

**BS EN 50341-2-18:2016**



**BSI Standards Publication**

# **Overhead electrical lines exceeding AC 1 kV**

Part 2-18: National Normative Aspects  
(NNA) for Sweden (based on  
EN 50341-1:2012)



## National foreword

This British Standard is the UK implementation of EN 50341-2-18:2016. This standard, together with the following list of National Normative Aspect standards, supersedes BS EN 50423-3:2005 and BS EN 50341-3:2001:

| Country Code | Origin                         | Ref                   |
|--------------|--------------------------------|-----------------------|
| AT           | Austrian National Committee    | BS EN 50341-2-1       |
| BE           | Belgian National Committee     | BS EN 50341-2-2       |
| CH           | Swiss National Committee       | BS EN 50341-2-3       |
| DE           | German National Committee      | BS EN 50341-2-4:2016  |
| DK           | Danish National Committee      | BS EN 50341-2-5:2017  |
| ES           | Spanish National Committee     | BS EN 50341-2-6:2017  |
| FI           | Finnish National Committee     | BS EN 50341-2-7:2015  |
| FR           | French National Committee      | BS EN 50341-2-8       |
| GB           | British National Committee     | BS EN 50341-2-9:2015  |
| GR           | Greek National Committee       | BS EN 50341-2-10      |
| IE           | Irish National Committee       | BS EN 50341-2-11      |
| IS           | Iceland National Committee     | BS EN 50341-2-12      |
| IT           | Italian National Committee     | BS EN 50341-2-13:2017 |
| LU           | Luxemburg National Committee   | No NNA available      |
| NL           | Nederland's National Committee | BS EN 50341-2-15      |
| NO           | Norwegian National Committee   | BS EN 50341-2-16:2016 |
| PT           | Portuguese National Committee  | BS EN 50341-2-17      |
| SE           | Swedish National Committee     | BS EN 50341-2-18:2017 |
| CZ           | Czech National Committee       | BS EN 50341-2-19:2015 |
| EE           | Estonian National Committee    | BS EN 50341-2-20:2015 |
| PL           | Polish National Committee      | BS EN 50341-2-22:2016 |
| SK           | Slovak National Committee      | BS EN 50341-2-23:2016 |

BS EN 50423-3:2005 and BS EN 50341-3:2001 will be withdrawn upon publication of the rest of the series.

The UK participation in its preparation was entrusted to Technical Committee PEL/11, Overhead Lines.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2017.

Published by BSI Standards Limited 2017

ISBN 978 0 580 96357 5

ICS 29.240.20

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2017.

## Amendments/corrigenda issued since publication

| Date | Text affected |
|------|---------------|
|------|---------------|

English Version

**Overhead electrical lines exceeding AC 1 kV - Part 2-18:  
National Normative Aspects (NNA) for Sweden (based on EN  
50341-1:2012)**

Lignes électriques aériennes dépassant 1 kV en courant  
alternatif - Partie 2-18 : Aspects Normatifs Nationaux (NNA)  
pour la Suède (sur la base de l'EN 50341-1:2012)

This European Standard was approved by CENELEC on 2016-11-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**

|                                                                                       |           |
|---------------------------------------------------------------------------------------|-----------|
| <b>Foreword .....</b>                                                                 | <b>7</b>  |
| <b>1 Scope .....</b>                                                                  | <b>8</b>  |
| <b>2 Normative references, definitions and symbols .....</b>                          | <b>8</b>  |
| 2.1 Normative references .....                                                        | 8         |
| 2.2 Definitions .....                                                                 | 11        |
| 2.3 Symbols .....                                                                     | 11        |
| <b>3 Basis of design .....</b>                                                        | <b>12</b> |
| 3.2 Requirements of overhead lines .....                                              | 12        |
| 3.2.2 Reliability requirements .....                                                  | 12        |
| 3.6 Design values .....                                                               | 13        |
| 3.6.2 Design values of an action .....                                                | 13        |
| 3.7 Partial factor method and design formula .....                                    | 13        |
| 3.7.3.2 Design situations related to permanent and variable actions .....             | 13        |
| 3.7.3.3 Design situations related to permanent, variable and accidental actions ..... | 14        |
| <b>4 Actions on lines .....</b>                                                       | <b>14</b> |
| 4.1 Introduction .....                                                                | 14        |
| 4.3 Wind loads .....                                                                  | 14        |
| 4.3.4 Turbulence intensity and peak wind pressure .....                               | 14        |
| 4.4 Wind forces on overhead line components .....                                     | 14        |
| 4.4.1 Wind forces on conductors .....                                                 | 14        |
| 4.4.1.1 General .....                                                                 | 14        |
| 4.4.1.2 Structural factor .....                                                       | 15        |
| 4.4.1.3 Drag factor .....                                                             | 15        |
| 4.4.2 Wind forces on insulator sets .....                                             | 15        |
| 4.4.3 Wind forces on lattice towers .....                                             | 15        |
| 4.4.3.1 General .....                                                                 | 15        |
| 4.4.3.2 Method 1 .....                                                                | 15        |
| 4.4.3.3 Method 2 .....                                                                | 16        |
| 4.4.4 Wind forces on poles .....                                                      | 16        |
| 4.5 Ice load .....                                                                    | 16        |
| 4.5.2 Ice forces on conductors .....                                                  | 16        |
| 4.6 Combined wind and ice loads .....                                                 | 18        |
| 4.6.2 Drag factors and ice densities .....                                            | 18        |
| 4.6.3 Mean wind pressure and peak wind pressure .....                                 | 18        |
| 4.6.4 Equivalent diameter D of ice covered conductor .....                            | 18        |
| 4.7 Temperature effects .....                                                         | 18        |
| 4.8 Security loads .....                                                              | 19        |

|          |                                                                                      |           |
|----------|--------------------------------------------------------------------------------------|-----------|
| 4.9      | Safety loads .....                                                                   | 19        |
| 4.9.1    | Construction and maintenance loads .....                                             | 19        |
| 4.12     | Load cases.....                                                                      | 19        |
| 4.12.2   | Standard load cases .....                                                            | 19        |
| 4.13     | Partial factors for actions .....                                                    | 24        |
| <b>5</b> | <b>Electrical requirements.....</b>                                                  | <b>26</b> |
| 5.3      | Insulation co-ordination.....                                                        | 26        |
| 5.4      | Classification of voltages and overvoltages.....                                     | 27        |
| 5.5      | Minimum air clearance distances to avoid flashover .....                             | 28        |
| 5.6      | Load cases for calculation of clearances.....                                        | 30        |
| 5.8      | Minimum internal clearances within the span and at the top of support.....           | 34        |
| 5.9      | External clearances .....                                                            | 39        |
| 5.9.1    | General .....                                                                        | 39        |
| 5.9.2    | External clearances to ground in areas remote from buildings, roads, etc.<br>.....   | 40        |
| 5.9.3    | External clearances to residential and other buildings .....                         | 43        |
| 5.9.4    | External clearances to crossing traffic routes.....                                  | 44        |
| 5.9.6    | External clearances to other power lines or overhead telecommunication<br>lines..... | 46        |
| 5.9.7    | External clearances to recreational areas (playgrounds, sports areas,<br>etc.).....  | 50        |
| <b>6</b> | <b>Earthing systems .....</b>                                                        | <b>51</b> |
| 6.1      | Introduction .....                                                                   | 51        |
| 6.1.3    | Earthing measures against lightning effects.....                                     | 51        |
| 6.1.4    | Transferred potentials.....                                                          | 51        |
| 6.2      | Ratings with regard to corrosion and mechanical strength .....                       | 51        |
| 6.2.1    | Earth electrodes.....                                                                | 51        |
| 6.2.2    | Earthing and bonding conductors.....                                                 | 52        |
| 6.4      | Dimensioning with regard to human safety .....                                       | 52        |
| 6.4.3    | Basic design of earthing systems with regard to permissible touch voltage<br>.....   | 52        |
| 6.4.4    | Measures in systems with isolated neutral or resonant earthing .....                 | 54        |
| <b>7</b> | <b>Supports.....</b>                                                                 | <b>54</b> |
| 7.1      | Initial design considerations.....                                                   | 54        |
| 7.2      | Materials .....                                                                      | 54        |
| 7.2.1    | Steel materials, bolts, nuts and washers, welding consumables .....                  | 54        |
| 7.2.6    | Wood .....                                                                           | 54        |
| 7.3      | Lattice steel towers .....                                                           | 55        |
| 7.3.1    | General .....                                                                        | 55        |

