Polski Komitet Normalizacyjny

POPRAWKA do POLSKIEJ NORMY

ICS 29.240.20;

PN-EN 50341-3:2002/AC

kwiecień 2009

Wprowadza
EN 50341-3:2001/AC:2009, IDT

Dotyczy
PN-EN 50341-3:2002

Elektroenergetyczne linie napowietrzne prądu przemiennego powyżej 45 kV -- Część 3: Zbiór normatywnych warunków krajowych

Na wniosek Komitetu Technicznego nr 80
ds. Ogólnych w Sieciach Elektroenergetycznych
Poprawka do Normy Europejskiej EN 50341-3:2001/AC:2009 Overhead electrical lines exceeding AC 45 kV - Part 3: Set of National Normative Aspects
ma status Poprawki do Polskiej Normy

nr ref. PN-EN 50341-3:2002/AC:2009

Corrigendum to EN 50341-3:2001

English version

NOTE This corrigendum applies in addition to the corrigenda of April 2006 and October 2006.

Add the Index of National Normative Aspects after the foreword of this Part 3.
Part 2 is hereby withdrawn.

This corrigendum relates to the following specific parts of EN 50341-3:

Part 3-1	Austria	Replacement of pages 25 and 26, addition of new pages 27 through 35 (resulting in renumbering of existing pages from 27 on)
Part 3-16	Norway	Full replacement
Part 3-18	Sweden	Replacement of page 38
Part 3-22	Poland	Additional part

February 2009

Index of National Normative Aspects

Reference	Country		Valid version in
	Code	Name	
EN 50341-3-1	AT	Austria	EN 50341-3:2001 modified by Corr. April 2006 + Corr. February 2009
EN 50341-3-2	BE	Belgium	EN 50341-3:2001
EN 50341-3-3	CH	Switzerland	EN 50341-3:2001
EN 50341-3-4	DE	Germany	Replaced by Corr. April 2006
EN 50341-3-5	DK	Denmark	EN 50341-3:2001
EN 50341-3-6	ES	Spain	EN 50341-3:2001
EN 50341-3-7	FI	Finland	Replaced by Corr. April 2006
EN 50341-3-8	FR	France	EN 50341-3:2001
EN 50341-3-9	GB	Great Britain and Northern Ireland	Replaced by Corr. April 2006
EN 50341-3-10	GR	Greece	EN 50341-3:2001
EN 50341-3-11	IE	Ireland	EN 50341-3:2001
EN 50341-3-12	IS	Iceland	EN 50341-3:2001
EN 50341-3-13	IT	Italy	EN 50341-3:2001
--	LU	Luxembourg	No NNA
EN 50341-3-15	NL	Netherlands	EN 50341-3:2001 modified by Corr. April 2006
EN 50341-3-16	NO	Norway	Replaced by Corr. February 2009
EN 50341-3-17	PT	Portugal	EN 50341-3:2001

Reference	Country		Valid version in
	Code	Name	
EN 50341-3-18	SE	Sweden	Replaced by Corr. April 2006, modified by Corr. February 2009
EN 50341-3-19	CZ	Czech Republic	Replaced by Corr. April 2006
EN 50341-3-20	EE	Estonia	Added by Corr. October 2006
--	SI	Slovenia	No NNA
EN 50341-3-22	PL	Poland	Added by Corr. February 2009
--	MT	Malta	No NNA
--	HU	Hungary	No NNA
--	SK	Slovakia	No NNA
--	LT	Lithuania	No NNA

EN 50341-3-1:2001/corrigendum February 2009

National Normative Aspects for Austria

Replace pages 25 and 26 by the following and insert new pages 27 through 35:

Clause National regulation

5.4.4 Clearances to ground in areas remote from buildings, roads, railways and navigable waterways

(A-dev) **AT.1** : **Clearances to ground in unobstructed countryside** (expression in German: „Geländeoberfläche"): the following applies:

additional requirements: none .

Clearances between conductors and the ground are to be measured right-angled to the surface of the ground. Minor unevenness in the ground may be ignored here.

Clearance of conductors	Values in metres	II	III	IV
(1) under normal conditions				
(1.1) above normal ground		6	7	8
(1.2) above ground inaccessible to heavy road vehicles carrying high loads		5	6	7
(1.3) above steeply sloping ground, normally not frequented		4	5	6
(1.4) from rock faces, laterally measured rectangular to rock face		3,5	4	5
(2) under exceptional loading conditions in cases (1.1)...(1.4)		3,5	4	5

(A-dev) **AT.3** : **Clearances to trees under the line and to trees beside the line (Forest aisles and isolated trees and shrubs),** the following applies:

additional requirements: none .

Lines of Groups II...IV should not become endangered through windbreaks, windfalls, timberwork, snow pressure on tree trunks or branches, etc. The height to which trees will grow until ready for harvesting, the nature of the soil, breakdown of the tree population, and the prevailing wind directions shall be taken into account.
The following minimum clearances may not be fallen short of. They apply to the branch-free space, i.e. these minimum clearances may not be violated by treetops or branches either. Should the safety of operational of the line so require, these clearances are to be increased as necessary (diseased, hanging, or shallow-rooting trees, on steep slopes or where there is a risk of landslide, etc.).

Minimum Clearances	Values in metres	II	III	IV
(1) laterally of the conductor		4	5	6
(2) below the conductor				
(2.1) under normal loading conditions		4	5	6
(2.2) under exceptional loading conditions		0,8	1,5	2,5

The Protective Zone determined by the lateral clearance according to (1) is to be kept free of branches above the conductor to the full height of the tree.

Clause National regulation

5.4.5.2 Clearances to residential and other buildings

(A-dev) **AT.1** : If the stipulated lateral clearances between overhead HV-lines and any of the facilities specified below being violated with the result that a conductor runs within the Protective Zone (subclause 2.1/AT.4) of a facility, then shortfalls of the clearances indicated in relevant subclauses of 5.4.5.2 may not be tolerated.

(A-dev) **AT.2** : for **buildings** other than residential and school buildings, industrial or trading complexes, and similar: additional requirements: none .
Clearances as from 5.4.5.2/AT.4 below apply.

(A-dev) **AT.3** : for **residential and school buildings, industrial or trading complexes, and similar**: Measures for „Enhanced Safety" apply.
Clearances as from 5.4.5.2/AT.4 below apply.

