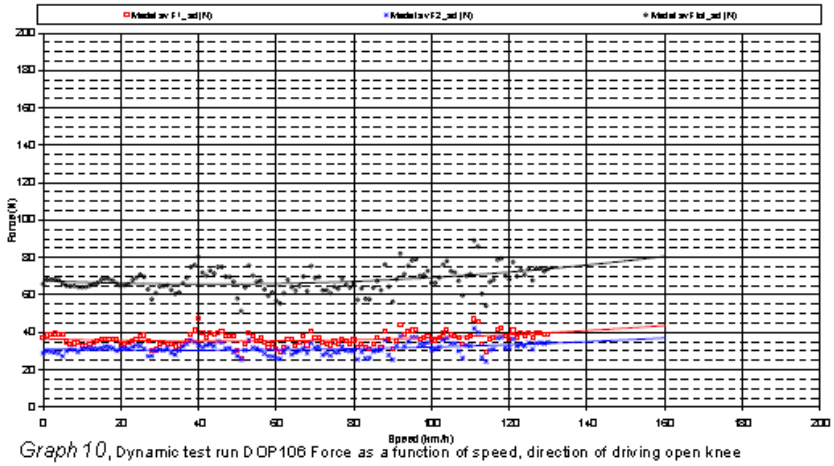
Graph 9, shows test DOP106, pantograph in Open knee, 1x300+1x150mm aerofoil.




*Graph 9*, Dynamic test run DOP106 Force as a function of speed, direction of Driving open knee

- The diagram shows the forces in function of train speed.
- *Max force* (green), *Average force* (blue), *Min force* red), *Standard deviation* (black) and Wind speed (violet).

Graph 10 shows test DOP106.



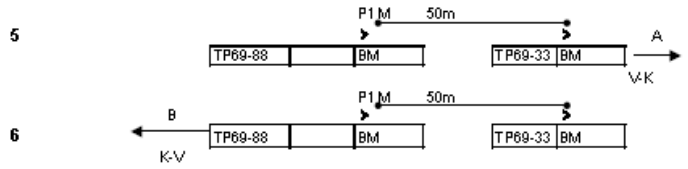

*Graph 10*, Dynamic test run DOP106 Force as a function of speed, direction of driving open knee

- The diagram shows *Ftot (black*
- The distribution between the carbon strips, *F1* (red) is the front Carbon strip and *F2* (blue) is the rear Carbon strip.

### 4.3.5 Results of dynamic tests 2 Multiple

The results see Table 13 were clearly satisfactory.

**2 multiple Configuration**




| File Name | Average Speed (km/h) | Average Windspeed 1 (km/h) | Average Windspeed 2 (km/h) | Average F1_ad (N) | Average F2_ad (N) | Average Ftot_ad (N) | Max of Ftot_ad (N) | Min of FtotAD (N) | Stdav of FtotAD (N) | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|
| DCL200.xls | 131 km/h | | 123 km/h | 35.6 N | 40.1 N | 75.8 N | 106.3 N | 16.8 N | 10.7 N | CFG 5, Vestby Kambo |
| DCL201.xls | 130 km/h | | 121 km/h | 35.1 N | 40.2 N | 75.3 N | 107.5 N | 38.7 N | 9.7 N | CFG 5, Vestby Kambo |
| Average | 131 km/h | | 122 km/h | 35.4 N | 40.1 N | 75.5 N | 106.9 N | 27.7 N | 10.2 N | |
| DOP200.xls | 126 km/h | 112 km/h | | 39.0 N | 34.4 N | 73.3 N | 106.3 N | 47.3 N | 8.8 N | CFG 6, Kambo -Vestby |
| DOP201.xls | 126 km/h | 112 km/h | | 39.1 N | 34.7 N | 73.8 N | 102.3 N | 49.2 N | 8.5 N | CFG 6, Kambo -Vestby |
| Average | 126 km/h | 112 km/h | | 39.0 N | 34.5 N | 73.6 N | 104.3 N | 48.2 N | 8.6 N | |

*Table 13*, Results of dynamic tests 2 multiple

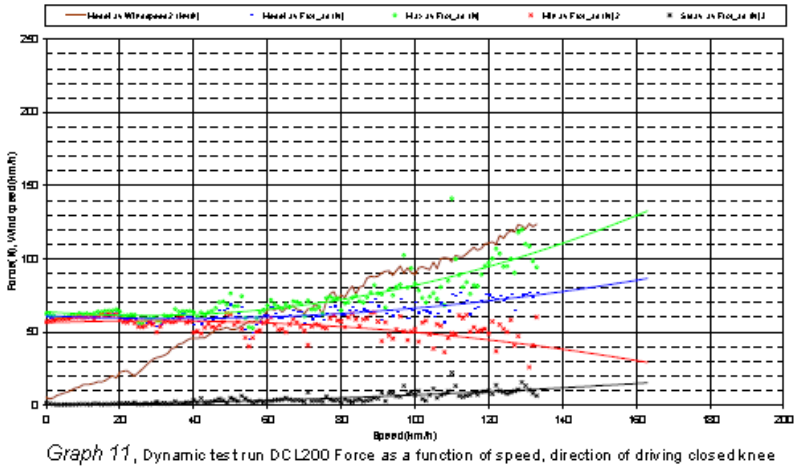
And Table 14 show average value for closed driving direction test DCL 200-DCL201 and for open driving direction test DOP 200-201.

| 2 multiple configuration NO | Direction of driving | Speed (km/h) | F1 (N) | F2 (N) | Average force (N) | Average Max force (N) | Average Min force (N) | STD (N) |
|---|---|---|---|---|---|---|---|---|
| 5 | Closed knee | 131 | 35.4 | 40.1 | 75.5 | 106.9 | 27.7 | 10.2 |
| 6 | Open knee | 126 | 39.0 | 34.5 | 73.6 | 104.3 | 48.2 | 8.6 |

*Table 14*, Results of dynamic tests 2 multiple

The diagrams from measure file DCL 200 and Dop200 shows few force peaks over 120N in both directions of driving; the peaks come from contact wire system (not well adjusted) The standard deviation is also low about 10N cfg 5 and 9N cfg 6, while the distribution between carbon strips is also entirely satisfactory.
In appendix shows all measure results in diagrams.

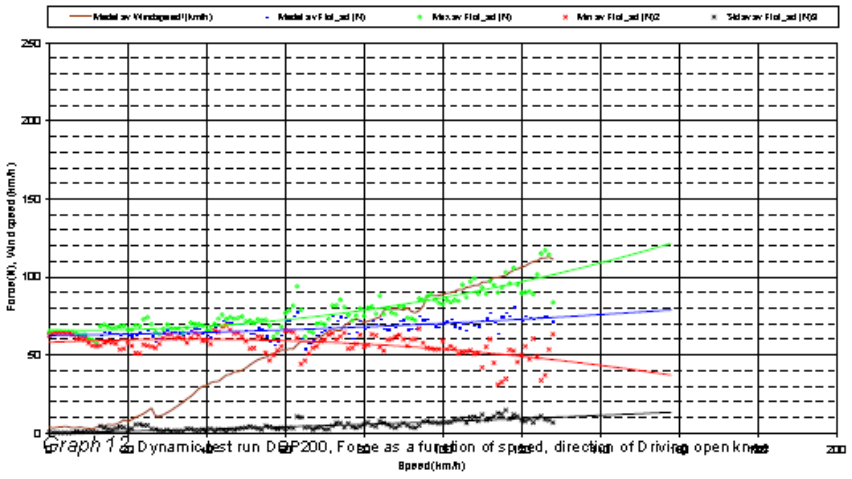
Graph 11 , test DCL200 cfg 5, pantograph in closed knee, 1x300+1x150 mm aerofoil.




*Graph 11*, Dynamic test run DCL200 Force as a function of speed, direction of driving closed knee

- The diagram shows the forces in function of train speed.
- *Max force* (green), *Average force* (blue), *Min force* red), *Standard deviation* (black) and Wind speed (violet).

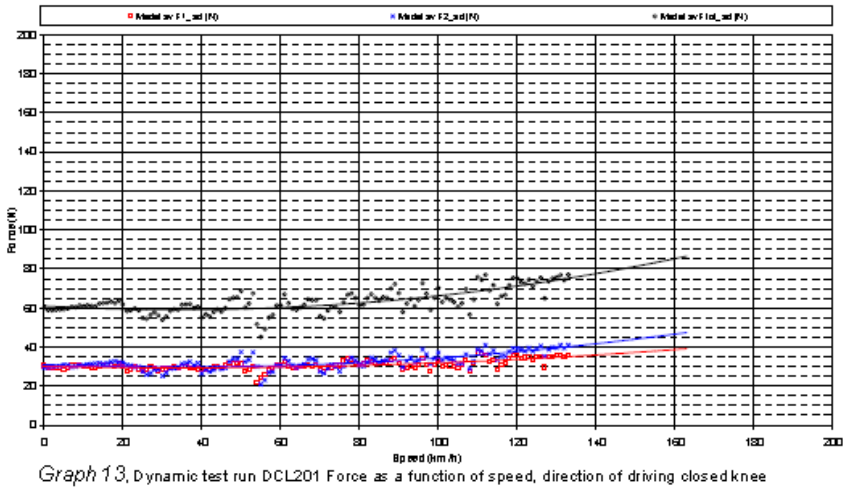
Graph 12 , shows test DOP200 cfg 6, pantograph in Open knee, 1x300+1x150 mm aerofoil.




*Graph 12*, Dynamic test run DOP200, Force as a function of speed, direction of driving open knee

- The diagram shows the forces in function of train speed.
- *Max force* (green), *Average force* (blue), *Min force* red), *Standard deviation* (black) and Wind speed (violet).

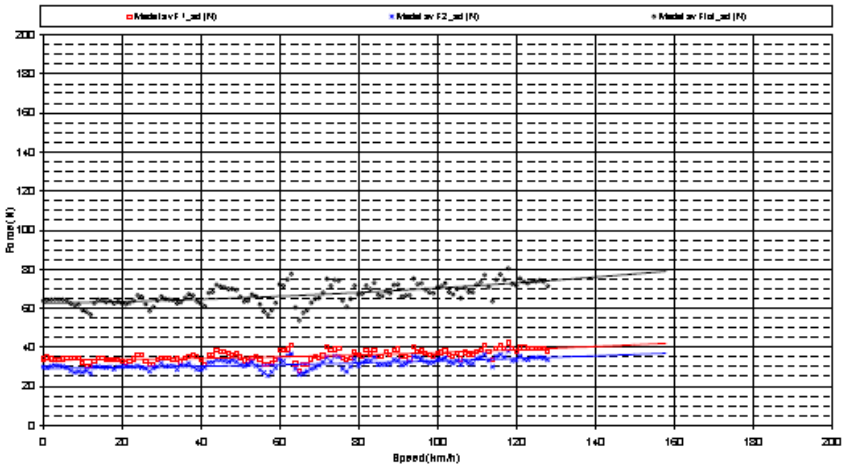
Graph 13, test DCL201 cfg 5, pantograph in closed knee.




*Graph 13*, Dynamic test run DCL201 Force as a function of speed, direction of driving closed knee

- The diagram shows the Ftot (black).
- Distribution of forces between the carbon strips, *F1* (red) is the rear Carbon strip and *F2* (blue) is the front Carbon strip

Graph 14, shows test DOP201 cfg 6, pantograph in Open knee.

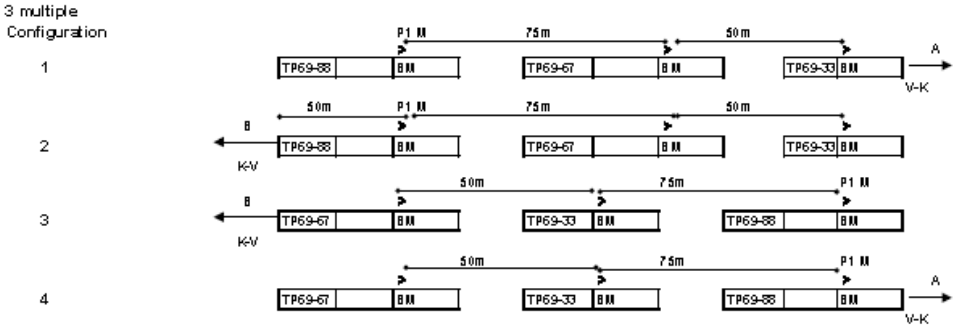



*Graph 14*, Dynamic test run DOP201, Force as a function of speed, direction of Driving open knee

- The diagram shows *Ftot (black*
- The distribution between the carbon strips, *F1* (red) is the front Carbon strip and *F2* (blue) is the rear Carbon strip.

### 4.3.6 Results of dynamic tests 3 Multiple

The results were clearly satisfactory, see Table below, and in the diagram few force peaks over 150N in both directions of driving; the peaks come from contact wire system (not well adjusted). The standard deviation is also low about 12-13N cfg1, 9.5N cfg 2, and 10-11 N for cfg 3, while the distribution between carbon strips is also entirely satisfactory.




| 3 multiple configuration NO | Direction of driving | Speed (km/h) | F1 (N) | F2 (N) | Average force (N) | Average Max force (N) | Average Min force (N) | STD (N) | Measure file |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Closed knee | 129<br>**130** | 34.1<br>**35.3** | 33.1<br>**36.7** | 67.2<br>**72.0** | 108.7<br>**116.5** | 8.9<br>**16.1** | 12.7<br>**12.6** | DCL301,<br>**DCL302** |
| 2 | Open knee | **127** | **38.8** | **35.5** | **74.3** | **105.9** | **40.6** | **9.5** | **DOP301** |
| 3 | Open knee | **133**<br>133<br>131 | **38.1**<br>39.0<br>39.5 | **35.6**<br>35.6<br>25.6 | **73.7**<br>74.6<br>75.1 | **109.2**<br>116.7<br>110.6 | **41.8**<br>36.4<br>46.8 | **10.0**<br>10.0<br>9.6 | **DOP303,**<br>DOP304<br>DOP305 |
| 4 | Closed knee | **130**<br>129 | **37.7**<br>37.6 | **39.7**<br>40.4 | **77.4**<br>78.0 | **116.1**<br>120.1 | **41.8**<br>39.1 | **10.8**<br>11.2 | **DCL303,**<br>DCL304 |

*Table 15*, Results of dynamic tests 2 multiple,

***NOTE.*** *Results and measure file in* ***extra bold type*** *is shows in diagram after. The other file shows only in appendix.*

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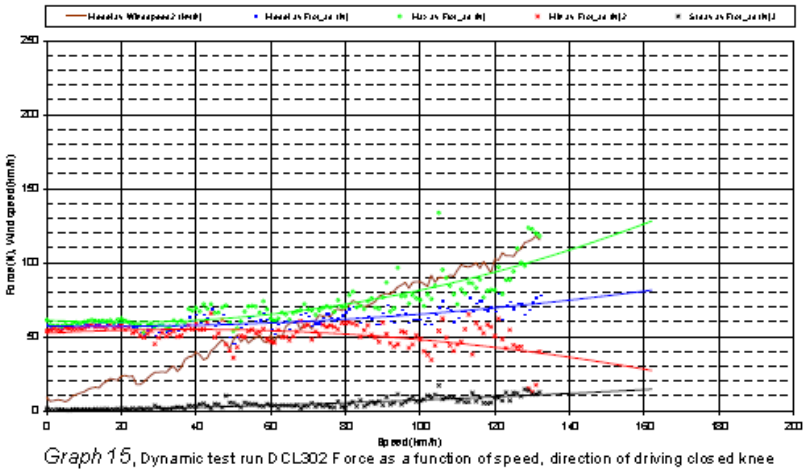
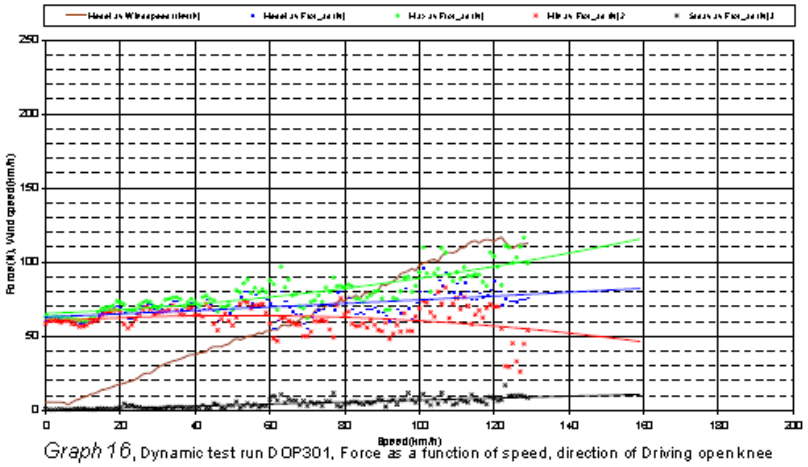
Graph 15, test DCL302 cfg 1, pantograph in closed knee, 1x300+1x150 mm aerofoil.




*Graph 15*, Dynamic test run DCL302 Force as a function of speed, direction of driving closed knee

- The diagram shows the forces in function of train speed.
- *Max force* (green), *Average force* (blue), *Min force* red), *Standard deviation* (black) and Wind speed (violet).