|         |                                                              |    |
|---------|--------------------------------------------------------------|----|
| 7.3.3   | Materials .....                                              | 55 |
| 7.3.6   | Ultimate limit states.....                                   | 55 |
| 7.3.6.1 | General .....                                                | 55 |
| 7.3.6.3 | Tension, bending and compression resistance of members ..... | 55 |
| 7.3.6.4 | Buckling resistance of members in compression .....          | 55 |
| 7.3.8   | Resistance of connections.....                               | 56 |
| 7.4     | Steel poles .....                                            | 56 |
| 7.4.1   | General .....                                                | 56 |
| 7.4.6.1 | Ultimate limit states, General.....                          | 56 |
| 7.4.8.1 | Connections, Basis .....                                     | 56 |
| 7.4.8.2 | Bolts (other than holding-down bolts) .....                  | 56 |
| 7.5     | Wood poles .....                                             | 56 |
| 7.5.1   | General .....                                                | 56 |
| 7.5.3   | Materials .....                                              | 57 |
| 7.5.5   | Ultimate limit states.....                                   | 57 |
| 7.5.5.2 | Calculation of internal forces and moments .....             | 57 |
| 7.5.5.3 | Resistance of wood elements.....                             | 57 |
| 7.5.5.4 | Decay conditions .....                                       | 58 |
| 7.5.7   | Resistance of connections.....                               | 58 |
| 7.5.8   | Design assisted by testing .....                             | 58 |
| 7.6     | Concrete poles.....                                          | 58 |
| 7.6.1   | General .....                                                | 58 |
| 7.6.2   | Basis of design .....                                        | 59 |
| 7.6.3   | Materials .....                                              | 59 |
| 7.6.4   | Ultimate limit states.....                                   | 59 |
| 7.6.5   | Serviceability limit states .....                            | 59 |
| 7.6.6   | Design assisted by testing .....                             | 60 |
| 7.7     | Guyed structures.....                                        | 60 |
| 7.7.3   | Materials .....                                              | 60 |
| 7.7.4.1 | Ultimate limit states, Basis.....                            | 60 |
| 7.7.4.2 | Calculation of internal forces and moments .....             | 60 |
| 7.7.4.3 | Second order analysis .....                                  | 60 |
| 7.7.6   | Design details for guys .....                                | 61 |
| 7.8     | Other structures .....                                       | 61 |
| 7.9     | Corrosion protection and finishes .....                      | 65 |
| 7.9.2   | Galvanising .....                                            | 66 |
| 7.9.3   | Metal spraying .....                                         | 66 |
| 7.9.6   | Use of weather-resistant steels .....                        | 66 |
| 7.9.7   | Protection of wood poles .....                               | 66 |

|           |                                                                                       |           |
|-----------|---------------------------------------------------------------------------------------|-----------|
| 7.10      | Maintenance facilities .....                                                          | 67        |
| 7.10.3    | Safety requirements.....                                                              | 67        |
| <b>8</b>  | <b>Foundations .....</b>                                                              | <b>67</b> |
| 8.1       | Introduction .....                                                                    | 67        |
| 8.2       | Basis of geotechnical design .....                                                    | 68        |
| 8.2.2     | Geotechnical design by calculation .....                                              | 68        |
| 8.2.3     | Design by prescriptive measures .....                                                 | 69        |
| 8.2.4     | Load tests and tests on experimental models .....                                     | 70        |
| 8.3       | Soil investigation and geotechnical data .....                                        | 71        |
| 8.4       | Supervision of construction, monitoring and maintenance .....                         | 72        |
| <b>9</b>  | <b>Conductors and earth-wires .....</b>                                               | <b>72</b> |
| 9.1       | Introduction .....                                                                    | 72        |
| 9.2       | Aluminium based conductors.....                                                       | 73        |
| 9.2.1     | Characteristics and dimensions.....                                                   | 73        |
| 9.2.3     | Conductor service temperatures and grease performance .....                           | 73        |
| 9.2.5     | Corrosion protection .....                                                            | 73        |
| 9.2.6     | Test requirements.....                                                                | 74        |
| 9.3       | Steel based conductors .....                                                          | 74        |
| 9.3.1     | Characteristics and dimensions.....                                                   | 74        |
| 9.3.3     | Conductor service temperatures and grease characteristics .....                       | 74        |
| 9.3.4     | Mechanical requirements .....                                                         | 74        |
| 9.4       | Copper based conductors.....                                                          | 74        |
| 9.5       | Conductors and ground wires containing optical fibre telecommunication circuits ..... | 75        |
| 9.5.1     | Characteristics and dimensions.....                                                   | 75        |
| 9.5.3     | Conductor service temperatures .....                                                  | 75        |
| 9.5.4     | Mechanical requirements .....                                                         | 75        |
| 9.6       | General requirements .....                                                            | 76        |
| 9.6.2     | Partial factor for conductor .....                                                    | 76        |
| 9.6.4     | Sag - tension calculations.....                                                       | 76        |
| 9.8       | Selection, delivery and installation of conductors.....                               | 79        |
| <b>10</b> | <b>Insulators .....</b>                                                               | <b>79</b> |
| 10.2      | Standard electrical requirements .....                                                | 79        |
| 10.7      | Mechanical requirements.....                                                          | 80        |
| 10.10     | Characteristics and dimensions of insulators .....                                    | 80        |
| 10.16     | Selection, delivery and installation of insulators .....                              | 80        |
| <b>11</b> | <b>Hardware .....</b>                                                                 | <b>81</b> |
| 11.2      | Electrical requirements .....                                                         | 81        |

|                |                                                                        |           |
|----------------|------------------------------------------------------------------------|-----------|
| 11.2.2         | Requirement applicable to current carrying fittings .....              | 81        |
| 11.6           | Mechanical requirements.....                                           | 81        |
| 11.7           | Durability requirements.....                                           | 82        |
| 11.14          | Selection, delivery and installation of fittings .....                 | 82        |
| <b>12</b>      | <b>Quality assurance, Checks and taking-over.....</b>                  | <b>83</b> |
| 12.2           | Checks and taking-over .....                                           | 83        |
| <b>Annex E</b> | <b>Electrical requirements .....</b>                                   | <b>84</b> |
| E.2            | Insulation co-ordination.....                                          | 84        |
| <b>Annex G</b> | <b>Earthing systems .....</b>                                          | <b>84</b> |
| G.2            | Material constants.....                                                | 84        |
| <b>Annex J</b> | <b>Lattice steel towers .....</b>                                      | <b>84</b> |
| J.5            | Design resistance of bolted connections .....                          | 84        |
| <b>Annex K</b> | <b>Steel poles .....</b>                                               | <b>84</b> |
| K.6            | Design of holding-down bolts - Table K.2 .....                         | 84        |
| <b>Annex M</b> | <b>Geotechnical and structural design of foundations .....</b>         | <b>85</b> |
| M.1            | Typical values of the geotechnical parameters of soils and rocks ..... | 85        |
| M.2.3          | Calculation of $R_S$ .....                                             | 85        |
| M.2.4          | Analytical evaluation of $R_d$ .....                                   | 85        |