(A-dev) **AT.4** : For all buildings mentioned in 5.4.5.2/AT.2 and 5.4.5.2/AT.3 the following applies:

	Values in metres		
	II	III	IV
(1) lateral distance of conductors from the nearest part of the building	4	5	6
(2) clearance of conductors from nearest part of building			
(2.1) under normal loading conditions	4	5	6
(2.2) under exceptional loading conditions	3,5	4	5
(3) clearance of conductors from flat roofs having up to 15 degree pitch, and flat constructions such as balconies and terraces, etc.			
(3.1) under normal loading conditions	5	6	7
(3.2) under exceptional loading conditions	3,5	4	5

(4) Mounting overhead lines at residential- or school buildings, industrial or trading complexes etc., external or internal substations: in sectors of the said mounting/tensioning areas of conductors the above mentioned clearances to facilities need not to be considered, Enhanced Safety applies.
Danger of electricity shall be payed attention to with measures which are to be considered as best appropriated (e.g. warning boards, barriers on roofs, etc.).
Doors and windows may not exist within the mentioned clearances (windows if they are not locked properly or it is not prevented to come into contact with live parts).

(5) If the buildings belong to the same power supply station as the line (power station, transforming station, switching station) then smaller clearances are permissible, Enhanced Safety applies.

(6) In the case of industrial and trading complexes, the special nature of the operations carried out (e.g. installations entailing a risk of fire or explosion) and also the operating/working space taken up by loading equipment, cranes, etc., must be taken into account, Enhanced Safety applies.

Clause National regulation

(7) Clearances of overhead lines to biogas installations

(7.1) General

(7.1.1) Definitions

(7.1.1.1) Biogas installation: An installation used in order to produce, process, store and/or use biogas.

(7.1.1.2) Objects: All containers and gasholders used to produce, process, store and/or use biogas.

(7.1.1.3) Discharges: All pipes such as blow-off pipes, discharges of overpressure protections, air dischargers of a biogas installation, irrespective whether they are integrated or separated.

(7.1.2) Protective zone of an object: the protective zone of an object is determined from the plan area which results when the ground plan of that object is enlarged equally on all sides by the extent indicated as follows:

- overhead lines < 110 kV ... 4,0 m
- overhead lines ≥ 110 kV ...10,0 m

(7.1.3) The outline of the non-deflected conductor shall not intersect the protective zone as defined according to (7.1.2). In addition for deflected conductors EN 50341-3-1:2001, § 5.4.5.2, AT.3, shall apply.

(7.1.4) The protection zone of objects shall be defined irrespective of the following factors:

- single-walled membrane gas tanks – stand-alone type,
- double membrane gas tanks – stand-alone type,
- single-walled membrane gas tanks – stand-alone type with supplementary sheeting for weather protection,
- gasholder for biogas – encapsulated type.

(7.1.5) Discharges are regarded as buildings according to EN 50341-3-1:2001, § 5.4.5.2, AT.2.

(7.1.6) Conductors (stationary or deflected), supports and foundations shall not extend into the explosive areas of the biogas installation (zone 0, 1 and 2). For the conductors the installation rules for normal and exceptional loading conditions apply.

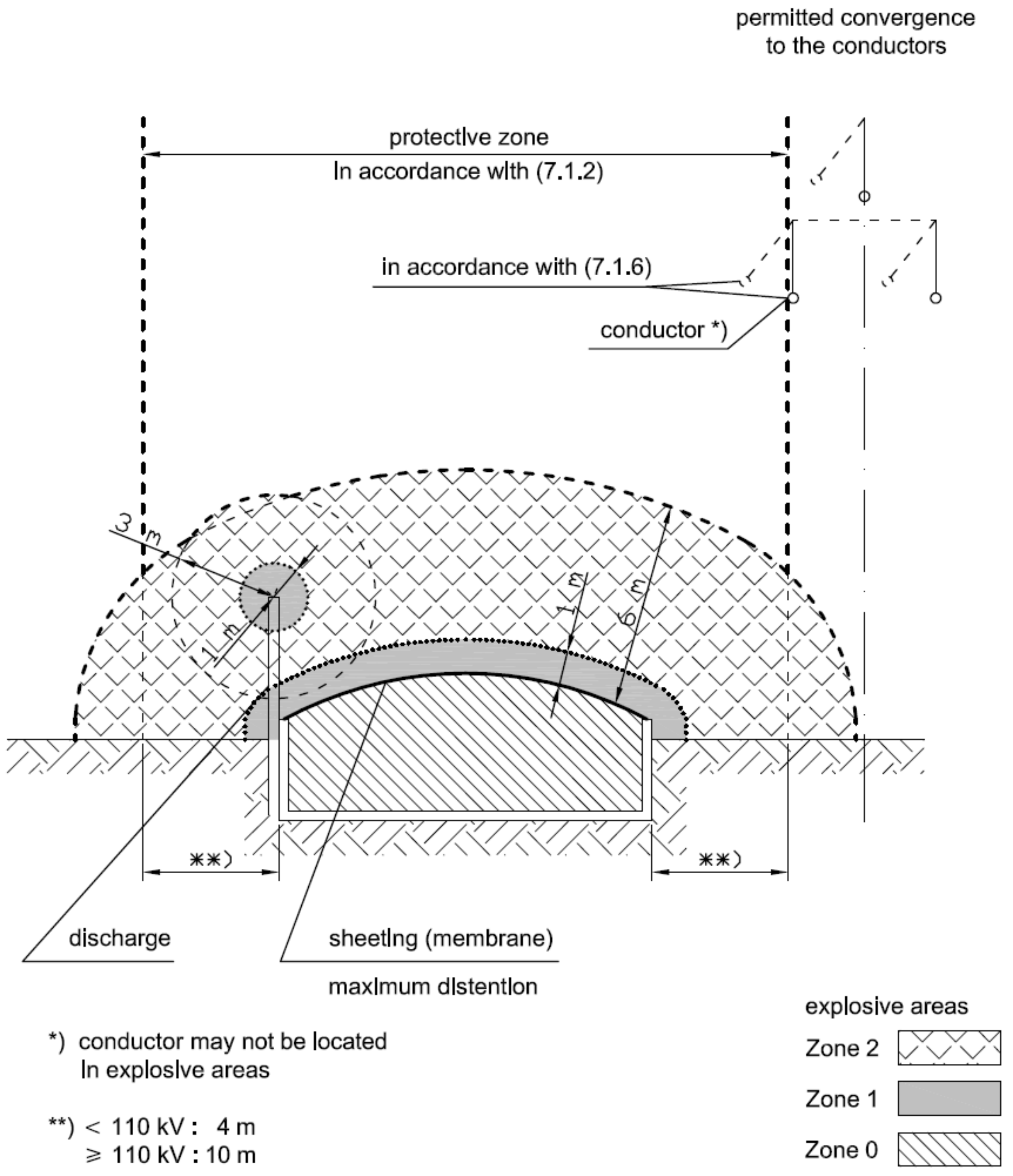
(7.2) Earthing installations

In case earthing installations of pressure vessels converge to the ones of overhead lines separate requirements have to be defined.