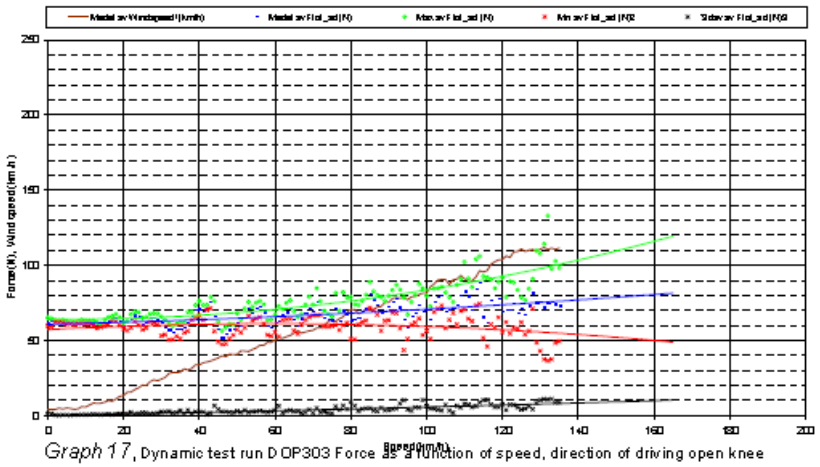
Graph 16, shows test DOP301 cfg 2, pantograph in Open knee, 1x300+1x150 mm aerofoil.




*Graph 16*, Dynamic test run DOP301, Force as a function of speed, direction of Driving open knee

- The diagram shows the forces in function of train speed.
- *Max force* (green), *Average force* (blue), *Min force* red), *Standard deviation* (black) and Wind speed (violet).

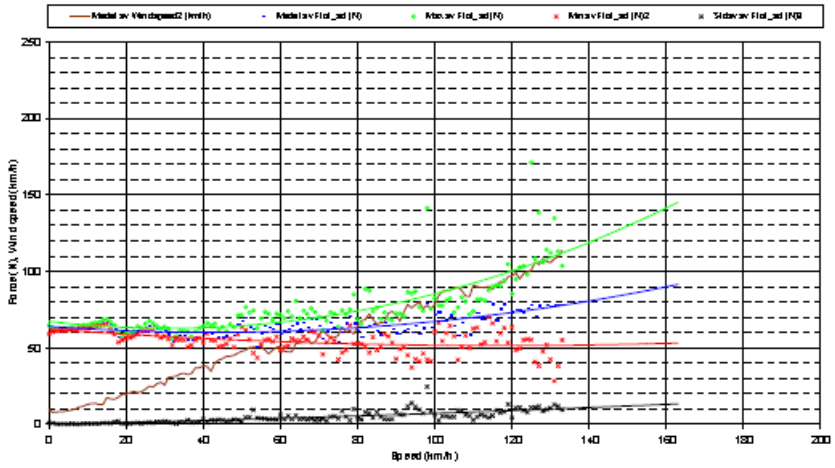
Graph 17, test DOP303 cfg 3, pantograph in open knee, 1x300+1x150mm aerofoil.



*Graph 17*, Dynamic test run DOP303 Force as a function of speed, direction of driving open knee

- The diagram shows the forces in function of train speed.
- *Max force* (green), *Average force* (blue), *Min force* red), *Standard deviation* (black) and Wind speed (violet).

Graph 18, shows test DCL303 cfg 4, pantograph in Closed knee, 1x300+1x150mm aerofoil.



*Graph 18*, Dynamic test run DCL303, Force as a function of speed, direction of Driving closed knee

- The diagram shows the forces in function of train speed.
- *Max force* (green), *Average force* (blue), *Min force* red), *Standard deviation* (black) and Wind speed (violet)

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## 5.0 Appendix

| | | |
|---|---|---|
| *5.1* | *Appendix A* | Aerodynamic test results, AC 101,AO101 |
| *5.2* | *Appendix B* | Dynamic test results Single, DCL106-108,DOP106-108 . |
| *5.3* | *Appendix C* | Dynamic test results 2 Multiple, DCL200,DCL201. |
| *5.3.1* | *Appendix D* | Dynamic test results 2 Multiple, DOP200,DOP201. |
| *5.4* | *Appendix E* | Dynamic test results 3 Multiple, DCL301,DCL302. |
| *5.4.1* | *Appendix F* | Dynamic test results 3 Multiple, DOP301. |
| *5.4.2* | *Appendix G* | Dynamic test results 3 Multiple, DOP303,DOP304,DOP305. |
| *5.4.3* | *Appendix H* | Dynamic test results 3 Multiple, DCL303,DCL304. |
| *5.5* | *Appendix I* | Video time list. |
| *5.6* | *Appendix J* | Picture of Wing configuration. |

# 13 APPENDIX J – ANALYSIS CONTACT FORCES

**Main analysis**

Twice a year, The National Railway Administration conducts measurements on all lines in Norway. Table 9 gives a summary of the contact force analysis on the most relevant locations where the OCL system is S20 or S25[1]. Here all $F_{max}$ and $F_{min}$ are in accordance with EN 50119:2009 table 4. One can also notice the small values of standard deviation[2], which is a sign that the OCL system is of high performance in regard to contact forces. Notice that the static contact force on all measurements is 55 N.

| Location and date | From Km | To Km | $F_{max}$ [N] | $F_{min}$ [N] | $F_m$ [N] | Standard deviation (Sigma) | Mean speed [km/h] |
|---|---|---|---|---|---|---|---|
| Arendal - Nelaug 8.10.2014 | 317,0000 | 283,0000 | 85,5 | 33,9 | 53,7 | 6,6 | 70,5 |
| Barkåker - Tønsberg 23.3.2015 | 107,5000 | 113,0000 | 80,2 | 50,1 | 61,8 | 5,5 | 116,4 |
| Bergen - Voss 10.9.2014 | 425,8655 | 414,0000 | 100,1 | 18,6 | 47,2 | 10,4 | 106,0 |
| Eidsvoll - Hamar 29.10.2014 | 73,0000 | 69,5720 | 86,1 | 49,2 | 66,0 N | 5,2 | 96,5 |
| Eidsvoll - Oslo S 10.6.2014 | 52,8375 | 3,7900 | 116,5 | 34,8 | 70,0 | 9,0 | 142,5 |
| Haugastøl - Hallingskeid 22.4.2014 | 286,4000 | 313,0000 | 127,8 N | 24,3 | 68,9 | 9,4 | 109,9 |
| Kornsjø - Sarpsborg 29.9.2014 | 169,4600 | 143,6905 | 114,4 | 70,0 | 88,4 | 6,3 | 80,3 |
| Lysaker - Asker 24.4.2014 | 7,9615 | 23,0000 | 115,7 | 24,2 | 65,5 | 8,7 | 112,2 |
| Nelaug - Arendal 8.10.2104 | 284,1005 | 317,0000 | 87,7 | 33,0 | 54,0 | 7,0 | 65,3 |
| Neslandsvatn - Nordagutu 8.10.2014 | 219,0000 | 146,5180 | 89,1 | 36,3 | 56,9 | 7,0 | 83,4 |
| Riksgrensen - Kongsvinger 15.9.2014 | 136,2315 | 115,0000 | 72,4 | 34,7 | 51,6 | 4,9 | 94,9 |
| Sandvatn - Kristiansand 7.10.2014 | 443,9995 | 368,2295 | 77,7 | 29,5 | 53,7 | 5,7 | 78,5 |
| Ski - Moss 29.9.2014 | 39,7000 | 60,2030 | 114,0 | 66,7 | 88,8 | 6,3 | 130,4 |

[1] Very short distances with the OCL systems have been omitted

[2] $\sigma << 0.3*F_m$

| Location and date | From Km | To Km | $F_{max}$ [N] | $F_{min}$ [N] | $F_m$ [N] | Standard deviation (Sigma) | Mean speed [km/h] |
|---|---|---|---|---|---|---|---|
| Stavanger - Sandnes 7.10.2014 | 598,6705 | 583,4430 | 86,2 | 37,1 | 57,2 | 6,9 | 79,1 |
| Trengereid - Bergen 1.9.2010 | 460,0000 | 468,0000 | 114,9 | 18,9 | 68,3 | 10,8 | 94,9 |
| Tønsberg - Barkåker 23.3.2015 | 113,0000 | 107,5000 | 79,6 | 43,9 | 60,4 | 5,0 | 74,8 |

**Table 9 OCL force analysis from In Office based on data from Roger1000**

## Force Sum Distribution

Below in Figure 17 - Figure 33 the distribution of the contact forces of the same locations can be studied.

