BS EN 50341-2-4:2016

BSI Standards Publication

Overhead electrical lines exceeding AC 1 kV

Part 2-4: National Normative Aspects (NNA) for Germany (based on EN 50341-1:2012)

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National foreword

This British Standard is the UK implementation of EN 50341-2-4:2016. 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
ES	Spanish National Committee	BS EN 50341-2-6
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
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
PT	Portuguese National Committee	BS EN 50341-2-17
SE	Swedish National Committee	BS EN 50341-2-18
CZ	Czech National Committee	BS EN 50341-2-19:2015
EE	Estonian National Committee	BS EN 50341-2-20:2015
SI	Slovak National Committee	BS EN 50341-2-21
PL	Polish National Committee	BS EN 50341-2-22

BS EN 50423-3:2005 and BS EN 50341-3:2001 will be withdrawn upon publication of the rest of the series.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

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EUROPEAN STANDARD

NORME EUROPÉENNE

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English Version

Overhead electrical lines exceeding AC 1 kV - Part 2-4: National Normative Aspects (NNA) for Germany (based on EN 50341-1:2012)

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CENELEC

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

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European foreword

The following 6 statements are required from CLC/TC 11 for all NNAs; statement 7 was added by the German National Committee (NC).

1 The German National Committee is identified by the following address:

Deutsche Elektrotechnische Kommission im DIN und VDE (DKE)
Stresemannallee 15 (VDE Haus)
D-60596 Frankfurt/Main
Germany
phone ++49 69 6308-(0) 224
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Name of the relevant technical body: Komitee 421 (K 421) “Freileitungen” (Overhead power lines)

2 The German NC and its technical body K 421 “Overhead power lines” of Deutsche Elektrotechnische Kommission im DIN und VDE (DKE) prepared this Part 2-4 of EN 50341, listing the German National Normative Aspects (NNA) under its sole responsibility, and duly passed it through the CENELEC and CLC/TC 11 procedures.

NOTE The German NC also takes sole responsibility for the technically correct co-ordination of this EN 50431-2-4 with EN 50341-1. It has performed the necessary checks in the frame of quality assurance/control. However, it is noted that this quality control has been made in the framework of the general responsibility of a standards committee under the national laws/regulations.

3 This EN 50341-2-4 is normative in Germany and informative in other countries.

4 This Part 2-4 has to be read in conjunction with EN 50341-1, hereafter referred to as Part 1. All clause numbers used in this NNA correspond to those of Part 1. Specific subclauses, which are prefixed “DE”, are to be read as amendments to the relevant text in Part 1. Any necessary clarification regarding the application of this combined NNA in conjunction with Part 1 shall be referred to the German 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 case of “boxed values” defined in Part 1, amended values, (if any) which are defined in Part 2-4 shall be taken into account in Germany.

However, any “boxed value”, whether in Part 1 or Part 2-4, shall not be amended in the direction of greater risk in a Project Specification.

6 The National German standards/regulations related to overhead electrical lines exceeding 1 kV AC are listed in 2.1 of this Part 2-4.

NOTE All national standards referred to in this Part 2-4 will be replaced by the relevant European Standards as soon as they become available and are declared by the German NC to be applicable and thus reported to the secretary of CLC/TC 11.

7 5.11.1/DE.1 is an “A-dev”
4.3/DE.1, 4.4.1/DE.1, 4.5.2/DE.1, 5.2.1/DE.1, 5.6.3.2/DE.1, 5.6.3.3/DE.1, 5.6.4/DE.1, 5.6.5/DE.1, and 9.6.4/DE.2 are “snc”.
All other subclauses DE.X are “ncpt”.

1 Scope

1.1 General

1.1 DE.1 General

(ncpt) (Supplement to DIN EN 50341-1 (VDE 0210-1):2013-11, clause 1.1)

This EN applies for planning and design of overhead lines with nominal voltages above AC 1 kV.

This EN needs not to be adopted for existing installations. Installations in the planning and construction stage may be completed adopting the standard edition valid at the beginning of planning.

1.2 Field of application

1.2 DE.1 Application for conductors with components for telecommunication

(ncpt) (Supplement to DIN EN 50341-1 (VDE 0210-1):2013-11, 1.2)

In Germany this EN is applicable for all types of conductors (according to the information in clause 1.2) which contain components for telecommunication.

1.2 DE.2 Application for installation of telecommunication equipment on supports

(ncpt) (Supplement to DIN EN 50341-1 (VDE 0210-1):2013-11, 1.2)

In Germany this EN is applicable for the installation of telecommunication equipment on supports. Reference is made to 4.11.1/DE.1 “Extension of utilization”.

2 Normative references, definitions and symbols

2.1 Normative references

The following documents which are quoted partly or as a whole in this document are necessary for the application of this document. In case of dated reference only the referred edition is applicable. In case of non-dated references the last edition of the referred document (including all modifications) is applicable.

DASt 022[1)], *Guideline of DASt for hot-dip-zink-coating of prefabricated loadbearing steel components*
DASt-Richtlinie – Feuerverzinken von tragenden Stahlbauteilen

DIN 1054:2010-12, *Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1:2009-09 + NA:2010-12*
Baugrund – Sicherheitsnachweise im Erd- und Grundbau – Ergänzende Regelungen zu DIN EN 1997-1:2009-09 + NA:2010-12

DIN 4102-7:1998-07, *Fire behaviour of building materials and building components – Part 7: Roofing – Definitions, requirements and testing*
Brandverhalten von Baustoffen und Bauteilen – Teil 7: Bedachungen – Begriffe, Anforderungen und Prüfungen

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1) Source: Stahlbau Verlags- und Service GmbH

DIN 48006-1, *Insulators for overhead lines – Part 1: Long-rod insulators LP with socket caps*
Isolatoren für Starkstrom-Freileitungen – Langstabisolatoren mit Pfannenkappen

DIN 48006-2, *Insulators for overhead lines – Part 2: Long-rod insulators LG with clevis caps*
Isolatoren für Starkstrom-Freileitungen – Langstabisolatoren mit Gabelkappen

DIN 48006-3, *Insulators for overhead lines – Part 3: solid-core (VK) insulators*
Isolatoren für Starkstrom-Freileitungen – Vollkernisolatoren VK

DIN 48200-1, *Copper wires for stranded conductors*
Drähte für Leitungsseile – Drähte aus Kupfer

DIN 48200-2, *Bronze wires for stranded conductors*
Drähte für Leitungsseile – Drähte aus Kupferknetlegierung

DIN 48201-1, *Copper stranded conductors*
Leitungsseile – Seile aus Kupfer

DIN 48201-2, *Bronze stranded conductors*
Leitungsseile – Seile aus Kupfer-Knetlegierungen (Bz)

DIN 48203-1, *Copper wires and copper stranded conductors; technical delivery conditions*
Drähte und Seile für Leitungen aus Kupfer – Technische Lieferbedingungen

DIN 48203-2, *Wrought copper alloy (Bz) wires and conductors; technical delivery conditions*
Drähte und Seile für Leitungen aus Kupferknetlegierungen (Bz) – Technische Lieferbedingungen

DIN VDE 0212-399 (VDE 0212-399), *Conductors for Overhead lines – Conductors of concentric stranded round galvanized steel wires*
Leiter für Freileitungen – Leiter aus konzentrisch verseilten runden verzinkten Stahldrähten

DIN VDE V 0212-490 (VDE V 0212-490):2014-12, *Fittings for overhead lines – Part 490: Components for the protection of birds – Requirements and tests*
Armaturen für Freileitungen – Teil 490: Bauteile für den Vogelschutz – Anforderungen und Prüfungen

DIN EN 10025-1:2005-02, *Hot rolled products of structural steels – Part 1: General technical delivery conditions*
Warmgewalzte Erzeugnisse aus Baustählen – Teil 1: Allgemeine technische Lieferbedingungen

DIN EN 10025-2:2005-04, *Hot rolled products of structural steels – Part 2: Technical delivery conditions for non-alloy structural steels*
Warmgewalzte Erzeugnisse aus Baustählen – Teil 2: Technische Lieferbedingungen für unlegierte Baustähle

DIN EN 1090-1, *Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components*
Ausführung von Stahltragwerken und Aluminiumtragwerken – Teil 1: Konformitätsnachweisverfahren für tragende Bauteile

DIN EN 1090-2, *Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures*
Ausführung von Stahltragwerken und Aluminiumtragwerken – Teil 2: Technische Regeln für die Ausführung von Stahltragwerken

DIN EN 12385-4:2008-06 + amendment 1:2009-01, *Steel wire ropes – Safety – Part 4: Stranded ropes for general lifting applications; German version EN 12385-4:2002+A1:2008*
Drahtseile aus Stahldraht – Sicherheit – Teil 4: Litzenseile für allgemeine Hebezwecke; Deutsche Fassung EN 12385-4:2002 + A1:2008

DIN EN 12843:2004-11, *Precast concrete products – Masts and poles; German version EN 12843:2004*
Betonfertigteile – Maste; Deutsche Fassung EN 12843:2004

DIN EN 1991-1-4:2010-12*, Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions; German version EN 1991-1-4:2005 + A1:2010 + AC:2010*
Eurocode 1: Einwirkungen auf Tragwerke – Teil 1-4: Allgemeine Einwirkungen – Windlasten; Deutsche Fassung EN 1991-1-4:2005 + A1:2010 + AC:2010

DIN EN 1991-1-4/NA:2010-12*, National Annex - Nationally determined parameters – Eurocode 1: Actions on structures – Part 1-4: General actions - Wind actions*
Nationaler Anhang – National festgelegte Parameter – Eurocode 1: Einwirkungen auf Tragwerke – Teil 1-4: Allgemeine Einwirkungen – Windlasten

DIN EN 1992-1-1:2011-01, *Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings; German version EN 1992-1-1:2004 + AC:2010*
Eurocode 2: Bemessung und Konstruktion von Stahlbeton- und Spannbetontragwerken – Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau; Deutsche Fassung EN 1992-1-1:2004 + AC:2010

DIN EN 1992-1-1/NA:2013-04, *National Annex – Nationally determined parameters – Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings*
Nationaler Anhang – National festgelegte Parameter – Eurocode 2: Bemessung und Konstruktion von Stahlbeton- und Spannbetontragwerken – Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau

DIN EN 1997-1:2009-09*, Eurocode 7: Geotechnical design – Part 1: General rules; German version EN 1997-1:2004 + AC:2009*
Eurocode 7: Entwurf, Berechnung und Bemessung in der Geotechnik – Teil 1: Allgemeine Regeln; Deutsche Fassung EN 1997-1:2004 + AC:2009

DIN EN 1997-1/NA:2010-12*, National Annex – Nationally determined parameters – Eurocode 7: Geotechnical design – Part 1: General rules*
Nationaler Anhang – National festgelegte Parameter – Eurocode 7: Entwurf, Berechnung und Bemessung in der Geotechnik – Teil 1: Allgemeine Regeln

DIN EN 50182, *Conductors for overhead lines – Round wire concentric lay stranded conductors*
Leiter für Freileitungen – Leiter aus konzentrisch verseilten runden Drähten

DIN EN 50183, *Conductors for overhead lines – Aluminium-magnesium-silicon alloy wire for overhead line conductors*
Leiter für Freileitungen – Drähte aus Aluminium-Magnesium-Silizium-Legierung

DIN EN 50189, *Conductors for overhead lines – Zinc coated steel wires for stranded conductors*
Leiter für Freileitungen – Verzinkte Stahldrähte

DIN EN 50341-1 (VDE 0210-1):2013-11*, Overhead electrical lines exceeding AC 1 kV – Part 1: General requirements – Common specifications; German version EN 50341-1:2012*
Freileitungen über AC 1 kV – Teil 1: Allgemeine Anforderungen – Gemeinsame Festlegungen; Deutsche Fassung EN 50341-1:2012

DIN EN 50413 (VDE 0848-1):2009-08, *Basic standard on measurement and calculation procedures for human exposure to electric, magnetic and electromagnetic fields (0 Hz - 300 GHz); German version EN 50413:2008*
Grundnorm zu Mess- und Berechnungsverfahren der Exposition von Personen in elektrischen, magnetischen und elektromagnetischen Feldern (0 Hz bis 300 GHz); Deutsche Fassung EN 50413:2008

DIN EN 50443 (VDE 0845-8):2012-08, *Effects of electromagnetic interference on pipelines caused by high voltage AC electric traction systems and/or high-voltage AC power supply systems; German version EN 50443:2011*
Auswirkungen elektromagnetischer Beeinflussungen von Hochspannungswechsel-strombahnen und/oder Hochspannungsanlagen auf Rohrleitungen; Deutsche Fassung EN 50443:2011

DIN EN 50522 (VDE 0101-2):2011-11, *Earthing of power installations exceeding 1 kV AC, German version EN 50522:2010*
Erdung von Starkstromanlagen mit Nennwechsel-spannungen über 1 kV; Deutsche Fassung EN 50522: 2010

DIN EN 60038 (VDE 0175-1):2012-04, *CENELEC standard voltages (IEC 60038:2009, modified); German version EN 60038:2011*
CENELEC-Normspannungen (IEC 60038:2009, modifiziert); Deutsche Fassung EN 60038:2011

DIN IEC 60273 (VDE 0674-4):1993-08, *Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1 000 V (IEC 60273:1990); German version HD 578 S1:1992*
Kenngrößen von Innenraum- und Freiluft-Stützisolatoren für Systeme mit Nennspannungen über 1 000 V (IEC 60273:1990); Deutsche Fassung HD 578 S1:1992

DIN EN 60383-1 (VDE 0446-1):1997-05, *Insulators for overhead lines with a nominal voltage above 1 kV – Part 1: Ceramic or glass insulator units for AC systems – Definitions, test methods and acceptance criteria (IEC 60383-1:1993); German version EN 60383-1:1996*
Isolatoren für Freileitungen mit einer Nennspannung über 1 kV – Teil 1: Keramik- oder Glas-Isolatoren für Wechselspannungssysteme – Begriffe, Prüfverfahren und Annahmekriterien (IEC 60383-1:1993); Deutsche Fassung EN 60383-1:1996

DIN EN 60433 (VDE 0446-7), *Insulators for overhead lines with a nominal voltage above 1 kV – Ceramic insulators for AC systems – Characteristics of insulator units of the long rod type*
Isolatoren für Freileitungen mit einer Nennspannung über 1 kV – Keramik-Isolatoren für Wechselspannungssysteme – Kenngrößen von Kettenisolatoren in Langstabausführung

DIN EN 60865-1 (VDE 0103):2012-09, *Short-circuit currents – Calculation of effects – Part 1: Definitions and calculation methods (IEC 60865-1:2011); German version EN 60865-1:2012*
Kurzschlussströme – Berechnung der Wirkung – Teil 1: Begriffe und Berechnungsverfahren (IEC 60865-1:2011); Deutsche Fassung EN 60865-1:2012

DIN EN 60889, *Hard-drawn aluminium wire for overhead line conductors*
Hartgezogene Aluminiumdrähte für Leiter von Freileitungen

DIN EN 61109 (VDE 0441-100), I*nsulators for overhead lines – Composite suspension and tension insulators for AC systems with a nominal voltage greater than 1000 V – Definitions, test methods and acceptance criteria*
Isolatoren für Freileitungen – Verbund-Hänge- und -Abspannisolatoren für Wechselstromsysteme mit einer Nennspannung über 1 000 V – Begriffe, Prüfverfahren und Annahmekriterien

DIN EN 61232, *Aluminium-clad steel wires for electrical purposes (IEC 61232:1993, modified)*
Aluminium-ummantelte Stahldrähte für die Elektrotechnik

DIN EN 61284 (VDE 0212-1):1998-05, *Overhead lines – Requirements and tests for fittings (IEC 61284:1997); German version EN 61284:1997*
Freileitungen – Anforderungen und Prüfungen für Armaturen (IEC 61284:1997); Deutsche Fassung EN 61284:1997

DIN EN 61854 (VDE 0212-2), *Overhead lines – Requirements and tests for spacers*
Freileitungen – Anforderungen und Prüfungen für Feldabstandhalter

DIN EN 61897 (VDE 0212-3), *Overhead lines – Requirements and tests for Stockbridge type aeolian vibration dampers*
Freileitungen – Anforderungen und Prüfungen für Schwingungsdämpfer Typ Stockbridge

DIN EN 61952 (VDE 0441-200):2009-06, *Insulators for overhead lines – Composite line post insulators for A.C. systems with a nominal voltage greater than 1 000 V – Definitions, test methods and acceptance criteria (IEC 61952:2008)*
Isolatoren für Freileitungen – Verbund-Freileitungsstützer für Wechselstromsysteme mit einer Nennspannung über 1 000 V – Begriffe, Prüfverfahren und Annahmekriterien (IEC 61952:2008); Deutsche Fassung EN 61952:2008

DIN EN 62004 (VDE 0212-303), *Thermal-resistant aluminium alloy wires for overhead line conductors*
Wärmebeständige Drähte aus Aluminiumlegierung für Leiter von Freileitungen

DIN EN ISO 1461, *Hot-dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods*
Durch Feuerverzinken auf Stahl aufgebrachte Zinküberzüge (Stückverzinken) – Anforderungen und Prüfungen

DIN EN ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs with specified property classes – Coarse thread and fine pitch thread*
Mechanische Eigenschaften von Verbindungselementen aus Kohlenstoffstahl und legiertem Stahl – Teil 1: Schrauben mit festgelegten Festigkeitsklassen – Regelgewinde und Feingewinde

DIN EN 1993-1-1*, Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings*
Eurocode 3: Bemessung und Konstruktion von Stahlbauten – Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau

DIN EN 1993-1-5*, Eurocode 3: Design of steel structures – Part 1-5: Plated structural elements*
Eurocode 3: Bemessung und Konstruktion von Stahlbauten – Teil 1-5: Plattenförmige Bauteile

DIN EN 1993-1-6, *Eurocode 3: Design of steel structures – Part 1-6: Strength and stability of shell structures*
Eurocode 3: Bemessung und Konstruktion von Stahlbauten – Teil 1-6: Festigkeit *und Stabilität von Schalen*

DIN EN 1995-1-1, *Eurocode 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings*
Eurocode 5: Bemessung und Konstruktion von Holzbauten – Teil 1-1: Allgemeines – Allgemeine Regeln und Regeln für den Hochbau

DIN EN 1995-1-2, *Eurocode 5: Design of timber structures – Part 1-2: General – Structural fire design*
Eurocode 5: Bemessung und Konstruktion von Holzbauten – Teil 1-2: Allgemeine Regeln – Tragwerksbemessung für den Brandfall

DIN VDE 0100-442 (VDE 0100-442):2013-06, *Low-voltage electrical installations – Part 4-442: Protection for safety – Protection of low-voltage installations against temporary overvoltages due to earth faults in the high-voltage system and due to faults in the low-voltage system (IEC 60364-4-44:2007 (Clause 442), modified); German implementation HD 60364-4-442:2012*
Errichten von Niederspannungsanlagen – Teil 4-442: Schutzmaßnahmen – Schutz von Niederspannungsanlagen bei vorübergehenden Überspannungen infolge von Erdschlüssen im Hochspannungsnetz und bei Fehlern im Niederspannungsnetz (IEC 60364-4-44:2007 (Abschnitt 442), modifiziert); Deutsche Übernahme HD 60364-4-442:2012

DIN VDE 0105-100 (VDE 0105-100), *Operation of electrical installations – Part 100: General requirements*
Betrieb von elektrischen Anlagen – Teil 100: Allgemeine Festlegungen

DIN VDE 0105-115 (VDE 0105-115), *Operation of electrical installations – Part 115: Particular requirements for agricultural plants*
Betrieb von elektrischen Anlagen – Besondere Festlegungen für landwirtschaftliche Betriebsstätten

DIN VDE 0845-6-1 (VDE 0845-6-1):2013-04, *Influence of high-voltage systems on telecommunication systems – Part 1: General, limits, calculation and measurement methods*
Maßnahmen bei Beeinflussung von Telekommunikationsanlagen durch Starkstromanlagen – Teil 1: Grundlagen, Grenzwerte, Berechnungs- und Messverfahren

DIN VDE 0845-6-2 (VDE 0845-6-2):2014-09, *Electromagnetic influence of electric power supply on telecommunication systems – Part 2: Influence by three phase ac systems*
Maßnahmen bei Beeinflussung von Telekommunikationsanlagen durch Starkstromanlagen – Teil 2: Beeinflussung durch Drehstromanlagen

VDE-AR-N 4210-11 (VDE-AR-N 4210-11):2011-08[2)], *Protection of birds on medium voltage overhead lines*
Vogelschutz an Mittelspannungsfreileitungen

Impregnated timber poles – Technical reference (FNN)
Imprägnierte Holzmaste – Technischer Hinweis (FNN)[3)]

2.2 Definitions

The terms and definitions listed in DIN EN 50341-1 (VDE 0210-1):2013-11 are supplemented and detailed for the purpose of this Part 2-4 as follows.

2.2 **DE.1**
Overhead line
(ncpt) the total of a system for overhead transmission of electrical energy consisting of supports and line components.

Note 1 to entry: Supports comprise towers, their foundations and earthings. Line components comprise overhead conductors and insulators together with their fittings.

2.2 **DE.2**
Tower and pole
(ncpt) part of the support consisting of tower body, earthwire peaks and crossarms.

Note 1 to entry: According to 2.2/DE.2.1 to DE.2.7 they serve for the following functions.

DE.2.1
Suspension towers
tower, which supports the conductors in a straight line

DE.2.2
Angle suspension tower
tower, which serves as suspension support for the conductors, where the line changes direction

[2)] Source: VDE-VERLAG GMBH

[3)] Source: VDE-InfoCenter - Verbandsgeschäftsstelle

DE.2.3
Angle tower
tower, which carries the resulting tensile forces at a point where the line changes direction

DE.2.4
Section tower and angle section tower
tower, which carries the conductor tensile force in line direction or in the resultant direction, respectively, and serve additionally as a rigid point in the line

DE.2.5
Dead end tower
tower, which carries the total conductor tensile forces in line direction on one side

DE.2.6
Special tower
tower, which serves for one or several of the above mentioned functions

DE.2.7
Guyed tower
tower, which is provided additionally with stay wires in order to stabilize the tower body

DE.2.8
Uplift or downward force

DE.2.8.1
Uplift force
component of the conductor tensile force due to different altitude of the suspension points; acting in opposite direction of the conductor deadweight.

DE.2.8.2
Downward force
component of the conductor tensile force due to different altitude of the suspension points; acting in direction of the conductor deadweight.

DE.2.9
Span length
horizontal distance between the attachment points of the conductor on two consecutive supports.

Note 1 to entry: When determining the horizontal distance of the attachment points of a conductor the angle of the crossarm to the line needs to be considered accordingly.

[SOURCE: IEV 466-03-02, modified, note added]

DE.2.10
Wind span of a tower or pole
horizontal distance between the points at midspan on each side of a support.

[SOURCE: IEV 466-03-07]

DE.2.11
Weight span of a tower or pole
horizontal distance between the lowest points of a conductor on either side of a support.

[SOURCE: IEV 466-03-08, modified, note deleted]

DE.2.12
Tower equipment
all components which are not part of the tower structure or the conductors themselves

Note 1 to entry: Insulators and fittings are in this category as well as radar markers and warning spheres when they are fitted directly at the tower or pole.

DE.2.13
Rotating crossarm
crossarm where halves of the crossarm are separately (swinging crossarm) or in total (turning crossarm) and movably fixed on or at the body.

2.2 **DE.3**
Foundation
(ncpt) part of the support fulfilling the task of transferring the structural loads from the tower or the pole to the subsoil and, at the same time, protecting the tower or pole against critical movements of the subsoil

DE.3.1
Compact foundation
foundation, which accommodates the tower body with one single foundation body

DE.3.2
Separate footing foundation
foundation, which accommodates the leg members of the tower with separate foundation bodies

DE.3.3
Working load of a foundation
load transferred from tower to the foundation for a given load case

DE.3.4
Failing load of a foundation
load under which the foundation fails.