Examples for biogas installations: see fig. 5.4.5.2/AT1 and AT2.

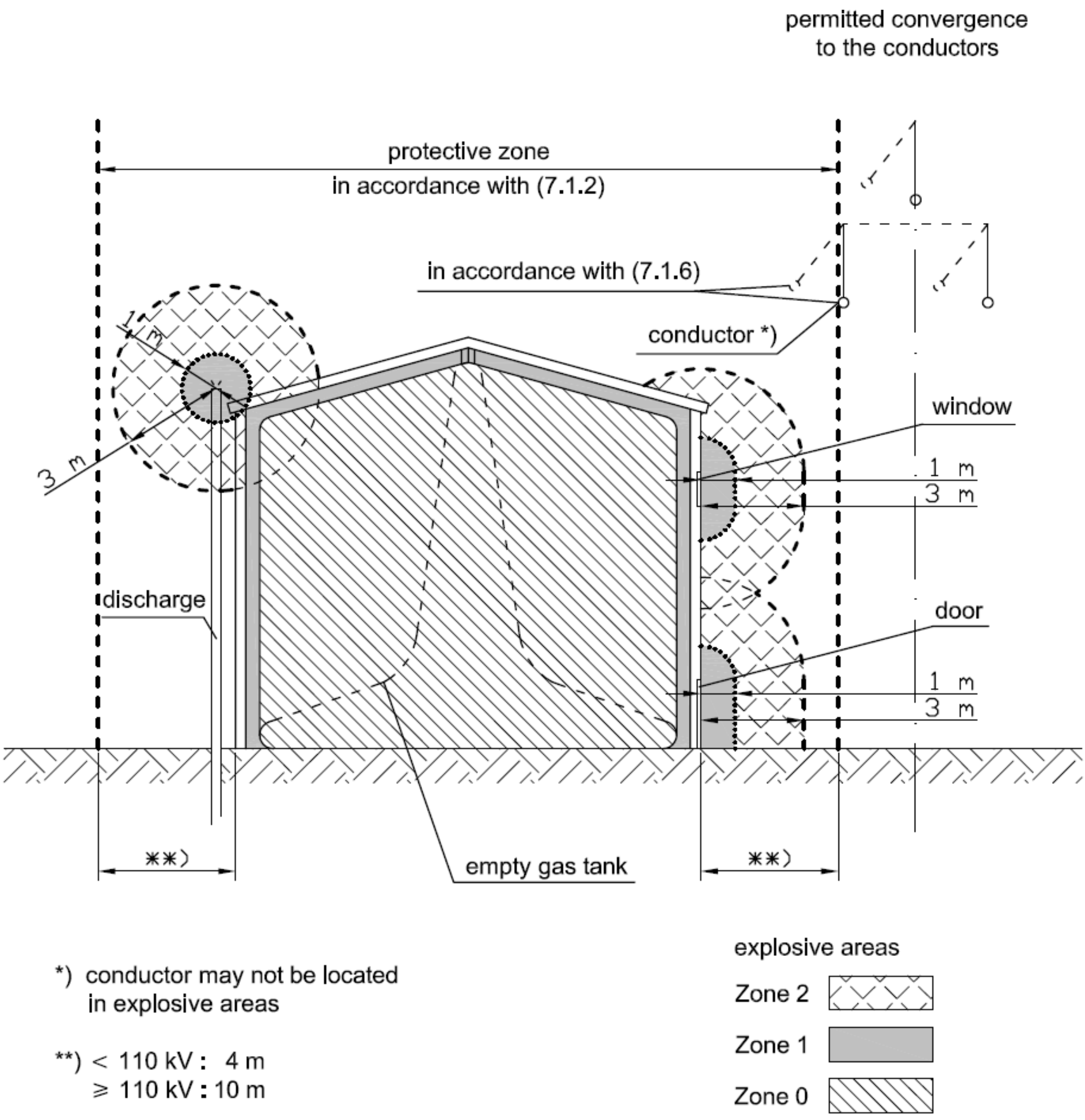
Clause National regulation

Figure 5.4.5.2/AT1: single-walled membrane gas tank – stand-alone type



Clause National regulation

Figure 5.4.5.2/AT2: gas tank – encapsulated type



*) conductor may not be located in explosive areas

**) < 110 kV : 4 m
≥ 110 kV : 10 m

(8) Clearances of overhead lines pressure vessels (gas, liquid gas)

(8.)1 General
(8.1.1) Definition

(8.1.1.1) Pressure vessels (in terms of this specification): stationary containers used to store gases and gas-overlaid materials, whose product of prescribed highest working pressure in bar and capacity in litres exceeds 3.000 (bar × litres).

(8.1.2) Overground (stand-alone) pressure vessels

(8.1.2.1) Object: The overground (stand-alone) pressure vessel, including those valves which are connected to the pressure vessel.

(8.1.2.2) Protective zone of the object for overground (stand-alone) pressure vessels: the protective zone of the object is determined from the plan area which results when the ground plan of that object is enlarged equally on all sides by 5 m (see example A). If explosive areas exceed the protective zone the dimensions for explosive areas shall apply (see protective zone for > 30.000 l liquid gas, fig. 5.4.5.2/AT4). The protective zone is determined irrespective whether the stand-alone pressure vessel is designed for

- gases heavier or lighter than air,
- gases about as heavy as air or,
- liquid gas.