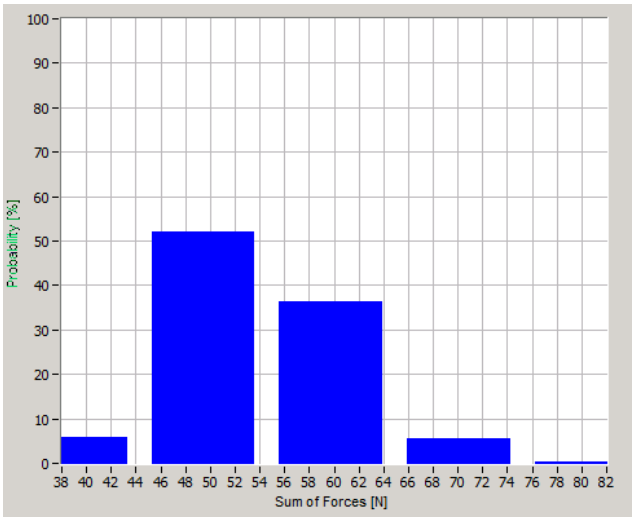


**Figure 17 Distribution of forces Arendal - Nelaug 8.10.2014**

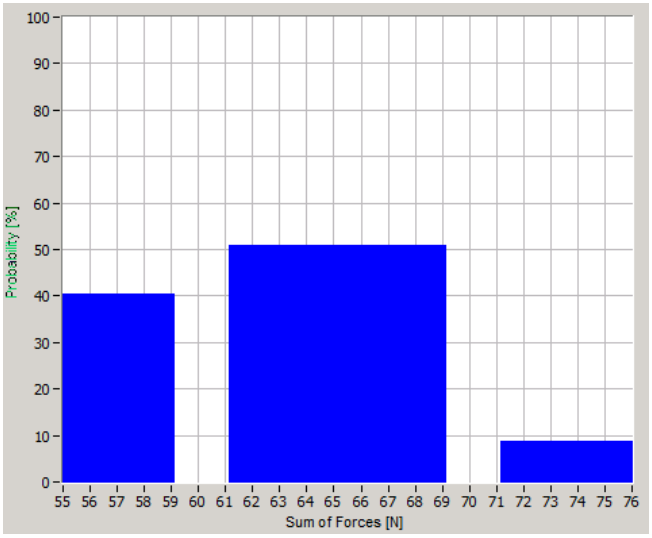


**Figure 18 Distribution of forces Barkåker - Tønsberg 23.03.2015**

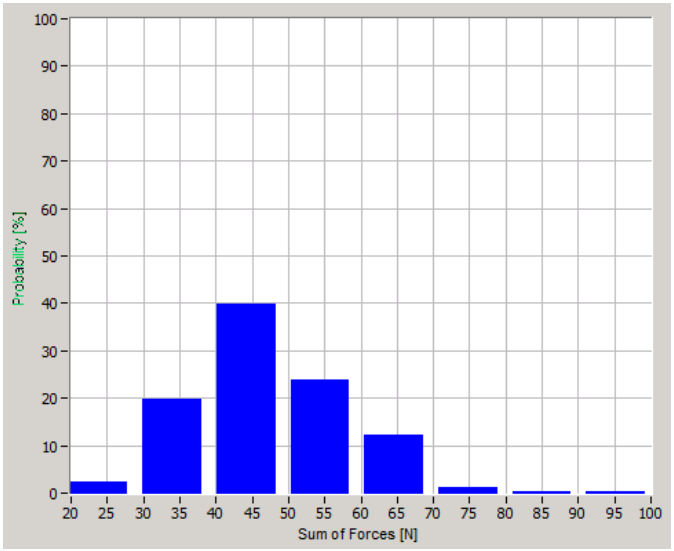


**Figure 19 Distribution of forces Bergen - Voss 10.09.2014**

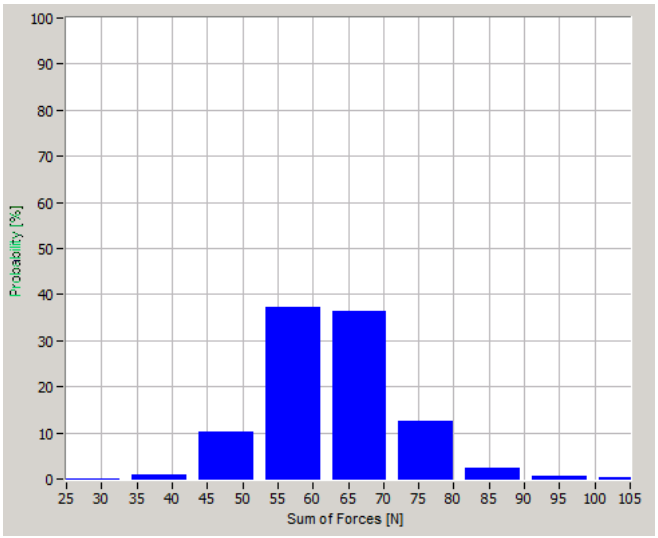


**Figure 20 Distribution of forces Dale - Bergen 25.06.2014**

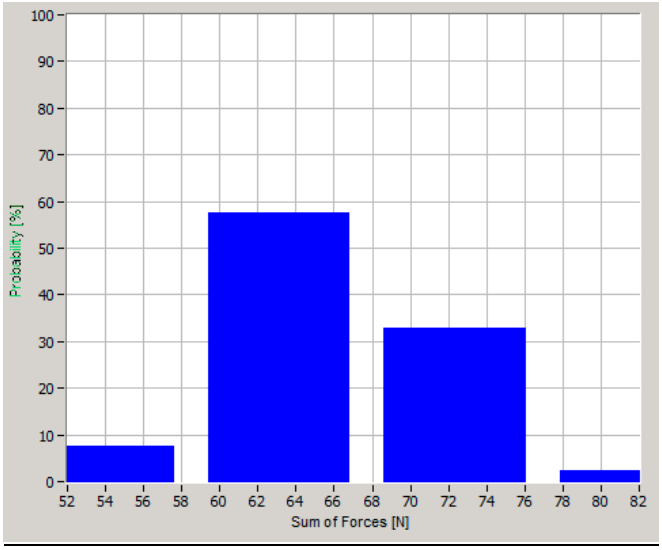


**Figure 21 Distribution of forces Eidsvoll - Hamar 29.10.2014**

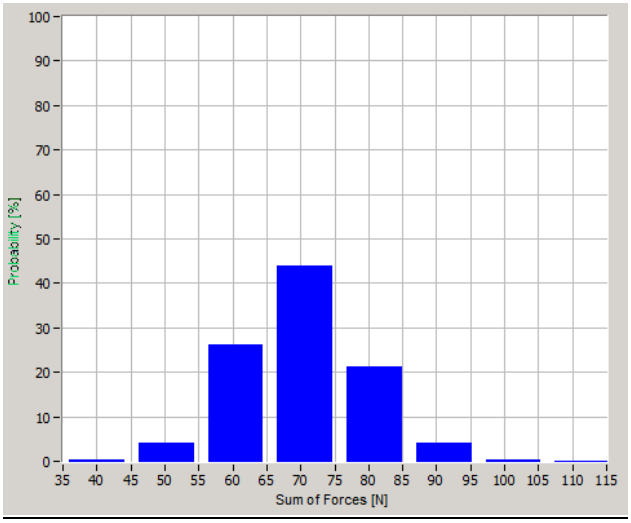


**Figure 22 Distribution of forces Eidsvoll - Oslo S 10.06.2014**

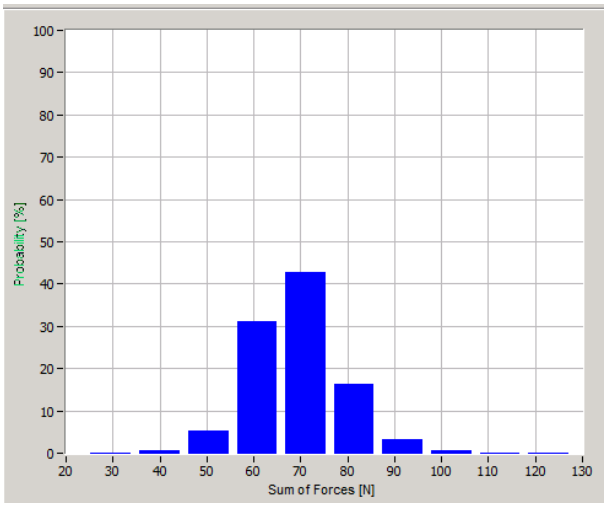


**Figure 23 Distribution of forces Haugastøl - Hallingskeid 22.04.2014**

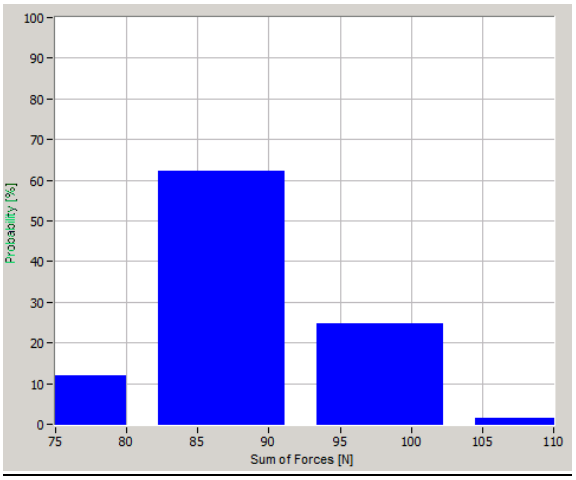


**Figure 24 Distribution of forces Kornsjø - Sarpsborg 29.09.2014**

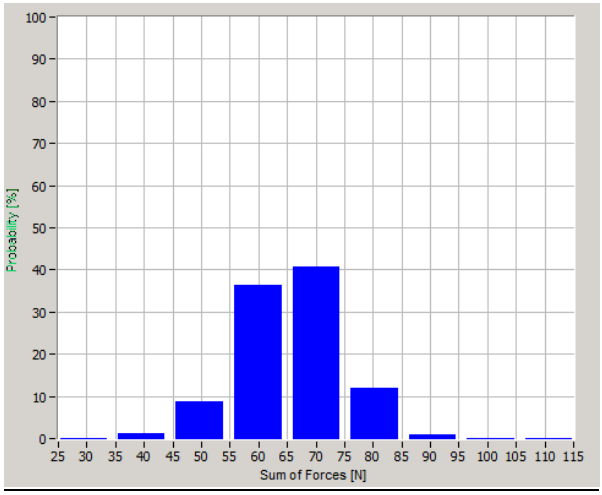


**Figure 25 Distribution of forces Lysaker-Asker 24.04.2014**

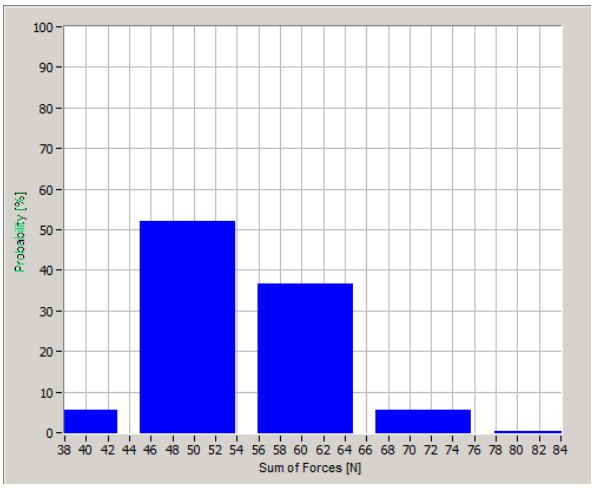


**Figure 26 Distribution of forces Nelaug - Arendal 08.10.2104**

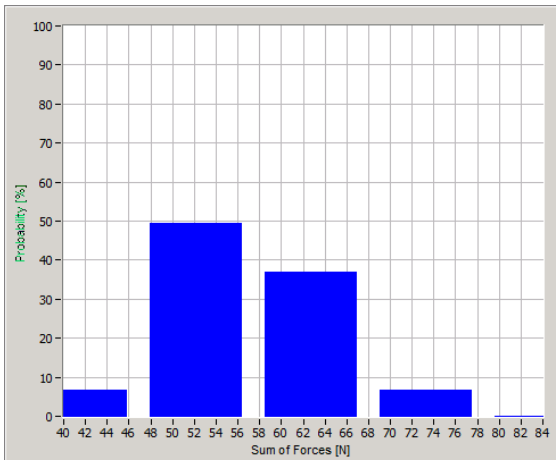


**Figure 27 Distribution of forces Neslandsvatn - Nordagutu 08.10.2014**

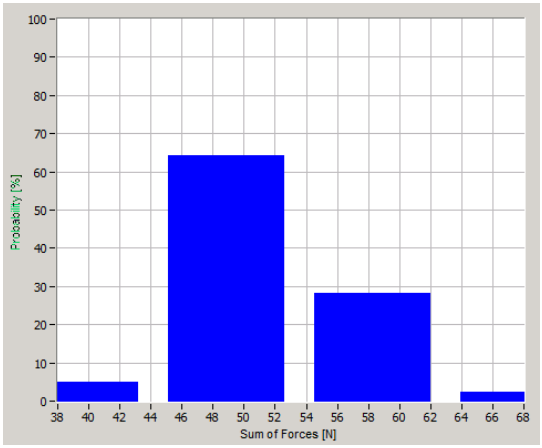


**Figure 28 Distribution of forces Riksgrensen - Kongsvinger 15.09.2014**

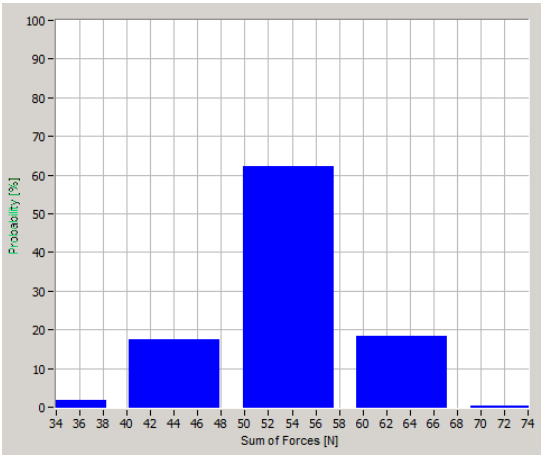


**Figure 29 Distribution of forces Sandvatn - Kristiansand 07.10.2014**

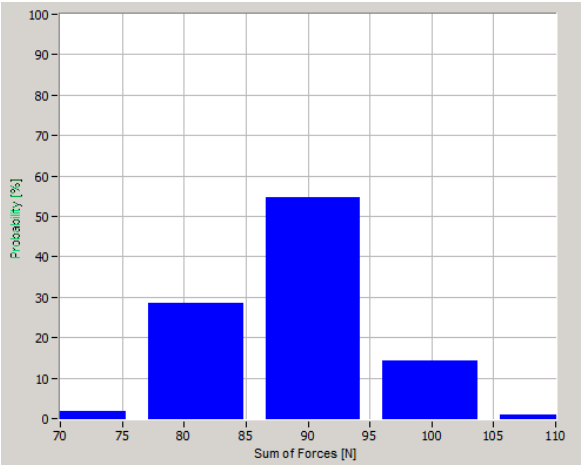


**Figure 30 Distribution of forces Ski - Moss 29.09.2014**

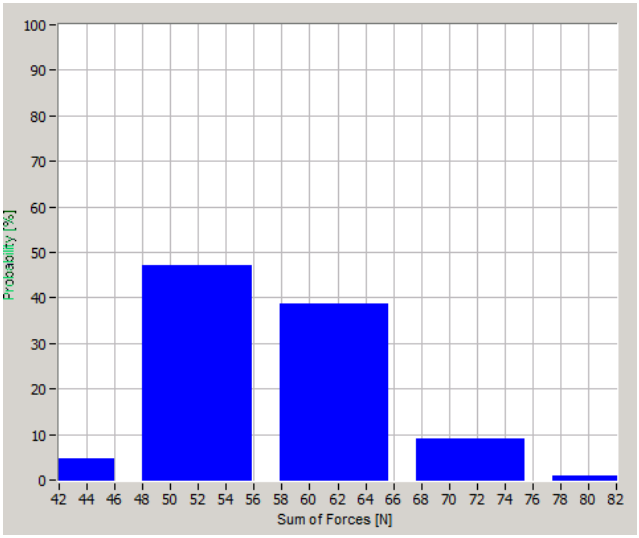


**Figure 31 Distribution of forces Stavanger - Sandnes 07.10.2014**

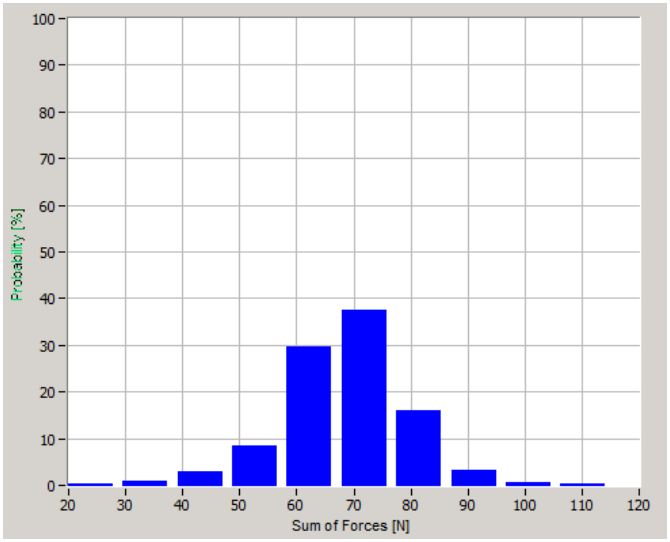


**Figure 32 Distribution of forces Trengereid - Bergen 01.09.2010**

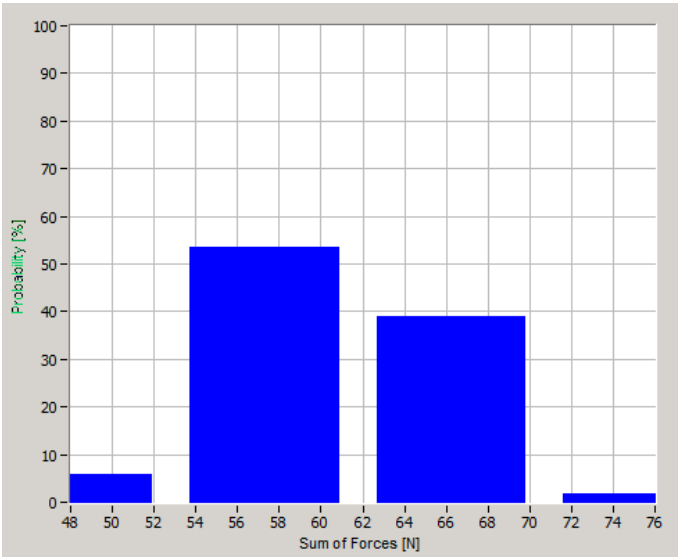


**Figure 33 Distribution of forces Tønsberg - Barkåker 23.03.2015**

## Further analysis

| Location and date | $\sigma_{max}$ [N][3] | $F_m+3*\sigma_{max}$ [N] | $F_{max}$ [N] |
|---|---|---|---|
| Arendal - Nelaug 8.10.2014 | 16,11 | 102,03 | 85,5 |
| Bergen - Voss 10.09.2014 | 14,16 | 89,68 | 100,1 |
| Barkåker - Tønsberg 23.3.2015 | 18,54 | 117.42 | 80,2 |
| Eidsvoll - Oslo S 10.6.2014 | 21,00 | 133,00 | 116,5 |
| Haugastøl - Hallingskeid 22.4.2014 | 20,67 | 130,91 | 127,8 |
| Kornsjø - Sarpsborg 29.9.2014 | 26,52 | 167,96 | 114,4 |
| Lysaker - Asker 24.4.2014 | 19,65 | 124,45 | 115,7 |
| Nelaug - Arendal 8.10.2104 | 16,20 | 102,60 | 87,7 |
| Neslandsvatn - Nordagutu 8.10.2014 | 17,07 | 108,11 | 89,1 |
| Riksgrensen - Kongsvinger 15.9.2014 | 15,48 | 98,04 | 72,4 |
| Sandvatn - Kristiansand 7.10.2014 | 16,11 | 102,03 | 77,7 |
| Ski - Moss 29.9.2014 | 26,64 | 168,72 | 114,0 |
| Stavanger - Sandnes 7.10.2014 | 17,16 | 108,68 | 86,2 |
| Trengereid - Bergen 1.9.2010 | 20,49 | 129,77 | 114,9 |
| Tønsberg - Barkåker 23.3.2015 | 18,12 | 79,6 | 114,76 |

**Table 10 The values of $\sigma_{max}$, $F_m + 3*\sigma_{max}$ and $F_{max}$**

As seen in figure 19, $F_{max} < F_m+3*\sigma_{max}$ for all cases, except Bergen-Voss 10.09.2014. As mentioned in 4.2.12 (3), most values are in this range, and Table 10 complies with this requirement.

[3] $\sigma_{max}=0,3*F_m$

# 14 APPENDIX K – GENERIC MAINTENANCE ROUTINES

Generiske Arbeidsrutiner JBV

## Generiske arbeidsrutiner - Elektro Høyspenning

**Sist oppdatert:** 29.01.2015

| AR nummer | Beskrivelse | Ajour pr. dato Navn | Dato |
|---|---|---|---|
| EH-BKT-0000-01 | Skilt for kjørende personell | HMA | 01.01.2015 |
| EH-BKT-0000-02 | Skilt - Advarsel | HMA | 01.01.2015 |
| EH-ASK-0000-01 | Avskjæring og gjerding mot høyspenning | HMA | 01.01.2015 |
| EH-MAS-0000-01 | Mast Tre | HMA | 01.01.2015 |
| EH-MAS-0000-02 | Mast Stål | HMA | 01.01.2015 |
| EH-MAS-0000-03 | Mast Betong | HMA | 01.01.2015 |
| EH-BAR-0000-01 | Bardun | HMA | 01.01.2015 |
| EH-BAR-0000-02 | Strever i stål | HMA | 01.01.2015 |
| EH-BAR-0000-03 | Strever i tre | HMA | 01.01.2015 |
| EH-AAK-0000-01 | Åk | HMA | 01.01.2015 |
| EH-UTL-0000-01 | Utligger | HMA | 01.01.2015 |
| EH-UTL-0000-02 | Avtrekk | HMA | 01.01.2015 |
| EH-KTL-0000-01 | Kontaktledning | HMA | 01.01.2015 |
| EH-KTL-0000-02 | KL Overtemperaturkontroll | HMA | 01.01.2015 |
| EH-KTL-0000-03 | KL Målevognskjøring | HMA | 01.01.2015 |
| EH-MSP-0000-01 | Målespenn kontakttrådslitasje | HMA | 01.01.2015 |
| EH-KTL-0000-04 | Avspenning Lodd | HMA | 01.01.2015 |
| EH-KTL-0000-05 | Avspenning Fjær | HMA | 01.01.2015 |
| EH-KTL-0000-06 | Avspenning Hydraulikk | HMA | 01.01.2015 |
| EH-KTL-0000-07 | Avspenning Gass | HMA | 01.01.2015 |
| EH-DSE-0000-01 | Dødseksjon | HMA | 01.01.2015 |
| EH-SIL-0000-01 | Seksjonsisolator | HMA | 01.01.2015 |
| EH-KON-0000-01 | Kondesatorbatterianlegg | HMA | 01.01.2015 |
| EH-SUG-0000-01 | Sugetransformator i mast | HMA | 01.01.2015 |
| EH-SUG-0000-02 | Sugetransformator i kiosk | HMA | 01.01.2015 |
| EH-TRF-0000-01 | Biforbrukstrafo | HMA | 01.01.2015 |
| EH-TRF-0000-02 | Kiosk for høyspenningsanlegg | HMA | 01.01.2015 |
| EH-IMP-0000-01 | Filterimpedans/PAK | HMA | 01.01.2015 |
| EH-RLE-0000-02 | Returleder | HMA | 01.01.2015 |
| EH-RKR-0000-01 | Returkrets | HMA | 01.01.2015 |
| EH-LED-0000-01 | Ledning | HMA | 01.01.2015 |
| EH-KAH-0000-01 | Kabel | HMA | 01.01.2015 |
| EH-JEL-0000-01 | Jordelektroder | HMA | 01.01.2015 |
| EH-JOR-0000-01 | Langsgående jordleder | HMA | 01.01.2015 |
| EH-JOR-0000-02 | Seksjonert jordleder | HMA | 01.01.2015 |
| EH-XBE-0000-01 | Beskyttelse | HMA | 01.01.2015 |
| EH-XIS-0000-01 | Isolator | HMA | 01.01.2015 |
| EH-XKO-0000-01 | Konsoll | HMA | 01.01.2015 |
| EH-XUK-0000-01 | Utjevningsforbindelse | HMA | 01.01.2015 |
| EH-BRY-0000-01 | Effektbryter (Siemens 3AF) | HMA | 01.01.2015 |
| EH-BRY-0000-02 | Skillebryter | HMA | 01.01.2015 |
| EH-BRY-0000-03 | Lastskillebryter | HMA | 01.01.2015 |
| EH-BRY-0000-04 | Jordslutter | HMA | 01.01.2015 |
| EH-BRY-0000-05 | Prøvebryterkrets | HMA | 01.01.2015 |
| EH-MAN-0000-01 | Manøvermaskin | HMA | 01.01.2015 |
| EH-VER-0000-01 | Elektromekanisk distansevern | HMA | 01.01.2015 |
| EH-VER-0000-02 | Elektroteknisk distansevern | HMA | 01.01.2015 |
| EH-VER-0000-03 | Numerisk distansevern | HMA | 01.01.2015 |
| EH-VER-0000-04 | Elektromekanisk overstrømsvern | HMA | 01.01.2015 |
| EH-VER-0000-05 | Elektroteknisk overstrømsvern | HMA | 01.01.2015 |
| EH-VER-0000-06 | Numerisk overstrømsvern | HMA | 01.01.2015 |
| EH-VER-0000-07 | Underspenningsvern | HMA | 01.01.2015 |
| EH-VER-0000-08 | Fasevern | HMA | 01.01.2015 |
| EH-VER-0000-09 | Ubalansevern Kondensatorbatteri | HMA | 01.01.2015 |
| EH-VER-0000-10 | Temperaturvern for prøvemotstand PT100 | HMA | 01.01.2015 |
| EH-VER-0000-11 | Termiske vern Kondensatorbatteri | HMA | 01.01.2015 |
| EH-VER-0000-12 | Termiske vern Termisk overstrømsrele for prøvebryter | HMA | 01.01.2015 |
| EH-VER-0000-13 | Lysbuevern (Med strømvilkår) | HMA | 01.01.2015 |
| EH-VER-0000-14 | Lysbuevern (Uten strømvilkår) | HMA | 01.01.2015 |
| EH-VER-0000-15 | Bryterfeilvern Effektbryter | HMA | 01.01.2015 |
| EH-VER-0000-16 | Bryterfeilvern Prøvebryter | HMA | 01.01.2015 |