Note 1 to entry: The failure is defined by inadmissible large foundation movements and occurs in the transition range between stable and unstable state of equilibrium.

2.2 **DE.4**
Conductors (of an overhead line)
(ncpt) a wire or combination of wires not insulated from one another, suitable for carrying an electric current

Note 1 to entry: One or more aluminium, aluminium alloy, copper, zinc coated or aluminium clad steel wires, or combinations thereof, wrapped together which collectively have the function of conducting an electric current.

Note 2 to entry: For certain purposes the separation into phase conductors conducting the operation current and earth wires according to DIN EN 50341-1 (VDE 0210-1):2013-11, 2.1.33 is necessary. This applies especially, however, not only for 5.8 and 5.9 of this standard.

[SOURCE: IEV 466-01-15, modified, Note 2 to entry added]

DE.4.1
Bundle conductors
set of individual conductors connected in parallel and disposed in a uniform geometrical configuration, that constitutes one phase or pole of a line.

[SOURCE: IEV 466-10-20]

DE.4.2
Rated tensile strength of a conductor
value which is calculated from the specified tensile strengths of the individual strands and can be taken from the conductor standards

Note 1 to entry: This term may have been introduced in other standards also as nominal strength or design strength of conductors.

DE.4.3
Nominal cross section of a conductor
cross-sectional parameter used for the designation of the conductor

DE.4.4
Actual cross section of a conductor
cross section of metal resulting from the conductor design

DE.4.5
Tensile stress of a conductor
theoretical value which results from the division of the rated conductor tensile force by the actual cross section

DE.4.7
Nominal failure stress of a conductor
rated tensile strength of a conductor divided by the nominal cross section of the conductor

DE.4.8
Everyday stress
horizontal component of the conductors tensile stress which occurs at the annual mean temperature (normally at +10 °C) without wind load

DE.4.9
Conductor temperature
temperature of a conductor due to the ambient temperature, wind, solar radiation and electric current

DE.4.10
Conductor sag
vertical distance between the conductor and the alignment of the conductor suspension points (suspension sets) or at attachments points (tension sets) at the supports

DE.4.11
Maximum conductor sag
the greater of the values of a resulting from the conductor temperature of –5 °C with ice load according to 4.5.2/DE.1 or from the maximum design temperature of the conductor without ice load

2.2 **DE.5 Insulator**

(ncpt) device intended for electrical insulation and mechanical fixing of equipment or conductors which are subject to electric potential differences

Note 1 to entry The definitions for insulators are given in DIN EN 60383-1 (VDE 0446-1) and DIN EN 61109 (VDE 0441-100).

[SOURCE: IEV 471-01-10, modified, Note 1 to entry added]

DE.5.1
Multiple insulator set
arrangement of several redundant insulator strings

2.2 **DE.6**
Accessory (fitting)

(ncpt) component, which can serve for the mechanical attachment, the electrical connection and the protection of conductors and insulators against mechanical vibrations and electric arcs as well as for potential control.

DE.6.1
Fittings for conductors

Dead end equipment, suspension equipment, conductor connections, vibration protection fittings, bundle spacers, fittings for marking the conductors, fittings for repair of conductors.

Note 1 to entry Clause 2.2/DE.6.3 applies for straps of wedge-type dead end clamps and suspension clamps as well as the clevis of compression-type dead end clamps.

DE.6.2
Other accessories for conductor attachments

side tie rods for line post insulator, top tie rods for line post insulator

DE.6.3
Accessories for insulator sets

components for connecting the dead end or suspension elements to the supports, components for connecting the insulators, arc and potential control accessories, components for compensation of length and for sagging.

Note 1 to entry The accessories for insulator sets are arranged between the dead end or suspension components and the first detachable part at the support, for example the jointing pin or the U-bolt. In case of line post insulators the pin is also included. The accessories for insulator sets, with exception of arc and potential control fittings are loaded by the conductor tensile forces and the forces of the conductor due to dead-weight, ice loads and wind forces. The insulators themselves are not included.

2.2 **DE.7 Overhead line design**

DE.7.1
Line section

(ncpt) part of an overhead line situated between two adjacent section supports

DE.7.2
Span

(ncpt) part of a line between two consecutive points of support

[SOURCE: IEV 466-03-01, modified, wording “of a conductor” deleted]

DE.7.3
Crossing span

(ncpt) part of an overhead line over or under a crossed installation situated between two adjacent supports

DE.7.4
Clearance

(ncpt) distance between conductors and objects, in between conductors or between conductors and ground surface to be kept under consideration of the sag

DE.7.5
Crossing object

(ncpt) fixed or movable part of a crossed installation for which the clearances to the overhead lines need to be demonstrated.

Note 1 to entry: Movable components may be considered by clearance gauges.

DE.7.6
Crossing

(ncpt) line section also with several consecutive crossing spans with a crossing object to which horizontal, vertical and shortest clearances shall be demonstrated.

Note 1 to entry: In this case, the horizontal minimum clearance from swung conductors forms the uttermost lateral border of the crossing section.

2.3 Symbols

Symbol	Signification	Unit	Reference to Subclause/clause
a	Distance between individual poles of a double- and A-type pole at half of the pole height	m	Table 4/DE.1 in 4.4.1/DE.1
a_{LTG}	Horizontal minimum clearance at a wind energy converter site depending on the system voltage according to table 5/DE.2	m	5.9.3/DE.2.1
a_{Raum}	Working space for erection cranes for construction and operation related works at wind energy converters	m	5.9.3/DE.2.1
d_{accept}	Distance between high- and low-voltage earthing electrodes	m	6.1.2/DE.2.2
A	Area	mm^2	J.3/DE.1
A_{ins}	Insulator area exposed to wind	m^2	4.4.2/DE.1
A_m	Area of a crossarm member exposed to wind	m^2	4.4.3.2/DE.1.3
A_{net}	Net cross-sectional area	mm^2	J.3/DE.1
A_{pol}	Projected area of a pole	m^2	4.4.4/DE.1
A_{t1} or A_{t2}	Area of tower face 1 or face 2 filled with sections	m^2	4.4.3.2/DE.1.1
A_{tQ}	Area of crossarm face filled with sections	m^2	4.4.3.2/DE.1.2
a_{som}	Shortest distance between live and earthed parts at three supports before the crossing span and three supports behind the crossing span	m	5.5.3/DE.1; 5.9.3/DE.1
a_{WEA}	Horizontal distance between the uttermost conductor in still air of an overhead line and the axis of a tower of a wind energy converter	m	5.9.3/DE.2.1
C_{ins}	Drag factor of insulator sets	–	4.4.2/DE.1
C_m	Drag factor for a crossarm member	–	4.4.3.2/DE.1.3
C_c	Drag factor for conductors	–	4.4.1/DE.1

C_{pol}	Drag factor for a single pole	–	4.4.4/DE.1
C_Q	Drag factor of a crossarm face	–	4.4.3.2/DE.1.2
C_{t1} or C_{t2}	Drag factor for tower face 1 or tower face 2	–	4.4.3.2/DE.1.1
d	Conductor diameter without ice load	m	4.4.1/DE.1, 4.5.2/DE.1
d_m	Mean value of the mean diameters of two single poles	m	Table 4/DE.1 in 4.4.1/DE.1
D_{el}	Minimum electrical clearance between phase conductor and earthed components	m	5.8/DE.1; 5.9.1/DE.1
D_I	Conductor diameter with ice load	m	4.6.4/DE.1
D_{pp}	Minimum electrical clearance phase-to-phase	m	5.8/DE.1; 5.9.1/DE.1
D_{WEA}	Diameter of the rotor of a wind energy converter	m	5.9.3/DE.2.1; 5.9.3/DE.2.2
E_d	Design value of an action	kN	4.13/DE.2
$f_{\beta m}$	Angle factor of a crossarm member	–	4.4.3.2/DE.1.3
G_K	Dead weight of conductors, insulators and supports	N	4.13/DE.2
G_m	Factor for the support	–	4.4.3.2/DE.1.3
g_I	Ice load	N/m	4.5.2/DE.1
G_c	Conductor response factor	–	4.4.1/DE.1
H	Altitude of terrain above O.D.	m	4.3/DE.1
h	Height of lower edge of wake	m	5.9.3/DE.2.2
h	Height above surface	m	4.3/DE.1
h_m	Height of a crossarm single member above terrain	m	4.4.3.2/DE.1.3
h_{WEA}	Height of the rotor hub above the local terrain surface	m	5.9.3/DE.2.2
I''_{k1}	Initial short-circuit alternating current in case of a single pole short-circuit with earth	A	Table 6/DE.2 in 6.3.2/DE.1
I''_{kEE}	Short-circuit current in case of a double earth short-circuit	A	Table 6/DE.2 in 6.3.2/DE.1
I_c	Capacitive earth short-circuit current	A	Table 6/DE.2 in 6.3.2/DE.1

I_{RES}	Residual short-circuit current	A	Table 6/DE.2 in 6.3.2/DE.1
I_{St}	Peak value of the lightning current	A	6.1.3/DE.1
i_{vv}, i_{yy}	Radius of inertia	m	J.6.2/DE.1
k_{e25}	Factor for an observation period of 25 years for the reference ice loads of an overhead line grid with a nominal voltage above AC 1 kV up to and including AC 45 kV.	–	4.5.2/DE.1
k_{w25}	Factor for an observation period of 25 years for wind forces of an overhead line grid with a nominal voltage above AC 1 kV up to and including AC 45 kV.	–	4.3/DE.1
k_1	Reduction factor for electric distances	–	5.8/DE.1; 5.8/DE.2
L	Buckling length	m	J.4.3.2/DE.1
L	Span length	m	4.4.1/DE.1
q	Wind pressure	N/m^2	4.3/DE.1
$q_{\mathrm{p}}(h)$	Wind pressure at the height h	N/m^2	4.3/DE.1
$q_{\mathrm{p}}(h_{\mathrm{m}})$	Maximum value of the wind pressure of a crossarm member at the height h_{m}	N/m^2	4.4.3.2/DE.1.3
Q_{CK}	horizontal conductor tensile forces	N	4.13/DE.2
Q_{IK}	Ice load on conductor	N	4.13/DE.2
q_0	Reference wind pressure at terrain height	N/m^2	4.3/DE.1
Q_{PK}	Construction load	N	4.13/DE.2
Q_{Wc}	Wind force on conductor	N	4.4.1/DE.1
$Q_{\mathrm{Wc}x}$	Wind force on tower or pole in direction of the crossarm axis	N	4.4.1/DE.1
Q_{Wcy}	Wind force on tower or pole rectangular to the crossarm axis	N	4.4.1/DE.1
Q_{Wins}	Wind force on insulator sets	N	4.4.2/DE.1
Q_{WK}	Wind force	N	4.13/DE.1
Q_{Wm}	Wind force on a crossarm single member	N	4.4.3.2 DE.1.3
Q_{Wpol}	Wind force on a single pole	N	4.4.4/DE.1
Q_{WtQx}	Component of the wind force on crossarm in parallel to the crossarm axis	kN	4.4.3.2/DE.1.2

Q_{WtQy}	Component of the wind force on crossarm rectangular to the crossarm	kN	4.4.3.2 DE.1.2
Q_{Wtx}	Component of the wind force on tower body in parallel to the crossarm axis	kN	4.4.3.2/DE.1.1
Q_{Wty}	Component of the wind force on tower body rectangular to the crossarm axis	kN	4.4.3.2/DE.1.1
r	Earth wire reduction factor	–	Table 6/DE.2 in 6.3.2/DE.1
R_{St}	Impulse earth resistance of a tower	Ω	6.1.3/DE.1
U_{St}	Lightning impulse withstand voltage	V	6.1.3/DE.1
U_m	highest operating voltage of equipment	kV	Table 5/DE.1 in 5.4.2/DE.1
U_n	nominal voltage of the system	kV	Table 5/DE.1 in 5.4.2/DE.1
U_s	maximum operating voltage	kV	Table 5/DE.1 in 5.4.2/DE.1
x	horizontal distance to the tower axis of a wind energy converter	m	5.9.3/DE.2.2
ΔA	Sum of the area of holes	mm^2	J.3/DE.1
ϕ	Angle between the wind direction and the crossarm axis	degree	4.4.1/DE.1, 4.4.3.2/DE.1.1
γ_C	Partial factor for conductor tensile forces	–	4.13/DE.1
γ_G	Partial factor for dead weight	–	4.13/DE.1
γ_I	Partial factor for ice forces	–	4.13/DE.1
γ_M	Partial factor for material	–	Table 3/DE.1 in 3.6.3/DE.1
γ_P	Partial factor for construction loads	–	4.9.1/DE.1, 4.13/DE.1
γ_R	Partial factor for strength		8.2.2/DE.1
γ_W	Partial factor for wind forces	–	4.13/DE.1
λ	Slenderness ratio	–	J.4/DE.3
θ_1, θ_2	Complement to the angle of line direction	degree	4.4.1/DE.1
ρ_I	Ice load density	N/m^3	4.6.4/DE.1
ϑ	Angle of wind action	degree	4.4.1/DE.1
ψ	Combination factor	–	4.13/DE.1

3 Basis of design

3.2 Requirements of overhead lines

3.2.1 Basic requirements

3.2.1 DE.1 Basic requirements

(ncpt) All components of an overhead line shall be selected, designed and installed such that they perform reliably and securely under climatic conditions regularly to be expected, under the operational voltage, under action of the operational current and under the short-circuit conditions to be expected. The effect of atmospheric overvoltages and switching overvoltages shall be considered.

These requirements are met if the overhead line is designed and installed according to this standard.

3.2.2 Reliability requirements

3.2.2 **DE.1 Reliability of overhead lines**

(ncpt) In Germany overhead lines shall be designed such that they meet the requirements of the reliability class 3 according to DIN EN 50341-1:2013-11, Table 3.1. This will be achieved by selecting of characteristic loads with a 50 years return period and multiplication with the stipulated partial factors. This does not apply to electric clearances.

3.2.5 Strength coordination

3.2.5 **DE.1 Coordination of line strength**

(ncpt) The coordination of line strength is achieved in the main by designing the lines in accordance with this National Normative Aspects in connection with the selected load cases.

3.2.6 Additional considerations

3.2.6 **DE.1 Protection of birds**

(ncpt) Crossarms, line post insulators and other components of overhead line poles with nominal voltages up to 45 kV shall be designed such that the birds cannot find possibilities for nesting in a dangerous proximity to the live conductors.

The measures described in the VDE application rule VDE-AR-N 4210-11:2011-08, clause 8, shall be applied.

3.4 Actions

3.4.3 Classification of actions by their nature and/or the structural response

3.4.3 **DE.1 Dynamic loads**

(ncpt) The dynamic loads caused by dropping of ice which adheres at the conductors are covered by the load cases H, J, K and L.

The consideration of loads caused by aeolian vibrations is not generally stipulated for overhead lines in Germany.

3.6 Design values

3.6.3 Design value of a material property

3.6.3 **DE. 1 Design values for a material property**

(ncpt) Table 3/DE.1 contains the material partial factors used for supports. Concerning concrete poles reference is made to DIN EN 12843.

Table 3/DE.1 – Material partial factors for towers and poles

Eurocode	**Material, Type of loading**	**Material partial factor** γ_M
EC2 Concrete and reinforced concrete	Compressive concrete strength	1,5
	Compressive concrete strength for pre-fabricated parts	1,4
	Reinforcement, yield strength or $\sigma_{0,2}$	1,15
EC3 Steel	Resistance of sections and stability (yield strength)	1,1
	Resistance of bolted and welded connections (ultimate tensile strength)	1,25
	Members with bore holes in tension (ultimate tensile strength)	
	Steel stranded conductors	1,65

3.6.4 Combination value of a variable action

3.6.4 **DE.1 Combination value of a variable action**

(ncpt) Concerning combination value reference is made to 4.13/DE.2.

4 Actions on lines

4.1 Introduction

4.1 **DE.1 Introduction**

(ncpt) The stipulated wind loads are based on DIN EN 1991-1-4/NA:2010-12. The stipulations for ice loads are based on a study of the German Meteorological Services (DWD) and long-term operational experience.

In order to ease the application the requirements are completely listed hereafter without reference to DIN EN 50341-1.

4.3 Wind loads

4.3 **DE.1 Wind loads**

(snc) The wind loads depend on the geographical area where the line is built. For the stipulation of wind loads, Germany is divided into four zones according to Figure 4/DE.1.

The wind pressure depend on the height above ground and shall be calculated as follows:

$q_p(h) = 1{,}5 \times q_0$ for $h \leq 7$ m

$q_p(h) = 1{,}7 \times q_0 \times (\frac{h}{10})^{0{,}37}$ for 7 m < $h \leq 50$ m

$q_p(h) = 2{,}1 \times q_0 \times (\frac{h}{10})^{0{,}24}$ for 50 m < $h \leq 300$ m

These wind pressures $q_p(h)$ consider gusts with peak wind velocities. The value h means the height of the wind action above the terrain in m and q_0 is the reference wind pressure for the zones defined by Figure 4/DE.1. The specified variation of height corresponds to a mixed profile for inland according to DIN EN 1991-1-4/NA:2010-12, since large areas with uniform roughness are very rare in Germany. Along a 5 km wide strip along the coast it shall be checked whether the selected terrain roughness is adequate. If not, the corresponding mixed profile for areas close to the coast should be selected from DIN EN 1991-1-4/NA:2010-12.

For practical line calculation the above mentioned relations may be replaced by a linear function or a stepped curve being defined on the safe side.

The reference wind pressure q_0 for the four zones according to Figure 4/DE.1 is:

– Wind zone W1: 320 N/m^2;

– Wind zone W2: 390 N/m^2;

– Wind zone W3: 470 N/m^2;

– Wind zone W4: 560 N/m^2.

For line sites with an altitude H between 750 m and 1 100 m above O.D. the reference wind pressure q_0 shall be increased by the factor (0,25 + H/1 000). Special considerations are required for sites on ridges or peaks in the low mountain range as well as above H = 1 100 m.

For overhead lines with nominal voltages above AC 1 kV and up to and including AC 45 kV the reference wind pressures for the wind zones W2 to W4 may be multiplied by the factor $k_{w25} = 0{,}9$ if the attachment height of the conductors does not exceed 20 m.

NOTE 1: All the specified values for the reference wind pressure q_0 result from the reference wind velocities represented by 10 minutes average values with a return period of 50 years in 10 m height above ground level applicable for the terrain category II according to DIN EN 1991-1-4/NA:2010-12:

– Wind zone W1: 22,5 m/s;

– Wind zone W2: 25,0 m/s;

– Wind zone W3: 27,5 m/s;

– Wind zone W4: 30,0 m/s.

NOTE 2: The factor k_{w25} = 0,9 takes care of the observation period of 25 years which is adjusted to an overhead line grid with a nominal voltage above AC 1 kV up to and including AC 45 kV.

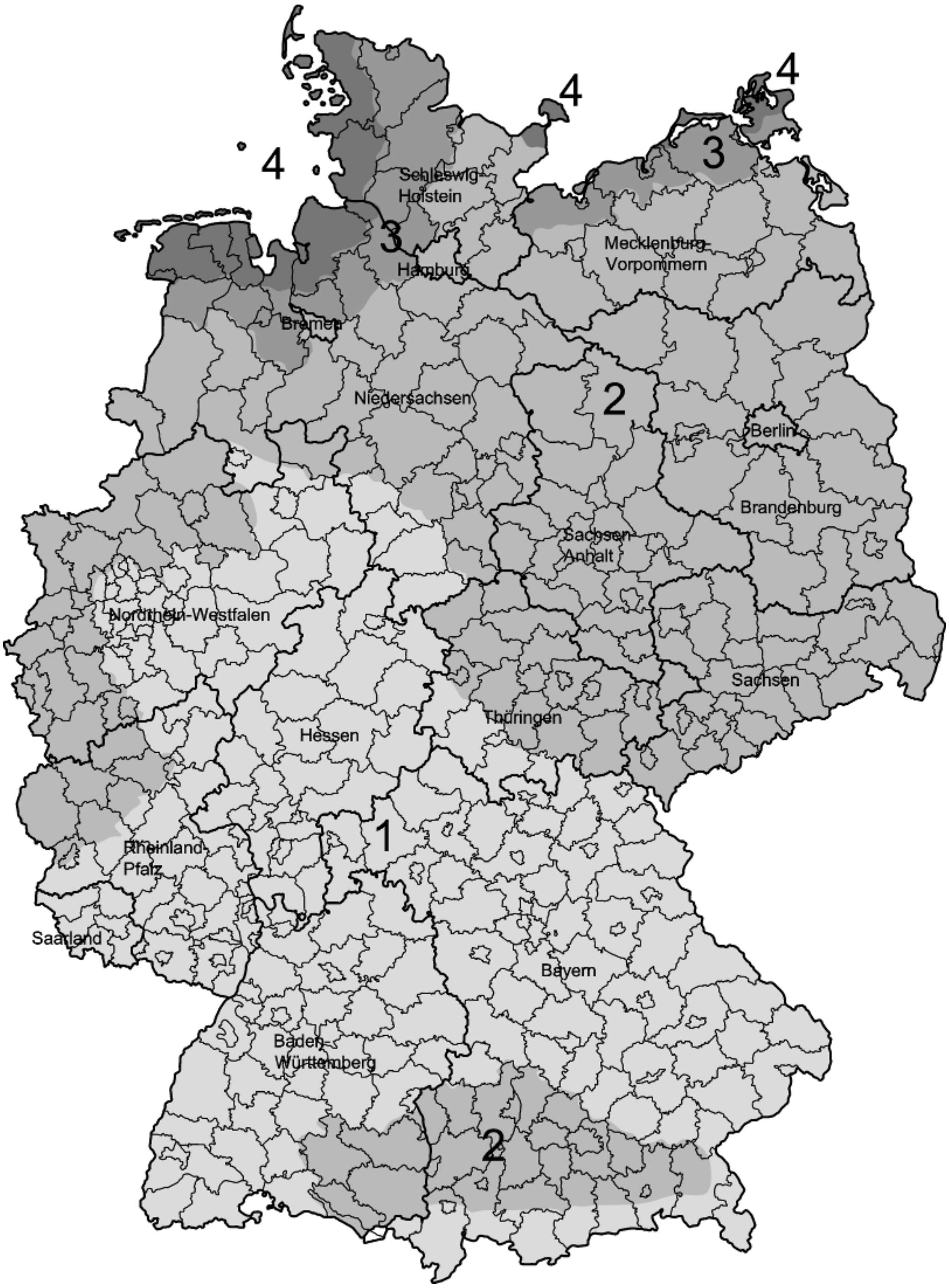


Figure 4/DE.1 – Map of wind zones for the Federal Republic of Germany according to DIN EN 1991-1-4/NA:2010-12

4.4 Wind forces on overhead line components

4.4.1 Wind forces on conductors

4.4.1 DE.1 Wind forces on conductors

(snc) The wind force on conductors shall be determined for the height of their attachment point at the support. The wind force on conductors acts horizontally and perpendicularly to the conductor within the span. In case of wind action under the angle ϑ to the perpendicular on the conductor within the span the wind force is (Figure 4/DE.2)

$$Q_{wc} = q_p(h) \times G_c \times C_c \times d \times L \times \cos^2 \vartheta$$

Where:

$q_p(h)$ Wind pressure according to 4.3/DE.1;

G_c Conductor response factor depending on the wind span length and the dynamic behaviour of the conductors.

In wind zones W1 and W2 it applies:

$G_c = 0{,}75$ for spans up to 200 m;

$G_c = 0{,}45 + 60/L$ for spans above 200 m.