**European foreword**

- 1 The Swedish National Committee (NC) is identified by the following address:  
SEK Svensk Elstandard - TK11 Overhead Lines  
Box 1284  
SE-164 29 KISTA  
Telephone no.: +46 8 444 14 00  
Facsimile no.: +46 8 444 14 30  
E-mail [sek@elstandard.se](mailto:sek@elstandard.se)
- 2 The Swedish NC has prepared this Part 2-18 of EN 50341, listing the Swedish national normative aspects (NNA), under the sole responsibility, and duly passed it through the CENELEC and CLC/TC 11 procedures.
- NOTE The Swedish NC also takes the sole responsibility for the technically correct co-ordination of this EN 50341-2-18 with EN 50341. It has performed the necessary checks in the frame of quality assurance/control. It is noted however that this quality assurance/control has been made in the framework of the general responsibility of a standard committee under the national laws/regulations.
- 3 This NNA is normative in Sweden and informative in other countries.
- 4 This NNA has to be read in conjunction with Part 1 (EN 50341-1). All clause numbers used in this NNA correspond to those of Part 1. Specific subclauses, which are prefixed "SE", are to be read as amendments to the relevant text in Part 1. Any necessary clarification regarding the application of this NNA in conjunction with Part 1 shall be referred to the Swedish NC who will, in co-operation with CLC/TC 11 clarify the requirements.
- When no reference is made in this NNA to a specific subclause, then Part 1 applies.
- 5 In the case of "boxed values" defined in Part 1, amended values (if any), which are defined in this NNA shall be taken into account in Sweden.
- However, any boxed value, whether in Part 1 or in this NNA, shall not be amended in the direction of greater risk in a Project Specification.
- 6 The national Swedish standards / regulations related to overhead electrical lines exceeding 1 kV (AC) are listed in subclause 2.1/SE
- NOTE All national standards referred to in this NNA will be replaced by the relevant European Standards as soon as they become available and are declared by the Swedish NC to be applicable and thus reported to the secretary of CLC/TC 11.

## 1 Scope

(ncpt)

### SE.1 Application to existing overhead lines

This Part 2-18 is applicable for new overhead lines only and not for existing lines.

(A-dev)

### SE.2 Maintenance, rebuilding or extension of an overhead line

Measures related to maintenance of the electrical installation shall fulfill the legislation in force when it was erected. In the case of a rebuilding or extension of an electrical installation (overhead line), the regulations in force shall be applied for the rebuilding or extension. (ELSÄK-FS 2008:1)

(ncpt)

### SE.3 Replacement

This Part 2-18 replaces the Swedish Standards SS-EN 50341-3-18, edition 1 and SS-EN 50423-3-18, edition 3.

(ncpt)

### SE.4 Optical ground wire (OPGW) and optical phase conductor (OPCON)

This Part 2-18 is applicable for installation of OPGW and OPCON, also known as OPPC, in overhead lines in Sweden.

(ncpt)

### SE.5 All dielectric self supporting optical cable (ADSS) and optical attached cable (OPAC)

This Part 2-18 is applicable for installation of ADSS and OPAC in overhead lines in Sweden.

NOTE The allowable electrical field for the ADSS cable should be taken into consideration when the conductor configuration is determined.

## 2 Normative references, definitions and symbols

### 2.1 Normative references

(A-dev)

#### SE.1 National normative laws, government regulations

| Reference         | Title                                                                                                                                                                                                                                                                |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ELSÄK-FS 2008:1   | Elsäkerhetsverkets föreskrifter om hur starkströmsanläggningar ska vara utförda<br><i>The Swedish National Electrical Safety Board - Regulations regarding design, and erection of electrical installations</i>                                                      |
| ELSÄK FS 2008:3   | Elsäkerhetsverkets föreskrifter om innehavarens kontroll av elektriska starkströmsanläggningar och elektriska anordningar<br><i>The Swedish National Electrical Safety Board - Regulations regarding supervision of the electrical installation by the possessor</i> |
| SFS 2009:22       | Starkströmsförordning<br><i>The Swedish Government - Ordinance concerning electrical installations</i>                                                                                                                                                               |
| BFS 2011:10 - EKS | Boverkets föreskrifter och allmänna råd om tillämpning av europeiska konstruktionsstandarder (eurokoder)<br><i>Swedish National Board of Housing, Building and Planning: Application of the European design standards</i>                                            |

NOTE If there is associated amendment instructions to the documents listed above, they shall be included.

(ncpt)

**SE.2 National normative standards referred to in this NNA**

| <b>Reference</b>      | <b>Title</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SS-EN 335:2013        | Träskydd - Definitioner och tillämpning av användningsklasser - Massivt trä och träbaserade produkter<br><i>Durability of wood and wood-based products — Use classes: definitions, application to solid wood and wood-based products</i>                                                                                                                                                                                                                               |
| SS-EN 351-1:2007      | Träskydd – Träskyddsbehandlat massivt trä – Del 1: Klassificering och upptagning av träskyddsmedel<br><i>Durability of wood and wood-based products – Preservative-treated solid wood – Part 1: Classification of preservative penetration and retention</i>                                                                                                                                                                                                           |
| SS-ISO 965-4          | Metrisk ISO-gängor för allmän användning – Gängtoleranser - Del 4: Gränsmått för varmförzinkade utvändiga gängor avsedda för användning tillsammans med invändiga gängor gängade till toleranskvalitet H eller G efter förzinkning<br><i>ISO general purpose metric screw threads - Tolerances - Part 4: Limits of sizes for hot-dip galvanized external screw threads to mate with internal screw threads tapped with tolerance position H or G after galvanizing</i> |
| SS-EN 1090-2:2008     | Utförande av stål- och aluminiumkonstruktioner – Del 2: Stålkonstruktioner<br><i>Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures</i>                                                                                                                                                                                                                                                                      |
| SS-EN 1999-1-1:2007   | Eurokod 9 : Dimensionering av aluminiumkonstruktioner – Del 1-1: Allmänna regler<br><i>Eurocode 9: Design of aluminium structures - Part 1-1: General structural rules</i>                                                                                                                                                                                                                                                                                             |
| SS-EN ISO 4892-3:2013 | Plast - Metoder för exponering i artificiellt ljus - Del 3: UV lysrör (ISO 4892-3:2013)<br><i>Plastics - Methods of exposure to laboratory light sources - Part 3: Fluorescent UV lamps (ISO 4892-3:2013)</i>                                                                                                                                                                                                                                                          |
| SS-EN 10164:2005      | Stålprodukter med förbättrade deformationsegenskaper i tjockleksriktningen - Tekniska leveransbestämmelser<br><i>Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions</i>                                                                                                                                                                                                                   |
| SS-EN 10204:2005      | Metalliska varor - Typer av kontrolldokument<br><i>Metallic products - Types of inspection documents</i>                                                                                                                                                                                                                                                                                                                                                               |
| SS-EN ISO 10684:2004  | Fästelement – Varmförzinkning av fästelement<br><i>Fasteners – Hot dip galvanized coatings</i>                                                                                                                                                                                                                                                                                                                                                                         |
| SS-EN 13670:2009      | Betongkonstruktioner – Utförande<br><i>Execution of concrete structures</i>                                                                                                                                                                                                                                                                                                                                                                                            |
| SS-EN 60060           | Högspänningsprovning<br><i>High-voltage test techniques</i>                                                                                                                                                                                                                                                                                                                                                                                                            |
| SS 11 23 18           | Aluminium och stål – Lina till friledning – Kontinuerlig krypprovning<br><i>Aluminium and steel – Stranded conductors for overhead lines – non-interrupted creep testing</i>                                                                                                                                                                                                                                                                                           |
| SS 424 05 02          | Isolatorer – Stödisolatorer av pinntyp för friledningar<br><i>Insulators – Pin insulators for overhead lines</i>                                                                                                                                                                                                                                                                                                                                                       |
| SS 424 05 21          | Stödisolator av massiv typ för friledningar<br><i>Line post insulators</i>                                                                                                                                                                                                                                                                                                                                                                                             |
| SS 424 05 31          | Isolatorer - Stagisolatorer<br><i>Insulators - Stay insulators</i>                                                                                                                                                                                                                                                                                                                                                                                                     |