(8.1.2.3) The outline of the non-deflected conductor shall not intersect the protective zone as defined according to (8.1.2.2). Additionally EN 50341-3-1:2001, § 5.4.5.2, AT.3, applies for stationary and deflected conductors.

(8.1.2.4) Conductors (stationary or deflected), supports and foundations shall not extend into the explosive areas (zone 0, 1 and 2). For the conductors the installation rules for normal and exceptional loading conditions apply.

(8.1.3) Imbedded (buried) pressure vessels

(8.1.3.1) Imbedded pressure vessels are covered on all sides with earth or sand with a minimum thickness of 0,5 m.

(8.1.3.2) Only the explosive areas apply to imbedded pressure vessels. Conductors (stationary or deflected), supports and foundations shall not extend into the explosive areas (zone 0, 1 and 2). For the conductors the installation rules for normal and exceptional loading conditions apply.

(8.1.4) Pressure vessels in fire-resistive rooms

(8.1.4.1) Only the explosive areas apply to pressure vessels which are located in fire-resistive rooms (ÖNORM B 3800). Conductors (stationary or deflected), supports and foundations shall not extend into the explosive areas (zone 0, 1 and 2). For the conductors the installation rules for normal and exceptional loading conditions apply.

(8.1.4.2) EN 50341-3-1:2001, § 5.4.5.2, AT.3, apply to the building.

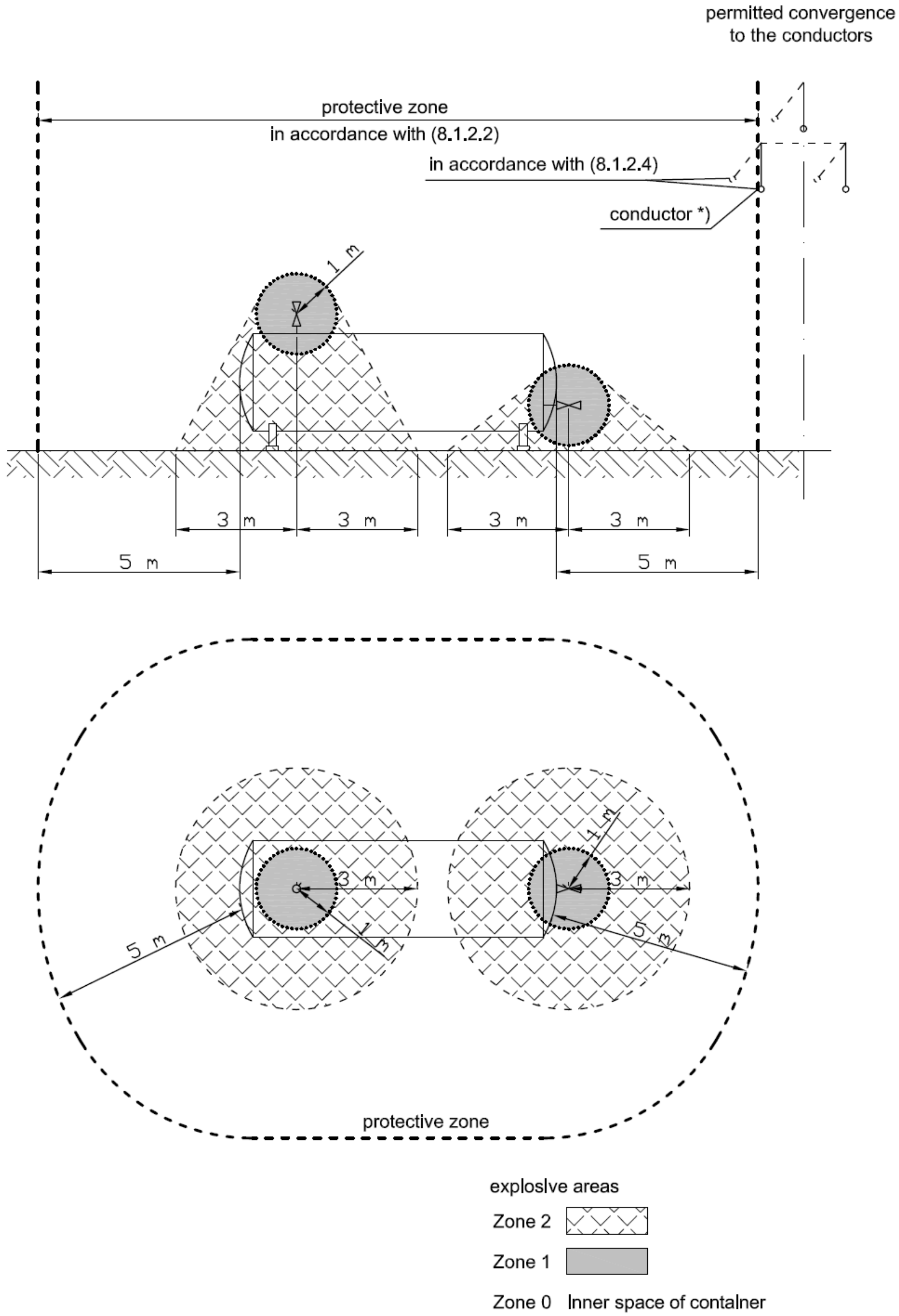
Clause National regulation

(8.2) Earthing installations
In case earthing installations of pressure vessels converge to the ones of overhead lines separate requirements have to be defined.

Examples for pressure vessels: see fig. 5.4.5.2/AT3 and AT4.