In wind zone W3 it applies:

$G_c = 0{,}67$ for spans up to 200 m;

$G_c = 0{,}40 + 54/L$ for spans above 200 m.

In wind zone W4 it applies:

$G_c = 0{,}60$ for spans up to 200 m;

$G_c = 0{,}36 + 48/L$ for spans above 200 m.

C_c Drag factor for conductors according to Table 4/DE.1;

d Conductor diameter;

L Span length; the wind span $(L_1 + L_2)/2$ shall be used for the design of towers or poles;

ϑ Angle between wind direction and the perpendicular on the conductor (Figure 4/DE.2).

The wind force acts half by half on both supports of the span. Using the designations according to Figure 4/DE.2 the wind force on a conductor shall be determined in the general case of wind action under an angle ϕ in relation to the crossarm axis and with the complements to the line angles $\theta_1/2$ and $\theta_2/2$ of the spans adjacent to the tower:

– in direction of the crossarm axis:

$$Q_{Wcx} = q_p(h) \times G_c \times C_c \times d \left[\pm L_1 \cos^2\left(\phi + \frac{\theta_1}{2}\right) \cos\frac{\theta_1}{2} + L_2 \cos^2\left(\phi - \frac{\theta_2}{2}\right) \cos\frac{\theta_2}{2} \right] / 2$$

– perpendicular to the crossarm axis:

$$Q_{\mathrm{W}cy} = q_{\mathrm{p}}(h) \times G_{\mathrm{c}} \times C_{\mathrm{c}} \times d \left[\pm L_1 \cos^2\left(\phi + \frac{\theta_1}{2}\right) \sin\frac{\theta_1}{2} - L_2 \cos^2\left(\phi - \frac{\theta_2}{2}\right) \sin\frac{\theta_2}{2} \right] / 2$$

These relations apply to $0 \le \phi \le 90°$. The upper sign applies to $(\phi + \theta_1/2) \le 90°$, the lower sign to $(\phi + \theta_1/2) > 90°$.

For a straight line tower and wind action under the angle ϕ there is:

$$Q_{\mathrm{W}cx} = q_{\mathrm{p}}(h) \times G_{\mathrm{c}} \times C_{\mathrm{c}} \times d \frac{L_1 + L_2}{2} \cos^2\phi \qquad Q_{\mathrm{W}cy} = 0 .$$

For a tower with symmetric complements of the line angle $\theta_1 = \theta_2 = \theta$ and wind action in direction of the crossarm axis the wind forces on a tower resulting from the wind action on the conductor is

$$Q_{\mathrm{W}cx} = q_{\mathrm{p}}(h) \times G_{\mathrm{c}} \times C_{\mathrm{c}} \times d \frac{L_1 + L_2}{2} \cos^3\left(\frac{\theta}{2}\right)$$

The component Q_{Wcy} can usually be disregarded.

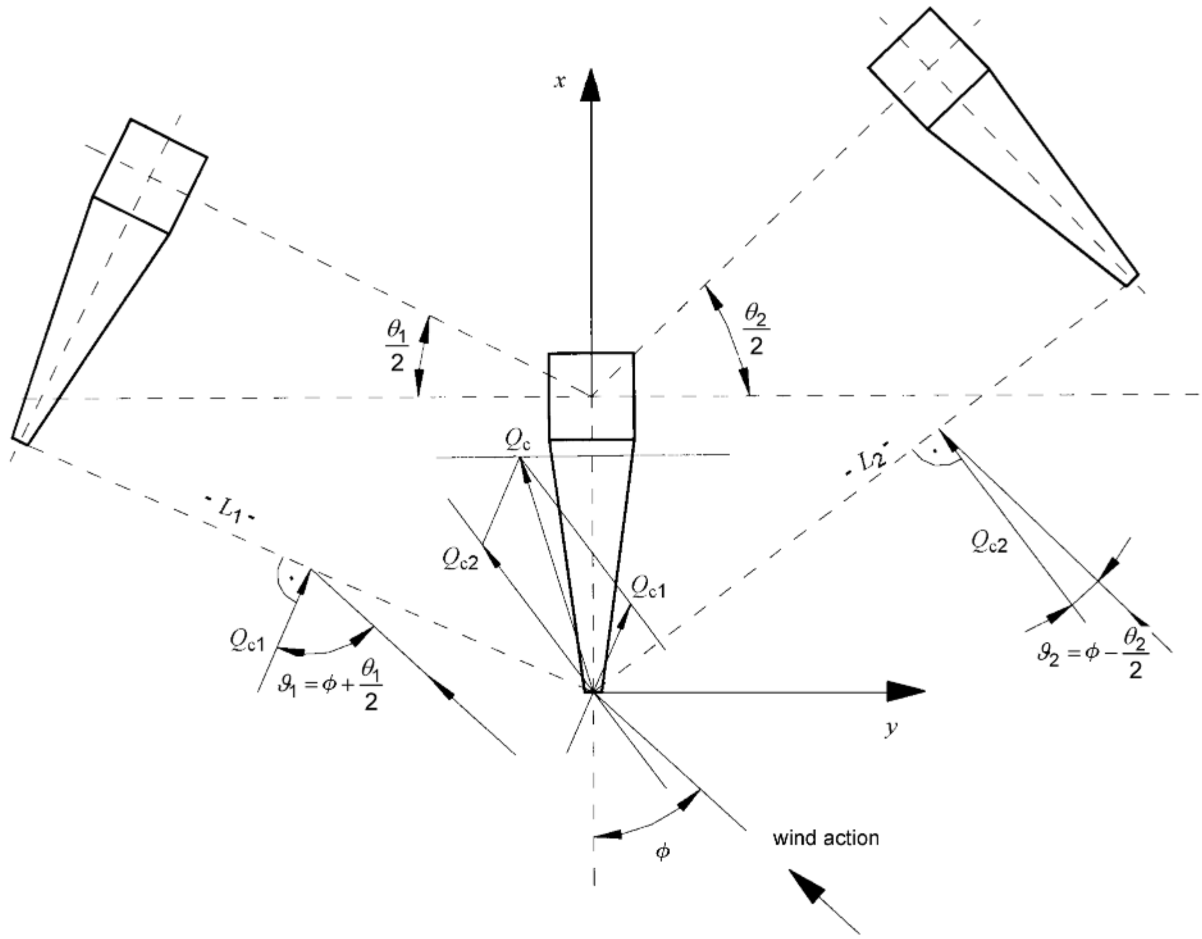


Figure 4/DE.2 – Wind action on conductors and resulting wind force in any wind direction

Table 4/DE.1 – Aerodynamic drag factors C_x

Component	C_x
Flat trust structures consisting of angle sections	1,6
Square and rectangular lattice towers consisting of angle sections	2,8
Flat trust structures consisting of tubes	1,2
Square and rectangular lattice towers consisting of tubes	2,1
Tubular steel, reinforced concrete and wood poles with circular cross section	0,7
Tubular steel and reinforced concrete poles with dodecagonal cross section	0,85
Tubular steel and reinforced concrete poles and clued wood poles with hexagonal, octagonal and decagonal cross section; clued wood poles with dodecagonal cross section	1,0
Tubular steel and reinforced concrete poles with square and rectangular cross section	1,4
Poles made from concrete with H-type cross section	1,6
Steel poles with H-type cross section	1,8
Double and A-type poles with circular cross sections	
Within the plane of the pole on the individual pole exposed to the wind	0,7
In the plane of the pole on the individual pole on the leeward side of the wind	
for $a < 2\ d_m$	0,0
for $2\ d_m \leq a \leq 6\ d_m$	0,35
for $a > 6\ d_m$	0,7
In the plane rectangular to the pole	
for $a < 2\ d_m$	0,8
for $a \geq 2\ d_m$	0,7
Where: a Distance between two individual poles at half height of the support, d_m Mean value of the mean diameters of the two individual poles.	
Conductor	
up to 12,5 mm diameter	1,2
above 12,5 mm up to15,8 mm diameter	1,1
above 15,8 mm diameter	1,0
with no circular cross section	1,3
Radar markers and aerial warning balls with diameters between 300 mm and 1 000 mm	0,4

4.4.2 Wind forces on insulator sets

4.4.2 DE.1 Wind forces on insulator sets

(ncpt) The wind force on insulator sets acts in direction of the wind action and is equal to

$$Q_{\mathrm{Wins}} = q_{\mathrm{p}}(h) \times C_{\mathrm{ins}} \times A_{\mathrm{ins}}$$

where:

$q_p(h)$ Wind pressure according to 4.3/DE.1;

C_{ins} = 1,2;

A_{ins} Area of the insulator exposed to the wind.

4.4.3 Wind forces on lattice towers

4.4.3.1 General

4.4.3.1 **DE.1 General**

(ncpt) The method 1 according to 4.4.3.2/DE.1 shall be used for the calculation of wind forces on a lattice steel tower

4.4.3.2 Method 1

4.4.3.2 **DE.1 Method 1**

4.4.3.2 **DE.1.1 Wind on tower body**

(ncpt) The wind forces on tower body shall be calculated for the individual panels according to their height h above ground level being assumed as acting in the centre of gravity of the individual tower panel. Depending on the angle ϕ of the wind action (Figure 4/DE.3) the following wind force components result approximately:

$$Q_{\mathrm{Wt}x} = q_{\mathrm{p}}(h)\left(1+0{,}2\sin^2 2\phi\right)\left(A_{\mathrm{t1}}\,C_{\mathrm{t1}}\cos^2\phi + A_{\mathrm{t2}}\,C_{\mathrm{t2}}\sin^2\phi\right)\cos\phi$$

$$Q_{\mathrm{Wt}y} = q_{\mathrm{p}}(h)\left(1+0{,}2\sin^2 2\phi\right)\left(A_{\mathrm{t1}}\,C_{\mathrm{t1}}\cos^2\phi + A_{\mathrm{t2}}\,C_{\mathrm{t2}}\sin^2\phi\right)\sin\phi$$

Where:

Q_{Wtx}	Component in parallel to the crossarm axis;
Q_{Wty}	Component perpendicularly to the crossarm axis;
$q_{\mathrm{p}}(h)$	Wind pressure stipulated in 4.3/DE.1 at the height h;
ϕ	Angle between wind direction and crossarm axis;
$A_{\mathrm{t1}}, A_{\mathrm{t2}}$	Areas filled with sections of the faces 1 and 2, respectively (DIN EN 50341-1 (VDE 0210-1):2013-11, Figure 4.2);
$C_{\mathrm{t1}}, C_{\mathrm{t2}}$	Drag factor of the face 1 and 2, respectively.

The drag factors C_{t1} and C_{t2} depend on the solidity ratio of the face 1 and 2, respectively (see DIN EN 50341-1 (VDE 0210-1):2013-11, Figure 4.3). They may be assumed approximately and uniformly as 2,8 in case of the usual design with angle sections.

If applicable, a differing distribution of the wind pressure q over the height of the tower shall be considered since such a distribution can lead to higher forces of individual elements. For consideration of differing distributions the wind pressure shall be assumed partially with 60 % of the standard value, in order to produce a higher force of the elements concerned.

4.4.3.2 **DE.1.2 Wind force on crossarms**

(ncpt) The wind force on crossarms shall also be calculated according to the height above ground level and be assumed as acting in the centre of gravity of a crossarm face. Depending on the angle ϕ of the wind direction (Figure 4/DE.3) the following wind force components result approximately:

$$Q_{\mathrm{WtQ}x} = 0{,}4\; q_{\mathrm{p}}(h) \times A_{\mathrm{tQ}} \times C_{\mathrm{Q}} \times \cos^2\phi$$

$$Q_{\mathrm{WtQy}} = q_{\mathrm{p}}(h) \times A_{\mathrm{tQ}} \times C_{\mathrm{Q}} \times \sin^2\phi$$

Where:

Q_{WtQx}	Component in parallel to the crossarm axis;
Q_{WtQy}	Component perpendicularly to the crossarm axis;
$q_p(h)$	Wind pressure stipulated in 4.3/DE.1 at the height h_m;
ϕ	Angle between wind direction and crossarm axis;
A_{tQ}	Area of the crossarm face filled with profiles (DIN EN 50341-1(VDE 0210-1):2013-11, Figure 4.2);
C_Q	Drag factor. For angle sections and U-sections $C_Q = 2{,}8$.

Alternatively the wind force on lattice crossarms may be estimated by summing up the wind force on the individual members according to 4.4.3.2/DE.1.3.

4.4.3.2 DE.1.3 Wind force on crossarms, alternative method

(ncpt) The wind force on crossarms is determined from the individual members by calculation of the wind force Q_{Wm} of each individual member. This force is then assigned to the adjacent nodes and divided there into the global directions x, y, z. Members which are protected by the lower chords of the crossarms need not to be considered.

The wind force acting perpendicularly on the member axis is determined by:

$$Q_{Wm} = q_p(h_m) \times G_m \times C_m \times A_m \times f_{\beta m}$$

Where:

m	Index of the considered member;
$q_p(h_m)$	Wind pressure stipulated in 4.3/DE.1 at the height h_m;
h_m	Height of the middle of the member above the terrain;
G_m	Factor for the type of support (≤1);
C_m	Drag factor, recommended: C_m = 1,6;
A_m	Area exposed to wind = $b_m \times L_m$, where: b_m = width of the member, L_m = length of the member;
$f_{\beta m}$	Angle factor.

The angle factor is assumed as $f_{\beta m} = \cos^2\beta$, where β is the angle between the wind action and the perpendicular to the member axis. The perpendicular, the member axis and the vector of wind action lie in one plane.

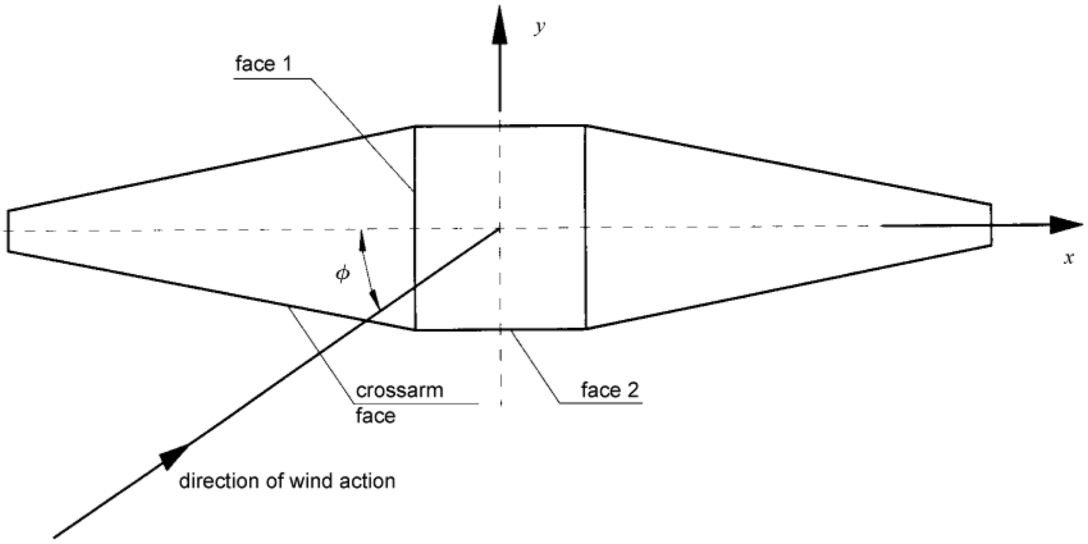


Figure 4/DE.3 – Wind action on towers

4.4.4 Wind forces on poles

4.4.4 **DE. 1 Wind force on poles**

(ncpt) The method 1 according to DIN EN 50341-1 (VDE 0210-1):2013-11, 4.4.4 shall be used for the determination of wind forces on single poles.

The wind force acts in direction of the wind and is

$$Q_{\mathrm{Wpol}} = 1{,}1 \times q_{\mathrm{p}}(h) \times C_{\mathrm{pol}} \times A_{\mathrm{pol}}$$

Where:

$q_{\mathrm{p}}(h)$ Wind pressure according to 4.3/DE.1;

C_{pol} Drag factor according to Table 4/DE.1;

A_{pol} Projected area of a pole.

The coefficient 1.1 takes care of the pole response. For crossarms the stipulation of 4.4.3.2/DE.1.2 and 4.4.3.2/DE.1.3 shall be considered accordingly.

4.5 Ice loads

4.5.2 Ice forces on conductors

4.5.2 **DE.1 Ice forces on conductors**

(snc) Ice is created by accretion of hard rime, clear ice or wet snow at the conductors of overhead lines. Concerning the design ice forces the area of application of this standard is divided into four zones. The characteristic values of the ice in N/m in these zones are:

Ice load zone E1: $g_{\mathrm{I}} = 5 + 0{,}1 \times d$;

Ice load zone E2: $g_{\mathrm{I}} = 10 + 0{,}2 \times d$;

Ice load zone E3: $g_{\mathrm{I}} = 15 + 0{,}3 \times d$;

Ice load zone E4: The ice in this zone shall be stipulated based on the experience of the operator of the grid or by a special expertise, however, at least with $g_I = 20 + 0{,}4 \times d$.

In the relations for the ice g_I, d is the conductor or sub-conductor diameter in mm.

Ice load zone E1 comprises areas where due to the climatic conditions and confirmed by long-term experience only low amount of ice occur, which did not result in failures at overhead lines.

Ice load zone E2 comprises areas where due to the climatic conditions, the geographical situation and confirmed by long-term experience high amount of ice need to be expected which led to failures in the past.

Ice load zone E3 comprises areas where due to climatic conditions, the geographical situation and confirmed by long-term experience often high amount of ice need to be expected which led to important failures of lines in the past.

Ice load zone E4 comprises areas where due to the climatic conditions, the geographical situation and the exposition extreme high amount of ice need to be expected. The assumptions for ice loads in this area shall be specified based on the experience of the line operator or by an special expertise.

Information on the definition of ice load zones are given in the informative Annex AA.

When planning a line its site or parts thereof shall be assigned to one of the defined ice load zones. The reasoning shall be recorded. The assignment may, for example, be carried out based on borders of counties or communities.

Local specialities, for example protected or exposed sites, regional operational experience, extraordinary conductor heights, crossings over rivers, the proximity to water may be taken into consideration by adequately reduced or increased assumptions for ice accretions. For such deviations from standardized values reasons shall be given and recorded. Any conductor design reducing the ice accretion as well as reducing twisting of conductors may be taken into consideration by corresponding ice load assumption. A proof of the efficiency of such methods shall be established for an installation by an expertise.

The ice loads on insulators depend on the lengths of the individual insulator strings. Ice load shall be stipulated with 50 N/m in ice load zone E1, with 100 N/m in ice load zone E2, 150 N/m in ice load zone E3 and with at least 200 N/m in ice load zone E4.

For radar markers and air traffic warning spheres with aerodynamic favourable shape, e. g. spheres or double cones, the ice accretion shall be stipulated by assuming an ice cover on the total surface being 10 mm thick in ice load zone E1, 20 mm thick in ice load zone E2, 30 mm thick in ice load zone E3 and at least 40 mm thick in ice load zone E4. For other designs the ice accretion shall be stipulated corresponding to the geometric shape. The specific weight ρ_I of the ice shall be assumed as 7 500 N/m³.

For towers no ice accretion need to be assumed.

In case of overhead lines with nominal voltages above AC 1 kV and up to and including AC 45 kV the ice loads g_I for the zones E2 up to E4 may be multiplied by the factor k_{e25} = 0,75, if the attachment height of the conductor does not exceed 20 m. This applies as well to insulators, radar markers and air traffic warning spheres.

NOTE 1 The factor k_{e25} = 0,75 takes care of the lower conductor attachment height and an observation period of 25 years adjusted to an overhead line grid with nominal voltages above AC 1 kV and up to and including AC 45 kV.

4.6 Combined wind and ice loads

4.6.4 Equivalent diameter D of ice-covered conductor

4.6.4 DE.1 Equivalent diameter D_I of ice-covered conductor

(ncpt) The equivalent diameter D_I in m of an ice-covered conductor may be calculated from:

$$D_I = \sqrt{d^2 + 4\, g_I / (\pi \times \rho_I)} = \sqrt{d^2 + 0{,}000\,170\, g_I}$$

Where:

d diameter of conductor (m);

g_I characteristic ice load on conductor (N/m) according to 4.5.2/DE.1)

ρ_I ice load density

4.6.6 Combination of wind velocities and ice loads

4.6.6.1 Extreme ice load g combined with a high probability wind velocity

4.6.6.1 DE.1 Extreme ice load g_I combined with a high probability wind velocity

(ncpt) Wind action on ice-covered conductors shall be assumed for the design of all types of supports.

The wind load on towers according to 4.4.3.2/DE.1 (lattice steel towers), according to 4.4.4/DE.1 (poles), on insulator sets according to 4.4.2/DE.1 and ice covered conductors according to 4.4.1/DE.1 shall be assumed. The wind pressure may be reduced to 50 %. The specific weight ρ_I of the ice may be assumed as 7 500 N/m^3, the drag factor as 1,0.

In case of overhead lines with nominal voltages above AC 1 kV and up to and including AC 45 kV the wind action on ice-covered conductors needs not to be considered for the load cases D, E and F for suspension poles with conductor attachment heights up to 15 m.

4.8 Security loads

4.8.1 General

4.8.1 DE.1 General

(ncpt) Security loads are considered in 4.12.2/DE.1 under the load cases H, J, K and L and shall be considered also for overhead lines with nominal voltages above AC 1 kV and up to and including AC 45 kV.

4.9 Safety loads

4.9.1 Construction and maintenance loads

4.9.1 DE.1 Construction and maintenance loads

(ncpt) Vertically acting loads of at least 1,0 kN shall be assumed for crossarms of suspension and angle suspension towers or poles and at least 2,0 kN for all other types of towers and poles. In case of lattice steel structures these forces shall be assumed as acting at the individual most unfavourable nodes of the lower chords of one crossarm face and in all other cases in the axis of the crossarm at the attachment point of a conductor.

The partial factor in this case is assumed as $\gamma_P = 1{,}5$.

4.9.2 Loads related to the weight of lines men

4.9.2 **DE.1 Loads related to the weight of lines men**

(ncpt) For all members with an angle less than 30° to the horizontal line, a vertical load of 1,0 kN acting in the centre of the member shall be assumed, however, without any other loads.

Step bolts and stirrups shall be rated for a concentrated load of 1,0 kN acting vertically at a statically unfavourable position.

The partial factor $\gamma_\mathrm{P} = 1{,}5$ applies for construction loads.

4.10 Forces due to short-circuit currents

4.10 **DE.1 Forces due to short-circuit currents**

(ncpt) Forces due to short-circuit currents are not stipulated and not required in general for design of overhead lines in Germany. Such loads may govern the rating in the span between the overhead lines and the substations.

4.11 Other special forces

4.11 **DE.1 Forces in case of extension of utilization**

(ncpt) In case of an extension of utilization of overhead line supports for additional applications such supports shall be considered as overhead line supports in the context of this standard.

Each individually planned extension of utilization requires a static proof of the existing support.

The check of stability is limited to those parts of the support and its foundations, which are affected by the loads resulting from the additional utilization. For this check only such load cases shall be considered which are affected by the forces due to the additional utilizations.

In general, the load cases A to F according to 4.12.2/DE.1 need to be considered.

Exceptional loads need not to be verified. A check of conductors, insulator sets and crossarms is, therefore, not required if they are not affected by additional utilization.

4.12 Load cases

4.12.1 General

4.12.1 **DE.1 General**

(ncpt) The following subclauses apply to overhead lines with nominal voltages above AC 1 kV.

When analyzing towers or poles and their foundations the loads assigned to the individual load cases in 4.12.2/DE.1 shall be assumed as acting simultaneously. For each member the load case shall be selected which produces the maximum forces.