Arbeidsrutiner Elektro Høyspenning
Side 1 av 86

## Generisk arbeidsrutine

Nr.:
EH-KTL-0000-01 Kontaktledning

Jernbaneverket

| Aktivitetsnr: | RCM ID | Arbeidsbeskrivelse | Type FV | Intervall | Myndighets nivå | Faggruppe | Sporfølgang | Prioritet | Kan avbrytes | Antall personer | Varighet | Kommentar | Dokument referanse: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | EH-KTL-KTLTRÅD-UAS-A | Kontroller horisontal posisjon midt i spennet (A- og C-mål) | TK M | 12 | L | SF | J | 2 | J | 2 | 0,6 | JD 542 kap. 5 | |
| 1010 | EH-KTL-KTLTRÅD-BRD-A | Sjekk og eventuelt mål punktslitasje på kontakttråd | TK V | 12 | L | SF | J | 4 | J | 2 | 0,5 | Grenseverdier for trådtykkelse:<br>- 6,4 mm (80 mm2 Cu ETP)<br>- 7,45 mm (100 mm2 Cu FRHC, 100mm2 CuAg0,10)<br>- 8,23 mm (120 mm2 CuAg0,10)<br>- 7,5 mm (80 mm2 Cu, 8-tallsprofil)<br>- 7,45 mm ( 100 mm2 Cu, 8-tallsprofil) | JD 542 kap.5h |
| 1020 | EH-KTL-STRØMSTIGE_CLINE-BRD-A | Kontroller strømstiger | TK V | 12 | L | SF | J | 3 | J | 2 | 0,3 | JD 542 kap. 5 | |
| 1030 | EH-KTL-STRØMBRU_CLINE-BRD-A | Kontroller strømbruer | TK V | 12 | L | SF | J | 3 | J | 2 | 0,3 | JD 542 kap. 5 | |
| 1040 | EH-KTL-HENGETR_MASSIV-BRD-A | Kontroller hengetråd for skeivstilling og skade | TK V | 12 | H | SF | J | 3 | J | 2 | 0,6 | JD 542 kap. 5 | |
| 1050 | EH-KTL-BÆRELINE-BRD-A | Kontroller bæreline for skade | TK V | 12 | L | SF | J | 3 | J | 2 | 0,6 | JD 542 kap. 5 | |
| 1055 | EH-KTL-KTLTRÅD-OVS-E | Kontroller avstand til omgivelsene (vegetasjon og konstruksjoner) | TK V | 12 | H | SF | J | 4 | J | 2 | 0,2 | JD 542 kap. 8 | FEF §8-4 |
| 1060 | EH-KTL-KTLTRÅD-FRL-E | Kontroller avstander til kryssing/nærføringer | TK V | 12 | L | SF | J | 2 | J | 2 | 0,25 | JD 540 kap. 4, JD 542 kap. 4, 8 og 12 | FEF §8-4 og §6-4 |
| 1070 | EH-KTL-KTLTRÅD-FRL-A | Kontroller fritt profil for strømavtaker | TK M | 24 | L | SF | J | 3 | J | 2 | 0,6 | JD 542 kap. 5 | |
| 1080 | EH-KTL-KTLTRÅD-OVS-A | Kontroller dynamisk isolasjonsavstand | TK M | 24 | L | SF | J | 3 | J | 2 | 0,5 | JD 542 kap. 5, JD 510 kap. 7 | |
| 1090 | EH-KTL-KTLTRÅD-UAS-E | Kontroller høyde i parallellfelt | TK M | 60 | L | SF | J | 4 | J | 2 | 0,5 | JD 542 kap. 5 | |
| 1110 | EH-KTL-KTLTRÅD-OVS-B | Kontroller statisk isolasjonsavstand | TK M | 120 | L | SF | J | 4 | J | 2 | 0,5 | JD 542 kap. 5, JD 510 kap. 7 | |
| 1120 | EH-KTL-KTLTRÅD-OVS-C | Kontroller E-mål | TK M | 120 | L | SF | J | 4 | J | 2 | 0,5 | JD 542 kap. 5, JD 520 kap. 5 figur 5.10 og 5.11 | |
| 1130 | EH-KTL-KTLTRÅD-FRL-C | Kontroller klemmefritt rom i sporveksel | TK M | 120 | L | SF | J | 4 | J | 2 | 0,5 | JD 542 kap. 5 | |
| 1140 | EH-KTL-YLINE-FES-A | Måle strekk i Y-line (System 20 og 25) eller U-mål (System 35) | TK M | 120 | L | SF | J | 4 | J | 2 | 1 | JD 542 kap. 5 | |
| 1150 | EH-KTL-KTLTRÅD-UAS-D | Kontroller horisontal posisjon midt i spennet (A- og C-mål) | TK M | ES | L | SF | J | 0 | N | 2 | 0,2 | JD 542 kap. 5 | |
| 1170 | EH-KTL-KTLTRÅD-FRL-B | Kontroller fritt profil for strømavtaker | TK M | ES | L | SF | J | 0 | J | 2 | 0,6 | JD 542 kap. 5 | |
| 1180 | EH-KTL-KTLTRÅD-OVS-D | Kontroller E-mål | TK M | ES | L | SF | J | 4 | J | 2 | 0,5 | JD 542 kap. 5, JD 520 kap. 5 figur 5.10 og 5.11 | |
| 1190 | EH-KTL-KTLTRÅD-FRL-D | Kontroller klemmefritt rom i sporveksel | TK M | ES | L | SF | J | 0 | J | 2 | 0,2 | JD 542 kap. 5 | |

Tilbake til: Oversikt EH





## Generisk arbeidsrutine

Nr.:
EH-KTL-0000-02 Kontaktledning - Overtemperaturkontroll

Jernbaneverket

| Aktivitetsnr: | RCM ID | Arbeidsbeskrivelse | Type FV | Intervall | Myndighets nivå | Faggruppe | Sporfølgang | Prioritet | Kan avbrytes | Antall personer | Varighet | Kommentar | Dokument referanse: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | EH-KTL-KTLTRÅD-DFO-A | Overtemperaturkontroll av kontakttråd med forbindelser | TK M | 60 | L | SF | J | 4 | N | 4 | 8 | JD 542 kap. 4 | |
| 1010 | EH-KAH-ENDEMUFFE-DFO-A | Overtemperaturkontroll av endemuffer for kabler til KL | TK M | 60 | L | SF | J | 4 | N | 4 | 4 | JD 542 kap. 4 | |
| 1020 | EH-KAH-SKJØTEMUFFE-DFO-A | Overtemperaturkontroll av skjøtemuffer for kabler til KL | TK M | 60 | L | SF | J | 4 | N | 4 | 4 | JD 542 kap. 4 | |
| 1030 | EH-RLE-NEDF-DFO-A | Overtemperaturkontroll av returleder med nedføringer | TK M | 60 | L | SF | J | 4 | N | 4 | 2 | JD 542 kap. 4 | |
| 1040 | EH-SUG-TILKOBLING-DFO-A | Overtemperaturkontroll av koblinger til sugetransformator | TK M | 60 | L | SF | J | 4 | N | 4 | 4 | JD 542 kap. 4 | |
| 1050 | EH-KON-FORB-DFO-A | Overtemperaturkontroll av forbindelser til kondensatorbatteri | TK M | 60 | L | SF | J | 4 | N | 4 | 2 | JD 542 kap. 4 | |
| 1060 | EH-TRF-BITRANS-DFO-A | Overtemperaturkontroll av koblinger til bi-forbrukstransformator | TK M | 60 | L | SF | J | 4 | N | 4 | 4 | JD 542 kap. 4 | |
| 1070 | EH-IMP-TILKOBLING-DFO-A | Overtemperaturkontroll av koblinger til filterimpedanser | TK M | 60 | L | SF | J | 4 | N | 4 | 4 | JD 542 kap. 4 | |

Tilbake til: Oversikt EH

Generiske Arbeidsrutiner JBV

## Generisk arbeidsrutine

EH-KTL-0000-03

**Nr.:**
**Kontaktledning - Målevognskjøring**

Jernbaneverket

| Aktivitetsnr: | RCM ID | Arbeidsbeskrivelse | Type FV | Intervall | Myndighets nivå | Faggruppe | Sporlåsing | Prioritet | Kan avbrytes | Antall personer | Vanskelighet | Kommentar | Dokument referanse: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | | Kontroller dynamisk horisontal plassering av kontaktråd | TK M | 6 | L | SF | J | 2 | N | 2 | 0,1 | JD 542 kap. 5 | |
| 1010 | | Kontroller høydeendringer i kontaktråd (stigning/fall) | TK M | 6 | L | SF | J | 2 | N | 2 | 0,1 | JD 542 kap. 5 | |
| 1020 | | Kontroller lave krefter | TK M | 6 | L | SF | J | 2 | N | 2 | 0,1 | JD 542 kap. 5 | |
| 1030 | | Kontroller høye krefter | TK M | 6 | L | SF | J | 2 | N | 2 | 0,1 | JD 542 kap. 5 | |
| 1040 | | Kontroller middelkraft | TK M | 6 | L | SF | J | 2 | N | 2 | 0,1 | JD 542 kap. 5 | |
| 1050 | | Kontroller posisjonering av kontaktråd i parallellfelt | TK M | 6 | L | SF | J | 2 | N | 2 | 0,1 | JD 542 kap. 5 | |
| | | | | | | | | | | | | | |

Tilbake til: Oversikt EH

# 15 APPENDIX L – TYPE TESTING OF PANTOGRAPH WBL85 ON TRAIN EL 18

Report 3EHP 9614 01 From ABB Verkehrssysteme AG, Schunk Nordiska AB – Type test protocol for locomotive EL 18 NSB.

| ABB / Schunk *NSB EL 18* | ABB Verkehrssysteme AG Schunk Nordiska AB Sweden | | | 3EHP 9614 01 |
|---|---|---|---|---|
| Zuständige stelle: Schunk Nordiska AB | Übernommen stelle: | Änderung: | Dok.-Art: | Bezeichnungs-Nr: |
| Ersteller: S.Ravelli | Geprüft: | Freigegeben: 96-xx-xx | Sprache: SV | Seite: 1 / 8 |
| Gültig für: | Ersatz für: | Ersetzt für: | Klassierungs-Nr: | Qartei: TYP18rapp2 |

Appendix L

# *Typ provningsprotokoll för Lok typ EL18 för Norska Statsbanan (NSB)*

## Innehållsförteckning

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5.1 Aerodynamiska prov 8

| ABB / Schunk *NSB EL 18* | Änderung: | Sprache: SV | Seite: 2 / 8 | 3EHP 9614 01 |
|---|---|---|---|---|

# 1. Typtest

## *1.1 Test namn*

Funktions test av strömavtagare WBL85

## *1.2 Test nr*

Provens test nr är 36

# 2. Allmänt

## *2.1 Introduktion*

***Denna test specifikation är ett typprov ochkan genomföras under följande förutsättningar:***

- Att alla höghastighetstester genomförs på NSB's kontaktledning och rälstyp typ "system 20"
- Att det finns minst 2 vagnar tillkopplade till test loket resp. loken som är typade för högre hastigheter.
- Att singeltester kommer att köras till en maximal hastighet av 160 km/h och värdena kommer att interpoleras till 200 km/h.
- Att multipel tester genomförs med två lok till en maximal hastighet av 160 km/h.
- Att alla tester endast kan genomföras under sommarhalvåret
- Att test spåret är fritt från andra fordon.
- Att testspåret har tillräcklig längd för att loket resp loken plus vagnar kan rulla ut vid en hastighet av 160 km/h
- Att det finns möjlighet för tillgång till spänningsfri kontaktledning för justering och intrimmning av strömavtagaren under hela test processen.
- Att det är möjligt på ett enkelt sätt vända loket så att möjligheten finns att köra testen i båda färdriktningar med påkopplade vagnar.

**Av ovanstående punkter kunde alla utom två hållas:**

- Testspårets längd var ej tillräckligt proven kunde därför inte genom föras som planerat.
- Multipeltesterna blev inställda p.g.a. hastighetsrestriktioner.

## 2.2 Mål för proven

Målet med proven är att kontrollera att strömavtagaren uppfyller NSB's krav och att strömavtagaren fungerar tillfredsställande vid högre hastigheter.

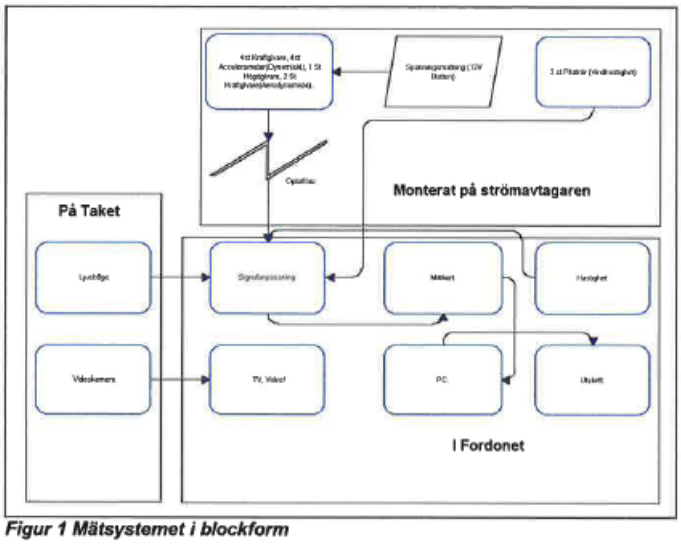
## 2.3 Test normer

Testen är baserad på IEC 494-37 och IEC 494-40

## 2.5 Mätutrustning

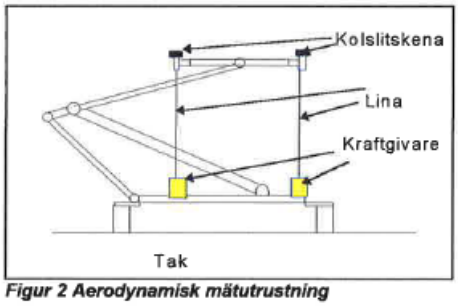
### 2.5.1 Allmänt

Mätsystemet är uppbyggt kring mätkortet DAP 3000-212, alla beräkningar och samplingar görs samtidigt i mätkortets processor innan mät värdena skickas in i mätdatorn för vidare bearbetning utskrift och lagring, figur 1 visar mätsystemet i blockform.

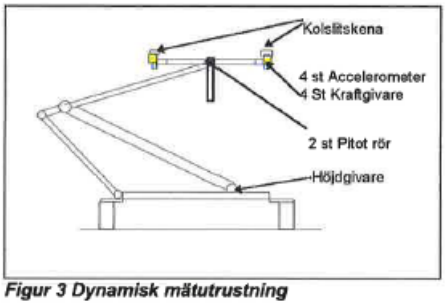



*Figur 1 Mätsystemet i blockform*

De dynamiska krafterna mäts med 4 st kraftgivare och kompenseras med 4 st accelerometrar se
Figur 3. För att övervinna potentialskillnaden mellan strömavtagare och tak (jord) leds




*Figur 2 Aerodynamisk mätutrustning*




*Figur 3 Dynamisk mätutrustning*

signalerna över optiska fibrer från strömavtagaren in till fordonet, alla övriga signaler är optoisolerade för att undvika störningar.

För att mäta det aerodynamiska tillskottet binds strömavtagaren ner med två isolerade linor och själva uppkraften mäts med två kraftgivare som dels sitter fastmonterade på strömavtagarens grundram och dels är linorna fastsatta på kolslitskenorna se Figur 2 .

Alla givare på strömavtagaren frånsett pitotrören är spänningsmatade med batteri på strömavtagaren

| ABB / Schunk<br>*NSB EL 18* | Änderung: | Sprache:<br>SV | Sida:<br>4 / 8 | 3EHP 9614 01 |
|---|---|---|---|---|

Vindhastigheten vid toppbygeln mäts med 2 st pitot rör som är monterade på vardera sidan av toppbygelns mittrör. Mätsignaler, strömförsörjning och övrig utrustning redovisas i tabellerna på nästa sida

| Typ | Strömför-brukning | Monterad |
|---|---|---|
| Batteri<br>24V DC | 120mA | På strömavt. |
| Batteri<br>18-36 V DC | 30A | I fordonet |
| Växelriktare<br>18-36 DC V ⇒ AC 220 V | | I fordonet |

***Tabell 2 Strömförsörjning***

| Signaltyp | Namn | | Område | Monterad |
|---|---|---|---|---|
| Kraftgivare 1 | P1 | ⇒ | Fmax=500N | På strömavt. |
| Kraftgivare 2 | P2 | ⇒ | Fmax=500N | På strömavt. |
| Kraftgivare 3 | P3 | ⇒ | Fmax=500N | På strömavt. |
| Kraftgivare 4 | P4 | ⇒ | Fmax=500N | På strömavt. |
| Accelerometer 1 | A1 | ⇒ | ±10g | På strömavt. |
| Accelerometer 2 | A2 | ⇒ | ±10g | På strömavt. |
| Accelerometer 3 | A3 | ⇒ | ±10g | På strömavt. |
| Accelerometer 4 | A4 | ⇒ | ±10g | På strömavt. |
| Vindhastighet 1 | Ws1 | ⇒ | område 0-100 m/s | På strömavt. |
| Vindhastighet 2 | Ws2 | ⇒ | Område 0-100 m/s | På strömavt. |
| Höjd | H1 | ⇒ | Område 0-3 Meter | På strömavt. |
| Ljusbåge | L1 | ⇒ | >1ms | På taket |
| Hastighetssignal | Gs | ⇒ | Omr. 0-300 km/h , 0-100V DC | I fordonet |

***Tabell 1 Mätsignaler***

| Namn | Typ | Monterad |
|---|---|---|
| Signalanpassning | Schunk2000 | I fordonet |
| Mätkort 16 kanaler | DAP 3000-212 | I fordonet |
| Optosändare/förstärkare | Schunk SS2100 | På strömavt. |
| Video | | I fordonet |
| Kamera | | På taket |
| Monitor | | I fordonet |
| PC | Compaq Prolina | I fordonet |

***Tabell 3 Annan utrustning***

# 3. Tid och plats

Proven genomfördes på den nybyggda sträckan Kongsvinger-Magnor under vecka 26 (24-27 Juni) vädret var varm och relativt vindstilla.