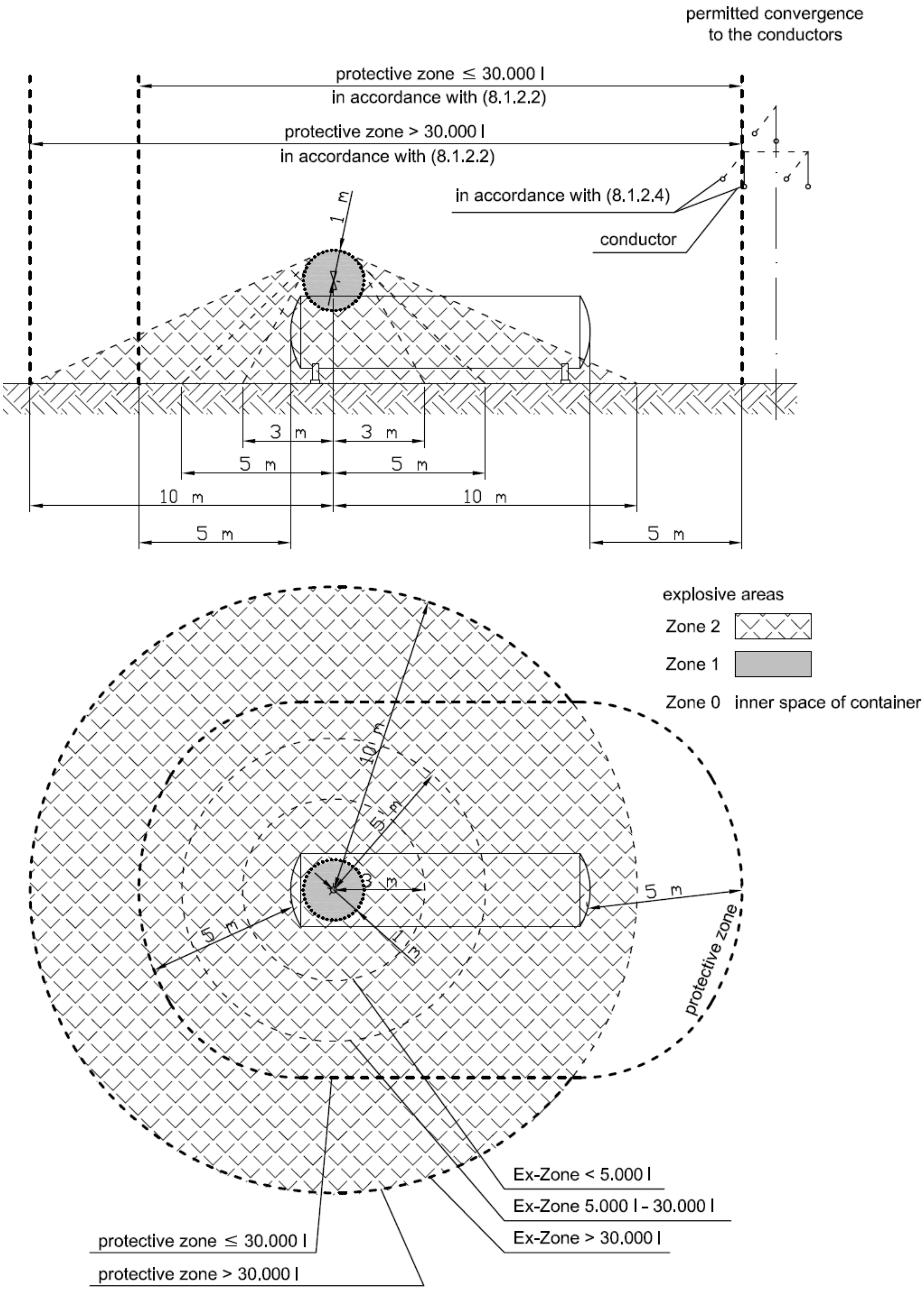
Clause National regulation

Figure 5.4.5.2/AT3: protective zone of pressure vessels, e.g. for methane



Clause National regulation

Figure 5.4.5.2/AT4: protective zone of pressure vessels, e.g. for liquid gas



Clause National regulation

(9) Clearances of overhead lines to petrol stations

(9.1) General

(9.1.1) Definition
Petrol stations are stationary installations used to provide land, water and air crafts with liquid fuel from dispensing devices (e.g. petrol pumps), including storage tanks.

(9.1.2) EN 50341-3-1:2001, § 5.4.5.2, AT.3, apply to petrol stations in accordance with 1.1. Additional requirements shall be applied in accordance with the following specifications.

(9.1.3) Conductors (stationary or deflected), supports and foundations shall not extend into the explosive areas (zone 0, 1 and 2). For the conductors the installation rules for normal and exceptional loading conditions apply.

Example for the protective zone of petrol stations: see fig. 5.4.5.2/AT5.

(9.1.4) Overground stand-alone containers for flammable liquids, hazard categories I and II[1]

(9.1.4.1) Protective zone for overground (stand-alone) containers for flammable liquids: the protective zone is determined from the plan area which results when the ground plan of the container is enlarged equally on all sides by 5 m.

(9.1.4.2) The outline of the non-deflected conductor shall not intersect the protective zone as defined according to (9.1.4.1) Supports and foundations shall not extend into the protective zone.

(9.1.4.3) When the explosive areas are additionally covered by non-combustible materials, EN 50341-3-1:2001, § 5.4.5.2, AT.3, shall apply.

(9.1.5) Imbedded containers for flammable liquids, hazard categories I and II[1]

(9.1.5.1) Only the explosive areas apply to imbedded containers (e.g. filler piece, ventilation). Conductors (stationary or deflected), supports and foundations shall not extend into the explosive areas (zone 0, 1 and 2).

(9.1.5.2) The lateral distance of the foundations of the supports from imbedded containers shall be chosen in a way that safeguards the stability of the overhead line. The minimum distance, however, shall never fall short of 1 m.

(9.2) Natural gas stations

For compressor units of natural gas refuelling stations (stand-alone, in housings or in fire-resistive rooms) the requirements for pressure vessels (subclause (8)) shall apply.

(9.3) Earthing installations

In case earthing installations of containers converge to the ones of overhead lines separate requirements have to be defined.