If section towers are systematically subject to permanent unbalanced tensile forces or to permanent torsional loads this shall be considered. If initially the circuits of supports will only be installed partially, this shall be considered when analyzing the supports. Partial installation of circuits needs not to be considered in case of load case H.

In case that the individual circuits of a support of a multiple-circuit line are used in a different manner then the load cases according to 4.12.2/DE.1 shall be combined according to the use of the individual circuits.

The conductor tensile forces shall be determined for all load cases with the actions according to 4.4.1/DE.1, 4.5.2/DE.1 and 4.6.6.2/DE.1, however without partial factors.

4.12.2 Standard load cases

4.12.2 **DE.1 Standard load cases**

(ncpt) The load cases consider the following combinations of forces:

a) Meteorologically caused forces (load cases A to G):

– Wind forces according to 4.4.1/DE.1 to 4.4.3/DE.1 or 4.4.4/DE.1 in three main directions (load cases A to C);

– Extreme ice load according to 4.5.2/DE.1 combined with high probability wind velocity according to 4.6.6.1/DE.1 in three main directions (load cases D to F);

– Forces on towers or poles with uplift loads (load case G);

b) Loads on section or angle section supports to provide rigid points in an overhead line (load case H);

c) Construction and maintenance loads (load case I);

d) Exceptional loads due to unbalanced ice accretion or ice shedding (load cases J to L).

In detail the following load cases apply; sub-divisions of load cases may result from the range of application (variation of weight spans, variation of the line angles etc.):

Load case A

Permanent loads and wind forces in x-direction (Figures 4/DE.2 and 4/DE.3), corresponding conductor horizontal tensile forces at +5 °C.

Load case B

Permanent loads and wind forces in y-direction (Figures 4/DE.2 and 4/DE.3), corresponding conductor horizontal tensile forces at +5 °C.

Load case C

Permanent loads and quartering wind forces at $\phi = 45°$, corresponding conductor horizontal tensile forces at +5 °C. If applicable, angles deviating from $\phi = 45°$ need to be considered.

Load case D

Permanent loads and wind forces in x-direction (Figures 4/DE.2 and 4/DE.3) and ice loads combined with wind forces according to 4.6.6.1/DE.1, corresponding conductor horizontal tensile forces at -5 °C.

Load case E

Permanent loads, wind forces in y-direction (Figures 4/DE.2 and 4/DE.3) and ice loads combined with wind forces according to 4.6.6.1/DE.1, corresponding conductor horizontal tensile forces at -5 °C.

Load case F

Permanent loads and quartering wind forces at $\phi = 45°$ and ice loads combined with wind forces according to 4.6.6.1/DE.1, corresponding conductor horizontal tensile forces at –5 °C. If applicable, angles deviating from $\phi = 45°$ need to be considered.

Load case G

Permanent loads, corresponding conductor horizontal forces at –20 °C

as well as

permanent loads and ice loads in one of the adjacent spans, no ice loads in the other adjacent span, whereby 50 % of the ice loads according to 4.5.2/DE.1 shall be assumed, corresponding conductor horizontal tensile forces at -5 °C.

NOTE Load case G shall be applied in case of uplift forces.

Load case H

Load case H shall be applied only in case of section and angle section support.

These supports shall be assumed with all circuits installed as planned.

Permanent loads, whereby permanent loads on all conductors at –20 °C,

as well as

permanent loads and ice loads on all conductors at –5 °C.

One-sided horizontal design force of one conductor and two thirds of the conductor horizontal design forces at all other conductors acting in line direction.

Load case I

Permanent loads and construction loads according to 4.9.1/DE.1, corresponding conductor horizontal tensile forces at +5 °C.

Load case J

Permanent loads and ice loads, whereby permanent loads and ice loads act on all conductors at –5 °C.

For supports, which carry up to two circuits, the horizontal tensile force of one conductor shall be assumed as reduced one-sidedly.

For supports, which carry more than two circuits the following shall be duly considered:

> For the third and fourth as well as for the fifth and sixth circuit the horizontal force of a conductor shall be assumed additionally as reduced by half of the value applying for the first and the second circuit.
>
> Only the horizontal force of one conductor shall be assumed as reduced for each half of a crossarm.
>
> The conductors with one-sided conductor tensile force acting in the same direction and the circuits shall be selected such that the most unfavourable force results for the individual components.
>
> In case of branch-off supports the number of circuits is equal to the sum of the circuits on the continuing and the branching lines. The one-sided reduced conductor tensile forces shall be assumed for these supports such that the torsional load of the continuing and branching lines are summed up.

In case of single-phase AC circuits provisions shall be made analogously in respect to the number of the conductors.

In case of suspension and angle suspension supports the horizontal tensile force of one conductor shall be reduced to one side as follows: in case of single conductors by 50 %, in case of bundle conductors with lengths of insulator sets up to 2,5 m by 35 %, in case of bundle conductors with lengths of insulator sets above 2,5 m by 25 % and in case of earth wires by 65 %.

In case of angle, section, angle section, dead end and angle dead end supports the horizontal forces of a single or bundle conductor shall be assumed as reduced by 100 % on one side.

Load case K

Permanent loads and ice loads, whereby the permanent loads and ice loads on all conductors act at –5 °C.

In case of suspension and angle suspension supports the horizontal tensile forces of all conductors shall be assumed to be reduced by 20 % in case of line post insulators or lengths of suspension insulator sets up to 2,5 m, in case of suspension insulator sets with lengths above 2,5 m by 15 % and by 40 % for earth wires.

In case of angle, sections and angle sections supports the horizontal tensile force of all conductors shall be assumed to be reduced by 40 % on one side.

Additionally, in case of supports with tension insulator sets of lines with two or more circuits it shall be assumed that at one of the circuits no ice accretion exists and there is no reduction of the horizontal tensile forces. The circuit without ice load shall be selected such that the torsional load resulting from the other circuits leads to the most unfavourable loading. At the circuit without ice accretion the conductor forces at –5 °C without ice load act. For other circuits and the earth wires the loads of the load case K apply without any modification.

Load case L

Permanent loads and ice loads, corresponding horizontal conductor tensile forces at –5 °C; failing of one insulator string of a multiple insulator set.

NOTE Effects of load case L are only decisive for crossarms.

4.12.2 **DE.2 Special stipulations for load cases of single, double and A-type wood poles**

(ncpt) For single, double and A-type circular wood poles in overhead lines with nominal voltages above AC 1 kV and up to and including AC 45 kV the load cases J to L need not to be considered. In case of load case H the one-sided horizontal tensile forces may be assumed as acting centrally as well as uniformly by two thirds of the tensile forces. These assumptions apply as well as for the tower body and its connection with the foundation and for the crossarms and their connection to the pole body.

For all other load cases the pole body, the crossarms and the connections of wood poles shall be verified according to DIN EN 1995-1-1:2010-12 and DIN EN 1995-1-2:2010-12 or by loading tests.

4.12.2 **DE.3 Reduction of the torsional loads**

(ncpt) If the torsion of suspension and angle suspension poles is avoided or reduced for example by application of sliding clamps, span wires or similar measures, this effect may be considered so far it is achieved by the measures which avoid or reduce the torsion.

For the selected measure the serviceability (DIN EN 50341-1 (VDE 0210-1):2013-11, 3.3.3) and durability (DIN EN 50341-1 (VDE 0210-1):2013-11, 3.2.8) shall be verified under the environmental and terrain conditions at line site for the service life of the line (DIN EN 50341-1 (VDE 0210-1):2013-11, 3.2.7).

4.13 Partial factors for actions

4.13 DE.1 Partial factors for actions

(ncpt) The specified partial factors replace the information given in DIN EN 50341-1 (VDE 0210-1):2013-11, Table 4.7.

Each load case combines loads of different origin. All actions are determined by their characteristic values and shall be multiplied by partial factors. For simplification, the relations and designations given in DIN EN 50341-1 (VDE 0210-1):2013-11, 4.13 are presented here as:

$$E_d = f\{\gamma_G G_K;\ \gamma_W Q_{WK};\ \gamma_I Q_{IK};\ \gamma_P Q_{PK};\ \gamma_C Q_{CK}\}$$

Where:

E_d Total load (design value of actions);

G_K Dead load of conductors, insulators and supports;

Q_{WK} Wind force as specified in 4.4.1/DE.1 to 4.4.4/DE.1;

Q_{IK} Ice forces on conductors as specified in 4.5.2/DE.1;

Q_{PK} Construction loads as specified in 4.9.1/DE.1 (loads from installation and maintenance) and 4.9.2/DE.1 (loads resulting from the weight of line men);

Q_{CK} Horizontal conductor tensile forces considering the temperature changes as well as wind and ice loads as specified in 4.12.2/DE.1.

The loads and forces G_K, Q_{WK}, Q_{IK}, Q_{PK} and Q_{CK} include the combination factors Ψ and take care as well of

– Aspects of reliability,
– Combination of actions,
– Coordination of strength,
– Specification of load cases.

The following data apply as partial factors

$\gamma_G = \gamma_W = \gamma_I = \gamma_C = 1{,}35$ for load cases A to I in case of unfavourable (force-increasing) action;

$\gamma_G = \gamma_I = 1{,}0$ for load cases A to F in case of favourable (force-decreasing) action, to be used only in case of suspension supports;

$\gamma_G = \gamma_W = \gamma_I = \gamma_C = 1{,}0$ for load cases J to L (exceptional load cases);

$\gamma_P = 1{,}5$ for construction loads in load case I.

NOTE

γ_G Partial factor for dead load;

γ_W Partial factor for wind loads;

γ_I Partial factor for ice loads;

γ_P Partial factor for construction loads;

γ_C Partial factor for horizontal conductor tensile forces.

5 Electrical requirements

5.2 Currents

5.2.1 Normal current

5.2.1 **DE.1 Normal current**

(snc) For the normal current the type and dimension of the conductor shall be selected such that the maximum design temperature of conductors shall not be exceeded at an ambient temperature of 35°C, a solar radiation of 900 W/m² and a wind velocity of 0,6 m/s acting perpendicularly to the conductors.

5.4 Classification of voltages and overvoltages

5.4.2 Representative power frequency voltages

5.4.2 **DE.1 Representative power frequency voltages**

(ncpt) According to DIN EN 60038 (VDE 0175-1), DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.1, is supplemented by the nominal voltage in the system U_n = 380 kV.

Table 5/DE.1 – Nominal voltages in the system and related maximum operational voltages and maximum voltage for equipment

Nominal system voltage U_n kV	Maximum operational voltage U_s kV	Maximum voltage for equipment (minimum value) U_m kV
380	420	420

5.5 Minimum air clearance distances to avoid flashover

5.5.3 Empirical method based on European experience

5.5.3 **DE.1 Compliance with condition** a_{som}

(ncpt) Only for stationary (and not moving) crossing objects a clearance according to 110 % of the minimum flashover gap a_{som} of the used insulator sets is required.

5.6 Load cases for calculation of clearances

5.6.3 Wind loads for determination of electric clearances

5.6.3.2 Normal wind loads for determination of internal and external clearances

5.6.3.2 **DE.1 Normal wind loads for determination of internal and external clearances**

(snc) The design wind load for the determination of electrical clearances is 58 % of the wind pressure stipulated in 4.3/DE.1; the requirements according to 4.4.1/DE.1 shall be complied with.

NOTE 1: This wind load corresponds to a return period of three years taking into account the stipulated factors in DIN EN 50341-1 (VDE 0210-1):2013-11, Table B.1. The operator of a line should stipulate higher wind loads to determine the clearances if high wind loads occur frequently and external objects within the range of swinging conductors would be at a risk.

In case of calculation of clearances under wind load conditions for conductors having a maximum conductor temperature less than 80 °C in standard operation a conductor temperature of constantly +40°C may be assumed and the effect of wind load on the sags of the conductors may be neglected.

NOTE 2: In case of higher permissible conductor temperatures generally applicable information cannot be given since many parameters affect the sags and swinging. For conductors with permissible final temperatures above 80°C the conductor temperatures in case of swinging should be determined in the context of the local situation of the conductors.

In case of differing heights of the fixing points of the conductors their mean value can be assumed as reference for the wind loads used for determining the conductor swinging.

5.6.3.3 Extreme wind loads for determination of internal clearances

5.6.3.3 **DE.1 Extreme wind loads for determination of internal clearances**

(snc) The verification of clearances under extreme wind conditions as mentioned in DIN EN 50341-1 (VDE 0210-1):2013-11, 5.6.3.1, is not required.

5.6.4 Ice loads for the determination of electric clearances

5.6.4 **DE.1 Ice loads for the determination of electric clearances**

(snc) As extreme value of ice load to determine the electrical clearances the specifications in 4.5.2/DE.1 for the characteristic ice loads shall be assumed.

For calculation the clearances under ice load conditions the conductor temperature shall be assumed with –5°C constantly.

As required in 5.9/DE.3.1.4 and 5.9.6/DE.1, the local loading of the crossing span with ice load shall be considered in case of crossings. In this case, 50 % of the ice loads defined in 4.5.2/DE.1 shall be assumed in the crossing span and no ice load in all the other spans of the line section.

5.6.5 Combined wind and ice loads

5.6.5 **DE.1 Combined wind and ice loads**

(snc) A verification of clearances under combined wind and ice loads is not required.

5.8 Internal clearances within the span and at the top of support

5.8 **DE.1 Internal clearances within the span and at the top of support**

5.8 **DE.1.1 General information for the verification of clearances**

(ncpt) When designing the tower top geometry the requirements due to the planned working or maintenance processes shall be considered.

The verification of the required minimum clearances is carried out in two steps:

a) Stipulation of electrical clearances D_{el} and D_{pp}

For this purposes the theoretical method according to DIN EN 50341-1 (VDE 0210-1):2013-11, Annex E, as well as the use of the empirical values according to DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.6, is permitted. The use of DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.6, is recommended.

b) Verification of internal clearances in between the individual phase conductors as well as between phase conductors and earthed components or earthwires according to DIN EN 50341-1 (VDE 0210-1):2013-11, 5.8

In-between the phase conductors as well as between the phase conductors and earthed components or earthwires in still air the clearance D_{pp} and D_{el}, respectively, shall be met. In swung condition the clearances D_{pp} and D_{el}, respectively, however multiplied with the factor k_1 stipulated in 5.8/DE.1.2 shall be met. Therefore, four different minimum clearances (D_{pp} and D_{el}, respectively, in still air; k_1xD_{pp} and k_1xD_{el}, respectively, in a swung condition) shall be verified depending on the load cases according to DIN EN 50341-1 (VDE 0210-1), 5.6.

Under certain conditions, the approximative method specified in 5.8/DE.1.3 enables the determination of mid-span clearances in still air in between phase conductors as well as between phase conductors and earthwires. These mid-span clearances provided the minimum clearances under wind action ($k_1\,D_{pp}$ and $k_1\,D_{el}$) respectively, can be assumed as complied with.

5.8 **DE.1.2 Reduction factor in case of design wind conditions**

(ncpt) In case of design wind conditions the values D_{pp} and D_{el} according to DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.6, multiplied by the factor $k_1=0{,}75$ are required as minimum clearances in-between the phase conductors and between phase conductors and earthed components.

5.8 **DE.1.3 Method for calculation of internal clearances within a span**

(ncpt) The approximative method according to DIN EN 50341-1 (VDE 0210-1):2013-11, Annex F, may be used for calculation of minimum clearances in mid span.

5.8 **DE.1.4 Effect of the insulator set for the determination of clearances at the support**

(ncpt) DIN EN 50341-1 (VDE 0210-1):2013-11, Annex F.3, applies to determine the clearances at supports.

5.8 **DE.1.5 Arrangement of circuits at the top of the support**

(ncpt) In case of overhead lines carrying circuits with differing voltages, the circuits with higher nominal voltages should be arranged above circuits with the lower nominal voltages.

5.9 External clearances

5.9.1 General

5.9.1 **DE.1 General information on verification of clearances**

(ncpt) Independently of this standard, DIN VDE 0105-100 (VDE 0105-100) shall be met in case of working close to overhead lines.

The verification of the required minimum clearances is carried out in two steps:

a) Verification of the electrical clearances D_{pp} and D_{el}
- according to DIN EN 50341-1 (VDE 0210-1):2013-11, 5.9.1 for overhead lines with nominal voltages above AC 1 kV and up to and including AC 45 kV and

- according to 5.8/DE. 1 a) for overhead lines above AC 45 kV.

b) Verification of the external clearances to ground and to crossing objects.

The minimum clearances specified in DIN EN 50341-1 (VDE 0210-1):2013-11, 5.9, consist of the distance D_{el} and a safety component. The load cases to be assumed are defined in DIN EN 50341-1 (VDE 0210-1):2013-11, 5.9, whereas the wind load according to 5.6.2.2/DE.1 and ice loads according to 5.6.4/DE.1 shall be considered.

If the electrical minimum clearance D_{el} according to DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.6, is used, then in case of stationary crossing objects according to 5.5.3/DE.1 compliance with minimum clearances of 110 % of the clearance a_{som} according to DIN EN 50341-1 (VDE 0210-1):2013-11, 5.5.3, is required. In this case it is considered as sufficient to determine the minimum flashover clearance of insulator sets in the range of three supports before the crossing span and three supports behind the crossing span. This study shall be carried out circuit by circuit, if necessary. The value achieved by this procedure is defined as a_{som} for the crossing span.

If for a certain application the condition

$$1{,}1 \times a_{som} > D_{el} + \text{safety clearance}$$

is met, the minimum clearance for the crossing object shall be 110 % of the distance a_{som}. Otherwise the sum from D_{el} and the safety clearance applies as minimum clearance.

EXAMPLE

Crossing object: roof with a slope > 15°

380 kV line

Distance a_{som} for the crossing span 4,50 m

Minimum clearance according to DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.11:

c = 2 m + D_{el} = 2 m + 2,80 m = 4,80 m.

Checking of the condition a_{som}:

1,1 × 4,50 m = 4,95 m > 4,80 m.

In this case, 4,95 m shall be obeyed as minimum clearance to the roof.

5.9.1 DE.2 General information to crossings

(ncpt) In this case also line sections shall be treated as crossings, which are considered in DIN EN 50341-1 (VDE 0210-1):2013-11 as approach and where the horizontal minimum clearances according to one of the Tables 5.10, 5.11, 5.12, 5.13, 5.14 or 5.15 are not met.

5.9.1 DE.3 Special requirements for crossings

5.9.1 DE.3.1 General

(ncpt) The following additional requirements shall be met at crossings, whereby special conditions are specified in some cases.

5.9.1 **DE.3.2 Attachment of conductors to multiple insulator sets**

(ncpt) Suspensions and terminations of conductors shall be carried out by multiple insulator sets, where the number of the insulator strings shall be at least the same as generally adopted at the overhead line (see also 10.7/DE.3).

5.9.1 **DE.3.3 Release clamps and rotating crossarms**

(ncpt) Release clamps and rotating crossarms shall not be used at supports of a crossing span.

5.9.1 **DE.3.4 Clearance in case of local ice load on spans**

(ncpt) For the evaluation of the clearance it shall be assumed, that the conductors in the crossing span are loaded by 50 % of the ice load according to 4.5.2/DE.1 at -5 °C while the conductors in all other spans of the line section are unloaded.

5.9.1 **DE.3.5 Clearance between conductors at local ice load**

(ncpt) For the evaluation of the clearance between the conductors it shall be assumed, that one of these conductors is loaded in the crossing span by 50 % of the ice load according to 4.5.2/DE.1 at -5 °C while the other conductors are unloaded. In this case a clearance of 0,75xD_{pp} according to DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.6, shall be maintained between the conductors of the crossing line.

This requirement applies only in case of traffic routes and overhead lines.

5.9.1 **DE.3.6 Clearance between the conductors in case of failure of an insulator string**

(ncpt) In case of failure of one insulator string of a multiple insulator set the clearance between the conductors in the crossing span shall be at least 0,75xD_{pp} according to DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.6. In this case the sags at –20 °C shall be assumed.

This requirement applies only in case of traffic routes and overhead lines.

5.9.1 **DE.3.7 Attachment of conductors at line post insulators**

(ncpt) These requirements apply only to lines with nominal voltages above AC 1 kV and up to and including AC 45 kV.

In straight line sections the conductors shall be fixed additionally by an auxiliary conductor at the second insulator of the same type which is arranged transversely to the line direction.

In case of wood poles in straight line with insulator supports which are not earthed, the fixing at one insulator only using an auxiliary wire is permitted. The auxiliary wire shall at least possess the same rated tensile strength as the conductor and be fixed to the conductor on both sides of the insulator at least with the maximum force which results from the action of external loads without partial factors.

5.9.1 **DE.3.8 Impacts of provisions to reduce the torsional loads**

5.9.1 **DE.3.8.1 General**

(ncpt) In case of provisions to reduce the torsional loads at one or both supports of the span the resulting increase of sag of the conductor shall be considered when verifying the external clearances.

5.9.1 **DE.3.8.2 Moveable crossarms**

(ncpt) When applying moveable crossarms a local ice load needs to be assumed in each span as described in 5.9.1/DE.3.4.

5.9.1 **DE.3.8.3 Sliding clamps**

(ncpt) When applying sliding clamps the sliding of a conductor as far as to the stop point of the sliding clamp needs to be assumed at one support of the span.

5.9.2 External clearances to ground in areas remote from buildings, roads etc.

5.9.2 **DE.1 Agriculture activities under an overhead power line**

(ncpt) In case of agricultural activities the stipulations in DIN VDE 0105-115 (VDE 0105-115) shall be met.

5.9.2 **DE.2 Minimum clearances to the ground surface**

(ncpt) Due to the height of agricultural vehicles a minimum clearance of 6 m to the standard ground profile is required for overhead lines with nominal voltages above AC 1 kV and up to and including AC 45 kV.

5.9.3 External clearances to residential and other buildings

5.9.3 **DE.1 Fire retardant roofs**

(ncpt) Roofs with roofing according to DIN 4102-7 are considered as fire retarding.

5.9.3 **DE.2 Clearances to wind energy converters**

5.9.3 **DE.2.1 Minimum clearances to the tower axis of a wind energy converter**

(ncpt) Between the uttermost conductor of the overhead line in still air and the central axis of the tower of the wind energy converter the following minimum clearances shall be met:

$$a_{WEA} = 0{,}5 \cdot D_{WEA} + a_{Raum} + a_{LTG}$$

Where:

a_{WEA} horizontal distance between the uttermost conductor of the overhead line in still air and the central tower axis of the wind energy converter

D_{WEA} Diameter of the rotor of the wind energy converter

a_{LTG} Voltage-related minimum horizontal clearance according to Table 5/DE.2

a_{Raum} Working space for erection cranes for construction and operational activities at the wind energy converter.

Table 5/DE.2 – Nominal voltages in the grid and voltage-related minimum clearances

Nominal voltage in the system U_n kV	Voltage-related minimum clearances a_{LTG} m
$1 < U_n \leq 45$	10
$45 < U_n \leq 110$	20
> 110	30
NOTE The voltage-related minimum clearances a_{LTG} include the space necessary for installation, operation and maintenance procedures of overhead lines.	

For each conductor it shall be checked, whether the sum of the horizontal clearance of conductor positions between the conductor in still air and the swung conductor and the protection distance according to DIN VDE 0105-100 (VDE 0105-100) is larger than the voltage-related minimum distance a_{LTG} at the site of the wind energy converter. The maximum of the determined values shall be used.

Under no circumstances during installation, operation and maintenance of the wind energy converter the minimum clearance to the conductor in still air may fall below the voltage-related minimum clearance a_{LTG}.

The necessary working space a_{Raum} shall be bindingly specified by the planner/operator of the wind energy converter for each project and then agreed upon by the operators of the overhead line and the wind energy converter.