Själva provsträckan valdes mellan Matrand och Magnor kontaktledningsystemet var av typ "System 20" med "Y-lina" , både bärlina och kontaktledning har en inspänningskraft av 1000 kg.

Proven kunde tyvärr inte slutföras helt på grund av att lokets ATC-antenn inte var godkänd och loket pga detta endast fick framföras med en max hastighet av 80 km/h.

Vi måste också påpeka att elsäkerheten på Grorud verkstad inte var den bästa, då delvis hela vårt mätsystem gick sönder pga slarv, som tur var föranledde det inträffade inte till några personskador.

| ABB / Schunk<br>*NSB EL 18* | Änderung: | Sprache:<br>SV | Seite:<br>5 / 8 | 3EHP 9614 01 |
|---|---|---|---|---|

# 4. Resultat av typ testen

## *4.1 Statiskt upptryck*

Före övriga prov genomfördes en kontroll av strömavtagarens statiska upptryck.

### 4.1.1 Test metod

Med hjälp av en fjädervåg kontrolleras det statiska upptrycket vid 5600 mm över RÖK . Upptrycket ställdes in till 55 N.

## *4.2 Aerodynamisk inställning IEC 494-37*

### 4.2.1 Test metod

Den totala medeluppkraften mäts dvs det statiska uppkraften plus det aerodynamiska tillskottet som strömavtagaren ger vid högre hastigheter. Strömavtagaren är upprest under testen och nedbunden till en höjd av 5500 mm över RÖK dvs ca 100 mm under normal kontaktledningshöjd som är 5600 mm med två isolerade linor. På ena sidan är linorna fastsatta i kolsltskenorna och på andra sidan är fastsatta med två kraftgivare mot strömavtagarens grundram.

Pga att provsträcka var så krokig och att det endast var på få platser möjligt att komma upp till max hastigheten som i detta fall var 160 km/h var vi tvungna att ändra körsätt. Se diagram 1

Loket accelererar upp till maximal hastighet som vi försökte hålla så länge som var möjligt sedan sänktes hastigheten och ökades sedan återigen till max hastighet osv.

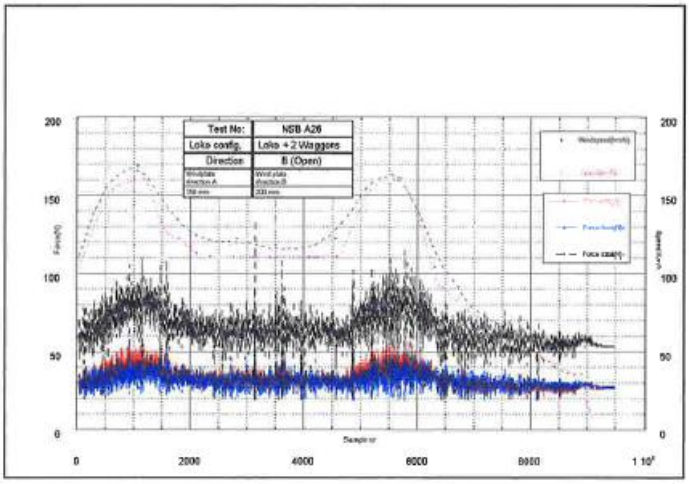



*Diagram 1*

### 4.2.2 Test rundor

Totalt kördes 29 prov med olika vindplåts inställningar, prov NSB A26 till NSB A29 är själva typproven och är den slutgiltiga inställningen se bilaga 1-4.

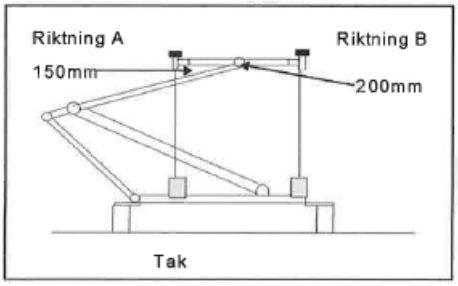
### 4.2.3 Mätutrustning för provet

Se punkt 2.5

### 4.2.4 Resultat

Resultatet är helt i sin ordning, strömavtagaren är i det närmaste neutral i båda färdriktningar.

- Slutgiltig inställning blev 150mm i riktning A (Closed direction) och 200mm i riktning B (Open direction) se Figur 4.
- Strömavtagarens medeluppkraft i riktning A är ca. 95N med en fördelning på Ca. 55N på bakre skenan och ca. 40 på främre vid en hastighet av 200 km/h. Obs. Värdena är interpolerade. Se diagram D2 och D4 bilaga 1 och 2.
- Strömavtagarens medeluppkraft i riktning B är ca. 95N med en fördelning på Ca. 50N på bakre skenan och ca. 45 på främre vid en hastighet av 200 km/h. Obs. Värdena är interpolerade. Se diagram D6 och D8 bilaga 3 och 4.




*Figur 4, Slutlig inställning*

| ABB / Schunk *NSB EL 18* | Änderung: | Sprache: SV | Seite: 7 / 8 | 3EHP 9614 01 |
|---|---|---|---|---|

## *4.3 Strömavtagnings försök (dynamiska prov) IEC 494-40*

### 4.3.1 Test metod

Den dynamiska kraften mellan Strömavtagare och kontaktledning mäts vid olika hastigheter upp till 160 km/h.
Även vid detta prov var vi tvungna att ändra körsätt, proven genomfördes på samma sätt som för den aerodynamiska inställningen, se punkt 4.2.1

### 4.3.2 Test rundor

Typtesten med kördes med optimerad inställning enligt punkt 4.2.4. totalt kördes 8 prov, själva typtesten kördes med singel lok test NSB D05, NSB D06 och med lok och två vagnar test NSB D07, NSB D08. Tyvärr gick det inte att köra fler prov pga problem med lokets ATC-antenn.

### 4.3.3 Mätutrustning för provet

Se punkt 2.5

### 4.3.4 Resultat

Resultaten även här är mycket tillfredsställande, det finns få kraftspikar och inga över 150 N i båda färdriktningar, se diagram bilaga 5-8. Standardavvikelsen är också låg och ligger kring 10-15 N i båda färdriktningar vid 160 km/h.

- Strömavtagarens medeluppkraft i riktning A är ca. 91N med en fördelning på några få Newton på båda skenor vid en hastighet av 200 km/h. Obs. Värdena är interpolerade. Se diagram D12 och D16 bilaga 6 och 8.
- Strömavtagarens medeluppkraft i riktning B är ca. 90N med en fördelning på Ca. 50N på bakre skenan och ca. 40 på främre vid en hastighet av 200 km/h. Obs. Värdena är interpolerade. Se diagram D10 och D14 bilaga 5 och 7.
- Standardavvikelsen vid 200 km/h är något vansklig att förutse pga av att max hastigheten bara kunde hållas under korta perioder, men enligt våra bedömningar kommer den att ligga kring 20 N vilket är helt OK.
  Se bilaga 11 diagram D21 och D22, här visas en sammanställning av totalkraften för 2 tester.
  Man kan med säkerhet bedöma att medelvärdet av max-min krafterna ligger inom $\pm 3 \times \sigma +$ *medelvärde* vid 200 km/h.

| ABB / Schunk<br>*NSB EL 18* | Änderung: | Sprache:<br>SV | Seite:<br>8 / 8 | 3EHP 9614 01 |
|---|---|---|---|---|

# 5. Bilagor

## 5.1 Aerodynamiska prov

| Körriktning | Test nr | Bilaga nr | Diagram nr | Visar typ av diagram |
|---|---|---|---|---|
| B (Open) | NSBA26 | Bil. 1 | D1 | Kraft, hastighet/sample |
| B (Open) | NSBA26 | Bil. 1 | D2 | Kraft/ hastighet Interpolering |
| B (Open) | NSBA27 | Bil. 2 | D3 | Kraft, hastighet/sample |
| B (Open) | NSBA27 | Bil. 2 | D4 | Kraft/ hastighet Interpolering |
| A (Closed) | NSBA28 | Bil. 3 | D5 | Kraft, hastighet/sample |
| A (Closed) | NSBA28 | Bil. 3 | D6 | Kraft/ hastighet Interpolering |
| A (Closed) | NSBA29 | Bil. 4 | D7 | Kraft, hastighet/sample |
| A (Closed) | NSBA29 | Bil. 4 | D8 | Kraft/ hastighet Interpolering |

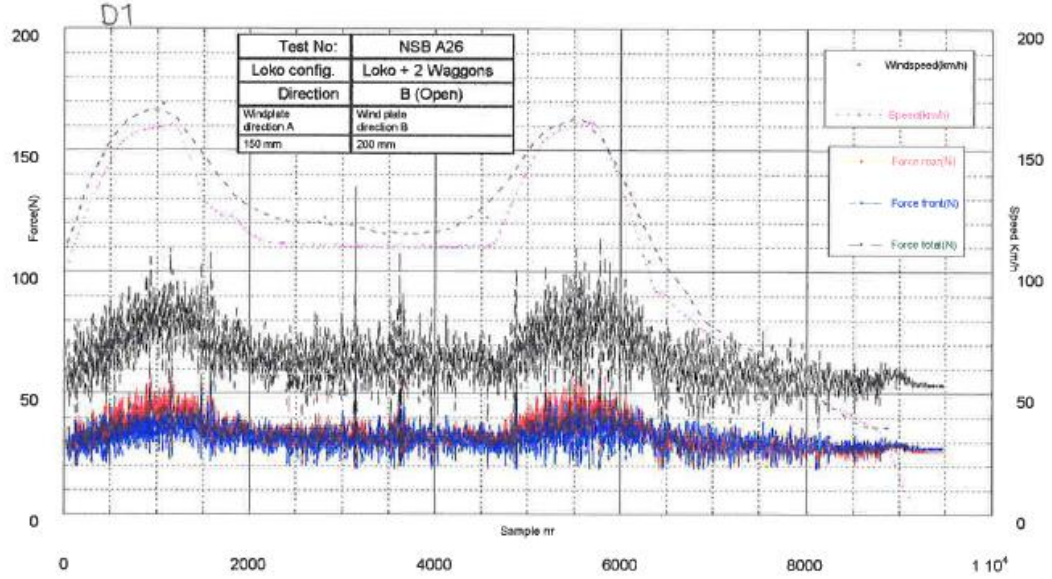
## 5.1 Dynamiska prov

| Körriktning | Test nr | Bilaga nr | Diagram nr | Visar typ av diagram |
|---|---|---|---|---|
| B (Open) | NSBD05 | Bil. 5 | D9 | Kraft, hastighet/sample |
| B (Open) | NSBD05 | Bil. 5 | D10 | Kraft/ hastighet Interpolering |
| A (Closed) | NSBD06 | Bil. 6 | D11 | Kraft, hastighet/sample |
| A (Closed) | NSBD06 | Bil. 6 | D12 | Kraft/ hastighet Interpolering |
| B (Open) | NSBD07 | Bil. 7 | D13 | Kraft, hastighet/sample |
| B (Open) | NSBD07 | Bil. 7 | D14 | Kraft/ hastighet Interpolering |
| A (Closed) | NSBD08 | Bil. 8 | D15 | Kraft, hastighet/sample |
| A (Closed) | NSBD08 | Bil. 8 | D16 | Kraft/ hastighet Interpolering |
| A (Closed) | NSBD06 | Bil. 9 | D17 | Kraft max,min,Std/hastighet Interpolering |
| A (Closed) | NSBD08 | Bil. 9 | D18 | Kraft max,min,Std/hastighet Interpolering |
| B (Open) | NSBD05 | Bil. 10 | D19 | Kraft max,min,Std/hastighet Interpolering |
| B (Open) | NSBD07 | Bil. 10 | D20 | Kraft max,min,Std/hastighet Interpolering |
| B (Open) | NSBD05<br>NSBD07 | Bil. 11 | D21 | Kraft max,min,Std/hastighet Interpolering |
| A (Closed) | NSBD06<br>NSBD08 | Bil. 11 | D22 | Kraft max,min,Std/hastighet Interpolering |