| Reference    | Title                                                                                                                                                                                                                                                            |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SS 424 08 06 | Linor av hård förzinkad ståltråd för luftledningar - Fe140-linor<br><i>Hard zinc-coated steel wire strands for overhead lines – Fe140 wire strands</i>                                                                                                           |
| SS 424 08 11 | Tråd av aluminiumlegering för linor för friledningar - AlMgSi-tråd<br><i>Aluminium alloy wire for stranded conductors for overhead line – AlMgSi wire</i>                                                                                                        |
| SS 424 08 12 | Linor av aluminiumlegering för friledningar – AlMgSi-linor<br><i>Aluminium alloy stranded conductors for overhead line – AlMgSi-conductor</i>                                                                                                                    |
| SS 424 08 13 | Tråd av aluminiumlegering för linor för friledningar - Al 59-tråd<br><i>Aluminium alloy wire for stranded conductors for overhead line – Al 59 wire</i>                                                                                                          |
| SS 424 08 14 | Linor av aluminiumlegering för friledningar - Al 59-linor<br><i>Aluminium alloy stranded conductors for overhead line – Al 59-conductor</i>                                                                                                                      |
| SS 424 12 50 | Najning<br><i>Ties</i>                                                                                                                                                                                                                                           |
| SS 424 12 51 | Förformad najningsspiral<br><i>Preformed ties</i>                                                                                                                                                                                                                |
| SS 436 02 61 | Luftledningskorsningar - Högspänningsledning (friledning), högst 52 kV, över allmän väg<br><i>Overhead line crossings - High voltage overhead line for max 52 kV above public road</i>                                                                           |
| SS 436 02 62 | Luftledningskorsningar - Högspänningsledning (friledning), högst 52 kV, över allmän väg - Trädsäkert korsningsspann<br><i>Overhead line crossings - High voltage overhead line for max 52 kV above public road - Crossing span safe for falling trees</i>        |
| SS 436 02 63 | Luftledningskorsningar - Högspänningsledning (friledning), högst 52 kV, över järnväg - Trädsäkert korsningsspann<br><i>Overhead line crossings - High voltage overhead line for max 52 kV above railway - Crossing span safe for falling trees</i>               |
| SS 436 02 65 | Luftledningskorsningar - Högspänningsledning (hängspiralkabel utan skärm), 1-24 kV, över allmän väg<br><i>Overhead line crossings - High voltage overhead line (self-supporting aerial cable without shield) 1-24 kV above public road</i>                       |
| SS 436 02 66 | Luftledningskorsningar - Högspänningsledning (hängspiralkabel utan skärm), 1-24 kV, över järnväg<br><i>Overhead line crossings - High voltage overhead line (self-supporting aerial cable without shield) 1-24 kV above railway</i>                              |
| SS 436 02 80 | Luftledningskorsningar - Högspänningsledning (metallskärmd hängkabel eller metallskärmd hängspiralkabel), 1-24 kV, över allmän väg<br><i>Overhead line crossings - High voltage overhead line (suspension cable with metal sheath) 1-24 kV above public road</i> |
| SS 436 02 81 | Luftledningskorsningar - Högspänningsledning (metallskärmd hängkabel eller metallskärmd hängspiralkabel), 1-24 kV, över järnväg<br><i>Overhead line crossings - High voltage overhead line (suspension cable with metal sheath) 1-24 kV above railway</i>        |

(ncpt)

**SE.3 National informative documents referred to in this NNA**

| Reference                               | Title                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NTR Dokument 3: 2013                    | Nordiska Träskyddsrådet – Nordiska regler för kvalitetskontroll av impregnerat trä – Del 1: Furu och andra lätt impregnerbara barrträdslag<br>The Nordic Wood Preservation Council – Nordic requirements for quality control of preservative treated wood – Part 1. Pine and other permeable softwoods |
| Korrosionsinstitutet<br>Bulletin nr 97  | Riktlinjer för användning av rosttröga stål - Korrosionstekniska synpunkter<br>Guidelines for use of weathering steel - Corrosion technical aspects                                                                                                                                                    |
| Korrosionsinstitutet<br>Bulletin No. 94 | Rosttröga stål i byggnader<br>Weathering steel in buildings                                                                                                                                                                                                                                            |

**2.2 Definitions**

(A-dev)

**SE.1.1 Reinforced lines type 1**

Overhead lines so designed that the forces which according to experience is expected to occur do not inflict damage which adversely will affect the capability of these lines or imply hazard to persons or property. (Brottsäker ledning: 6 kap. 1 and 7 §§ together with 7 kap. 8 §, ELSÄK-FS 2008:1).

(A-dev)

**SE.1.2 Reinforced lines type 2**

Design of overhead line within the nominal voltage of 1-25 kV in urban area with reliability level 2, efficient earth fault protection and particular measures to reduce the risk of falling trees. (Ledning i förstärkt utförande: 5 kap. 4 § and 6 kap. 1, 7 and 8 §§, ELSÄK-FS 2008:1).

(ncpt)

**SE.2 Similar conductors**

Similar conductors are conductors which have the same cross section, material, sag and attachment, see also Table 5.8/SE.1.

(ncpt)

**SE.3 Demarcation span**

Single spans which separate a line section build as a reinforced line type 1 with timber pole support and with highest system voltage equal to or less than 55 kV. The demarcation span shall be supported by demarcation supports which are timber pole supports without longitudinal guys.

**2.3 Symbols**

(ncpt)

**SE.1**

| Symbol    | Signification                                          | Reference          |
|-----------|--------------------------------------------------------|--------------------|
| $E_i$     | Modulus of elasticity, initial stage (before ice load) | 9.6.4/SE.1         |
| $E_{iL}$  | Modulus of elasticity, initial lower                   | 9.6.4/SE.1         |
| $E_{iU}$  | Modulus of elasticity, initial upper                   | 9.6.4/SE.1         |
| $E_p$     | Modulus of elasticity, final stage (after ice load)    | 9.6.4/SE.1         |
| $f_{ctm}$ | Mean value of axial tensile strength of concrete       | 7.6.5/SE.1         |
| $g_e$     | Dead weight of the conductor                           | 4.5.2/SE.1 to SE.2 |
| $g_{i0}$  | Ice-load at no wind                                    | 4.5.2/SE.1 to SE.2 |