5.9.3 DE.2.2 Verification for the wake of wind energy converters

(ncpt) It shall be checked whether the conductors of an overhead line are situated in or outside of the wake of a wind energy converter:

– If the conductors lie within the wake and the minimum distance between the tower central axis of the wind energy converter and the closest conductor in still air is less than three times the rotor diameter it is required to take care of an adequate vibration protection.

– If the conductors lie outside the wake the presence of a wind energy converter does not require any vibration-damping measures.

The wake of a wind energy converter is determined by the lower edge according to (see Figure 5/DE.1):

$$h = h_{WEA} - \frac{D_{WEA}}{2} - 0{,}1\,x$$

where:

D_{WEA}	diameter of the rotor of the wind energy converter;
h_{WEA}	height of the rotor hub above the local terrain surface;
x	horizontal distance between the tower central axis of the wind energy converter and the rotor plane.

When calculating the affects of the wake a pivoting range of ±45 ° of the rotor plane related to the shortest distance between the wind converter tower axis and conductor needs to be considered.

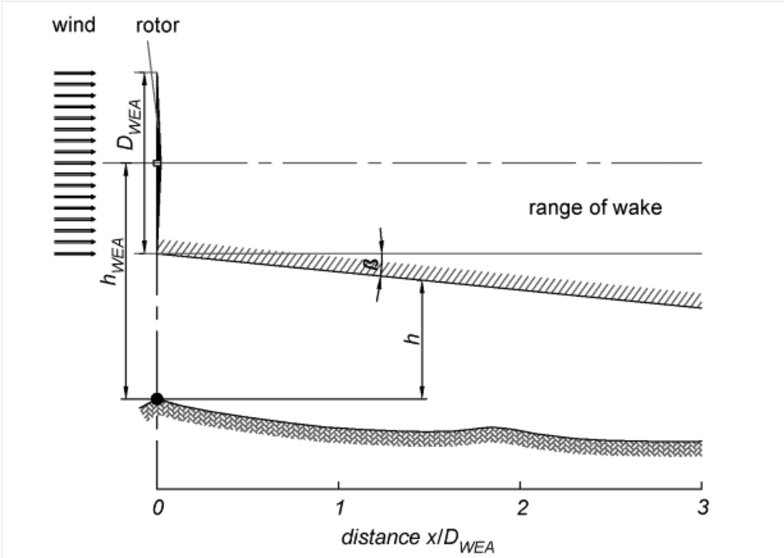


Figure 5/DE.1 – Description of the wake behind a wind energy converter, where tan β = 0,1 has to be assumed.

5.9.4 External clearances to crossing traffic routes

5.9.4 **DE.1 Definitions**

(ncpt) Traffic routes are defined as motorways, highways, provincial and county roads, local connection roads and frequently used service and access roads, trolley-bus lines and rope-way installations, railways with and without overhead contact lines and waterways.

All roads and lanes which do not correspond to the above mentioned specifications shall be considered as secondary roads.

5.9.4 **DE.2 Minimum clearances to road surface and top of rail**

(ncpt) Due to the height of vehicles a minimum clearance of 7 m to the road surface or to top of rail (if the line is not electrified) is required for overhead lines above AC 1 kV and up to and including AC 45 kV.

5.9.4 **DE.3 Clearance to railways with planned electrification**

(ncpt) In case of planned electrification a clearance of 11,5 m + D_{el} shall be obeyed to the top of rail of the railway.

5.9.5 External clearances to adjacent traffic routes

5.9.5 **DE.1 Definitions**

(ncpt) The definitions according to 5.9.4/DE.2 apply.

5.9.6 External clearances to other power lines or overhead telecommunication lines

5.9.6 **DE.1 Load cases to be considered for the verification of clearances in case of overhead line crossings**

(ncpt) **Load case 1**

- maximum sag of the overcrossing line at maximum design temperature according to 9.2.3/DE.1 or 9.4/DE.3.
- sag of the undercrossing line at +40 °C conductor temperature.

Load case 2

- sag at -5 °C and ice load for the overcrossing overhead line. For the sag the higher value shall be assumed which results either from ice load according to 4.5.2/DE.1 or for the local ice load on conductors according to 5.9.1/DE.3.4.
- sag at –5 °C without ice load for the undercrossing overhead line.

Load case 3

- wind load for the design of electrical clearances according to 5.6.3.2/DE.1 at +40 °C conductor temperature rectangularly to the conductor of the first overhead line (being over- or undercrossing);
- simultaneously wind load according to 5.6.3.2/DE.1 on the other overhead line multiplied by the square of cosine of the angle of incidence (angle between the perpendicular on this line and the wind direction). The wind pressure shall be reduced in this case by up to 40 %.

5.9.6 **DE.2 Horizontal clearance between the vertical axis at the swung conductor and components of a telecommunication line**

(ncpt) To the horizontal clearance the requirements according to DIN EN 50341-1 (VDE 0210-1):2013-11, Table 5.14 apply: 1,0 m + D_{el} .

5.11 Electric and magnetic fields

5.11.1 Electric and magnetic fields under a line

5.11.1 **DE.1 Limits**

(A-dev) The limiting values according to the 26th Regulation for application of the German Federal Republic Emission Protection Law (Regulation on electro-magnetic fields) of 2013-08-22 apply.

5.11.1 **DE.2 Expositon of people to electric and magnetic fields**

(ncpt) Measuring and calculation procedures for the exposition of people to electric and magnetic fields are described in DIN EN 50413 (VDE 0848-1).

5.11.2 Electric and magnetic field Induction

5.11.2 **DE.1 Interference of pipe lines**

(ncpt) DIN EN 50443 (VDE 0845-8) applies in respect of effects of electric-magnetic interference on pipe lines.

5.11.2 **DE.2 Technical recommendations**

(ncpt) Moreover, the technical recommendations of the arbitration board for interference issues should be taken into consideration.

5.11.3 Interference with telecommunication circuits

5.11.3 **DE.1 Interference with telecommunication systems circuits**

(ncpt) Concerning the measures in case of interference with telecommunication circuits the specifications according to DIN VDE 0845-6-1 (VDE 0845-6-1) and DIN VDE 0845-6-2 (VDE 0845-6-2) shall be considered.

5.11.3 **DE.2 Technical recommendations**

(ncpt) Moreover, the technical recommendations of the arbitration board for interference issues should be taken into consideration.

6 Earthing systems

6.1 Introduction

6.1.2 Requirements for dimensioning of earthing systems

6.1.2 **DE.1 Cable dead-end supports**

DE.1.1 General design

(ncpt) DIN EN 50522 (VDE 0101-2):2011-11, Annex G, shall be applied.

DE.1.2 Special design

(ncpt) On cable dead-end supports the cable sheaths and metallic end-sealing boxes shall be earthed independently of the material of the supports, so far as the following design is not adopted:

If the reinforcement, metallic sheaths or screens of cables are only connected to the earthing system at one end they shall to be protected against unintended touching, if the permissible touch voltage is exceeded. A connection with the earthing system by isolating units may be made, in order to avoid corrosion.

In any case, the permissible touch voltage at the support shall be obeyed.

6.1.2 **DE.2 Connection of systems at common or separate earthing systems**

DE.2.1 General design

(ncpt) DIN EN 50522 (VDE 0101-2) and DIN VDE 0100-442 (VDE 0100-442) shall be obeyed.

DE.2.2 Special design

(ncpt) The bodies of electrical equipment of low-voltage systems which are arranged within the high-voltage installation shall be connected to the high-voltage earthing system by separated earthing systems via protective conductors to provide protection against indirect touching (see Figures 6/DE.1 and 6/DE.2).

For operating voltages above AC 1 kV up to and including AC 45 kV a distance of 20 m is used for d_{accept} in many cases (see DIN EN 50522 (VDE 0101-2):2011-11, 6.1.3)

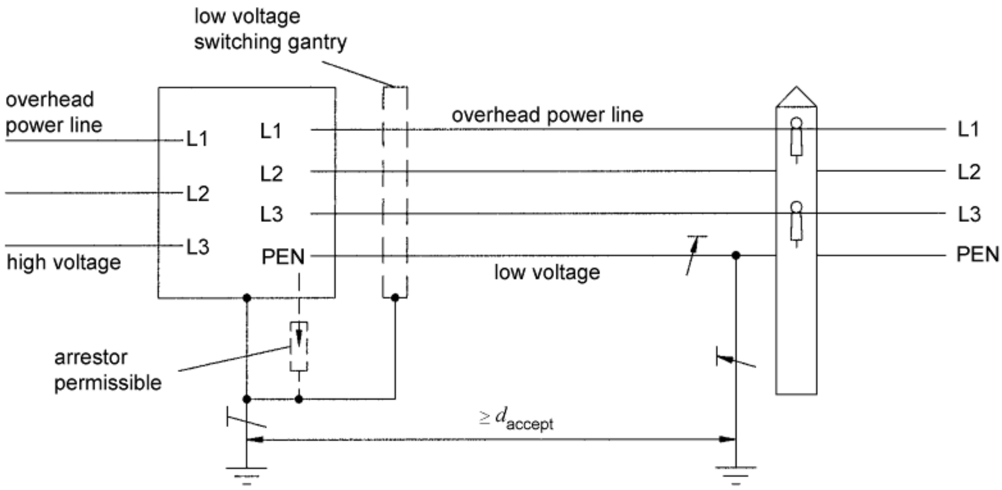


Figure 6/DE.1 – Separated earthing systems with connection via an overhead line

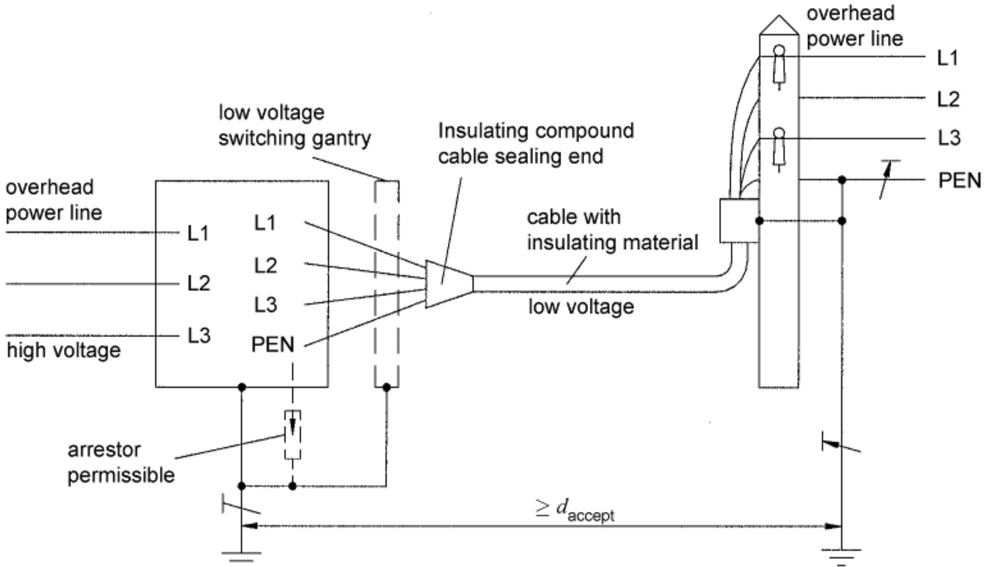


Figure 6/DE.2 – Separated earthing systems via cable connection

6.1.3 Earthing measures against lightning effects

6.1.3 **DE.1 Avoiding of back-flashovers**

(ncpt) In case of a lightning stroke in an earthed component of an overhead line a discharge may result to operationally live parts (back-flashover). Such flashovers may not be expected in general if the impulse earth resistance R_{St} suffices the following relation:

$$R_{St} \leq \frac{U_{St}}{I_{St}}$$

Where:

R_{St} Impulse earth resistance of the tower earthing. In case of a limited spatial extend (earth rods < 10 m, radial counterpoises < 20 m) the earth resistance R_E (see DIN EN 50341-1 (VDE 0210-1:2013-11), H.2.2) may be used as an approximation.

U_{St} Lightning impulse withstand voltage of the isolation ($U_{90\%\_ff\_is}$);

I_{St} Peak value of the lightning current at the tower, see Table 6/DE.1.

Table 6/DE.1 – Cumulative frequency of lightning currents on towers of lines with shield wires

Lightning current I_{St} at the tower up to	20 kA	30 kA	40 kA	50 kA	60 kA
Cumulative frequency of lightning strokes	80 %	90 %	95 %	98 %	99 %
NOTE This means for example that the lightning current will not exceed 40 kA in 95 % of all lightning strokes.					

6.3 Dimensioning with regard to thermal strength

6.3.2 Current rating calculation

6.3.2 **DE.1 Decisive current for rating of the earthing system**

(ncpt) Table 6/DE.2 specifies the decisive currents for rating of earthing systems.

Table 6/DE.2 – Decisive currents for rating of the earthing system

	Decisive for thermal loading [a]		Decisive for earthing and touch voltages
	Earth electrode	Earthing conductors	
Systems with isolated return point	[b]	I''_{kEE} [d]	$r \times I_c$ [e]
Resonant earth systems	[b]	I''_{kEE} [d]	$r \times I_{RES}$
Systems with low resistant neutral earthing	I''_{k1} [c]	I''_{k1}	$r \times I''_{k1}$
Resonant earth systems and systems with temporarily low resistant neutral earthing	[b]	I''_{kEE}	$r \times I_{RES}$

[a] The minimum cross sections according to DIN EN 50341-1 (VDE 0210-1), 6.2.2., shall be considered.

[b] The minimum cross sections according to DIN EN 50341-1 (VDE 0210-1), 6.2.2, are sufficient.

[c] If several paths of currents are possible the resulting distribution of currents may be considered.

[d] If the duration of failure is less than 1 s the currents I_C and I_{RES} , respectively, may be used.

[e] If in a local limited high-voltage system, for example in an industrial installation, an earth fault will last presumably over a longer period, for example several hours, then I''_{kEE} should be considered.

Legend

I_C Calculated or measured capacitive earth fault current.

I_{RES} Earth fault residual current. If the precise value is not known, a value $0{,}1 x I_C$ may be used for calculation.

I''_{kEE} Double earth fault current. It may be assumed as 85 % of single circuit initial earth faul currentt.

I''_{k1} Initial short-circuit current in case of a single phase earth fault.

r Earth wire reduction factor (see DIN EN 50341-1 (VDE 0210-1):2013-11, H.4.5).

6.4 Dimensioning with regard to human safety

6.4.2 Touch voltage limits at different locations

6.4.2 DE.1 Example for limits of touch voltage

(ncpt) DIN EN 50341-1 (VDE 0210-1):2013-11, Figure 6.1 shall be replaced by Figure B.2 of DIN EN 50522 (VDE 0101-2):2011-11.

6.4.3 Basic design of earthing systems with regard to permissible touch voltage

6.4.3 DE.1 Supplementary measures

(ncpt) Supplement to DIN EN 50341-1 (VDE 0210-1):2013-11, Figure 6.2 (8): Measures to guarantee the personal safety in case of exceedingly high touch voltages up to $U_E \leq 4\ U_{TP}$ are for example

- safe guarding by electrically non-conductive fences (also suitable planting),
- insulation of the site,
- potential grading

and the measures described under DIN EN 50341-1 (VDE 0210-1):2013-11, 6.4.4.

6.4.3 **DE.2 Immediate automatic switching off**

(ncpt) An automatic switching-off of an earth failure within 0,6 s is understood as immediate automatic switching-off as mentioned for systems operation in the chart of DIN EN 50341-1 (VDE 0210-1):2013-11, Figure 6.2 (3).

6.4.4 Measures in systems with isolated neutral or resonant earthing

6.4.4 **DE.1 Supports at sites, which are freely accessible for people**

(ncpt) At sites, which are freely accessible for people and where people stay within few weeks relatively long (several hours per day) or for short time, however, very often (several times a day) it shall be guaranteed that the permissible touch voltages are obeyed at supports independently of the measures mentioned under DIN EN 50341-1 (VDE 0210-1):2013-11, 6.4.4.

6.4.4 **DE.2 Measures in system with short-term low resistance neutral earthing and fault location**

(ncpt) The same conditions apply as mentioned under DIN EN 50341-1 (VDE 0210-1):2013-11, 6.4.4 as well as under 6.4.4/DE.1.

6.5 Site inspection and documentation of earthing systems

6.5 **DE.1 Information for inspection of earthing systems**

(ncpt) For inspection of earthing systems at overhead line supports it is sufficient to check their condition at some sites every five years. The verification can be achieved by the following methods:

– Visual inspection (earth electrodes and earth conductors);

– Measurements (see DIN EN 50341-1 (VDE 0210-1):2013-11, H.4.3).

7 Supports

7.1 Initial design considerations

7.1 **DE.1 Loads and load conditions**

(ncpt) Supports shall be designed according to their function and to the load cases as defined in 4.12.2/DE.1. The structural design shall be carried out based on ultimate loads.

7.1 **DE.2 Tower outline and geometry**

(ncpt) The main basic dimensions and the tower top geometry shall be defined before rating, whereby the electrical requirements, the number of circuits, the span lengths, the soil conditions and the configuration of insulators shall be considered.

7.1 **DE.3 Transformer stations installed on towers**

(ncpt) Within crossing sections transformer stations shall only be installed on towers if these are rated as section supports.

NOTE The requirements for planning and installation of transformers and switch gears on supports are specified in DIN EN 61936-1 (VDE 0101-1).

7.2 Materials

7.2.1 Steel materials, bolts, nuts and washers, welding consumables

7.2.1 **DE.1 Material for steel components**

(ncpt) Standards for materials of steel components are given in 2.1.

In general, only structural steel S235J0 and S235J2 as well as S355J0 and S355J2 according to DIN EN 10025-1:2005-02 and DIN EN 10025-2:2005-04 may be used.

The requirements of DIN EN 1090-1 and DIN EN 1090-2 shall be considered.

7.2.1 **DE.2 Materials for bolts**

(ncpt) In general, only the strength qualities 5.6, 8.8 and 10.9 according to DIN EN ISO 898-1, may be used.

7.2.6 Wood

7.2.6 **DE.1 Materials for wood poles**

(ncpt) To wood poles DIN EN 1995-1-1 and for circular wood poles DIN EN 14229 apply.

7.2.8 Other materials

7.2.8 **DE.1 Glass fibre reinforced plastic**

(ncpt) Glass fibre reinforced plastic (GRP) may be used as material for poles in systems with nominal voltages above AC 1 kV up to and including AC 45 kV. For the use of these materials an authorization by the Civil Engineering Supervisory Body (Institut für Bautechnik) is required.

7.3 Lattice steel towers

7.3.1 General

7.3.1 **DE.1 Minimum dimensions of components**

(ncpt) The minimum thickness of components and the bolt diameters shall be specified under due consideration of corrosion effects especially in case of thin-walled cold-formed sections.

The thickness of components shall not fall below 4 mm. In case of hollow sections used for tower members the thickness may be reduced to 3 mm if an adequate protection against corrosion is ensured.

If weakened by boreholes, angle sections with widths below 35 mm and flat bars with a width below 30 mm are not permitted.

7.3.5 Structural analysis

7.3.5 **DE.1 Eccentricity of member connections**

(ncpt) The eccentricity of member connections at nodes shall be kept as small as possible.

For leg members of lattice steel towers the eccentricity at joints may be disregarded provided that the centroidal axis is calculated in an average position at the joints.

In case of compression bracing members of lattice steel towers consisting of one single angle (for example members between leg members or between chords) being connected by only one of both angle legs the eccentricity of load application may be disregarded.

7.3.5 **DE.2 Inclination of bracings**

(ncpt) It is recommended to choose the inclination of bracings to the horizontal by not more than 45°.

NOTE In case of very steep diagonal bracings it is possible to overestimate the forces in the bracings and underestimate the forces in the leg members.

7.3.6 Ultimate limit states

7.3.6.1 General

7.3.6.1 **DE.1 Partial factors for materials**

(ncpt) For lattice steel towers the following partial factors for materials shall be used:

γ_{M0} = 1,1

γ_{M1} = 1,1

γ_{M2} = 1,25

7.3.6.3 Tensile, bending and compression resistance of members

7.3.6.3 **DE.1 Tensile resistance of lattice members**

(ncpt) The tensile resistance of lattice members shall be calculated according to J.3.

7.3.6.4 Buckling resistance of members in compression

7.3.6.4 **DE.1 Buckling resistance of compression loaded members**

(ncpt) The compression resistance of lattice members shall be calculated according J.4.

Flexural torsional buckling of equal leg sections shall be verified according to J.4/DE.3 and torsional buckling according to J4/DE.4.

7.3.8 Resistance of connections

7.3.8 **DE.1 Rating of bolted connections**

(ncpt) Bolted connections shall be rated according J.5.

7.3.8 **DE.2 Securing of bolted connections**

(ncpt) Bolted connections shall be secured against getting unintentionally loose. This can be achieved by a sufficient tightening of the nuts. For this purpose spring washers may be used as indicators.

7.3.8 **DE.3 Punching of holes for rivets and bolts**

(ncpt) Due considerations shall be made for defining the limit of material thickness between the methods of drilling and punching. The effect of the material ductility shall be duly considered. Steel according to 7.2.1/DE.1 is sufficiently ductile and may be punched. However, this does not apply to holes for rivets and bolts in angle sections and plates of more than 12 mm thickness. Permanent supervision shall ensure that sharp punches and suiting dies are used for manufacturing.

Structural members of crossarms which are permanently loaded in tension shall not be punched.

7.3.8 **DE.4 Dimensions of connecting elements**

(ncpt) Diameters of bolts less than 12 mm are not permitted for structurally loaded members. The minimum strength quality for bolts M12 is 5.6. Rivets with a finished diameter less than 13 mm are not permitted.

The maximum permissible diameter of beaten rivets, the maximum permissible diameter of threads of mechanically loaded bolts and the diameter of related boreholes, which are determined by the width of the angle legs of sections as well as of their edge distances, may be taken from Table 7/DE.1.

7.3.8 **DE.5 Edge and borehole distances**

(ncpt) The minimum possible edge distances in direction of the force are stipulated in Table 7/DE.1. The minimum distances between the centre of boreholes shall be not less than 2,5 times the diameter of the boreholes. The edge distances rectangular to the direction of the force shall not be less than 1,2 times the diameter of the borehole.

The values of the edge distances in direction of the force, which need to be measured starting at the middle of the borehole, may in no case fall below the specified minimum; the maximum values shall be used in case of tensile loaded parts of the vertical frame work of crossarms as well as in joints of leg members.

The maximum distances between the centres of boreholes shall not exceed the lower values of 10 times the borehole diameter or 20 times the material thickness of that component having the smallest thickness being situated at the surface of the joint.

Table 7/DE.1 – Dimensions of connections and edge distances of jointing components

Dimensions in millimeter

Dimension of bolt		**M 12**	**M 16**	**M 20**	**M 24**	**M 27**	**M 30**
Maximum diameter of borehole	Hexagon bolts: Rivets:	14 13	18 17	22 21	26 25	29 28	32 31
Minimum width of angle legs		35	50	60	70	75	80
Minimum edge distance in direction of the force		20 25	25 35	30 40	40 50	45 55	50 65

7.4 Steel poles

7.4.1 General

7.4.1 **DE.1 General**

(ncpt) This subclause applies to solid wall poles with circular or polygonal cross sections.

7.4.5 Structural analysis

7.4.5 **DE.1 Structural analysis**

(ncpt) The analysis of the internal forces should be based on the second order theory. If a more precise verification is not carried out the effect of the second order theory shall be considered by adding the following supplements to the moments calculated based on the first order theory:

– Suspension towers, angle suspension and angle towers: 5 %;

– Sections towers, angle sections towers and dead-end towers: 3 %.

This applies only to supports where the distance between the foundation upper surface and the upper end of the uppermost crossarm is at maximum 40 m.