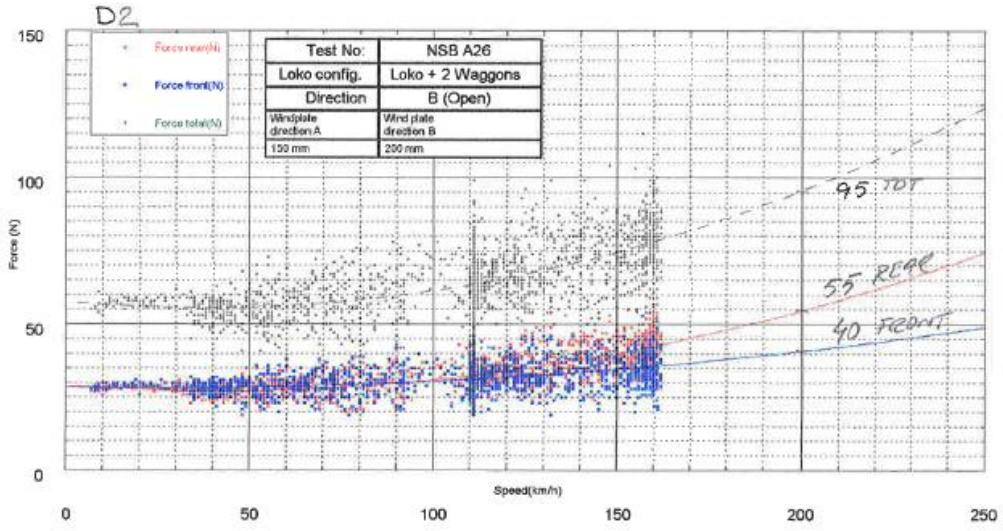
BIL 1

# Aerodynamic test

D1



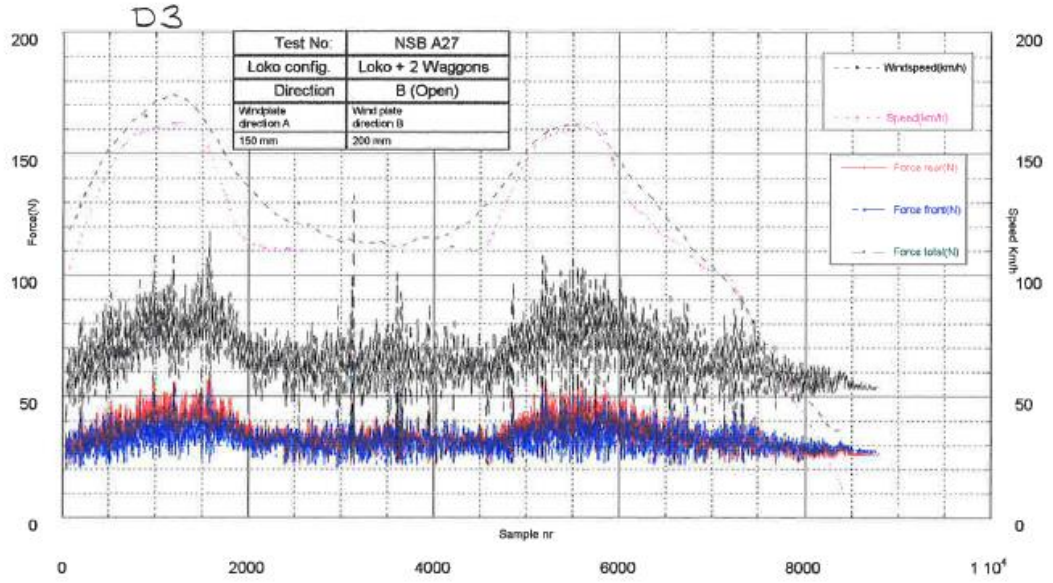

D2



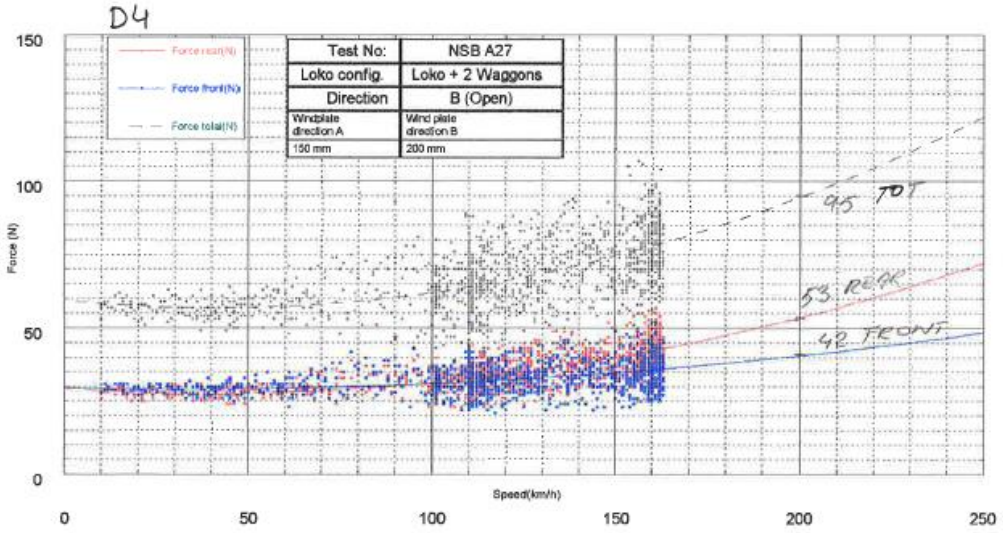
BIL 2

# Aerodynamic test

D3



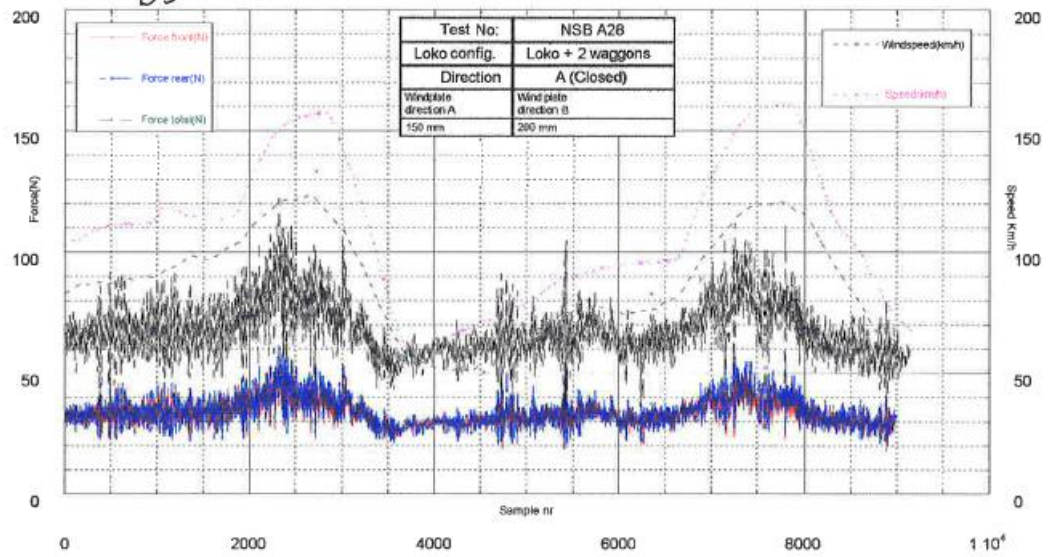

D4



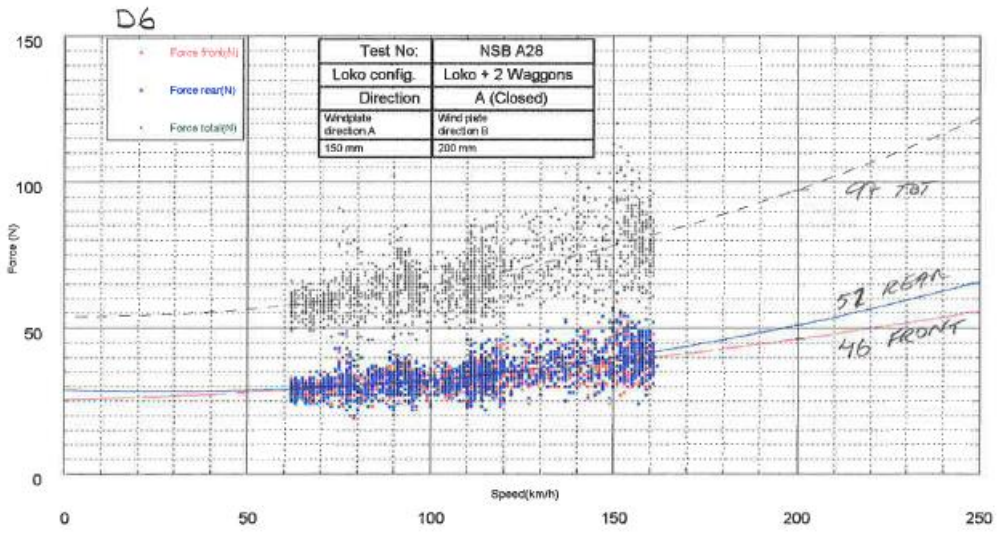
BIL 3.

# Aerodynamic test

D5



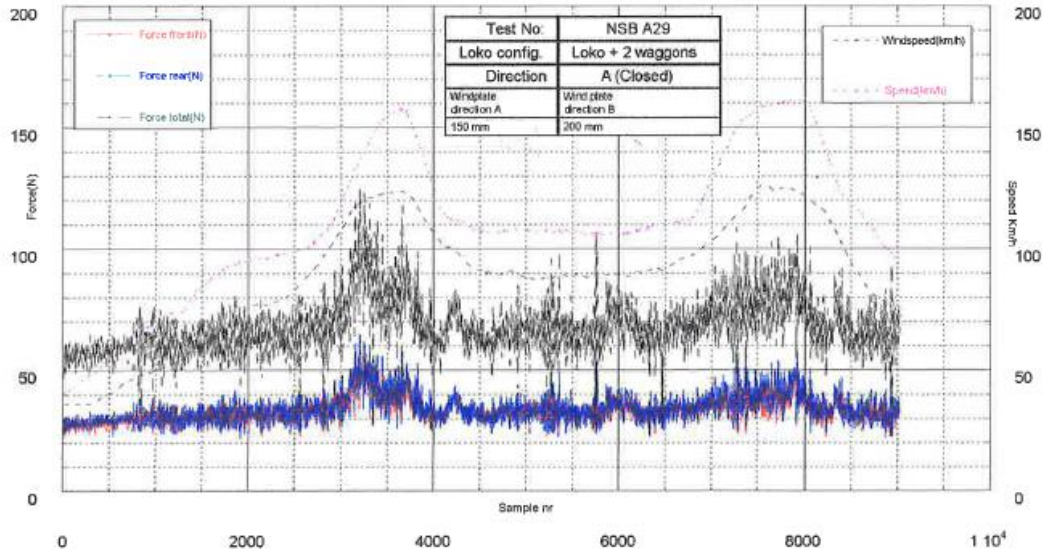

D6



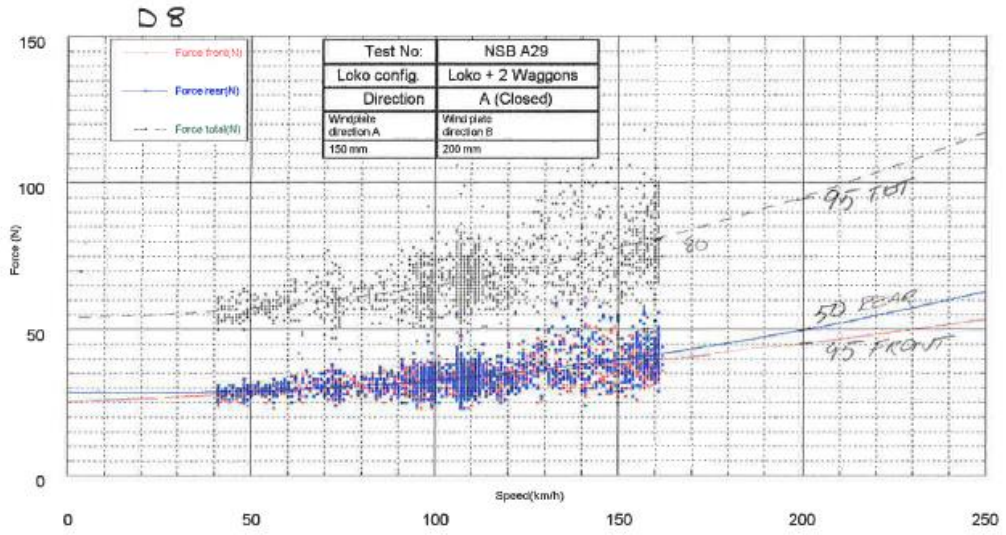
BIL 4

# Aerodynamic test

D7



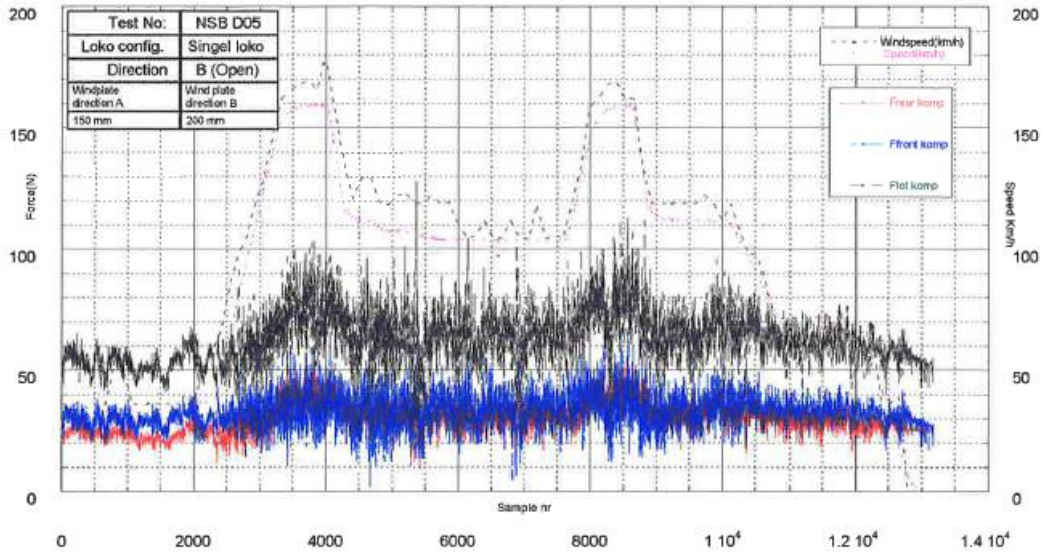

D8



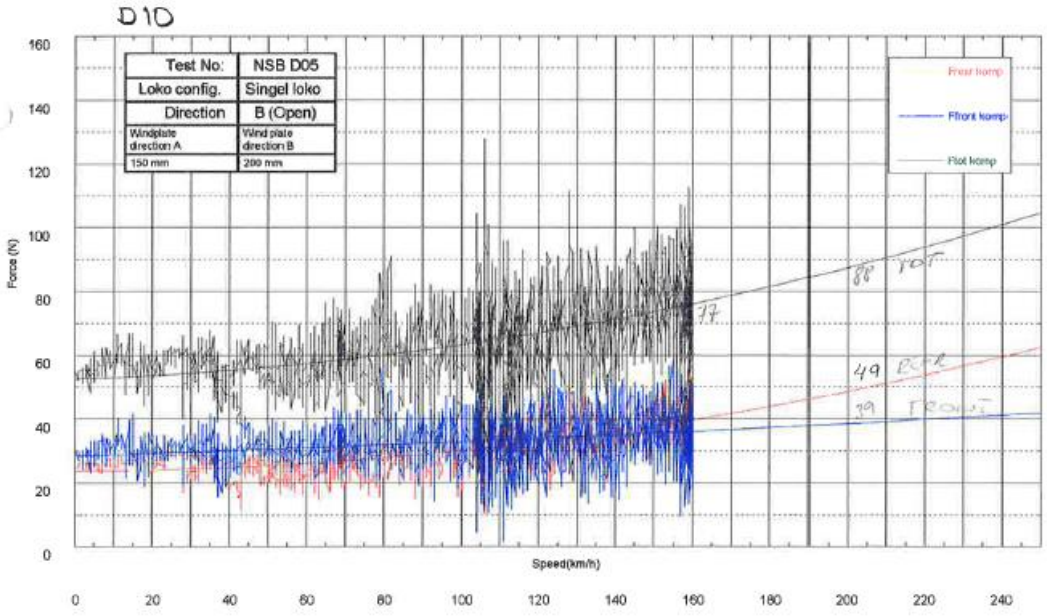
# Dynamic test

BIL 5

D9



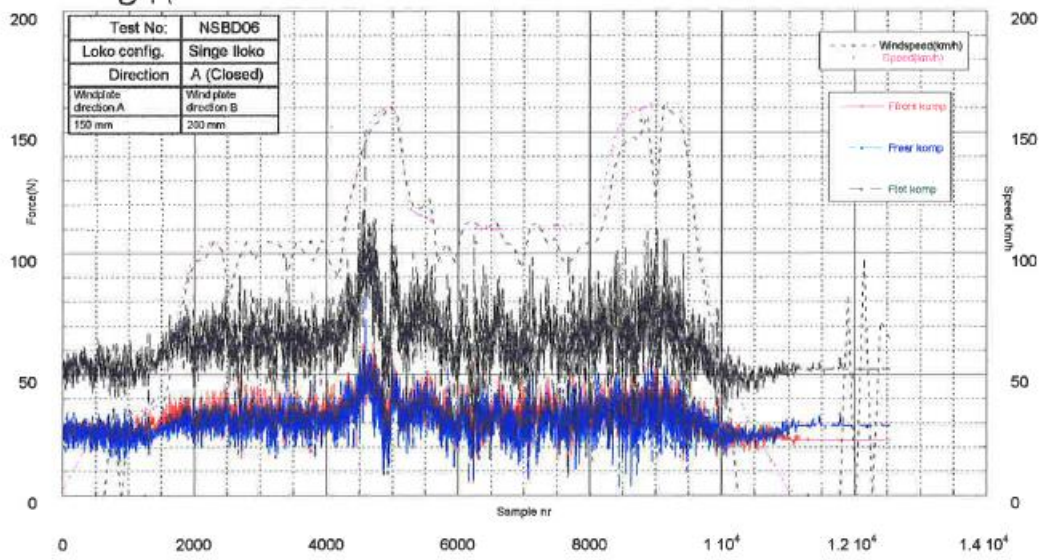

D10



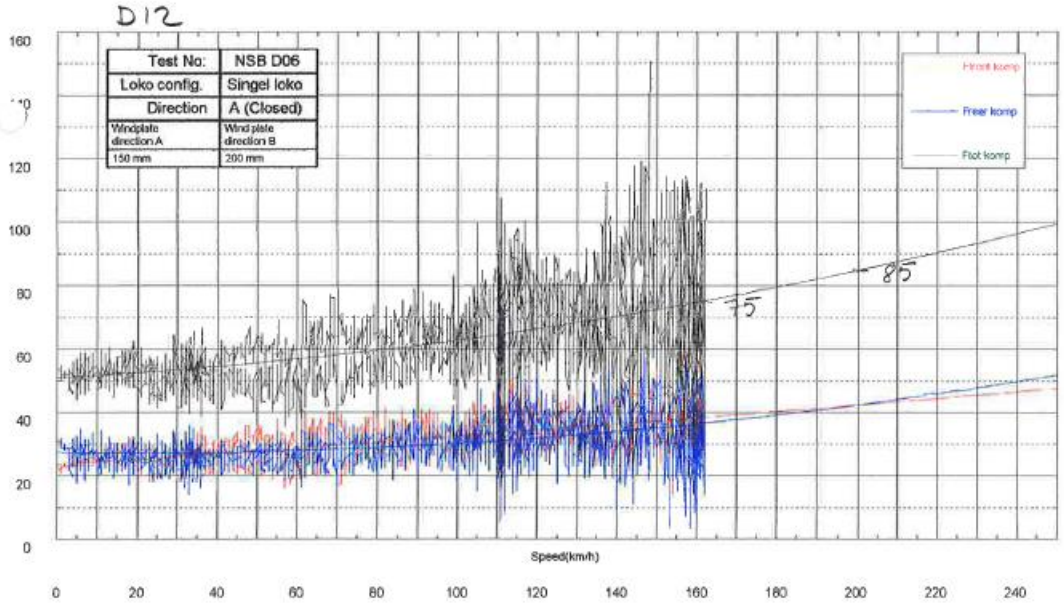
BIL 6.