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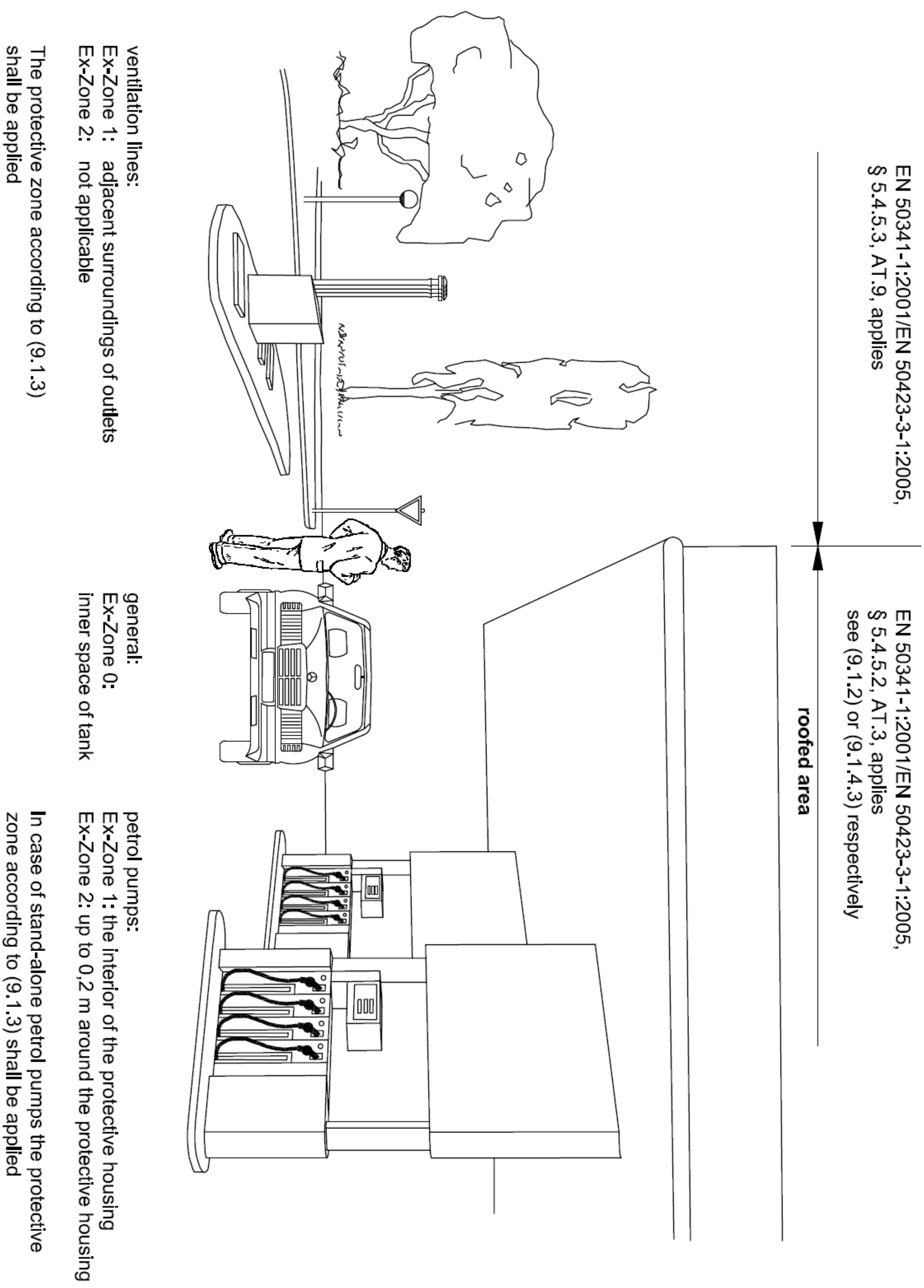
[1] according to Federal Decree 240/1991 on flammable liquids, „Verordnung über brennbare Flüssigkeiten – VbF“

Clause National regulation

Figure 5.4.5.2/AT5: protective zone of petrol stations, exemplary illustration. The explosive areas have to be defined for each case according to the authorization of the petrol station.



National Normative Aspects (NNA)

for

NORWAY

based on EN 50341-1:2001

and

EN 50423-1:2005

Version circulated with corrigendum February 2009.

Contents

Foreword

1 The Norwegian National Committee (NC) is identified by the following address:

Norsk Elektroteknisk Komité
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Visiting address Strandveien 18, Lysaker
Phone no. +47 67 83 31 00
Fax no. +47 67 83 31 01
E-mail: Nek@nek.no

2 The Norwegian NC has prepared this Part 3-16 of EN 50341 and EN 50423, listing the Norwegian national normative aspects, under its sole responsibility, and duly passed it through the CENELEC and CLC/TC 11 procedures.

NOTE The Norwegian NC also takes sole responsibility for the technically correct coordination of the merged EN 50341-3-16 and EN 50423-3-16 with EN 50341-1 and EN 50423-1 respectively. It has performed the necessary checks in the frame of quality assurance/control. It is noted however that this quality assurance/control has been made in the framework of the general responsibility of a standards committee under the national laws/regulations.

3 This merged EN 50341-3-16 and EN 50423-1-16 is normative in Norway and informative for other countries.

4 This merged EN 50341-3-16 and EN 50423-3-16 has to be read in conjunction with EN 50341-1 and EN 50423-1, hereinafter referred to as Part 1. All clause numbers used in this Part 3-16 correspond to those of Part 1.

Specific subclauses, which are prefixed “NO”, are to be read as amendments to the relevant text in Part 1. Any necessary clarification regarding the application of Part 3-16 in conjunction with Part 1 shall be referred to the Norwegian NC who will, in cooperation with CLC/TC 11 clarify the requirements.

When no reference is made in Part 3-16 to a specific subclause, then Part 1 applies.

5 In the case of “boxed values” defined in Part 1, amended values (if any) which are defined in Part 3-16 shall be taken into account in Norway.

However any boxed values, whether in Part 1 or Part 3-16, shall not be amended in the direction of greater risk in a Project Specification.

6 The Norwegian NC declares in accordance with subclause 3.1 of Part 1 that this Part 3-16 follows the “General approach” (4.1), and that consequently subclause 4.2 “Empirical Approach” is not applicable for Norway.

7 The national Norwegian standards/regulations related to overhead electrical lines exceeding 1 kV (AC) are identified in 2.3/NO1.

NOTE All national standards referred to in this Part 3-16 will be replaced by the relevant European Standards as soon as they become available and are declared by the Norwegian NC to be applicable and thus reported to the secretary of CLC/TC 11.

Clause National regulation

1 Scope

(ncpt) **NO.1** Note 1, Note 2, Note 3

All 3 notes of clause 1 of Part 1 are normative in Norway.
This Part 3-16 is applicable for new overhead lines only and not for existing lines in Norway. If some planning/design or execution work on existing lines in Norway has to be performed, the degree of application of this Standard shall be agreed upon by the parties concerned and the authorities.

2 References, terms and definitions

2.3 NO.1 References

Act No. 4 of 24 May 1929 of Supervision of Electrical Installations and Electrical Equipment Regulations for Electrical Installations – system for generating, transmission and distribution.