7.4.6 Ultimate limit states

7.4.6.1 General

7.4.6.1 **DE.1 General**

(ncpt) The partial factors γ_M for materials shall be assumed as follows:

a) Strength of cross-sectional areas γ_{M1} = 1,10;

b) Strength of the residual cross-sectional areas at boreholes γ_{M2} = 1,25;

c) Strength of connections (see 7.4.8).

7.4.6.2 Resistance of cross section areas

7.4.6.2 **DE.1 Cut-outs**

(ncpt) If the bearing cross section is reduced by cut-outs for doors etc., a static analysis for the weakened cross section shall be carried out on the basis of the effectively available cross section.

7.4.6.2 **DE.2 Verification of buckling**

(ncpt) In case of longitudinal forces and bending the verification against plate and cylinder buckling may be carried out according to DIN EN 50341-1 (VDE 0210-1):2013-11, Annex K.

In case of longitudinal forces, bending and shear (transverse force and torsion) the verification shall be carried out for buckling of plates in accordance to DIN EN 1993-1-5 and for cylinder buckling in accordance to DIN EN 1993-1-6.

7.4.7 Serviceability limit states

7.4.7 **DE.1 Serviceability limit states**

(ncpt) The load-depending deflection of a tower may be analytically calculated according to the first order theory without consideration of the foundation movements. The slipping within slip joints shall be taken into account. The lateral deflection of the pole at the top shall be limited as follows:

– Suspension and angle suspension poles:

  4 % of the length of the pole when being loaded according to load cases A or D as defined by 4.12.2/DE.1 with a partial factor $\gamma_F = 1{,}0$;

– Angle poles, section poles and dead end poles:

  2,5 % of the length of the pole when being loaded according to load case D as defined in 4.12.2/DE.1 with a partial factor $\gamma_F = 1{,}0$.

Independently of the pole length the deflection of the pole top of a section, angle section or dead end pole under maximum load according to load case D may not increase by more than 0,5 m compared with the situation under everyday loads (+10°C, no wind).

7.4.8 Resistance of connections

7.4.8.3 Slip joint connections

7.4.8.3 **DE.1 Slip joint connections**

(ncpt) The following additional specifications shall be complied with:

– Conicity of pole body: ≥ 10 mm/m;

– Wall thickness: ≤ 16 mm.

– Slip joints may be used in cases of wall thicknesses above 16 mm, if the stability and serviceability are demonstrated by a static analysis, which was verified by tests.

7.5 Wood poles

7.5.2 Basis of design

7.5.2 **DE.1 Basis of design**

(ncpt) Wood poles which do not have circular cross sections shall be designed according to DIN EN 1995-1-1 and DIN EN 1995-1-2.

DIN EN 14229:2011-02 applies to circular poles.

7.5.3 Materials

7.5.3 **DE.1 Use of circular-shaped wood poles**

(ncpt) Circular-shaped wood poles may not be used for crossings with motorways, waterways, public railways with or without overhead contact lines and with ropeway systems.

For other crossings circular-shaped wood poles may only be used in straight line sections or with line angles of 160° and above. For line angles below 160° A-type poles shall be adopted.

7.5.5 Ultimate limit states

7.5.5.1 Basis

7.5.5.1 **DE.1 Partial factor**

(ncpt) The partial factor γ_{M1} for circular-shaped wood poles shall be assumed for normal and exceptional loads as follows:

γ_{M1} = 1,40

7.5.5.3 Resistance of wood elements

7.5.5.3 **DE.1 Resistance of wooden elements**

(ncpt) The rating of wood poles shall be carried out according to DIN EN 1995-1-1:2010-12. The values of strength class C35 according to DIN EN 338:2009-10, Table 1, may be applied without additional tests of material as values for verification of the characteristic features of circular-shaped wood (Picea Abies, Pinus Sylvestris). Deviating from this data the elasticity modulus in parallel to the fibre directions may be assumed with $E_{0,mean}$ = 9 000 N/mm². Other characteristic values may be adopted for limited areas of origin if they are supported by tests according to DIN EN 14229:2011-02.

7.5.6 Serviceability limit states

7.5.6 **DE.1 Serviceability limit states**

(ncpt) It is recommended that wood poles are rated so that the bending displacement at the tower top does not exceed 10 % of the pole length in the serviceability limit states.

7.5.7 Resistance of connections

7.5.7 **DE.1 Resistance of connections**

(ncpt) DIN EN 1995-1-1:2010-12 applies to the rating of connections.

7.6 Concrete poles

7.6.2 Basis of Design

7.6.2.1 General rules

7.6.2.1 **DE.1 Load assumptions**

(ncpt) Concrete poles and their crossarms shall be designed on the basis of the loading assumptions given in 4.12.2/DE.1.

7.6.4 Ultimate limit states

7.6.4 **DE.1 Ultimate limit state**

(ncpt) The requirements of DIN EN 1992-1-1/NA shall be complied with.

7.6.5 Serviceability limit states

7.6.5 **DE.1 Serviceability limit states**

(ncpt) The requirements of DIN EN 1992-1-1/NA shall be complied with.

In case of pre-stressed concrete poles concrete tensile stresses may not occur under the conditions mentioned in DIN EN 50341-1 (VDE 0210):2013-11, 7.6.5.

NOTE Working loads are defined as the characteristic loads of the load cases decisive for the loads in case of serviceability.

7.7 Guyed structures

7.7.1 General

7.7.1 **DE.1 Limitation of application**

(ncpt) Guyed supports are permitted; however, for voltage levels above 45 kV only for temporary use.

7.7.3 Materials

7.7.3 **DE.1 Stays for supports**

(ncpt) Galvanized round-shaped flexibly stranded ropes with steel core according to DIN EN 12385-4 or galvanized steel ropes according to DIN VDE 0212-399 (VDE 0212-399) shall be used as stay wires. Ropes with thickly galvanized strands should preferably be used.

Steel ropes with any other type of corrosion protection may be used if that protection is at leas as effective as the specified galvanising.

The partial factor for steel ropes is γ_M = 1,65.

The failing load of the rope provided with end fittings shall be demonstrated by tensile tests on at least one sample per rope diameter. This test may be disregarded if

- the design of the rope and the end fitting as well as the corresponding mechanical strength data can be taken from a proven standard or
- a proof has already been carried out for comparable design and dimensions.

Stays for supports shall be equipped with devices for retightening. The connection of the stay ropes with the anchor device shall be accessible. The jointing elements shall be secured against unintentional loosening.

Stays for supports made of materials with insulating characteristics shall be additionally equipped beyond arm‘s reach with an insulator designed for adequate mechanical and electrical strength (see DIN EN 0522 (VDE 0101-2):2011-11, Annex G).

The stays for all other supports shall be bonded to the earthing system of the supports.

7.8 Other structures

7.8 **DE.1 Minimum requirements**

(ncpt) For other tower or pole designs and for towers or poles made of other standardized materials the same minimum requirements apply correspondingly as in case of the above mentioned tower or pole types. Towers or poles made of aluminium alloys shall be designed according to the relevant standards.

7.9 Corrosion protections and finishes

7.9.1 General

7.9.1 **DE.1 Selection of the protection and finishing system**

(ncpt) The selection of the protection system shall be carried out depending on the requirements which apply to the individual project and are described in the project specification.

7.9.2 Galvanising

7.9.2 **DE.1 Hot-dip galvanising**

(ncpt) The requirements according to DIN EN 1090-1 and DIN EN 1090-2 shall be considered.

Hot-dip galvanization shall be carried out according to DIN EN ISO 1461 und DASt 022.

7.9.4 Paint over galvanising in plant (Duplex system)

7.9.4 **DE.1 Paint over galvanising in plant (Duplex system)**

(ncpt) When components will receive an additional coloured layer after galvanising then a protection system according to DIN EN 12944-4 shall be selected. DIN EN 12944 shall be obeyed in respect to the preparation of surface, application and check of the cover.

7.9.7 Protection of wood poles

7.9.7 **DE.1 Protection of wood poles**

(ncpt) If wood poles will be used more than three years they shall be effectively protected against rotting and infestation by insects according to “Technical information – Impregnated wood poles” (FNN) by wood protection agents. Boreholes and block-outs shall be effectively treated with wood protection agents, especially if they are prepared afterwards.

7.10 Maintenance facilities

7.10.1 Climbing

7.10.1 **DE.1 Walkways for climbing and access**

(ncpt) The following rules apply to access ways of overhead line supports to be newly installed.

Lattice steel structures for lines with a nominal voltage above AC 1 kV up to and including AC 45 kV do not need any special access ways for climbing and access to working positions, if the distance between nodes at the leg members does not exceed 0,6 m and the distance of two adjacent leg members is not more than 1,0 m.

Steel lattice towers, which do not comply with this specification and carry several circuits special access ways with technical equipment or protection against falling are necessary at least at two diagonally opposed leg members.

This can be:

- Ladders;
- Step bolt arrangements;
- Stirrup arrangements.

Alternatively, access ways with technical equipment for protection against falling can be carried out as:

– a single step bolt arrangement of a step ladder at tower faces perpendicularly to the line direction

or

– a ladder within the tower body.

NOTE 1 Technical devices for protection against falling can be rope protection systems, section rail systems, protective step bolts (for example “pig tails”) etc.

NOTE 2 This standard only applies to the installation of new lines (see section 1 “Application”). The stipulations specified here may not be interpreted as a prejudice for the requirement of refitting towers within the existing grid

In case of a two-line step bolt arrangement the angle between the planes of the two bolt arrangements shall be at least 90°.

The foothold of the step bolts and stirrups shall amount to at least 300 mm for single-line arrangements and at least 150 mm in case of two-line step bolt arrangements. The flat thread width shall be at least 20 mm and the diameter of cylindrical threads at least 24 mm. To provide a protection against sliding a lateral stop at least 20 mm high measured from the top of the step shall be provided. Step bolts with a hexagon head meet the requirements for an adequate lateral stop.

Basically, the step bolts and stirrups should be arranged with a constant distance of ≤ 333 mm. If due to design of the tower the distances between two consecutive step bolts or stirrups of an arrangement cannot be equal and/or less than 333 mm, the distance between two adjacent step bolts or stirrups may vary up to 100 mm but the spacing between step bolts or stirrups shall not exceed 403 mm. In the vicinity of the crossarm joints, structural components may be used as treads instead of step bolts or stirrups.

Clause 4.9.2/DE.1 applies to rating of step bolts and stirrups.

Crossarms shall be equipped with a walkway and a handrail unless the crossarms are designed as follows:

– The spacing between the members which are used for walking may not exceed the dimension 0,6 m in parallel to the lower chord in a distance of 0,6 m

and

– the structural elements arranged at distances up to 1,7 m above any standing position can be held onto continuously.

Poles do not require any walkways for climbing and access to working positions, if climbing devices independent from the pole are used such as ladders or elevating platforms. If such climbing devices are not available steel and concrete reinforced poles shall be equipped with technical devices for protections against falling. A device shall be provided as access to the crossarms. Thereby, a mountable device is preferred, which can withstand the expected loadings.

7.10.1 **DE.2 Access for working close to or at live system components**

(ncpt) If working at supports is planned without switching-off the circuits access shall to be provided which may be installed permanently or temporarily.

The access ways shall be designed such that the requirements for electric safety according to DIN VDE 0105-100 (VDE 0105-100) will be met.

7.10.2 Maintainability

7.10.2 **DE.1 Protection from falling during working at towers**

(ncpt) The design of overhead electrical line towers shall allow the use of personal protection equipment (PPE) from falling when working on the tower.

7.10.3 Safety requirements

7.10.3 **DE.1 Protection against climbing**

(ncpt) Protection against climbing is ensured if the walkways, e. g. step bolts arrangements at lattice steel towers start at least 2,20 m above ground level. Any protection of the framework against unauthorized climbing is not required in principle.

7.10.3 **DE.2 Information of safety for the public**

(ncpt) The requirements for providing safety information for the public shall be specified within project specifications or company standards.

7.10.3 **DE.3 Identification of circuits for authorized persons**

(ncpt) The requirements for provision of identification of circuits for authorized persons shall be specified in project specifications or company standards.

7.10.3 **DE.4 Device for connection of earth wires and support earthing**

(ncpt) If earth wires are installed, devices for the connection of earth wires with the support earthing shall be provided. Details shall be specified in project specifications or company standards.

8 Foundations

8.2 Basis of geotechnical design

8.2.2 Geotechnical design by calculation

8.2.2 **DE.1 Geotechnical design by calculation**

(ncpt) In Germany the semi-empirical methods according to DIN EN 50341-1 (VDE 0210-1):2013-11, M.3, is recommended.

The geotechnical design is based on the data of the support design. Partial factors on actions are already included in the actions on the foundation.

The design resistance may be determined with the design method 2. Using this verification method 2 the partial factors are adopted on the characteristic resistances.

The partial factors γ_R for the calculation of the resistance are specified in DIN EN 50341-1 (VDE 0210-1):2013-11, M.3.

8.2.3 Design by prescriptive measures

8.2.3 **DE.1 Foundation of single poles made of wood for overhead lines with nominal voltage above AC 1 kV up to and including AC 45 kV**

(ncpt) If the embedding depth of single poles made of circular wood is at least 1/6 of their total length, however, not less than 1,6 m, and no verification of inclination is required, a stability verification may be waived in case of bearable soil. In case of double poles the same procedure may be used if the two single poles are arranged perpendicular to the loading direction. Embedding of wood poles in concrete is not permitted.

8.2.3 **DE.2 Foundation of single poles made of steel, concrete, glass-fibre reinforced plastic for overhead lines with nominal voltage above AC 1 kV up to and including AC 45 kV**

(ncpt) If the embedding depth of single poles made of steel, concrete, glass-fibre reinforced plastic in good bearing soil is at least 1/6 of their total length, however, not less than 1,6 m a stability verification may be waived, if the moment at foundation upper face as well as the width of the pole is similar as in case of circular wood poles and the verification of the inclination is not required. If the moments at foot level are higher or the pole width is smaller the usual geotechnical verifications and the verification of the internal reliability and serviceability of the foundation body are required.

8.2.4 Load tests and tests on experimental models

8.2.4 **DE.1 Load tests**

(ncpt) Load tests for acceptance are carried out usually at piles of supports up to a certain percentage (usually 90 %) of the design tensile load E_d. After being successfully tested the piles shall be completely serviceable.

NOTE 1 The acceptance test mentioned above is identical with the “proof test” according to DIN EN 61773 (VDE 0210-20).

NOTE 2 In case of mini compression piles the verification of the compression strength can be verified by a tensile test on the basis of the design value for the compression loading.

8.6 Interaction between support foundations and soil

8.6 **DE.1 Semi-empirical design procedure**

(ncpt) When using the semi-empirical design procedure according to 8.2.2/DE.1 the decisive criteria for the interaction between support foundation and soil are met.

9 Conductors and earth wires

9.2 Aluminium based conductors

9.2.1 Characteristics and dimensions

9.2.1 **DE.1 Dimensions and materials**

(ncpt) If conductors with a configuration or dimension not specified in DIN EN 50182 are produced from materials which are specified in DIN EN 50183, DIN EN 50189, DIN EN 60889, DIN EN 61232 or DIN EN 62004 a verification of suitability of the materials is not required.

9.2.1 **DE.2 Mechanical characteristics**

(ncpt) Configuration, mechanical characteristics and permissible everyday stress for conductors with aluminium as conducting material are specified in Table 9/DE.1. Thereby, reference is made to the definitions in 2.2/DE.4 as far as they concern conductors.

Table 9/DE.1 – Mechanical characteristics, permissible everyday stress for standard conductors according to DIN EN 50182

Conductor type and reference standard	**Cross-sectional ratio**	**Number of stands**	**Coefficient of thermal expansion** ε_t 10^{-6}/K	**Effective modulus of elasticity** E kN/mm^2	**Everyday stress** N/mm^2	
					AL1/ ST1A	**AL3/ ST1A**
AL1/ST1A and AL3/ST1A	1,4:1	14/7	15,0	110	90	104
		14/19				
	1,7:1	12/7	15,3	107	84	102
	4,3:1	30/7	17,8	82	57	69
	6,0:1	6/1	19,2	81	56	67
		26/7	18,9	77		
	7,7:1	24/7	19,6	74	52	63
		54/7	19,3	70		
		54/19	19,4	68		
	11,3:1	48/7	20,5	62	44	53
	14,5:1	45/7	20,9	61	40	50
	23,1:1	72/7	21,7	60	35	-
AL1	/	7	23,0	60	30	
		19 37		57		
		61 91		55		
AL3 (E-AlMgSi)	/	7	23,0	60	44	
		19 37		57		
		61 91		55		

NOTE 264-AL1/34-ST1A corresponds to Al/St 265/35, 264-AL3/34-ST1A corresponds to E-AlMgSi/St 265/35, 117-AL3 corresponds to E-AlMgSi 120.

9.2.1 **DE.3 Provisions to take into account the conductor creep**

(ncpt) During their life conductors will suffer permanent elongation (creep) resulting in an increase of the sag. At no time this increase of sag shall cause the clearance to fall below the specified values. Corresponding provisions shall be made during planning and installation of a line.

9.2.3 Conductor service temperatures and grease characteristics

9.2.3 **DE.1 Thermal rating**

(ncpt) Configuration and cross section of a conductor using aluminium as conducting material shall be selected such that the conductor loaded by the maximum operational current under consideration of the ambient conditions or by the maximum short-circuit load to be expected may not assume a temperature, which would result in an inadmissible reduction of its mechanical strength.

The permissible conductor temperature at operational current is 80 °C for AL1, AL3, AL1/ST1A and AL3/ST1A. The permissible temperature for conductors made of high temperature resistant materials shall be stipulated individually.

DIN EN 50182 contains information on the permanently permissible current of standardized conductors.

DIN EN 60865-1 (VDE 0103) applies to the mechanical and thermal short-circuit strength. Departing from DIN EN 60865-1 (VDE 0103) the conductor temperatures for AL1, AL3, AL1/ST1A and AL3/ST1A shall be limited to the values given in Table 9/DE.2. The permissible conductor temperatures for conductors made of high temperature resistant materials shall be specified individually.

Table 9/DE.2 – Permissible conductor temperature in case of short-circuit load for conductors using aluminium as conducting material

Type of conductor	Material	Permissible conductor temperature in case of short circuit °C
Congenerous conductors	AL1	130
	AL3	160
Reinforced conductors	AL1/ST1A	160
	AL3/ST1A	160

9.3 Steel based conductors

9.3.1 Characteristics and dimensions

9.3.1 **DE.1 Characteristics and dimensions**

(ncpt) For the dimensions and materials for conductors made of steel it applies additionally:
DIN VDE 0212-399 (VDE 0212-399), *Conductors for Overhead lines – Conductors of concentric stranded round galvanized steel wires.*
Leiter für Freileitungen – Leiter aus konzentrisch verseilten runden verzinkten Stahldrähten

If materials are used, the mechanical and electrical characteristics of which deviate from the data listed in DIN VDE 0212-399 (VDE 0212-399), DIN EN 50189 or DIN EN 61232, their characteristics and their suitability for the special case shall be verified.

If conductors the configuration or dimensions of which are not listed in DIN EN 50182 or DIN VDE 0212-399 (VDE 0212-399) are used with materials listed in DIN EN 50189, DIN EN 61232 or DIN VDE 0212-399 (VDE 0212-399) no special verifications for the suitability of the materials are required.

9.3.3 Conductor service temperatures and grease characteristics

9.3.3 DE.1 Conductor service temperatures

(ncpt) Configuration and cross section of a conductor made of steel strands shall be selected such that the conductor loaded by the maximum operational current under consideration of the ambient conditions or by the maximum short-circuit load to be expected may not assume a temperature, which would result in an inadmissible reduction of its mechanical strength.

For the mechanical and thermal short-circuit strength DIN EN 60865-1 (VDE 0103) is decisive. Departing from DIN EN 60865-1 (VDE 0103) the permissible conductor temperature shall be limited to the values given in Table 9/DE.3.

Table 9/DE.3 – Permissible conductor temperature in case of short-circuit load for conductor made of steel

Conductor type	**Material**	**Permissible conductor temperature in case of short circuit °C**
Plain conductors	ST1A, ST4A, A20SA	200

9.3.4 Mechanical requirements

9.3.4 DE.1 Mechanical characteristics

(ncpt) Configuration, mechanical data and permissible everyday stresses for conductors made of steel strands are specified in Table 9/DE.4. In this context reference is made to the definitions concerning conductors in 2.2/DE.4.

Table 9/DE.4 – Mechanical characteristics, permissible everyday stresses for standardized conductors according to DIN VDE 0212-399 (VDE 0212-399) and DIN EN 50182

Conductor type and reference standard	**Number of strands**	**Coefficient of thermal expansion** ε_t 10^{-6}/K	**Effective modulus of elasticity** E kN/mm^2	**Everyday stress** σ_{10} N/mm^2
ST1A and ST4A DIN VDE 0212-399 (VDE 0212-399),	7			ST1A – 130 ST4A – 150
	19		175	
A20SA DIN EN 50182	7 19 37	13,0	159	137
	61		157	

9.4 Copper based conductors

9.4 DE.1 Characteristics and dimensions

(ncpt) To the dimensions and materials for conductors with strands made of copper or copper wrought alloys the following standards apply:

DIN 48200-1, *Wires for conductors – Copper wires for stranded conductors*
Drähte für Leitungsseile – Drähte aus Kupfer

DIN 48201-1, *Conductors – Copper stranded conductors*
Leitungsseile – Seile aus Kupfer

DIN 48200-2, *Wires for conductors – Bronze wires for stranded conductors*
Drähte für Leitungsseile – Drähte aus Kupferknetlegierung

DIN 48201-2, *Conductors – Bronze stranded conductors*
Leitungsseile – Seile aus Kupfer-Knetlegierungen (Bz)

If materials are used the mechanical and electrical characteristics of which differ from the data listed in the mentioned standards, their characteristics and suitability for each case of application shall be verified.

If conductors, the configurations and dimensions of which are not listed in the mentioned standards, however, are made of materials listed in the mentioned standards no special verification of suitability for the materials is required.

9.4 DE.2 Mechanical characteristics

(ncpt) Configuration, mechanical characteristics and permissible everyday stresses for conductors made of copper or copper rod alloys are specified in Table 9/DE.5. Reference is made to the conductor-related definitions given in 2.2/DE.4.

Table 9/DE.5 – Mechanical characteristics, permissible everyday stresses for conductors according to DIN 48201-1 and DIN 48201-2

Conductor type and reference standard	**Number of strands**	**Coefficient of thermal expansion** ε_t 10^{-6}/K	**Effective modulus of elasticity** E kN/mm^2	**Everyday stress** σ_{10} N/mm^2
Copper DIN 48201-1	7	17	113	85
	19 37		105	
	61		100	
Copper wrought alloys (Bz I … Bz III) DIN 48201-2	7	17,0	113	100
	19 37		105	
	61		100	

9.4 **DE.3 Thermal rating**

(ncpt) Conductor type and cross section of a conductor with strands made of copper or copper wrought alloy shall be selected such that the conductor loaded by the maximum operational current and considering the ambient conditions or by the maximum short-circuit loading to be expected, does not lead to an inadmissible reduction of its mechanical strength.

The permissible conductor temperature at operational current is 70°C for conductors made of copper or copper wrought alloys.

Information on the permanent current capacity of standardized conductors is given in DIN 48201-1 and DIN 48201-2.

For the mechanical and thermal short-circuit strength DIN EN 60865-1 (VDE 0103) is decisive. Apart from DIN EN 60865-1 (VDE 0103) the permissible conductor temperature shall be limited to values according to Table 9/DE.6.

Table 9/DE.6 – Permissible conductor temperature in case of short-circuit loading for conductors made of copper

Conductor type	Material	Permissible conductor temperature in case short- circuit °C
Plain conductors	Cu, Bz I - Bz III	170

9.4 **DE.4 Testing requirements**

(ncpt) Conductors made of copper or copper wrought alloys shall be tested according to the requirements of the following standards.