# Dynamic test

D11



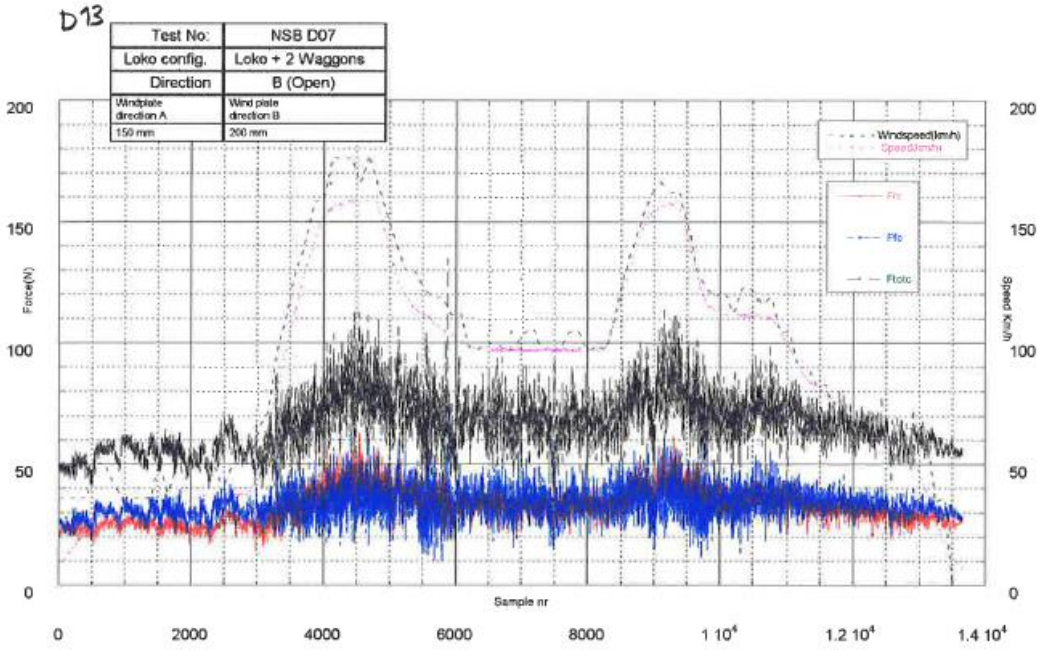

D12



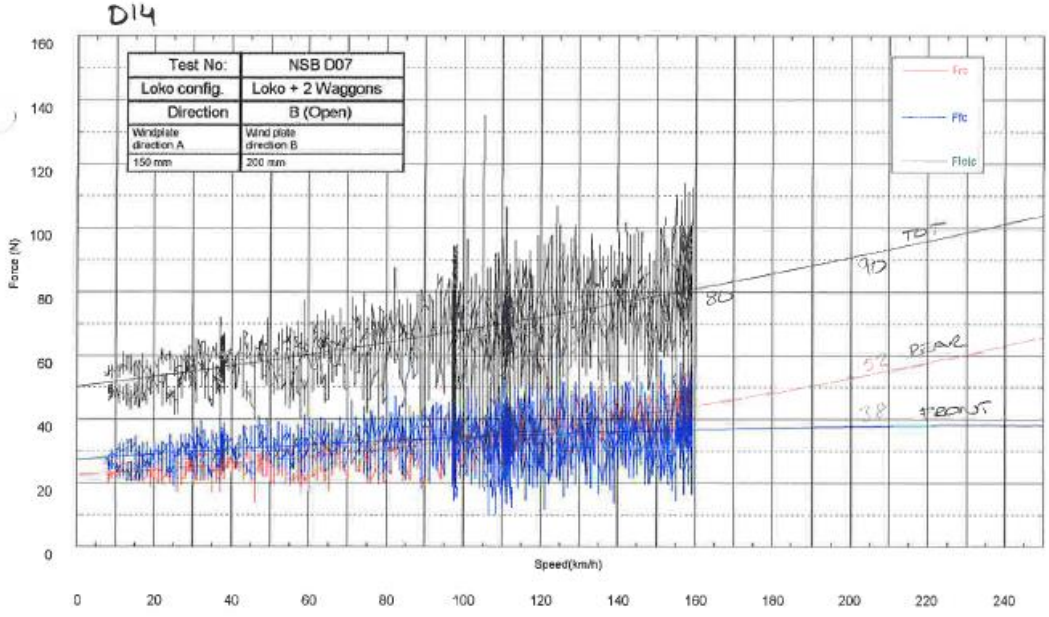
# Dynamic Test

BIL 7.

D13



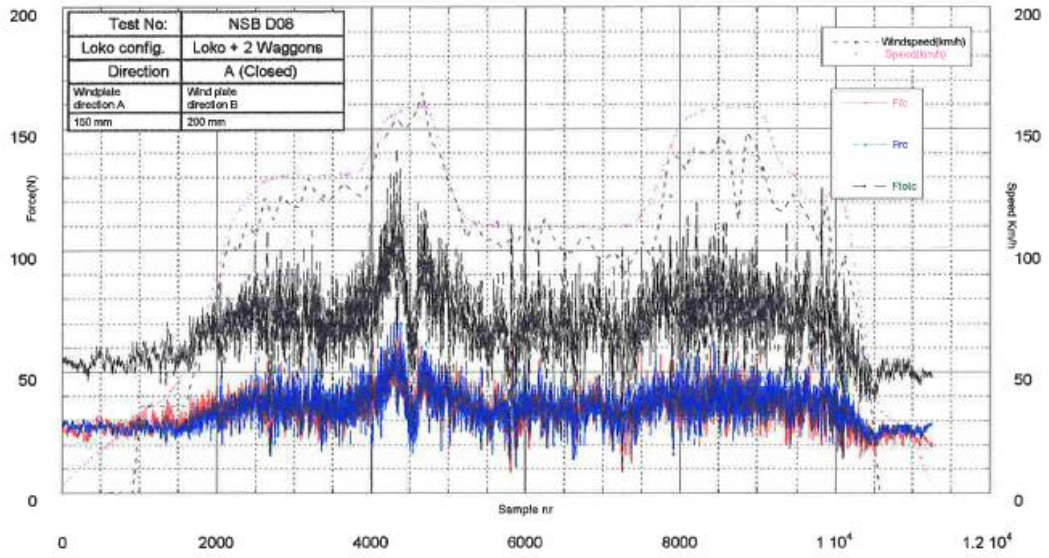

D14



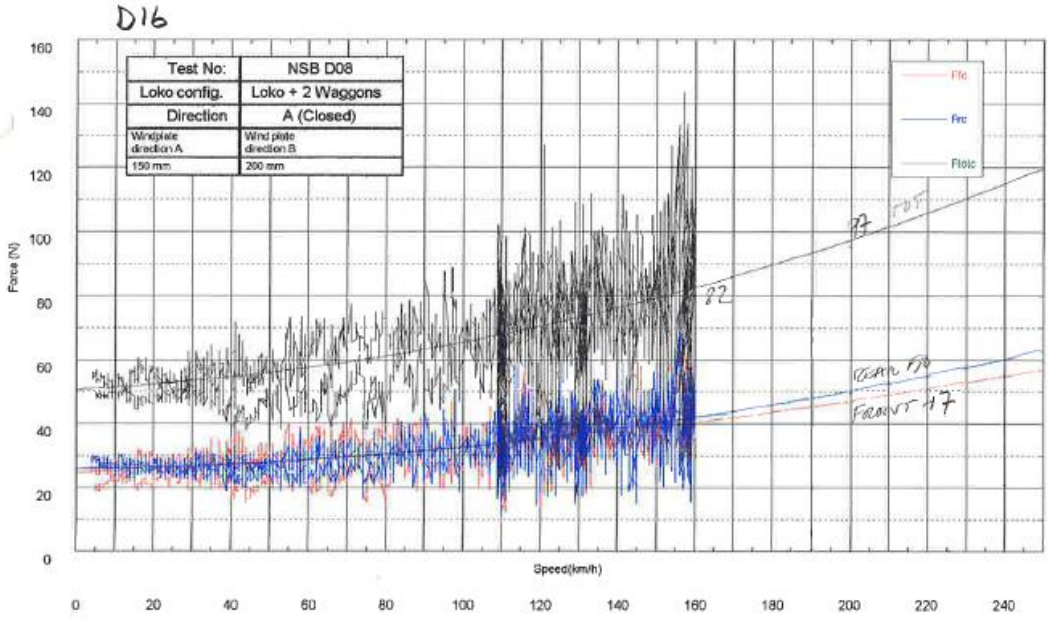
# Dynamic Test

BIL 8

D15



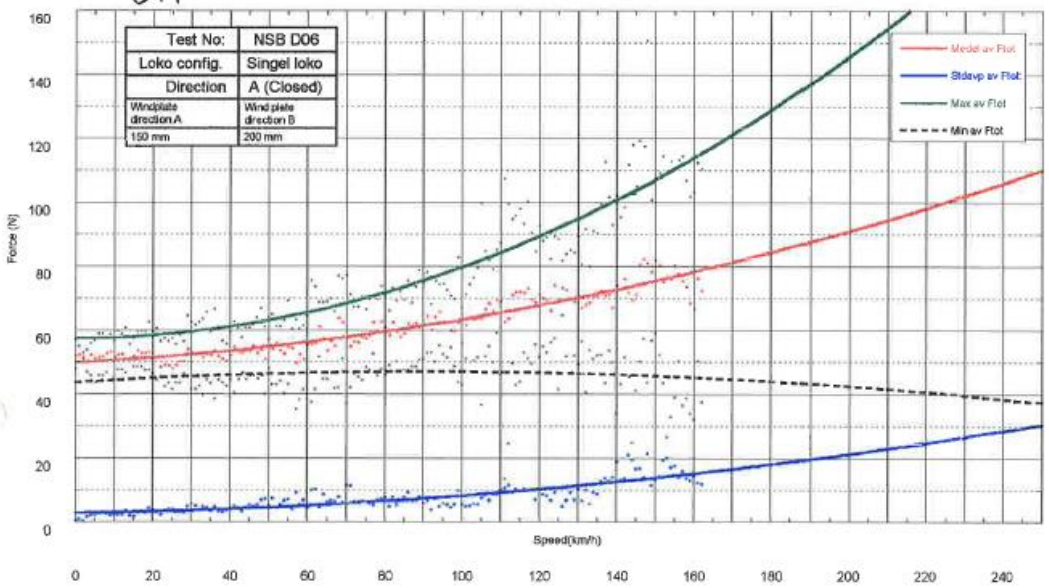

D16



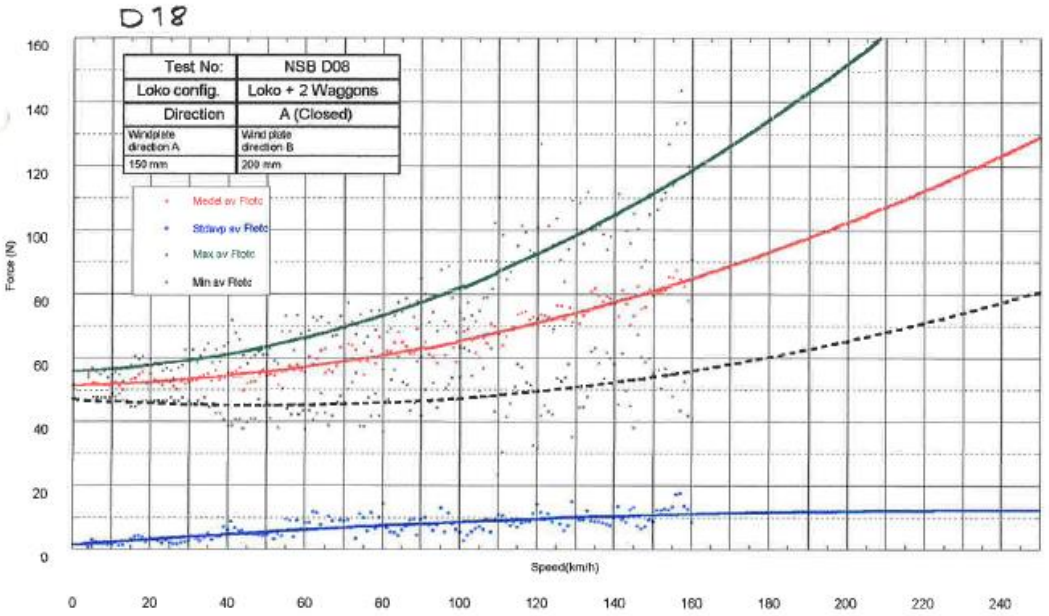
# Dynamic Test Direction A (Closed)

BIL 9.

D17



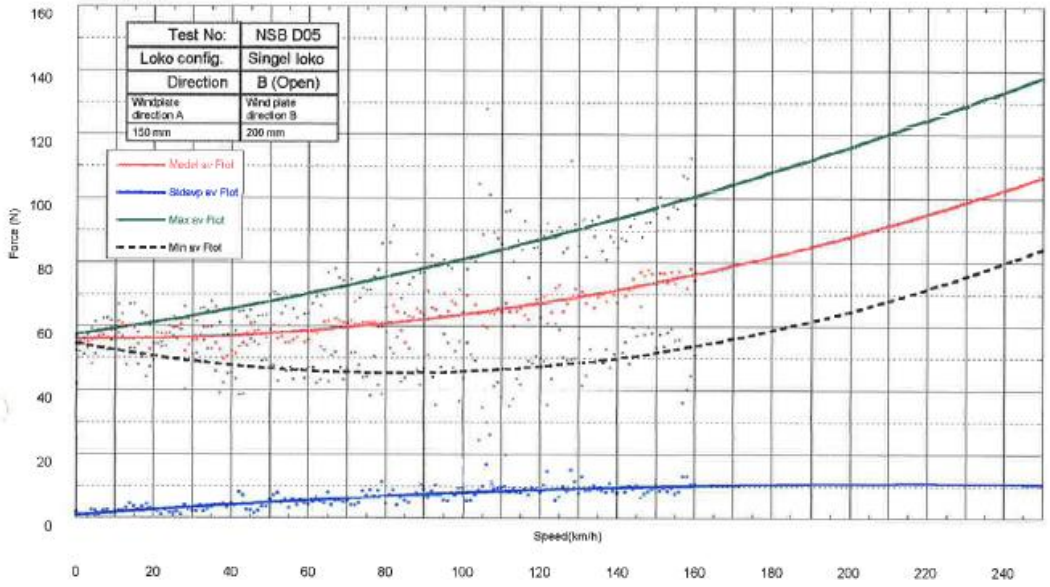

D18



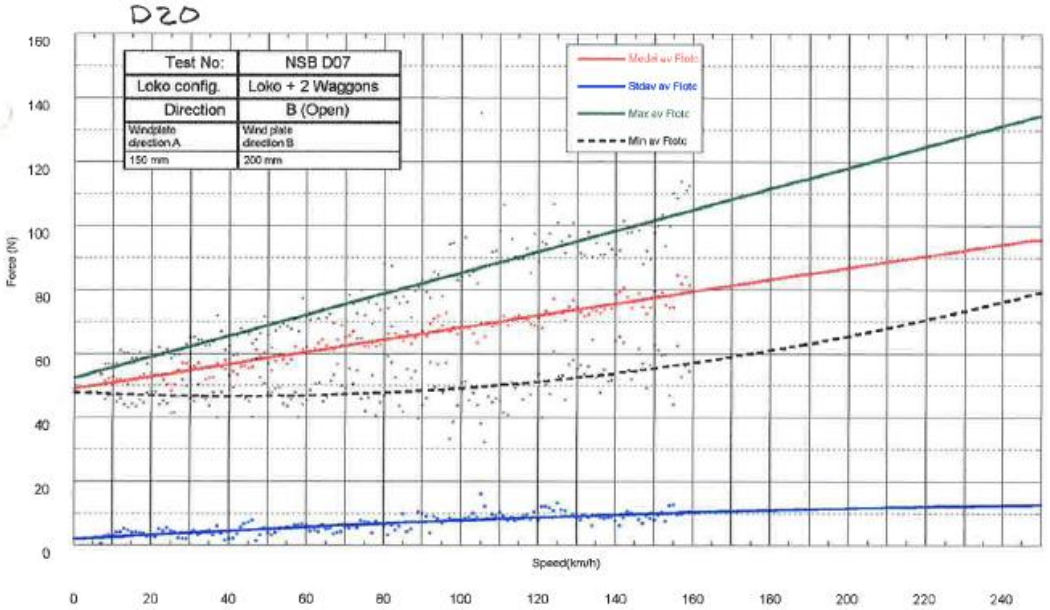
BIL 10.

# Dynamic Test Direction B (Open)

D19

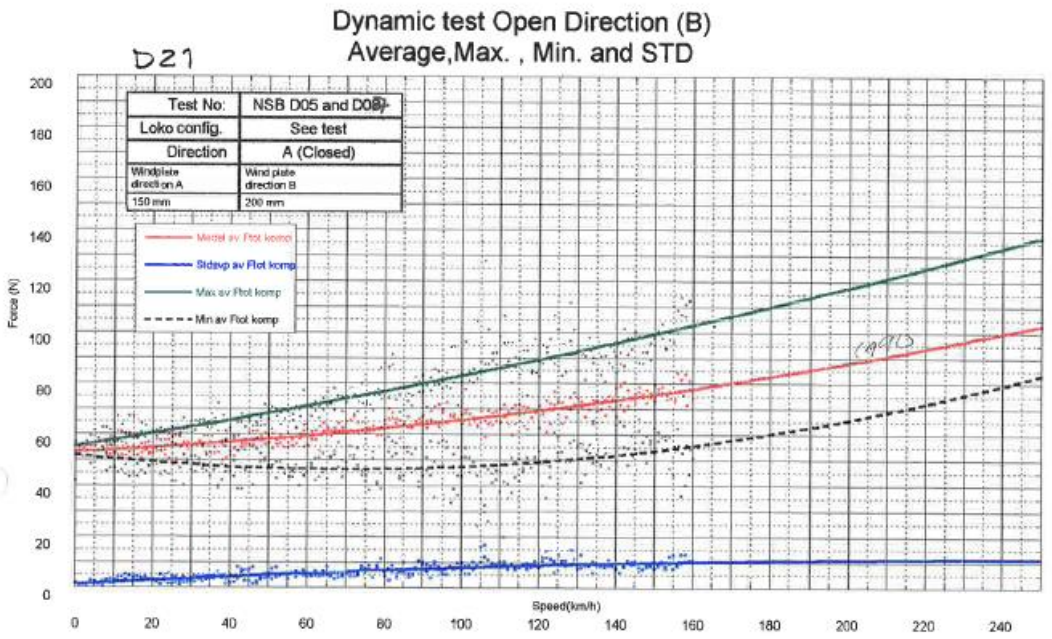



D20

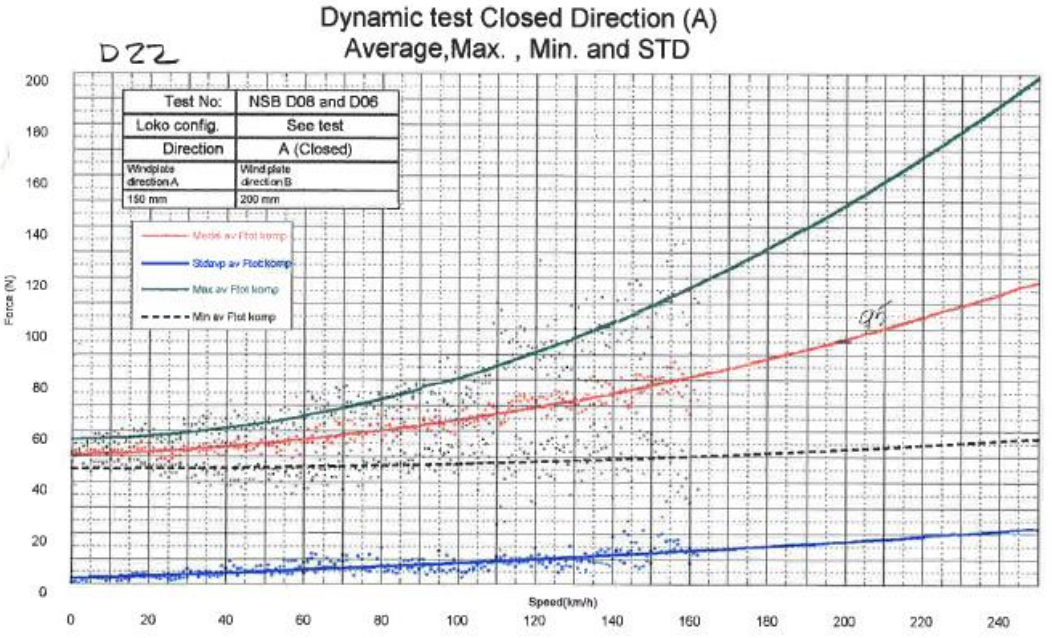


BIL 11.