| Symbol                | Signification                                                              | Reference                   |
|-----------------------|----------------------------------------------------------------------------|-----------------------------|
| $g_{iw}$              | Ice-load at normal wind                                                    | 4.5.2/SE.1 to SE.2          |
| $g_{w0}$              | Normal wind load at bare conductor                                         | 4.5.2/SE.1 to SE.2          |
| $g_{wi}$              | Normal wind-load at conductor covered by ice load                          | 4.5.2/SE.1 to SE.2          |
| <b>H</b>              | Horizontal clearance                                                       | Table 5.8/SE.1 to SE.2      |
| <b>h</b>              | Horizontal clearance at mixed conductor configuration, height above ground | Table 5.8/SE.1 to SE.2, 4.3 |
| <b>k</b>              | Voltage coefficient for distances                                          | Table 5.8/SE.1 to SE.3      |
| <b>S</b>              | Voltage dependent distance                                                 | 5.9.1/SE.1                  |
| <b>U<sub>SK</sub></b> | Lightning impulse withstand voltage                                        | 5.5/SE.1 to SE.2.2          |
| <b>U<sub>SL</sub></b> | Switching impulse withstand voltage                                        | 5.5/SE.1 to SE.2.2          |
| <b>U<sub>V</sub></b>  | Short duration wet power frequency withstand voltage                       | 5.5/SE.1 to SE.2.2          |
| <b>V</b>              | Vertical clearance                                                         | Table 5.8/SE.1 to SE.2      |
| <b>v</b>              | Vertical clearance at mixed conductor configuration                        | Table 5.8/SE.1 to SE.2      |
| <b>W</b>              | Free space, from high water level, for sailing, given by the authorities   | Table 5.9.4/SE.2            |
| <b>X</b>              | Clearance between conductors, factor in conductor calculation              | Table 5.8/SE.3, 9.6.4/SE.1  |
| $\epsilon_c$          | Strain elongation due to creep                                             | 9.6.4/SE.1                  |
| $\epsilon_s$          | Strain elongation due to stress                                            | 9.6.4/SE.1                  |
| $\sigma$              | Stress value                                                               | 9.6.4/SE.1                  |
| $\sigma_0$            | Stress value in conductor at 0 °C                                          | 9.6.4/SE.1                  |
| $\sigma_p$            | Highest stress value at which $E_{IL}$ is valid                            | 9.6.4/SE.1                  |

### 3 Basis of design

#### 3.2 Requirements of overhead lines

##### 3.2.2 Reliability requirements

(A-dev)

##### SE.1.1 Reliability level 2

Reliability level 2 with partial factors in accordance with 4.13 of this NNA shall be used for overhead lines of class A in Sweden for which this NNA is applicable.

(ncpt)

##### SE.1.2 Reliability level 1

Reliability level 1 with partial factors in accordance with 4.13 of this NNA shall be used for overhead lines of class B in Sweden for which this NNA is applicable.

(A-dev)

##### SE.1.3 Class A

Lines designed for the ice load in accordance with 4.5.2/SE.1.1, SE.1.2, SE.2 and 4.6.4./SE.1.1 and fulfilling the fault current capacity requirements of 11.14/SE.1 Examples are reinforced lines and other lines which are intended to be a part of systems which are used for transmission and distribution over the entire country or which otherwise are of substantial importance. (5 kap. 4 § together with 6 kap. 1 and 7 §§, ELSÄK-FS 2008:1).

(ncpt)

**SE.1.4 Class B**

Lines designed for the ice load in accordance with 4.5.2/SE.1.3, SE.1.4, SE.2 and 4.6.4./SE.1.2. Examples are distribution lines.

Deviation from this classification can be justifiable in special cases. However the requirements for class B are the minimum requirements for all lines.

(A-dev)

**SE.2.1 Reinforced lines type 1**

Reinforced lines of type 1 shall fulfil the requirements of class A. Reinforced line of type 1 is demarcated by terminal supports. For lines on timber poles with highest system voltage equal to or less than 55 kV the terminal supports for a reinforced line type 1 can be replaced by demarcation spans. The demarcation spans itself are not considered as a reinforced line.

The route and design of reinforced lines of type 1 shall be such that the risk of damage is prevented as far as possible. Reinforced line of type 1 may thus not be routed over or in perilous vicinity of shooting ranges, chemical industries which emit gas that is harmful to line materials, or locations where combustible objects or inflammables exist to such an extent that a fire could be perilous for the line. Nor may a reinforced line of type 1 or demarcation spans be routed close to buildings or structures of such low structural strength that will not withstand occurring wind loads. It shall be guaranteed that falling trees will not damage the line of type 1 or the demarcation span. (Brottsäker ledning: 6 kap. 1 and 7 §§ together with 7 kap. 8 §, ELSÄK-FS 2008:1).

(A-dev)

**SE.2.2 Reinforced lines type 2**

Reinforced lines of type 2 shall fulfil the requirements of class A. Lines with highest system voltage up to and including 25 kV and routed over urban areas. Reinforced line of type 2 need not to be demarcated by terminal poles or demarcation spans. However the requirements for reinforced line of type 2 shall also be applied for minimum one span outside the border of the urban area for reinforced lines of type 2 routed in forest. Lines routed in forests shall have a minimum clearance between tree trunk and phase of 3,5 m. Exceptions for a few stray trees down to a clearance distance to 2 m may occur if an investigation state a healthy tree with a solid root system. Remaining vegetation and twigs from trees shall for worst case have a clearance of minimum 1 m (Ledning i förstärkt utförande: 5 kap. 4 § and 6 kap. 1, 7 and 8 §§, ELSÄK-FS 2008:1).

**3.6 Design values****3.6.2 Design values of an action**

(ncpt)

**SE.1**

When calculating the effect of the action on the conductor tension, the partial factors  $\gamma_F$  shall be applied to the difference in actual conductor tension and tension at 0 °C in bare conductor. The partial factors  $\gamma_F$  shall not be applied to wind and ice loads for calculation of the conductor tension.

**3.7 Partial factor method and design formula****3.7.3.2 Design situations related to permanent and variable actions**

(ncpt)

**SE.1**

For all load cases and load combinations the basic design equation is:

$$E_d = \sum \gamma_G G_K + \sum \gamma_Q Q_{nK}$$

### 3.7.3.3 Design situations related to permanent, variable and accidental actions

(ncpt)

#### SE.1

For all load cases and load combinations the basic design equation is:

$$E_d = \sum \gamma_G G_K + \sum \gamma_Q Q_{nk}$$

## 4 Actions on lines

### 4.1 Introduction

The Swedish approach for calculation of climatic loads on transmission lines can be classified as an approach 3 method. The value of the peak wind pressure is given directly.

### 4.3 Wind loads

#### 4.3.4 Turbulence intensity and peak wind pressure

(snc)

#### SE.1

The characteristic wind pressure  $q_p(h)$  depends on the height  $h$  and the gust wind speed. Height  $h$  is the vertical distance in metres from the ground or water surface to the centre of gravity of the wind exposed surface. For a transmission line, which crosses over a single height on a plain or flat country,  $h$  is the height to the centre of gravity over the plain.

Values given below are valid for Sweden in general. In mountainous regions and at exposed locations along the coast line higher wind pressures may occur, which have to be considered.

(snc)

#### SE.1.1 For normal wind conditions the following formulas are valid

$$\text{for } h \leq 25 \text{ m} \quad q_p(h) = 500 \quad (\text{N/m}^2)$$

$$\text{for } h > 25 \text{ m} \quad q_p(h) = 500 + 6 \cdot (h - 25) \quad (\text{N/m}^2)$$

(snc)

#### SE.1.2 For extreme wind conditions the following formulas are valid

$$\text{for } h \leq 10 \text{ m} \quad q_p(h) = 800 \quad (\text{N/m}^2)$$

$$\text{for } h > 10 \text{ m} \quad q_p(h) = 800 + 6 \cdot (h - 10) \quad (\text{N/m}^2)$$

NOTE For determining electrical clearances the formulas for normal wind conditions shall be used.

### 4.4 Wind forces on overhead line components

#### 4.4.1 Wind forces on conductors

##### 4.4.1.1 General

(ncpt)

#### SE.1

The recommended method for calculating the reference height of the conductor is proposal 1 from Table 4.3, but any of the other proposals can be selected to simplify the calculations.

For the calculation of the mechanical conductor tension in a line-section, a reference height of 25 m can be assumed if no other value may be considered more appropriate.

For covered and insulated conductors the diameter of the conductor (d) is to be taken as the overall diameter including the thickness of insulation.

#### 4.4.1.2 Structural factor

(ncpt)

##### SE.1

The structural factor for the conductor is:

for spans  $G_C = 0,5$

for jumpers  $G_C = 1,0$

#### 4.4.1.3 Drag factor

(ncpt)

##### SE.1

Method 1 is recommended.