DIN 48203-1, Copper wires and copper stranded conductors – technical delivery conditions
Drähte und Seile für Leitungen aus Kupfer – Technische Lieferbedingungen

DIN 48203-2, Wrought copper alloy (Bz) wires and conductors – technical delivery conditions
Drähte und Seile für Leitungen aus Kupferknetlegierungen (Bz) – Technische Lieferbedingungen

9.6 General requirements

9.6.2 Partial factor for conductors

9.6.2 **DE.1 Maximum conductor stress**

(ncpt) At –20 °C without ice loads or

at –5 °C and ice load according to 4.5.2/DE.1 or

at –5 °C and ice load combined with wind load according to 4.6.6.1/DE.1 or

at +5 °C with wind load according to 4.4.1/DE.1

the tensile stress at the fixing point of the conductor multiplied by the partial factor $\gamma_C = 1{,}35$ shall not exceed a value which is obtained from 95 % of the rated tensile strength of the conductor divided by the material partial factor $\gamma_M = 1{,}25$.

9.6.2 **DE.2 Loads in case of everyday stress**

(ncpt) At the annual mean temperature which can be assumed to be +10 °C the horizontal component of the conductor tensile stress without wind load should not exceed the everyday stress according to Table 9/DE.1, Table 9/DE.4 or Table 9/DE.5.

Depending on the design of the suspension assemblies and the efficiency of the vibration protection the horizontal component of the conductor tensile stress may exceed the values given in Table 9/DE.1, Table 9/DE.4 or Table 9/DE.5 by up to 25 %.

The every day stress for self-supporting metal-reinforced telecommunication aerial cables shall be chosen in relation to Table 9/DE.1 or Table 9/DE.4 depending on material and configuration of the supporting reinforcement.

9.6.3 Minimum cross sections

9.6.3 **DE.1 Minimum cross sections**

(ncpt) The minimum cross sections are specified in Table 9/DE.7.

Table 9/DE.7 – Minimum cross sections

Conductor type and designation	**Standard**	**Minimum conductor cross section**
AL1/ST1A	DIN EN 50182	34-AL1/6-ST1A
AL1		48-AL1
AL3/ST1A		34-AL3/6-ST1A
AL3		34-AL3
Copper	DIN 48201-1	DIN 48201-25-E-Cu
Copper wrought alloy (Bz I … Bz III)	DIN 48201-2	DIN 48201-25-Bz
ST1A and ST4A	DIN VDE 0212-399 (VDE 0212-399)	25-St1A
A20SA	DIN EN 50182	24-A20SA

9.6.4 Sag-tension calculations

9.6.4 **DE.1 Maximum sag**

(snc) Maximum sag (see 2.2/DE.4.11) shall be assumed as the greater of the values resulting from

– –5 °C conductor temperature with ice load according to 4.5.2/DE.1 (see 5.6/DE.1) or

– maximum design temperature of the conductor without ice load.

9.6.4 **DE.2 Stress due to aeolian vibrations**

(ncpt) Conductors are excited to vibration by laminar wind flows which may lead to damage by failure of individual strands and eventually of the whole conductor. Occurrence and intensity of the vibration to be expected depend on the material, design and cross section of the conductor, on the magnitude of the everyday stress, on the local wind and terrain conditions, on design of the suspension arrangements and on the fittings used as well as on the span length and the height of the conductors above ground level.

When selecting the everyday stress according to 9.6.2/DE.2 there will be only a minor probability of vibration failure of reinforced conductors made of aluminium and steel as well as in case of plain conductors made of copper, of copper wrought alloys, of steel or of aluminium-clad steel, assuming favourable environmental conditions and a suitable design of the suspension devices. In case of lines susceptible to vibration, possible damage can be effectively counteracted by provision of vibration protection fittings.

Conductors with a small portion of steel, plain conductors made of aluminium or aluminium alloy and reinforced conductors made of aluminium alloy and steel, conductors with diameters larger than 25 mm as well as conductors in spans longer than 500 m are more susceptible to vibration. If an increased susceptibility to vibration is assumed or has been observed the design of suspension sets and of the damping devices shall be suitably selected in order to care for an effective protection of the conductors.

10 Insulators

10.1 Introduction

10.1 **DE.1 Long rod insulators**

(ncpt) Porcelain long rod insulators according to DIN 48006-1 and DIN 48006-2 as well as composite suspension and strain insulator sets according to DIN EN 61109 (VDE 0441-100) are summarized under the term long rod insulators. The application of DIN EN 60433 (VDE 0446-7) for porcelain long rod insulators shall be agreed upon individually.

10.1 **DE.2 Solid core insulators**

(ncpt) Insulators according to DIN 48006-3 are designated as solid core insulators.

10.1 **DE.3 Overhead power line post insulators**

(ncpt) The term post insulators comprises Indoor post insulators and open air post insulators according to DIN IEC 60273 (VDE 0674-4) as well as composite post insulators according to DIN EN 61952 (VDE 0441-200)

10.7 Mechanical requirements

10.7 **DE.1 Mechanical rating**

(ncpt) The mechanical rating of the insulators shall be determined by dividing the load on the individual insulator strings.

In the case of strain insulator sets the conductor tensile force shall be assumed at

- –20 °C without ice load or
- –5 °C and ice load according to 4.5.2/DE.1 or
- –5 °C and ice load combined with wind load according to 4.6.6.1/DE.1 or
- +5 °C with wind load according to 4.4.2/DE.1.

For suspension insulator sets and line post insulators the maximum force shall be assumed as the resultant from

– conductor dead weight, combined wind and ice load and the resultant of the horizontal conductor tensile force, if any, or

– conductor dead weight, wind load and the resultant of the horizontal conductor tensile forces, if any, or

– conductor dead weight, ice load and unbalanced force of the horizontal conductor tensile forces in case of exceptional load.

The design load is:

$$E_d = f\{\gamma_G G_K;\ \gamma_W Q_{WK};\ \gamma_I Q_{IK};\ \gamma_C Q_{CK}\}$$

Where:

E_d total load;

G_K permanent loads according to DIN EN 50341-1 (VDE 0210-1):2013-11, 4.2;

Q_{WK}, Q_{IK} variable loads according to DIN EN 50341-1 (VDE 0210-1):2013-11, 4.3 to 4.6;

Q_{CK} conductor horizontal tensile force;

γ_G; γ_W; γ_I; γ_C partial factors; these factors shall be assumed as 1,35 in case of normal load cases and 1,0 in case of exceptional load cases.

In case of mechanical rating the material partial factors according to Table 10/DE.1 shall be considered.

Table 10/DE.1 – Material partial factors for insulators (related to the mechanical failing load)

Type of insulator	**Material partial factor** γ_M
Cap and pin insulators	2,3
Long rod insulators	2,3
Solid core insulators	2,3
Line post insulators and overhead line posts	1,85
Insulators for stay wires	1,85
NOTE So far stipulated otherwise by the purchaser, the rated failing load of composite suspension and composite dead-end insulators can be obtained from the routine testing force divided by 0,8.	

10.7 DE.2 Line post insulators

(ncpt) Line post insulators may only be used at suspension poles or at angle suspension poles, however, not for section poles.

10.7 DE.3 Multiple insulator sets

(ncpt) Multiple insulator sets comprise two or more insulator strings. The permissible load of an insulator set comprising *n* strings may be taken at maximum as *n*-times the permissible load of an individual insulator string. In this case a distribution of the total load as uniformly as possible on the individual insulator strings shall be ensured.

In case of failing of a string of a multiple insulator string

- any expected internal dynamic forces and bending moments shall be duly counteracted to avoid failure of the remaining strings;
- a distribution of the total load as equally as possible over the remaining insulator strings shall be guaranteed.

NOTE The rating of the insulators in the remaining insulator strings of a multiple insulator set in case of failure of an insulator string is covered by the rating for the normal load case.

In this case the loads according to load case L defined in 4.12.2/DE.1 shall be assumed.

10.9 Material selection and specification

10.9 DE.1 Materials and design

(ncpt) Materials and design of non-standard insulators shall be selected such that they withstand atmospheric effects. In case of non-standard insulators their properties and their suitability for the given application shall be approved individually.

10.10 Characteristics and dimensions of insulators

10.10 DE.1 Characteristics and dimensions of insulators

(ncpt) Characteristic values and dimensions of line post insulators and insulators for strain insulator sets shall be specified by the line operator in a project specification based on the loads and partial factors as specified in this standard.

11 Hardware

11.1 Introduction

11.1 DE.1 Other line accessories

(ncpt) The stipulations for the fittings of insulator sets apply as well to other conductor accessories with regard to the definition 2.2/DE.6.2. Components for bird protection shall be tested in accordance with the requirements of DIN VDE V 0212-490 (VDE V 0212-490).

11.2 Electrical requirements

11.2.1 Requirements applicable to all fittings

11.2.1 DE.1 Accessories for insulator sets

(ncpt) Accessories for insulator sets shall withstand the short-circuit loading to be expected and shall not assume a temperature in case of the maximum expected short-circuit loading which could lead to an inadmissible reduction of the mechanical strength.

NOTE For the rating of accessories made of structural steel according to DIN EN 10025 and/or heat-treatable steel according to DIN EN 10083-2 the specific current densities

– 70 A/mm^2 for mechanically tensile loaded fittings and
– 80 A/mm^2 for mechanically not tensile loaded fittings

are acceptable under the assumption of an initial temperature of 35 °C and a short-circuit period of 1 s.

11.2.2 Requirements applicable to current carrying fittings

11.2.2 **DE.1 Requirements applicable to current carrying fittings**

(ncpt) Fittings carrying the current shall be selected such that

– under the impact of the maximum permissible conductor current no higher temperatures are assumed as the conductors themselves;

– under the maximum permissible permanent current and the maximum short-circuit load to be expected no temperatures will be reached, which would lead to an inadmissible reduction of accessories´ mechanical resistance.

NOTE The initial temperature of fittings results from the conductor temperature and/or the operational current.

11.6 Mechanical requirements

11.6 **DE.1 Mechanical rating**

(ncpt) Stipulations for the mechanical rating of conductor fittings, other conductor fittings and fittings for insulator sets are:

For strain insulator sets the maximum load by the conductor tensile force shall be assumed as normal load cases at

– –20 °C without ice load or

– –5 °C with ice load according to 4.5.2/DE.1 or

– –5 °C with ice load combined with wind load according to 4.6.6.1/DE.1 or

– +5 °C with wind load according to 4.4.2/DE.1.

For suspension insulator sets the resulting force from

– conductor dead weight, ice load, combined wind and ice load and, if any, the resultant from the horizontal conductor tensile forces or

– conductor dead weight, wind action, and if any, the resultant from the horizontal conductor tensile forces

shall be assumed as normal load case and the resulting force from

– conductor dead weight, ice load and unbalanced part of the horizontal conductor tensile forces

as exceptional load case.

The design force is

$$E_{\mathrm{d}} = f\ \{\gamma_{\mathrm{G}} G_{\mathrm{K}};\ \gamma_{\mathrm{W}} Q_{\mathrm{WK}};\ \gamma_{\mathrm{I}} Q_{\mathrm{IK}};\ \gamma_{\mathrm{C}} Q_{\mathrm{CK}}\},$$

where

E_d	total loading;
G_K	permanent loads according to DIN EN 50341-1 (VDE 0210-1):2013-11, 4.2;
Q_{WK} , Q_{IK}	variable loads according to DIN EN 50341-1 (VDE 0210-1):2013-11, 4.3 to 4.6;
Q_{CK}	horizontal conductor tensile forces;
γ_G; γ_W; γ_I; γ_C	partial factors; these shall be assumed as 1,35 at normal load cases and as 1,0 at exceptional load cases.

At normal and exceptional load cases the design force E_d shall not exceed the specified minimum damage load (SMDL, according to DIN EN 61284) of suspension clamps, tension clamps as well as other conductor attachments and fittings for insulator sets, such that no inadmissible permanent deformation occurs. For fittings for insulator sets according to the DIN VDE 0212 standard series no verification is necessary.

The specified minimum failing load SMFL of a conductor fitting, of other conductor attachments or of a fitting for insulator sets shall at least correspond to the design load E_d multiplied by the material partial factor γ_M = 2,4.

11.6 **DE.2 Arcing and potential grading fittings**

(ncpt) Arcing and potential grading fittings may not be loaded mechanically.

11.6 **DE.3 Retention forces of conductor connections, tension clamps and suspension clamps loaded by tensile forces**

(ncpt) Conductor connectors and dead-end clamps being tensile loaded shall sustain the conductor with 1,55 times the tensile forces in case of maximum load according to 9.6.2/DE.1 or by 0,85 times of 95 % of its rated tensile force. The lower value is decisive in each case.

Suspension clamps shall sustain the conductor with the tensile forces according to 4.12.2/DE.1. This does not apply to suspension clamps which should enable the conductor to slide.

11.6 **DE.4 Multiple insulator sets**

(ncpt) Fittings for multiple insulator sets shall guarantee an as equal as possible distribution of forces on the individual insulator strings.

Failing of an insulator string is treated as an exceptional load case.

In case of failure of a string of a multiple insulator set

- control of occurring conductor dynamical forces and moments shall be guaranteed,
- an as equal as possible distribution of the total forces on the remaining insulator strings shall be guaranteed,
- an exceeding of the SMDL of conductor fittings, of other conductor attachments and of the fittings for insulator sets is permissible.

NOTE The required residual resistance of fittings in the remaining insulator strings of a multiple insulator set after failure of an insulator string is covered by rating for the normal load cases.

11.6 DE.5 Verification of restraining forces, the specified minimum damage load SMDL and the specified minimum failing load SMFL of tensile and suspension clamps

(ncpt) According to DIN EN 61284 the specified minimum failing load SMFL of wedge-type dead-end clamps shall be demonstrated by tests with corresponding steel ropes instead of the conductor for which the clamp will be used. The specified minimum failing load SMFL of the bodies of compression-type tensile clamps can be demonstrated by calculation with adequate methods. During testing, also the specified minimum damage load SMDL shall be verified. The retention force and the specified minimum failing load SMFL of suspension clamps can be demonstrated according to DIN EN 61284.

12 Quality assurance, checks and taking-over

DIN EN 50341-1 (VDE 0210-1):2013-11 applies without any amendments.

Annex G
(normative)

Calculation methods for earthing systems

G.4 Touch voltage and body current

G.4.1 Equivalence between touch voltage and body current

G.4.1 **DE.1** **Body impedance Z_B depending of the touch voltage U_T**

(ncpt) DIN EN 50341-1 (VDE 0210-1):2013-11, Table G.5 shall be replaced by Table B.2 of DIN EN 50522 (VDE 0101-2).

G.4.1 **DE.2** **Relation between duration of failure t_F and touch voltage U_{TP}**

(ncpt) DIN EN 50341-1 (VDE 0210-1):2013-11, Table G.6 shall be replaced by Table B.3 of DIN EN 50522 (VDE 0101-2).

Annex J
(normative)
Angles in lattice steel towers

J.2 General

J.2 DE.1 General

(ncpt) The calculation method described in this Annex J applies to angle and U-sections within lattice steel towers with bolt and rivet connections.

The tensile strength of angle sections, which are connected by one leg only, shall be calculated according to J.3/DE.1 and J.3/DE.2.

The buckling strength of compression loaded members of lattice steel towers shall be calculated according to J.4.1/DE.1, J.4.1/DE.2, J.4.1/DE.3 and J.4.1/DE.4.

Bolt and rivet connections shall be rated according to J.5/DE.1.

J.3 Tensile resistance of angles connected through one leg

J.3 DE.1 Calculation of the net cross section

(ncpt) The net cross section of a tensile loaded angle section or part of it is the smallest value which results from differing possible failure lines and shall be calculated from

$A_{net} = A - \Delta A$,

where

A_{net} net cross section;

A cross section along the studied failing line;

ΔA sum of all borehole areas within the studied failure line.

J.3 DE.2 Tensile strength of angle sections

(ncpt) For tensile loaded angle sections the design tensile force N_{Sd} may not exceed the strength $N_{u,Rd}$:

1) Angle sections with two connected legs

$$N_{Sd} \le N_{u,Rd} = \eta_i \times 0{,}9 \times A_{net} \frac{f_u}{\gamma_{M2}}$$

2) Angle sections with only one leg connected by only one bolt (DIN EN 50341-1 (VDE 0210-1):2013-11, Figure J.1)

$$N_{Sd} \le N_{u,Rd} = \eta_i \times \left(b_1 - d_0\right) t \frac{f_u}{\gamma_{M2}}$$

3) Angle sections with one leg connected by several bolts (DIN EN 50341-1 (VDE 0210-1):2013-11, Figure J.1)

$$N_{Sd} \le N_{u,Rd} = \eta_i \times \left(b_1 - d_0 + \frac{b_2}{2}\right) t \frac{f_u}{\gamma_{M2}}$$

where

η_i = 0,9 reduction factor.

J.4 Buckling resistance of angles in compression

J.4.1 Flexural buckling resistance

J.4.1 **DE.1 Rating of compression members**

(ncpt) In Germany the rating is carried out in accordance with DIN EN 50341-1 (VDE 0210-1):2013-11, J.4 and DIN EN 1993-1-1:2005. An additional loading test is not required.

J.4.1 **DE.2 Flexural buckling**

(ncpt) The method given in DIN EN 50341-1 (VDE 0210-1):2013-11, J.4.1 applies.

The following condition shall be met:

$$\frac{N_{\mathrm{Ed}}}{N_{\mathrm{Rd}}} \leq 1$$

The partial factor shall be assumed as $\gamma_{\mathrm{M1}} = 1{,}1$ and the imperfection factor by α = 0,49, corresponding to the buckling curve c.

J.4.1 **DE.3 Torsional flexural buckling**

(ncpt) The slenderness ratio for torsional flexural buckling shall be calculated by an approved method and then used when calculating the reduction factor χ, as explained in DIN EN 50341-1 (VDE 0210-1):2013-11, J.4.1. For isosceles angle sections the slenderness ratio may be calculated approximately according to the formula

$$\overline{\lambda}_p = \frac{5}{\pi}\frac{b}{t}\sqrt{\frac{f_y}{E}\frac{A_{\mathrm{eff}}}{A}}\ .$$

J.4.1 **DE.4 Torsional buckling**

(ncpt) For profiles with cruciform cross sections the torsional buckling shall be considered. For this type of sections the slenderness ratio may be calculated approximately by the formula

$$\overline{\lambda} = 1{,}61\sqrt{\frac{I_{\mathrm{P}}}{I_{\mathrm{T}}}\frac{f_{\mathrm{y}}}{E}\frac{A_{\mathrm{eff}}}{A}}\ ,$$

where

I_{P} polar moment of inertia;

I_{T} St. Venant torsional moment of inertia.

J.4.3 Slenderness of members

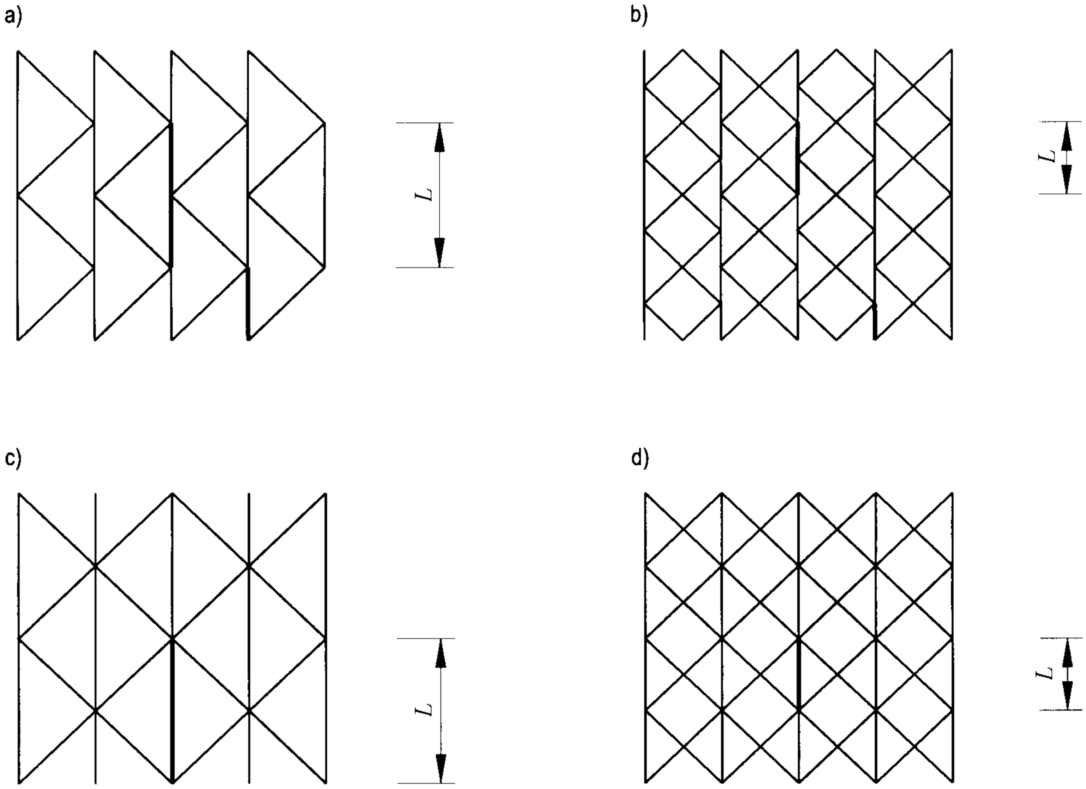
J.4.3.2 Leg members and chords

J.4.3.2 **DE.1 Buckling lengths and slenderness ratio of leg members**

(ncpt) If the bracing members are arranged staggered according to Figure J.4/DE.1, a) or b), the buckling length may be assumed as equal to the geometrical member length L if the slenderness ratio $\lambda = L/i_{yy}$ does not exceed 80. If $\lambda > 80$, the buckling length may only be assumed as the single member length L, if the member forces increase from top downwards and the member lengths in the upper part of the tower or tower section are not more than in the lower part. If these conditions are not met in the case λ > 80 the buckling length shall be assumed as 1,1 times the member length L and, therefore, $\lambda = 1{,}1L/i_{yy}$ applies.

If the diagonal bracings are not arranged staggered as shown in Figures J.4/DE.1, c) or d), the buckling length shall be assumed as the geometrical member length L and the slenderness ratio shall be assumed as $\lambda = L/i_{vv}$.

It shall be dealt with analogously in case of the lower chords of crossarms.



Case a) and b): $\lambda = L/i_{yy}$ or $\lambda = 1{,}1\,L/i_{yy}$ according to J.4.3.2/DE.1

Case c) and d): $\lambda = L/i_{vv}$

Figure J.4/DE.1 – Slenderness ratio λ of leg members

J.4.3.3 Primary bracing pattern

J.4.3.3.1 General

J.4.3.3.1 **DE.1 General**

(ncpt) Typical primary bracing arrangements are shown in Figure J.4/DE.2. Secondary bracings may be used to divide the primary bracing and leg members as shown in Figure J.4/DE.3.

It is proven practice to limit the slenderness ratio in case of primary diagonal members to 200 and of secondary bracing members to 240.

Bracing members usually consist of one section only. For compound members reference is made to DIN EN 50341-1 (VDE 0210-1):2013-11, J.4.3.4.