D21




D22



# 16 APPENDIX M – DEFECT / DAMAGE TO NNRA'S OCL

Jernbaneverket

**Appendix L: Feil / skade på JBV's kontaktledningsanlegg**

**Rapport nr.:**_____

**1 STASJONERINGSSTED:** ☐

**2 FEIL INNTRAFF DATO:** _____

**3 TOGFORSINKELSE:**
☐ Kode 1: Med togforsinkelse ☐ Kode 2: Uten togforsinkelse

**4 BANEREGION:**
☐ 1 Baneregion Øst
☐ 2 Baneregion Sør
☐ 3 Baneregion Vest
☐ 4 Baneregion Nord

**5 BANENUMMER:** ☐

**6 FEIL KM / STED:** ☐

**7 TYPE ANLEGG:**
☐ 1 Kontaktledning
☐ 2 Returstrømkrets
☐ 3 Øvrige høysp.ledninger/kabler
☐ 9 Annet _ _ _ _ _ _ _ _ _

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**8 ANLEGGSBETEGNELSE:**
☐ 100 Tabell 3
☐ 101 Tabell 13
☐ 102 Tabell 23
☐ 103 Tabell 44
☐ 104 Tabell 54
☐ 105 Tabell 54 1000/500
☐ 107 1000/800 i tunnel
☐ 108 1000/1200 i tunnel
☐ 109 1000/1000, E-7099
☐ 110 System 35
☐ 111 System 35 MS
☐ 112 System 20 A
☐ 113 System 20 B
☐ 114 System 20 C1
☐ 115 System 20 C2
☐ 116 System 20 C3
☐ 117 System 25
☐ 119 Annet, prøvestrekninger _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

**9 FEILBEHEFTET ANLEGGSDEL, ANLEGGSDEL HVOR FEIL FØRST INNTRAFF:**

**Oppheng:**
☐ 0200 Utligger
☐ 0201 Bærelineholder
☐ 0202 Kontakttrådklemme
☐ 0203 Hengtrådklemme
☐ 0204 Traverser / konsoller
☐ 0206 Lett direksjonsstag E-4336
☐ 0206 Lett direksjonsstag E-7023
☐ 0207 Lett direksjonsstag E-7084
☐ 0208 Lett direksjonsstag E-7198
☐ 0209 Andre, eldre lette direk.stag
☐ 0219 Annet _ _ _ _ _ _ _ _ _

:

**Master, åk:**
☐ 0220 Stålmast
☐ 0221 Betongmast
☐ 0222 Tremast
☐ 0223 Åk 1-2-3
☐ 0224 Åk 11-12-13-14
☐ 0225 Hengemast
☐ 0229 Annet _ _ _ _ _ _ _ _ _

**Isolatorer:**
☐ 0250 Returledningsisolator
☐ 0251 Bardunisolator, kurve
☐ 0252 Bardunisolator, rett strekk
☐ 0253 Støtteisolator, endemuffe
☐ 0254 Piggisolator
☐ 0255 Stavisolator, porselen
☐ 0256 Stavisolator, glass
☐ 0257 Stavisolator, kompositt
☐ 0258 Stavisol., avsp. porselen
☐ 0259 Stavisol., avsp. glass
☐ 0260 Stavisol., avsp. kompositt
☐ 0261 Si E-2724
☐ 0262 Si E-4789 Bicc
☐ 0263 Si E-4790 Bicc
☐ 0264 Si E-5215 Diamond

Forts. neste side

Side 2 av 6

**9 FEILBEHEFTET ANLEGGSDEL, ANLEGGSDEL HVOR FEIL FØRST INNTRAFF:**

**Diverse:**
- 0480 Sugetrafo >= 600 A
- 0481 Sugetrafo < 600 A
- 0482 Filterimpedanse >= 600 A
- 0483 Filterimpedanse < 600 A
- 0484 Reservestrømstrafo
- 0485 Høysp.kabel PEX
- 0486 Høysp.kabel Olje/papir
- 0487 Kl.bryter E-2021
- 0488 Kl.bryter E-4473
- 0489 Kl.bryter Siemens F-148
- 0490 Manøvermaskiner
- 0491 CTC-omformer
- 0492 Oversp.vern, suger
- 0493 Oversp.vern, kabel
- 0494 Disneuter
- 0499 Annet _ _ _ _ _ _ _ _ _

**Ledninger, avspenninger:**
- 0230 Kl-anlegget totalt
- 0231 Kontakttråd
- 0232 Bæreline
- 0233 Massiv hengetråd
- 0234 Fleksibel hengetråd
- 0235 Ledninger Cu
- 0236 Ledninger Al
- 0237 Ledninger Al, isolerte
- 0238 Barduner
- 0239 Avspenningsliner
- 0240 Loddavspenningsliner
- 0241 Strømstige/bru og br. ledn.
- 0242 Kontakttrådkryss
- 0243 Jordingstråd
- 0244 Skinneforbinder
- 0245 Impedansforbindelse
- 0249 Annet _ _ _ _ _ _ _ _ _

**Isolatorer:**
- 0265 Si E-5302 Flury
- 0266 Si E-7086 Flury
- 0267 Si E-7087 Flury
- 0268 Si E-7326 Siemens
- 0279 Annet _ _ _ _ _ _ _ _ _

**10 TYPE FEIL:**
- 10 Avbrent
- 11 Deformert
- 12 Nedrevet anlegg
- 13 Gjennom- / overslag / kortslutning
- 14 Knusing
- 15 Kontaktfeil
- 16 Mekanisk feil/løsnet detalj
- 17 Nedhengende fremmedlegmer
- 18 Sikringsbrudd
- 19 Brudd
- 29 Annet _ _ _ _ _ _ _ _ _



**11 FEILÅRSAKER SOM :**

**kan forhindres**
- 001 Fugler / dyr
- 002 Forurensing, sot osv.
- 003 Feilbetjening
- 004 Feil innst. beskyttelsesrelé
- 005 Endr. av spor - kl ikke just.
- 006 Graving
- 007 Trenedfall
- 008 Mangl. kontroll/vedlikehold
- 009 Feilkonstruksjon
- 010 Feil montering
- 011 Utilstrekkelig isolasj. avstand
- 012 Materialfeil / -tretthet
- 013 Korrosjon
- 014 Slitasje
- 015 Spenningsforskj. i seksj.felt
- 016 Forskyvning mast / stolpe
- 017 Overbelastning kabel
- 018 Nedising
- 019 Konflikt strømavt. / kontaktledn.
- 029 Annet _ _ _ _ _ _ _ _ _

**vanskelig kan forhindres**
- 100 Forsettelig skade / hærverk
- 101 Brann
- 102 Sprenging/graving, eksterne
- 103 Arbeidsredskap / -maskin
- 104 Kjøretøy, ikke skinnegående
- 105 Avsporing / togkollisjon
- 106 Ras
- 107 Flom
- 108 Unormalt sterk vind > 30 m/s
- 109 Ekstrem lav temp. <-35 gr. C
- 110 Ekstrem høy temp. >35 gr. C
- 111 Feil pga. linjearbeid
- 112 Lynnedslag
- 113 Strømavtagerfeil
- 114 Feilmanøver på lok/motorvogn
- 115 Feil lasting/forskjøvet last
- 116 Lok eller motorvognfeil
- 119 Annet _ _ _ _ _ _ _ _ _

**12 ÅRSAKSTILHØRIGHET:**
- 1 JBV kontaktledning/sterkstrøm
- 2 JBV andre
- 3 NSB BA Teknisk sektor
- 4 NSB BA Persontrafikk
- 5 NSB BA Godstrafikk
- 6 NSB BA Eiendom
- 7 Andre, eksterne

| | |
|---|---|
| **13 FEIL INNTRAFF:** | kl. _ _ // _ _ |
| **14 PERSONELL VARSLET:** | kl. _ _ // _ _ |
| **15 PERSONELL RYKKET UT:** | kl. _ _ // _ _ |
| **16 ANKOMST FEILSTED:** | kl. _ _ // _ _ |
| **17 VENTETID:** | _ _ t. _ _ min. |
| **18 UTKOBLINGSTID:** | _ _ t. _ _ min. |
| **19 FEIL UTBEDRET:** | kl. _ _ // _ _ |
| **20 ANVENDT PERSONELL:** | _ _ _ stk. |
| **21 SKINNEGÅENDE KJØRETØY:** | _ _ _ stk. |
| **22 BIL:** | _ _ _ stk. |

**23 MERKNADER:**



Merknader forts.

**24 MATERIELL:**

Angi medgått type og mengde.

| | | | | |
|---|---|---|---|---|
| **25 RAPPORTSKRIVERS UNDERSKRIFT:** | Dato: | _____ | Sign.: | _____ |
| **26 STREKNINGSLEDERS UNDERSKRIFT:** | Dato: | _____ | Sign.: | _____ |
| **27 OMRÅDESJEFENS UNDERSKRIFT:** | Dato: | _____ | Sign.: | _____ |
| **28 BANESJEFENS UNDERSKRIFT:** | Dato: | _____ | Sign.: | _____ |

# 17 APPENDIX N – DESIGN PARAMETERS FOR OVERHEAD CONTACT LINES

Design parameters for OCL systems used in the NNRA

| **Design** | **Speed** |
|---|---|
| S20 B | $v \leq 160$ km/h |
| S20 A and C | $160 < v \leq 200$ km/h |
| S25 | $200 < v \leq 250$ km/h |

**Table 11 OCL designs and their speed limits**

**Design S20 A**

| | |
|---|---|
| Contact wire | RiS 100 |
| Catenary | Bz II 50 |
| Stich wire | Bz II 25 |
| Dropper | Bz II 10 |
| Tension force Cat./Ctw. | 10000 N |
| Tension force Stich wire | 2300 N |
| Stitch wire length | 14.0m |
| Distance 1st dropper | 4.0 m |
| Longest dropper distance | 11.0 m |
| R < 800 | No stich wire |
| Sag | x/1000 |
| | |
| System height | 1.60 m |
| Stagger | ± 0.30 m |
| Parallel distance 2 ctw. | 0.20 m () |
| Parallel distance 2 ctw. | 0.45 m (insulated sections) |
| Contact wire height | 5.60 m |
| Lowest contact wire height | 5.05 m |
| Uplift | 0.15 m |
| Lift | 0.50 m |
| ½ | 750 m |
| Max difference in SH | 0.30 m |
| Max span length () | 70 m |
| Max span length () | 65 m |
| Max span length (insulated sections) | 58 m |
| Min span length | 25 m |
| Max difference in span length | 14 m |

**Design 20 B**

| | |
|---|---|
| Contact wire | RiS 100 |
| Catenary | Bz II 50 |
| Dropper | Bz II 10 |
| Tension force Cat./Ctw. | 10000 N |
| Distance 1st dropper | 5.0 m |
| Longest dropper distance | 11.0 m |
| Sag | x/1000 |
| | |

| | |
|---|---|
| System height | 1.60 m |
| Stagger | ± 0.30 m |
| Parallel distance 2 ctw. | 0.20 m () |
| Parallel distance 2 ctw. | 0.45 m (insulated sections) |
| Contact wire height | 5.60 m |
| Lowest contact wire height | 5.05 m |
| Uplift | 0.15 m |
| Lift | 0.50 m |
| ½ | 730 m |
| Max difference in SH | 0.50 m |
| Max span length () | 70 m |
| Max span length () | 65 m |
| Max span length (insulated sections) | 58 m |
| Min span length | 25 m |
| Max difference in span length | 14 m |

**Design 20 $C_1$**

| | |
|---|---|
| Contact wire | RiS 100 |
| Catenary | Bz II 50 |
| Stich wire | Bz II 25 |
| Dropper | Bz II 10 |
| Tension force Cat./Ctw. | 13000 N |
| Tension force Stich wire | 2300 N |
| Stitch wire length | 14.0m |
| Distance 1st dropper | 4.0 m |
| Longest dropper distance | 9.25 m |
| R ≤ 700 | No stich wire |
| Sag | x/1000 |
| | |
| System height | 0.75 m |
| Stagger | ± 0.30 m |
| Parallel distance 2 ctw. | 0.20 m () |
| Parallel distance 2 ctw. | 0.45 m (insulated sections) |
| Contact wire height | 5.60 m |
| Lowest contact wire height | 5.05 m |
| Uplift | 0.15 m |
| Lift | 0.50 m |
| ½ | 450 m |
| Max difference in SH | 0.30 m |
| Max span length () | 45 m |
| Max span length () | 44 m |
| Max span length (insulated sections) | 44 m |
| Min span length | 29 m |
| Max difference in span length | 9 m |

**Design 20 $C_2$**

| | |
|---|---|
| Contact wire | RiS 100 |
| Catenary | Bz II 50 |
| Dropper | Bz II 10 |
| Tension force Cat./Ctw. | 13000 N |
| Distance 1st dropper | 5.0 m |
| Longest dropper distance | 9.25 m |
| Sag | x/1000 |
| | |
| System height | 0.75 m |
| Stagger | ± 0.30 m |
| Parallel distance 2 ctw. | 0.20 m () |
| Parallel distance 2 ctw. | 0.45 m (insulated sections) |
| Contact wire height | 5.60 m |
| Lowest contact wire height | 5.05 m |
| Uplift | 0.15 m |
| Lift | 0.50 m |
| ½ | 450 m |
| Max difference in SH | 0.30 m |
| Max span length () | 45 m |
| Max span length () | 44 m |
| Max span length (insulated sections) | 44 m |
| Min span length | 29 m |
| Max difference in span length | 9 m |

**Design 25**

| | |
|---|---|
| Contact wire | RiS 120 |
| Catenary | Bz II 70 |
| Stich wire | Bz II 35 |
| Dropper | Bz II 10 |
| Tension force Cat./Ctw. | 15000 N |
| Tension force Stich wire | 2800 N |
| Stitch wire length (65 m – 55 m) | 18.0 m |
| Stitch wire length (55 m – 40 m) | 14.0m |
| Distance 1st dropper | 5.0 m |
| Longest dropper distance | 10.0 m |
| R ≤ 1200 | No stich wire |
| Sag | No sag |
| | |
| System height | 1.80 m |
| Stagger | ± 0.30 m |
| Parallel distance 2 ctw. | 0.45 m |
| Contact wire height | 5.30 m |
| Uplift | 0.15 m |
| Lift | 0.50 m |
| ½ | 600 m |
| Max difference in SH | 0.15 m |

| | |
|---|---|
| Max span length () | 65 m |
| Max span length () | 51 m |
| Max span length (insulated sections) | 51 m |
| Min span length | 29 m |
| Max difference in span length | 13 m |

**Design 25 (Tunnel)**

| | |
|---|---|
| Contact wire | RiS 120 |
| Catenary | Bz II 70 |
| Stich wire | Bz II 35 |
| Dropper | Bz II 10 |
| Tension force Cat./Ctw. | 15000 N |
| Tension force Stich wire | 2800 N |
| Stitch wire length | 14.0m |
| Distance 1st dropper | 5.0 m |
| Longest dropper distance | 10.0 m |
| R ≤ 1200 | No stich wire |
| Sag | No sag |
| | |
| System height | 1.10 m |
| Stagger | ± 0.30 m |
| Parallel distance 2 ctw. | 0.45 m |
| Contact wire height | 5.30 m |
| Uplift | 0.15 m |
| Lift | 0.50 m |
| ½ | 600 m |
| Max difference in SH | 0.15 m |
| Max span length () | 50 m |
| Max span length () | 45 m |
| Max span length (insulated sections) | 45 m |
| Min span length | 29 m |
| Max difference in span length | 10 m |