#### 4.4.2 Wind forces on insulator sets

(ncpt)

##### SE.1

The structural factor, the drag factor and the area of the insulator can be simplified to

$$G_{ins} \cdot C_{ins} \cdot A_{ins} = 0,16 \cdot L_{ins} \quad (m^2)$$

where

$L_{ins}$  is the length of one insulator string (m).

The formula for wind forces on insulator sets can therefore be written

$$Q_{Wins} = q_p(h) \cdot 0,16 \cdot L_{ins}$$

#### 4.4.3 Wind forces on lattice towers

##### 4.4.3.1 General

(ncpt)

##### SE.1

The wind forces on a tower can be determined with method 1 or with method 2.

Reference height of each tower section or each tower member is the height above ground of the geometrical centre of the tower section or the tower member being considered.

##### 4.4.3.2 Method 1

(ncpt)

##### SE.1

The structural resonance factor is  $G_t = G_{tc} = 1,0$

(ncpt)

##### SE.2 For lattice support the drag factor is:

rectangular cross section with flat sided members

$$C_t = 3,95 - 5,79 \cdot \chi + 3,86 \cdot \chi^2$$

rectangular cross section with cylindrical members

$$C_t = 2,30 - 3,24 \cdot \chi + 2,94 \cdot \chi^2$$

triangular cross section with flat sided members

$$C_t = 3,40 - 4,71 \cdot \chi + 3,37 \cdot \chi^2$$

triangular cross section with cylindrical members

$$C_t = 1,95 - 2,68 \cdot \chi + 2,76 \cdot \chi^2$$

where  $\chi$  is the solidity ratio, see Figure 4.2.

(ncpt)

**SE.3 For tower body or portal leg with triangular cross section the wind load is:**

$$Q_{wt} = q_p(h) \cdot G_t \cdot A_t \cdot C_t \quad (\text{N/m})$$

#### 4.4.3.3 Method 2

(ncpt)

**SE.1**

The structural resonance factor is  $G_m = 1,0$

The drag factor is  $C_m = 1,6$  for flat-sided members and 1,0 for cylindrical members.

#### 4.4.4 Wind forces on poles

(ncpt)

**SE.1**

Method 1 is preferred.

The structural resonance factor is  $G_{pol} = 1,0$

#### 4.5 Ice load

##### 4.5.2 Ice forces on conductors

(snc)

**SE.1 Uniform ice load**

For transmission lines in regions where greater uniform ice load is expected, higher values than those given below have to be considered.

(snc)

**SE.1.1 Ice load at normal wind conditions for class A lines**

$$\text{Ice load at normal wind conditions} \quad g_{iw} = \pi \cdot 2,916 + \pi \cdot 0,162 \cdot d \quad (\text{N/m})$$

where

$d$  = bare conductor diameter (mm).

For covered and insulated conductors the diameter of the conductor ( $d$ ) is to be taken as the overall diameter including the thickness of insulation.

Ice load  $g_{iw}$  shall be used in the load cases of normal wind referred to in 4.12.2/SE.

(snc)

**SE.1.2 Ice load at no wind for class A lines**

$$g_{i0} = \sqrt{(g_{iw} + g_e \cdot 9,81)^2 + g_{wi}^2} - g_e \cdot 9,81 \quad (\text{N/m})$$

where

$g_{iw}$  = ice load at normal wind, N/m

$g_e$  = dead weight of the conductor, kg/m

$g_{wi}$  = normal wind load at conductor covered by ice load, N/m

$g_{i0}$  = ice load at no wind, minimum 20 N/m

Ice load  $g_{i0}$  shall be used in the load cases at still air referred to in 4.12.2/SE.

(snc)

**SE.1.3 Ice load at normal wind conditions for class B lines**Ice load at normal wind conditions  $g_{iw} = \pi 0,441 + \pi 0,063 d$  (N/m)

where

 $d$  = bare conductor diameter (mm).

For covered and insulated conductors the diameter of the conductor ( $d$ ) is to be taken as the overall diameter including the thickness of insulation.

Ice load  $g_{iw}$  shall be used in the load cases of normal wind referred to in 4.12.2/SE.

(snc)

**SE.1.4 Ice load at no wind for class B lines**

$$g_{i0} = \sqrt{(g_{iw} + g_e \cdot 9,81)^2 + g_{wi}^2} - g_e \cdot 9,81 \quad (\text{N/m})$$

where

 $g_{iw}$  = ice load at normal wind, N/m $g_e$  = dead weight of the conductor, kg/m $g_{wi}$  = normal wind load at conductor covered by ice load, N/m $g_{i0}$  = ice load at no windIce load  $g_{i0}$  shall be used in the load cases at still air referred to in 4.12.2/SE.

(snc)

**SE.1.5 Ice load at normal wind conditions for overhead insulated cables**Ice load at normal wind conditions  $g_{iw} = 20 \text{ N/m}$ Ice load  $g_{iw}$  shall be used in the load cases of normal wind referred to in 4.12.2/SE.

(snc)

**SE.1.6 Ice load at no wind for overhead insulated cables**Uniform ice load at no wind  $g_{i0} = 20 \text{ N/m}$ Ice load  $g_{i0}$  shall be used in the load cases at still air referred to in 4.12.2/SE.

(snc)

**SE.2 Non uniform ice load**

Non-uniform ice load is supposed to appear in any single span while the adjacent spans have no ice. Still air can be assumed during non-uniform ice load.

Non-uniform ice load is expected to be 10 Newton per metre conductor in Sweden in general. For transmission lines in regions where greater non-uniform ice load is expected, higher values have to be considered.

Higher non-uniform ice loads than 10 Newton per metre conductor can be expected within the following regions:

- Within a zone of some tenths of km width, in open terrain towards the sea along the coast between the cities of Gävle and Haparanda. In such terrain transmission lines shall be designed for a non-uniform ice load of minimum 20 Newton per metre conductor.
- North of the river Dalälven, in upland terrain approximately 400 m above sea level and higher. In such terrain transmission lines shall be designed for a non-uniform ice load of minimum 30 Newton per metre conductor.
- Bare mountain regions at altitude above forest. In such terrain the non-uniform ice load can considerably exceed the values given under a) and b). Due to lack of experience no values can be pre-set and such value shall be determined for each individual case.

## **4.6 Combined wind and ice loads**

### **4.6.2 Drag factors and ice densities**

(snc)

#### **SE.1**

The ice density is:  $\rho_i = 9000 \text{ N/m}^3 = 917,4 \text{ kg/m}^3$

(snc)

#### **SE.2**

The drag factor for ice covered conductors (including insulated cables) is:  $C_{ic} = 1,0$

### **4.6.3 Mean wind pressure and peak wind pressure**

(snc)

#### **SE.1**

The wind at ice condition is the normal wind conditions given in 4.3.4/SE.1.1

### **4.6.4 Equivalent diameter D of ice covered conductor**

(snc)

#### **SE.1 Ice thickness at normal wind condition**

(snc)

##### **SE.1.1 Ice thickness at normal wind condition for class A**

Ice thickness at normal wind condition 18 mm

For determining the wind surface for ice coated conductors the diameter increased by twice the ice thickness shall be used for the surface calculation.

For covered conductors the diameter of the conductor (d) is to be taken as the overall diameter including the thickness of insulation.

(snc)

##### **SE.1.2 Ice thickness at normal wind condition for class B**

Ice thickness at normal wind condition 7 mm

For determining the wind surface for ice coated conductors the diameter increased by twice the ice thickness shall be used for the surface calculation.

For covered conductors the diameter of the conductor (d) is to be taken as the overall diameter including the thickness of insulation.

(snc)

##### **SE.1.3 Ice thickness at normal wind condition for overhead insulated cables**

Ice thickness at normal wind condition 10 mm

For determining the wind surface for ice coated conductors the diameter increased by twice the ice thickness shall be used for the surface calculation.