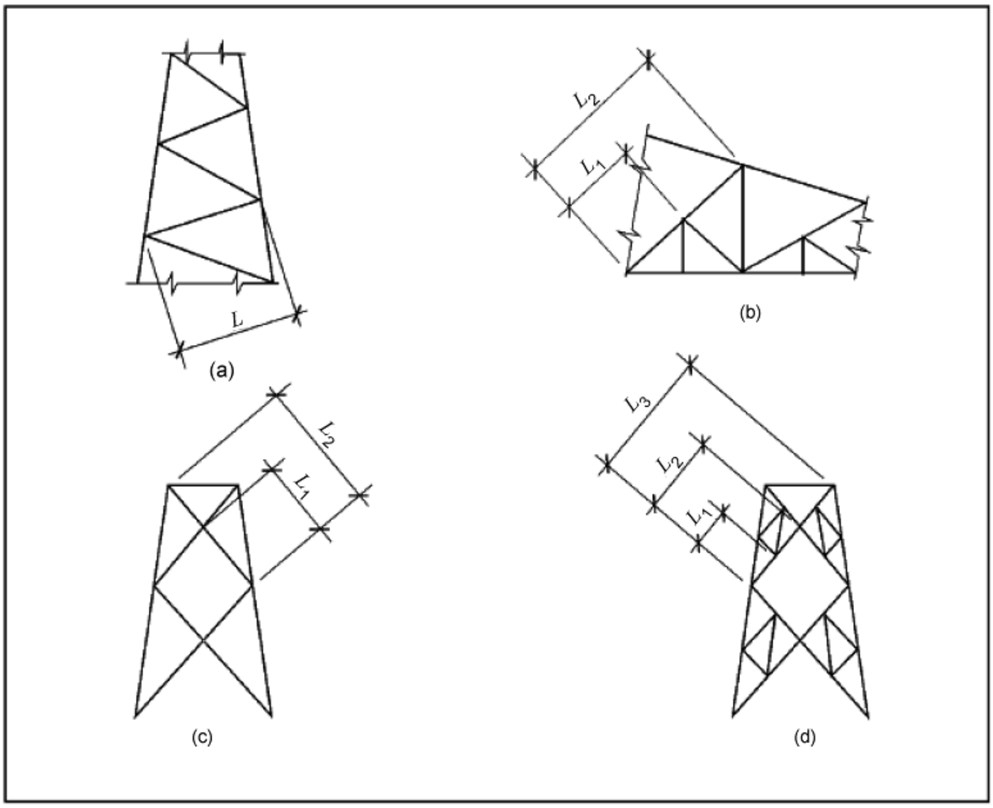


Figure J.4/DE.2 – Usual diagonal bracings

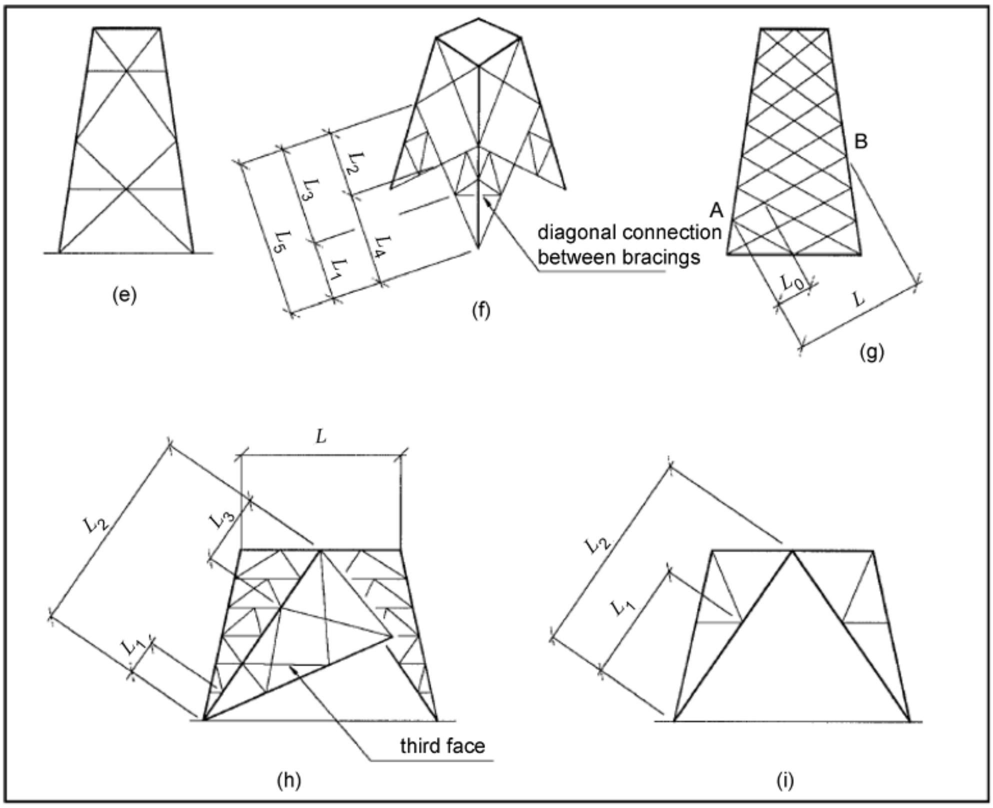


Figure J.4/DE.3 – Application of secondary and spatial bracing systems

J.4.3.3.2 Single lattice

J.4.3.3.2 **DE.1 Single warren diagonals**

(ncpt) A bracing with single warren diagonals is usually adopted, when the load is low and the lengths are relatively short, for example at the tower peak (see Figure J.4/DE.2 (a)). The slenderness ratio is then obtained from

$$\lambda = \eta \times \frac{L}{i_{\text{vv}}}$$

In case of the Figure J.4/DE.2 (b) ii applies to angle sections

$$\lambda_1 = \eta \times \frac{L_1}{i_{\text{vv}}} \text{ and } \lambda_2 = \eta \times \frac{L_2}{i_{\text{yy}}}$$

The reduction factor η is defined in J.4.3.3.3/DE.5.

J.4.3.3.3 Cross bracing

J.4.3.3.3 **DE.1 Maximum value of λ_1 and λ_2**

(ncpt) There, two slenderness ratios shall be determined:

1) λ_1 according to J.4.3.3.3/DE.2;
2) λ_2 according to J.4.3.3.3/DE.3.

The higher of both values is decisive.

The reduction factor η used in the following formulae for λ is defined in J.4.3.3.3/DE.5.

J.4.3.3.3 **DE.2 Buckling within the framework plane**

(ncpt) Under the condition that both members run through without a joint (see Figure J.4/DE.2 (c)) and are connected by at least one bolt, their point of intersection can be assumed as a fixed point within the diagonal plane. The buckling length is, therefore, ηL_1 and the slenderness ratio shall be assumed as

$$\lambda_1 = \eta \times \frac{L_1}{i_{\text{vv}}}$$

J.4.3.3.3 **DE.3 Buckling out of the framework plane**

(ncpt) Restraining of displacement perpendicularly to the framework plane depends on the relation $\frac{|S_\text{d}|}{|N_\text{d}|}$,

where,

S_d force in the supporting member (tension or compression),

N_d force in the compression member.

In case of calculation of the slenderness ratio λ_2 three cases shall be distinguished:

1) S_d is a tensile force and $\frac{|S_\text{d}|}{|N_\text{d}|} \geq \frac{2}{3}$

$$\lambda_2 = \lambda_1 = \eta \times \frac{L_1}{i_{\text{vv}}} \text{ (the intersection point is a fixed point)}$$

2) S_d is a tensile force and $\frac{|S_d|}{|N_d|} < \frac{2}{3}$

$$\lambda_2 = \eta \times \frac{L_1}{i_{yy}} \sqrt{2 - 1{,}5\ \frac{|S_d|}{|N_d|}}$$

3) S_d is a compression force and $|S_d| < |N_d|$

$$\lambda_2 = \eta \times \frac{L_1}{i_{yy}} \sqrt{2 + 2{,}0\ \frac{|S_d|}{|N_d|}} \qquad \text{with } \lambda_2 \le \frac{L_2}{i_{yy}}$$

J.4.3.3.3 **DE.4 Crossed diagonals with redundant members**

(ncpt) 1) If redundant members are provided in order to stabilise the leg members (see Figure J.4/DE.2 (d)), these members reduce the buckling length related to the weak axis (i_{vv}) to L_1 In this case the slenderness ratio shall be assumed as

$$\lambda_1 = \eta \times \frac{L_1}{i_{vv}}.$$

2) Buckling shall also be verified using the buckling length L_2 related to the axis i_{yy} concerning the buckling perpendicularly to the frame work plane:

$$\lambda_2 = \eta \times \frac{L_2}{i_{yy}}.$$

The value λ_2 shall be multiplied by an adequate factor depending on $\frac{|S_d|}{|N_d|}$ according to J.4.3.3.3/DE.3.

3) The slenderness of the total length of diagonal L_3 (see Figure J.4/DE.2 (d)) for buckling perpendicularly to the yy-axis may not exceed 350.

J.4.3.3.3 **DE.5 Reduction factor η used in the formulae for λ**

(ncpt) In case of single or double warren diagonals the value η = 0,9 may be assumed within the formula for λ, if

– the member ends are fixed rigidly and

– the member ends are sufficiently clamped and

– the cross-sectional area is less than that of the leg members.

A sufficient clamping is given for example if leg members and diagonals consist of angle sections.

For crossed diagonals with redundant members the value η = 0,9 may be adopted in the formulae for λ, if

– the three conditions mentioned above are complied with and

– the redundant members support the member at third points and

– the crossing point is fixed by a stabilizing third diaphragm which does not lie within the face plane.

If these conditions are not met, then η = 1 applies.

J.4.3.3.8 K-bracing

J.4.3.3.8 **DE.1 Slenderness ratios**

(ncpt) The reduction factor η used in the following formulae for λ is defined in J.4.3.3.8/DE.2 and J.4.3.3.8/DE.3.

The length L_1 refers to the buckling length for buckling perpendicularly to the weak axis (i_{vv}). The slenderness ratio shall be assumed as follows:

$$\lambda_1 = \eta \times \frac{L_1}{i_{vv}}$$

Buckling with a buckling length L_2 perpendicularly to the bracing of the face shall be checked if no third face (see Figure J.4/DE.3 (h)) is available. Under consideration of the relevant radius of intertia the slenderness ratio shall be assumed as:

$$\lambda_2 = \eta \times \frac{L_2}{i_{yy}} \text{ or } \lambda_2 = \eta \times \frac{L_2}{i_{zz}}.$$

If a third face with diagonal triangular bracing is provided, the length of L_3 between the fixing points of the redundant members is used for testing of buckling perpendicularly to the tower face. Under consideration of the relevant radius of inertia the slenderness ratio shall be assumed as:

$$\lambda_3 = \eta \times \frac{L_3}{i_{yy}} \text{ or } \lambda_3 = \eta \times \frac{L_3}{i_{zz}}$$

J.4.3.3.8 **DE.2 Reduction factor η in case of K-framework without redundant members**

(ncpt) In this case the value η = 0,9 may be assumed in the formulae for λ, if the first three conditions specified in J.4.3.3.3/DE.5 are met.

If these conditions are not met, then η = 1 shall be assumed.

J.4.3.3.8 **DE.3 Reduction factor η in case of K-framework with redundant members**

(ncpt) In this case the value η = 0,9 may be assumed in the formulae for λ, if all six conditions of J.4.3.3.3/DE.5 are met.

If these conditions are not met, then η = 1 shall be assumed.

J.4.3.4 Compound members

J.4.3.4.3. Design

J.4.3.4.3 **DE.1 Distance between batten plate**

(ncpt) In case of arrangement of batten plates according to the lower Figure in DIN EN 50341-1 (VDE 0210-1):2013-11, Figure J.5, the value c mentioned there may be divided in half.

J.4.4 Secondary (or redundant) bracing members

J.4.4 **DE.1 Hypothetical force**

(ncpt) In order to design redundant members it is necessary to introduce a hypothetical force F_h acting transversally to the supported main member at each node of the connection of a redundant member. The resulting member forces from this loading need not to be added to the existing member forces within the structural system.

The hypothetical force is assumed by a value F_h= N/50 at each node and acting within the tower face. There, N means the longitudinal force of the supported main member.

J.5 Design resistance of bolted connections

J.5.1 General

J.5.1 **DE.1 Strength in case of bearing**

(ncpt) The bearing resistance $F_{b, Rd}$ calculated according to DIN EN 50341-1 (VDE 0210-1):2013-11, Table J.3 shall be reduced by the factor 0,80.

Annex M
(informative)

Geotechnical and structural design of foundations

M.3 Sample semi-empirical models for resistance estimation

M.3.1 Geotechnical design by calculation

M.3.1.1 General

M.3.1.1 **DE.1 General**

(ncpt) Typical values of the specific weight are 22 kN/m^3 for not reinforced concrete and 24 kN/m^3 for reinforced concrete.

In general, the geotechnical design and the determination of the internal forces are carried out with the design values of foundation loads obtained from the tower analysis.

In case of verification using the design values the dead weight of the foundation body and the soil dead weight shall be increased by the partial factor γ_F = 1,35.

M.3.1.2 Monoblock foundations

M.3.1.2 **DE.1 Monoblock foundations**

(ncpt) When using design procedures considering lateral fixing, which are based on tests (e. g. Sulzberger or Bürklin) the characteristical values (design values divided by 1,35) shall be used for the loads and the soil pressures. The inclination of the foundation shall not exceed 1 % in this case. If the moment of resistance due to lateral earth pressure exceeds the moment of resistance due to the pressure on the base area of the foundation the theoretical verification of the stability with the factor 1,0 is sufficient. The decreasing portion of the lateral withstand resistance on the total resistance of the foundation requires the increasing of stability values, which shall reach the value 1,5 if the lateral resistance of the soil is approaching zero.

M.3.1.3 Slab foundations

M.3.1.3 **DE.1 Slab foundations**

(ncpt) The dead weight of the foundation body and the vertical load component of the soil shall be increased by the partial factor γ_F = 1,35.

M.3.1.4 Grillage-typ slab foundations

M.3.1.4 **DE.1 Single grillage foundations**

(ncpt) The dead weight of the foundation body and the vertical load component of the soil shall be increased by the partial safety factor γ_F = 1,35.

M.3.1.5 Single-pile foundations

M.3.1.5 **DE.1 Single-pile foundations**

(ncpt) If the verification is carried out by calculation with data gained from experience and from soil investigations DIN EN 1997-1:2009-09, 7.7, and the supplementing rules according to DIN 1054:2010-12 shall be adopted.

The dead weight of the foundation body and of the soil which acts vertically above the foundation base shall be increased by the partial factor γ_F = 1,35.

M.3.1.6 Separate stepped block foundations, pad and chimney foundations

M.3.1.6 **DE.1 Stability conditions in case of loading by compression**

(ncpt) The dead weight of the foundation body and the vertical acting soil weight shall be increased by the partial factor γ_F = 1,35.

M.3.1.6 **DE.2 Additional conditions**

(ncpt) For calculation the component G the dead weight of the foundation body and of the soil which lies situated vertically above the foundation basis shall be increased by the partial factor γ_F =1,35.

For the vertical component of the tensile force Z, which acts on the foundation the design values obtained from the tower analysis shall be assumed.

M.3.1.9 Pile foundations

M.3.1.9 **DE.1 Buckling stability**

(ncpt) NOTE 1 As a rule, no verification of the buckling stability is required, if the piles are surrounded by a soil with a representative shearing strength in a condition within a value of c_u > 10 kPa. In case of micro piles and small injection piles buckling may also occur in case of soil characterized by an undrained shearing strength of c_u > 10 kPa.

M.3.2 Structural design of concrete foundations

M.3.2 **DE.1 Design procedure**

(ncpt) The civil engineering design is based on limit design loads. The design values resulting from the analysis of the support shall be used. In case of unfavourable (load increasing) action of the dead weight of the foundation body and the loading to the soil shall be multiplied by the partial factor γ_F =1,35. In case of favourable (load reducing) action, for example in case of punching verification of foundations loaded by tensile forces the dead weight of the foundation body and the load of the soil acting vertically may only be multiplied by the partial factor γ_F = 1,0.

M.3.2 **DE.2 Minimum reinforcement**

(ncpt) The required minimum reinforcement according to DIN EN 1992-1-1:2011-01 and DIN EN 1992-1-1/NA:2013-04, 9.2.1.1, may be waived in case of foundations without external loading constraints, if the internal forces according to DIN EN 1992-1-1:2011-01, 5.4, are calculated and all verifications of limit states are complied with.

Annex AA
(informative)

Assumptions for ice loads

The informative ice load zone map according to Figure AA.1 considers meteorological information on the basis of measured ice load data available in Germany nowadays and their statistical evaluation and the dependency on the altitudes of the terrain. Ice load events and observations made during the long-term line operation and load assumptions applied successfully by the line operators over long periods were considered as well. In the informative ice load zone map the borders of the ice load zones E1, E2 and E3 are depicted.

Ice load zone E1, in general, comprises areas with altitudes less than 400 m.

Ice load zone E2, in general, comprises areas with altitudes between 400 m and 600 m.

Ice load zone E3, in general, comprises areas with altitudes between 600 m and 750 m.

The ice load zone E4 is included in the presentation of ice load zone E3. Ice load zone E4 comprises especially areas with altitudes above 750 m. The quantity of ice loads within the ice load zone E4 should be stipulated on the basis of experience of the line operator or by a special expertise, whereby the assumptions according to 4.5.2/DE.1 should be considered.

The decisive altitude of the terrain may be determined by averaging of the altitudes within the line section in question.

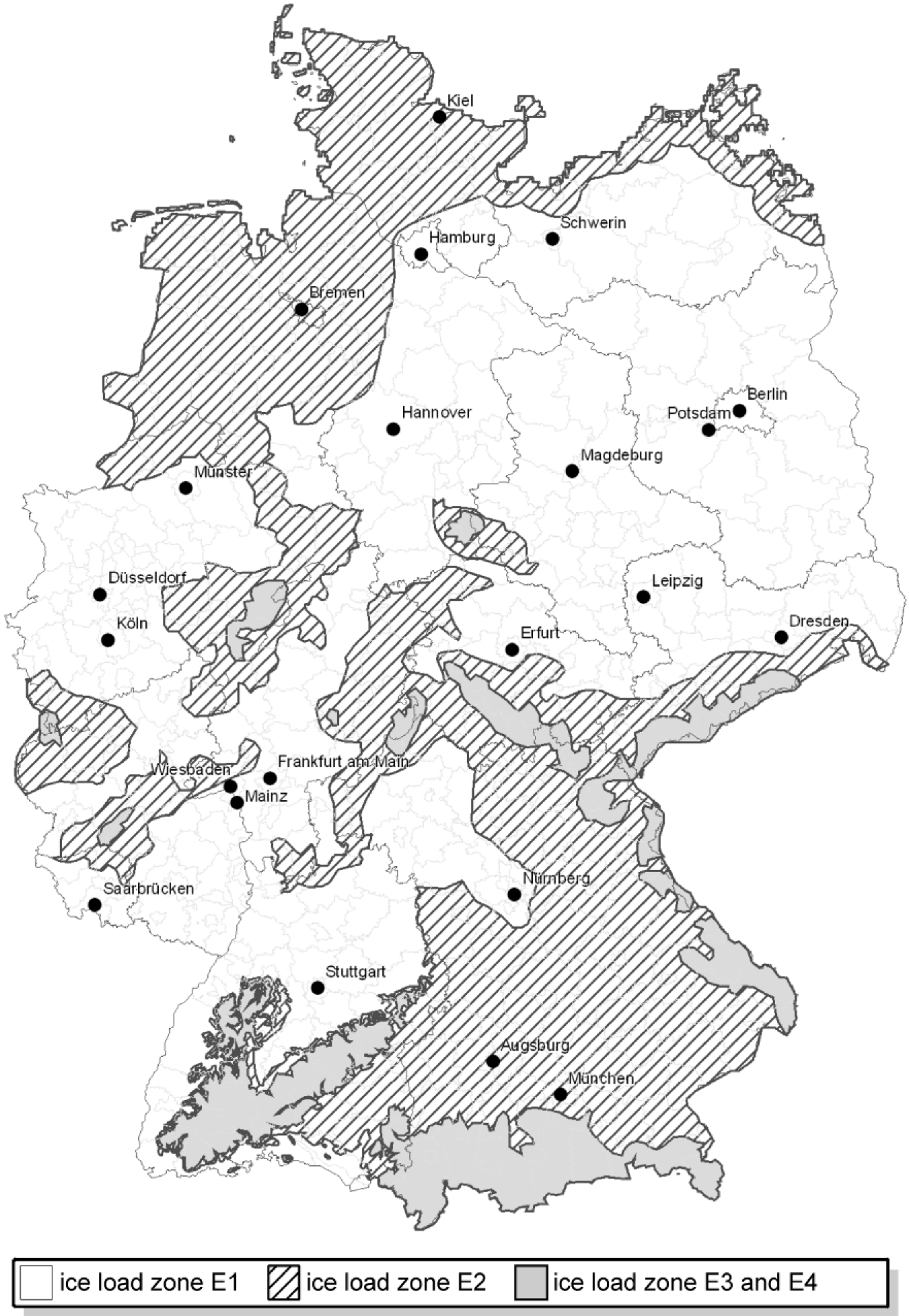
Protected and exposed sites may lead to a deviation by one ice load zone in respect to the recommendation of the ice load zone map.

Indications for protected and exposed sites may be derived, among other things, by consideration of the relative terrain altitude and the wind velocities.

Due to the higher mean altitudes and the positive operator experience in the Southwest of Germany, it can be stipulated that

– areas with altitudes below 500 m belong usually to ice load zone E1,
– areas with altitudes between 500 m and 650 m belong usually to ice load zone E2,
– areas with altitudes between 650 m and 800 m belong usually to ice load zone E3,
– areas with altitudes above 800 m belong usually to ice load zone E4.

These assignments of ice load zones in Southwest Germany were considered in the informative ice load zone map, Figure AA.1.



NOTE The basics for this ice load zone map are et al. explained in the publications: Elektrizitätswirtschaft 107(2008), No. 9; Elektrizitätswirtschaft 108(2009), No. 9; Elektrizitätswirtschaft 108(2009), No. 10 and Elektrische Bahnen 108(2010), No. 4

Figure AA.1 – Ice load zone map for the German Federal Republic (informative)

Literature

DIN EN 61773 (VDE 0210-20):1997-08, Overhead power lines – Testing of foundations for structures (IEC 61773:1996).
Freileitungen – Prüfung von Tragwerksgründungen (IEC 61773:1996), Deutsche Fassung EN 1773:1996

DIN EN 10083-2:2006-10, Steels for quenching and tempering – Part 2: Technical delivery conditions for non alloy steels; German version EN 10083-2:2006.
Vergütungsstähle – Teil 2: Technische Lieferbedingungen für unlegierte Stähle; Deutsche Fassung EN 0083-2:2006

DIN EN 10025 (all parts): Hot rolled products of structural steels
Warmgewalzte Erzeugnisse aus Baustählen

Kießling, F.; Pietschke, M.; Schmidt, B.:
Neue Windlastannahmen für Freileitungen,
en: New wind load assumptions for overhead lines,
in Elektrizitätswirtschaft 107(2008) No. 9, pp.18 to 23.

Kießling, F.; Wichura, B.:
Eislasten an Freileitungen, meteorologische Vorhersagegen und Beobachtungen an Leitungen,
en: Ice loads on overhead power lines, meteorological pre-casts and observations at lines,
in Elektrizitätswirtschaft 108(2009) No. 9, pp. 54 to 60.

Kießling, F.: Lenkenhoff, N.:
Erstellen einer Eislastzonenkarte,
en: Drafting of an ice load map,
in Elektrizitätswirtschaft 108(2009) No. 10, pp.62 to 65.

Fundinger, N.: Kießling. F.: Lenkenhoff, N.; Schmidt, B.:
Eislasten an Freileitungen, neue Eislastzonenkarte für Deutschland,
en: Ice loads on overhead lines, new ice load map for Germany,
in Elektrische Bahnen 108(2010) No. 4, pp. 158 to 163.

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