EN 1991-1-4 Actions on structures including NAD. Part 1-4 General actions. Wind actions.

3 Basis of design

3.1 NO.1 General
(ncpt)

The design philosophy of the Norwegian overhead lines shall be based on the General Approach.

4 Actions on lines

4.2.2.1.5 NO.1 Reference wind speed V_R
(snc)

See 4.2.2.2

Table 4.2.2.1.5/NO.1

Return period T	Conversion factor q_T/q_{50}
3	0,58
50	1,00
150	1,18
500	1,40

In fjords or valleys the given wind pressure values apply for a line direction parallel to the main direction of the fjord or valley. If the line direction is perpendicular to the fjord/valley direction, or if the line along a fjord/valley passes the mouth of a branch fjord/valley, the given wind pressure should be multiplied by 1,4.
For regions not listed in the table, meteorologist should be consulted.

Clause National regulation

4.2.2.1.6 (snc) *NO.1 Wind speed V_h at arbitrary height above ground*

The wind pressure is referred to 10 m above ground, but allowed to be used up to 20 m above ground.

Table 4.2.2. is not used.

4.2.2.2 (ncpt) *NO.1 Dynamic wind pressure*

The dynamic wind gust pressure, q_h, is calculated according to EN 1991-1-4 including NAD. Reference wind speeds are given in Annex 2.

Note: q_h in this norm is equivalent to $q_p(z)$ in EN 1991-1-4.

4.2.2.4.1 (ncpt) *NO.1 Wind forces on conductors*

Wind pressure on conductors gives forces transversal to the direction of the line as well as higher tension in the conductors. From each of the two neighbouring spans the load on the tower is

$$F_c = \zeta^2 \cdot q_h \cdot C_{xc} \cdot G_L \cdot d \cdot \frac{L}{2}$$

where

- ζ = 0,9 (average direction factor (when EN 1991-1-4 including NAD is used)
- q_h = dynamic wind pressure as defined in 4.2.2.2 based on the highest perpendicular component of the wind speed on the conductor.
- C_{xc} = drag coefficient for the conductor. For ordinary stranded conductors and regular wind speeds, C_{xc} = 1,0. For smooth conductors C_{xc} = 1,1.
- G_L = span factor (see below).
- d = diameter of conductor.
- L = length of span

The total wind pressure on bundled conductors is set equal to the sum of that on the individual conductor without taking into accout possible sheltering effects on leeward conductors.

The span factor can be calculated as follows:

G_L = 1	for span lengths up to 100 m
G_L = 1 - (L - 100)/1 000	for span lengths between 100 and 450 m
G_L = 0,65	for span lengths exceeding 450 m

Other span factors can be used after consulting a meteorologist, or as documented otherwise.

The direct forces on an angle tower due to wind pressure shall be calculated as for ordinary tangent towers. The transvers component of the conductor tension, calculated with respect to the design wind load shall be added to the direct wind force as stated above.

Clause National regulation

4.2.2.4.4 (ncpt) *NO.1 Wind forces on poles*

It is allowed to use lower values for the drag factors, when based on tests or on EN 1991-1-4.

4.2.3.2 (snc) *NO.1 Characteristic ice load*

Table 4.2.3.2/NO.1 gives general 50 year values for the different regions in Norway, and is ment to be the basis for design where no other information is available. The given values will be currently adjusted as new information is available. The given values may be deviated from if separate evaluations are made by meteorologist.

For regions not covered in the table, meteorlogist should be consulted.

To arrive at the actual design values according to the reliability class, the values of Table 4.2.3.2 (NO.1) has to be multiplied by the conversion factor given in Table 4.2.3.2 (NO.2).

Table 4.2.3.2/NO.2

Return period T	Conversion factor g_T/g_{50}
3	0,35
50	1,00
150	1,25
500	1,50

4.2.3.2 (ncpt) *NO.1 Characteristic ice load*

The values for ice loads with a return period of 50 years given in table 4.2.3.2/NO.1 may be replaced with other values when this is sufficiently evaluated and documented.

4.2.4 (snc) *NO.1 Combined wind and ice loads*

This load case may be omitted where adviced by meteorologist.

4.2.4.1 (snc) *NO.1 Combined probabilities*

Ice load with high probability to occur: I_T, T=3.
Wind pressure with low probability to occur: $B_i^2 \cdot q_{hT}$, T=50, 150 or 500.
B_i=0,7 for wet snow. B_i=0,85 for hard rime ice.

In the areas 1, 2, 4 and 5 (see table 4.2.3.2/NO1) it may be calculated with wind pressure q_{h500} without ice in stead of calculating combined ice and wind pressure.

4.2.4.2 (snc) *NO.1 Drag factors and ice densities*

These are given only for wet snow and hard rime ice since these are the two ice types considered for design purposes in Norway.

Clause National regulation

Table 4.2.6/NO – Drag factors C_{cl} and density ρ_I (kg/m3) for various types of ice

Ice type	Wet snow	Hard rime ice
C_{cl}	1,0	1,1
ρ_I	600	700

Table 4.2.3.2/NO.1 - Design ice loads

No	Region	Height above sea level (m)	Design ice load (N/m) 50 year return period
1	Main areas of the South East region*)	0 - 200	30
2	Main areas of the South East region*)	200 - 400	40
3	Main areas of the South East region	400 - 600	50
4	Østfold and Vestfold	0 - 200	20
5	Telemark and Agder	0 - 200	35
6	Telemark and Agder	200 - 400	50
7	The coast Rogaland – Stad	0 - 200	35
8	Fjordane Rogaland – Stad	0 - 400	40
9	The coast Stad – Namdalen	0 - 200	40
10	The fjords Stad – Namdalen	0 - 400	40
11	The coast Namdalen – Lofoten	0 - 200	40
12	The inland of Nordland	0 - 200	30
13	The coast Vesterålen – Nordkapp	0 - 100	35
14	The inland Troms - Vest-Finnmark	0 - 200	30
15	The coast of Aust-Finnmark	0 - 100	30
16	The inland of Aust-Finnmark	0 - 200	20
*)Except areas mentioned in no 3 and 4.			

4.2.5 (snc) *NO.1 Temperature effects*

(1) The minimum temperature to be considered with no other climatic action is the yearly minimum temperature with a return period of 50 years, but not higher than - 20 ^{o}C.