For insulated cables the diameter of the conductor (d) is to be taken as the overall diameter including the thickness of insulation.

## **4.7 Temperature effects**

(snc)

#### **SE.1**

The design temperature in all load-cases given in 4.12.2/SE shall be 0 °C unless otherwise noted.

Temperatures for calculation of clearances, see 5.6/SE.2.

## 4.8 Security loads

(ncpt)

### SE.1

Two methods to determine the security load are available: "basic assumption" and "alternative assumption". The most favourable method can be chosen.

(ncpt)

#### SE.1.1 Basic assumption

For a fixed attached conductor or shield wire, i.e. tension insulator set, pin or line post insulator or shield wire attachment, a reduction factor equal to 0,4 shall be applied to the horizontal component of the conductor force on one side of the support, at uniform ice, conductor temperature 0 °C, in still air at initial conductor tension. For a not fixed attached conductor, i.e. suspension insulator set, a reduction factor equal to 0,7 shall be applied to the horizontal component of the conductor force on one side of the support. No contributing support from the other conductors shall be considered. The vertical component of the conductor force (weight span) shall not be reduced.

(ncpt)

#### SE.1.2 Alternative assumption

100 % conductor tension reduction for the conductor or shield wire, located at the most unfavourable position, at no ice, conductor temperature 0 °C, in still air at initial conductor tension. When establishing the residual static load it may be assumed, except in crossings, that the adjacent spans are equal to the ruling span of the transmission line. No partial factors apply when establishing the residual static load.

After that the residual static load has been established it shall be increased by applying a partial factor in accordance with Table 4.7/SE.1 or Table 4.7/SE.2 as appropriate.

Relaxation of load resulting from any swing of the insulator assemblies, deflection or rotation of the support and the interaction with other conductors may be made. For bundle conductors, the reduction will affect all sub conductors in the bundle. The weight span shall not be reduced.

## 4.9 Safety loads

### 4.9.1 Construction and maintenance loads

(ncpt)

#### SE.1

All supports shall have the strength and be assembled in such a way that no permanent deformation occurs during construction and maintenance.

## 4.12 Load cases

### 4.12.2 Standard load cases

(ncpt)

#### SE.1

Load cases according to SE.2 and SE.3 are valid for lines with bare and covered conductors.

Load cases according to SE.4 are valid for demarcation spans.

Load cases according to SE.5 are valid for lines with for lines with overhead insulated cables.

The design temperature for the following load cases shall be in accordance with 4.7/SE.1.

The tension load in the conductors for the following load cases shall be calculated in accordance with 9.6.4/SE.1 with partial factors according to Table 4.7/SE.1 and 4.7/SE.2. See also 3.6.2/SE.1.

(ncpt)

## **SE.2 Tangent and angle supports**

(ncpt)

### **SE.2.1 Load case 1a Wind load**

This load case shall be used for all types of lines with bare and covered conductors except lines with supports of natural grown timber poles.

- Dead weight
- Wind load on the conductors and on the support with accessories in accordance with 4.3.4/SE.1.2.

(ncpt)

### **SE.2.2 Load case 2a Uniform ice loads on all spans**

- Dead weight
- Uniform ice load at no wind on the conductors in accordance with 4.5.2/SE.1.2 or SE.1.4.
- An additional vertical load  $Q_k$  of 1000 N, equivalent to the weight of a linesman with tools, acting in the most unfavourable point. The load is not required for pin insulator hooks and structural parts, which cannot be climbed.

Ice loads on supports can in general be neglected.

(ncpt)

### **SE.2.3 Load case 2b Uniform ice loads, transversal bending**

This load case can normally be ignored in Sweden.

(ncpt)

### **SE.2.4 Load case 2c - 2d Unbalanced ice loads**

These load cases can normally be ignored in Sweden.

(ncpt)

### **SE.2.5 Load case 3 Combined wind and ice load**

- Dead weight
- Ice load at normal wind on the conductors in accordance with 4.5.2/SE.1.1 or SE.1.3.
- Normal wind load on the conductors and on the support with accessories in accordance with 4.3.4/SE.1.1.

Ice loads on supports can in general be neglected.

(ncpt)

### **SE.2.6 Load case 4 Minimum temperature with/without wind loads**

These load cases can normally be ignored in Sweden for lines with bare and covered conductors.

(ncpt)

### **SE.2.7 Load case 5a Security loads, torsional loads**

Natural grown timber poles with accessories and transmission line class B supports do not have to be designed for this load case.

Suspension insulator sets and line-post insulators do not have to be designed for this load case.

(ncpt)

#### **SE.2.7.1 Basic assumption**

- Dead weight
- Uniform ice load at no wind on the conductors in accordance with 4.5.2/SE.1.2.
- Reduction of the conductor tension on one side of the support in accordance with 4.8/SE.1.1, Basic assumption. The reduction of the conductor tension is assumed to occur in one conductor only, regardless of the number of circuits per support or the number of conductors per phase.

In this load case crossarms and insulator attachments may be permanently deformed. Clearances shall be maintained to keep the transmission line in provisional service.

Ice loads on supports can in general be neglected.

(ncpt)

#### **SE.2.7.2 Alternative assumption**

- Dead weight
- Reduction of the conductor tension on one side of the support in one conductor (one bundle) in accordance with 4.8/SE.1.2, Alternative assumption

(ncpt)

#### **SE.2.8 Load case 5b Security loads, longitudinal loads**

This load case can normally be ignored in Sweden except for demarcation spans.

(ncpt)

#### **SE.2.9 Load case 6a Safety loads, construction and maintenance loads**

4.9 to be fulfilled.

(ncpt)

#### **SE.2.10 Load case 6b Safety loads, loads due to the weight of linesmen**

See SE.2.2

(ncpt)

#### **SE.3 Terminal support**

(ncpt)

##### **SE.3.1 Load case 1a Wind load**

This load case shall be used for all types of lines with bare and covered conductors except lines with supports of natural grown timber poles.

- Dead weight
- Wind load on the conductors and on the support with accessories in accordance with 4.3.4/SE.1.2.
- Conductor tensions from all conductors or conductor tensions from the conductors on one side of the support, whichever resulting in the most severe stress.

(ncpt)

##### **SE.3.2 Load case 2a Uniform ice loads on all spans**

- Dead weight
- Uniform ice load at no wind on the conductors in accordance with 4.5.2/SE.1.2 or SE.1.4.
- Conductor tension from all conductors on one side of the support. Terminal support that demarcates reinforced transmission line shall, in this load case, be designed for the one-sided conductor tensions from all the conductors in the reinforced transmission line. Terminal support that terminates a transmission line at a substation shall be designed for the one-sided conductor tensions from all conductors in the terminated transmission line. It is also recommended to design the terminal support for the one-sided conductor tensions from the conductors between the terminal support and the substation.
- An additional vertical load  $Q_k$  of 1000 N, equivalent to the weight of a linesman with tools, acting in the most unfavourable point. The load is not required for pin insulator hooks and structural parts that cannot be climbed.

(ncpt)

##### **SE.3.3 Load case 2b Uniform ice loads, transversal bending**

This load case can normally be ignored in Sweden.

(ncpt)

#### **SE.3.4 Load case 2c - 2d Unbalanced ice loads**

These load cases can normally be ignored in Sweden.

(ncpt)

#### **SE.3.5 Load case 3 Combined wind and ice load**

- Dead weight
- Ice load at normal wind on the conductors in accordance with 4.5.2/SE.1.1 or SE.1.3.
- Normal wind load on the conductors and on the support with accessories in accordance with 4.3.4/SE.1.1.
- Conductor tensions from all conductors or conductor tensions from the conductors on one side of the support, whichever resulting in the most severe stress.

(ncpt)

#### **SE.3.6 Load case 4 Minimum temperature with/without wind loads**

These load cases can normally be ignored in Sweden for lines with bare and covered conductors.

(ncpt)

#### **SE.3.7 Load case 5a Security loads, torsional loads**

- Dead weight
- Uniform ice load at no wind on the conductors in accordance with 4.5.2/SE.1.2 or SE. 1.4.
- Conductor tension from all conductors, however for some conductors the tension shall be reduced as follows:
- For transmission line class A the reduction of the conductor tension shall be the number and combinations of conductors which results in the most unfavourable case. Reduction in conductor tension in accordance with 4.8/SE.1.1, Basic assumption.
- For transmission line class B reduction of the conductor tension in one conductor in accordance with 4.8/SE.1.1, Basic assumption.

(ncpt)

#### **SE.3.8 Load case 5b Security loads, longitudinal loads**

This load case can normally be ignored in Sweden except for demarcation spans.

(ncpt)

#### **SE.3.9 Load case 6a Safety loads, construction and maintenance loads**

4.9 to be fulfilled.

#### **SE.3.10 Load case 6b Safety loads, loads due to the weight of linesmen**

See SE.3.2

(ncpt)

#### **SE.4 Demarcation support of timber poles**

(ncpt)

##### **SE.4.1 Load case 1a Wind load**

This load case can normally be ignored for lines with natural grown timber poles in Sweden.

(ncpt)

##### **SE.4.2 Load case 2a Uniform ice loads on all spans**

- Dead weight
- Uniform ice load at no wind on the conductors in accordance with 4.5.2/SE.1.2.
- An additional vertical load  $Q_k$  of 1000 N, equivalent to the weight of a linesman with tools, acting in the most unfavourable point. The load is not required for structural parts that cannot be climbed.

(ncpt)

**SE.4.3 Load case 2b Uniform ice loads, transversal bending**

This load case can normally be ignored in Sweden.

(ncpt)

**SE.4.4 Load case 2c - 2d Unbalanced ice loads**

These load cases can normally be ignored in Sweden.

(ncpt)

**SE.4.5 Load case 3 Combined wind and ice load**

- Dead weight
- Ice load at normal wind on the conductors in accordance with 4.5.2/SE.1.1.
- Normal wind load on the conductors and on the support with accessories in accordance with 4.3.4/SE.1.1.

(ncpt)

**SE.4.6 Load case 4 Minimum temperature with/without wind loads**

This load case can normally be ignored in Sweden for lines with bare and covered conductors.

(ncpt)

**SE.4.7 Load case 5a Security loads, torsional loads**

This load case can normally be ignored for demarcation spans.

(ncpt)

**SE.4.8 Load case 5b Security loads, longitudinal loads**

- Dead weight
- Full reduction of the conductor tension on one side of the support in all conductors

In this load case crossarms and insulator attachments may be permanently deformed. Special strength requirements for timber poles in this load case are stated in 7.5.5.3/SE.1. The clearances shall be maintained to keep the transmission line in provisional service. The ground clearance is equal to the requirements at short circuit condition in accordance with 5.9.2/SE.1 and SE.2.

(ncpt)

**SE.4.9 Load case 6a Safety loads, construction and maintenance loads**

4.9 to be fulfilled.

(ncpt)

**SE.4.10 Load case 6b Safety loads, loads due to the weight of linesmen**

See SE.4.2.

(ncpt)

**SE.5 Overhead insulated cable lines**

(ncpt)

**SE.5.1 Load case 1a Wind load**

This load case can normally be ignored for lines with overhead insulated cables in Sweden.

(ncpt)

**SE.5.2 Load case 2a - 2d Ice load at no wind**

These load cases can normally be ignored for lines with overhead insulated cables in Sweden.

(ncpt)

**SE.5.3 Load case 3 Combined wind and ice load**

- Dead weight
- Ice load at normal wind on the conductors in accordance with 4.5.2/SE.1.5.

- Normal wind load on the conductors in accordance with 4.3.4/SE.1.1.

(ncpt)

#### **SE.5.4 Load case 4 Minimum temperature without wind loads**

This load case can normally be ignored for supports.

- Dead weight of conductor
- Minimum temperature in accordance with 5.6/SE.2.1

(ncpt)

#### **SE.5.5 Load case 5a, 5b Security loads**

This load case can normally be ignored for lines with overhead insulated cables in Sweden.

(ncpt)

#### **SE.5.6 Load case 6a Safety loads, construction and maintenance loads**

4.9 to be fulfilled.

(ncpt)

#### **SE.5.7 Load case 6b Safety loads, loads due to the weight of linesmen**

- Dead weight
- An additional vertical load  $Q_k$  of 1000 N, equivalent to the weight of a linesman with tools, acting in the most unfavourable point. The load is not required for structural parts that cannot be climbed.

### **4.13 Partial factors for actions**

(ncpt)

#### **SE.1**

The loads which are referred to in the load cases are characteristic load values and shall be multiplied with the partial factors  $\gamma_G$  and  $\gamma_Q$ . Each load case is divided in two load combinations in accordance with Table 4.7/SE.1.

(ncpt) Table 4.7/SE.1 - Partial factors for actions

| Action                                                                                                                                                                                                                                                                                  | Partial factors<br>Symbol | Load combination |                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|------------------|-----------------|
|                                                                                                                                                                                                                                                                                         |                           | 1 <sup>1)</sup>  | 2 <sup>2)</sup> |
| Permanent actions:                                                                                                                                                                                                                                                                      |                           |                  |                 |
| Dead weight of insulators, supports, foundations, soil and ground water                                                                                                                                                                                                                 | $\gamma_G$                | 1,0              | 1,0             |
| Dead weight of conductors                                                                                                                                                                                                                                                               | $\gamma_G$                | 1,1              | 1,0             |
| Conductor tension for bare conductors at 0 °C                                                                                                                                                                                                                                           | $\gamma_G$                | 1,1              | 1,0             |
| Variable actions:<br>Wind and ice loads. Additional loads.<br><br>Residual static load at one-sided conductor tension reduction, alternative assumption according to 4.8/SE.1.2<br><br>Difference in actual conductor tension and tension at 0 °C on bare conductor.                    | $\gamma_Q$                | 1,43             | 1,0             |
| Dynamic maintenance and construction loads:<br>e.g. stringing loads or dynamic loads during transportation                                                                                                                                                                              | $\gamma_G$                | 1,8              | 1,3             |
| 1) Load combination 1 is normally determinant for supports and guys.<br>2) Load combination 2 is valid for conductors, earth-wires and insulators. Load combination 2 is also valid when checking deformations, electrical clearances and concrete cracks (Serviceability limit state). |                           |                  |                 |

(ncpt)

**SE.2 Partial factors for actions at guy failure**

Partial factors shall be taken from Table 4.7/SE.2 with reference to Table 5.8/SE.5. The most unfavourable load combination shall be used.

(ncpt) Table 4.7/SE.2 - Partial factors for actions at guy failure

| Action                                                                                                                   | Partial factors<br>Symbol | Load combination |
|--------------------------------------------------------------------------------------------------------------------------|---------------------------|------------------|
|                                                                                                                          |                           | 1                |
| Permanent actions:                                                                                                       |                           |                  |
| Dead weight of conductors                                                                                                | $\gamma_G$                | 1,1              |
| Dead weight of insulators, supports, foundations, soil and ground water                                                  | $\gamma_G$                | 1,0              |
| Conductor tension for bare conductors at +15 °C <sup>1)</sup>                                                            | $\gamma_G$                | 1,1              |
| Variable actions:<br>Wind load. Difference at +15 °C between conductor tension at normal wind and no wind. <sup>1)</sup> | $\gamma_Q$                | 1,43             |
| 1) At final stadium after the conductor has been subject to ice load and after conductor creep.                          |                           |                  |