(2) For the extreme wind pressure condition, the temperature is set equal to 0 ^{o}C.

(3) Wind acting during minimum temperature condition is not to be considered.

Clause National regulation

(4) As in Part 1.

(5) For the combination of wind and ice, the temperature is set equal to 0 °C.

4.2.6 *NO 1.1 Construction and maintenance loads*

4.2.6.1 (ncpt) *NO 1.1 General*

Additional national requirements:

NO 1.1 Tower erection
Tower erection gives often dynamic and unbalanced loads. The strength of actual lifting points and other stressed members should therefore be designed to withstand the double of the load the construction method implies. A Factor of 1,45 can be used if the workmanship is carefully controlled. Possible wind loads during construction should be considered.

NO 1.2 Stringing and sagging of conductors
NO 1.2.1 Conductor tension. Effect on structures
The structure should withstand the double of the sagging tension in all conductors being pulled out. A lower strength of the structure can be accepted if well documented calculation proves this to be justifiable, but never less than 1,45 times the load. The tension shall be taken for the lowest temperature allowed during the sagging.

NO 1.2.2 Vertical loads
The increased vertical component of the conductor tension due to the angle the conductor makes in a vertical plane through the attachment point, shall be taken into account. This may be of practical significance especially if the tower is situated at a high level in the terrain in a long declined section. The vertical load will be increased if stringing equipment and/or temporary anchoring is placed close to the tower

NO 1.2.3 Transverse loads
Angle towers shall be designed to resist transverse loads due to conductor tension as described in NO 1.2.1. Possible wind loads should be considered.

NO 1.2.4 Longitudinal loads acting on temporary anchorage towers and dead end towers
Towers used as anchorage towers/dead end towers during stringing and sagging shall be designed to take up loads as described in NO 1.2.1 for all combinations of loads - or no load - in the many attachment points representing the stringing succession.

Such towers can be strengthened (reinforced) by use of guy wires to obtain the necessary longitudinal strength. These guy wires will increase the vertical loads in the attachment points and should be prestretched if they are attached to stiff towers. It is therefore needed to check the tension in the guy wires and take into account the vertical loads in the attachment points.

Clause	National regulation

NO 1.2.5 Longitudinal loads acting on suspension towers
It should be taken into account that a longitudinal load will act on a suspension tower when the conductor is in the stringing pulleys.

NO 1.3 Maintenance loads
All attachment points shall be designed to take up the double of the vertical load normally caused by the sagging. A lower strength of the attachment points can be accepted if well documented calculation proves this to be justifiable, but never less than 1,45 times the mentioned load.

4.2.6 *NO.1 Construction and maintenance loads*

4.2.6.2 *NO.1 Loads related to the weight of linesmen*
(ncpt) Steps (of any kind) shall be rated for a concentrated ultimate load of 1,5 kN acting vertically at the most unfavourable position

4.2.7 *NO.1 Security Loads*
(snc)

Does not apply to towers made of wooden poles.

The following applies: Load cases are specified to give minimum requirements to the resistance of the towers by giving failure containment loads. All attachment points for phase conductors and ground wires shall be checked against conductor/wire breakage. This can be done by taking the one-sided tension of a conductor equal to the sagging tension without wind or ice loading, however taking into account the relaxation due to any swing of the insulator assemblies, deflection or torsion of tower, foundation, hinged cross arms or hinged columns, and interaction with other phase conductors and/or ground wires. For overhead lines with short insulator strings or pin insulators, this can lead to unreasonably large longitudinal forces. In such cases the longitudinal load has to be specifically evaluated to reduce the damages of the overhead line in case of a possible conductor breakage. The one-sided tension can be limited by certain devices (e.g. friction clamps). Then the minimum requirements can be reduced correspondingly.

Unbalanced tension in the other conductors is not to be considered. For certain overhead lines stronger security may be required. This can be done by considering more load cases by increasing the number of attachment points in the tower exposed to one-sided tension, and exposing the tower to torsional loads which it has to withstand. This requirement is especially advisable for overhead lines with two or more circuits. Sectioning by using more anchorage towers is a security measure to be required in the case of important power lines in regions with severe icing.

If this load case gives unreasonably high loads for suspension towers, a reduction of the loads may be given in the Project Specification.

4.2.8 *NO.1 Short circuit loads*
(ncpt)

This may be included in the project specification.

Clause National regulation

4.2.9.1 (ncpt) *NO.1 Avalanches, creeping snow*

Research is going on in this field, and measures to be taken are included in the project specification if deemed necessary.

4.2.9.2 (ncpt) *NO.1 Earth quakes*

Not considered in Norway.

4.2.10 (snc/ncpt) *NO.1 Load cases*

The following apply:
Calculations shall be based on the ice and wind loads and temperature actions as given in 4.2.2, 4.2.3, 4.2.4 and 4.2.5 of Part 1, taking into account the Norwegian NNA. This implies that to arrive at the reference values, the tabulated 50 year values for wind and ice loads have to be multiplied with conversion factors according to the chosen reliability class.
Calculations shall be based on the real components of the loads, vertical, transvers and longitudinal, in the different load cases. Weight of towers, conductors, insulators and accessories shall be taken into account in all load cases. Swings of insulators, accessories and towers as well as interactions with other phases and conductors shall be taken into account in all load cases.
Wind and ice loads directly on towers and guy wires shall be considered.
It is distinguished between following types of towers according to their function:

- suspension towers and angle suspension towers (B+VB)
- anchorage towers and angle anchorage towers (F+VF)
- dead end towers and angle dead end towers (E+VE)

The different load cases to be considered, are shown in Table 4.2.10 (NO).

Table 4.2.10/NO - Load cases (1/2)

Load cases	Description of load cases	Valid for tower type
Uniform ice load	The reference value g_R is applied uniformly on all conductors and ground wires on all spans in the section.	All
Transverse bending	An ice load equal to 0,7 times the reference value is applied on all conductors and spans on one side (transversally) of the tower and an ice load 0,3 times the reference value on the other, see Figure NO.1.	All
Unbalanced ice load Longitudinal bending	An ice load equal to 0,7 times the reference value is applied on all conductors in 3 consecutive spans of a section and an ice load 0,3 times the reference value on all the other spans of the section. All load cases arising when the "load train" with the 3 spans is moved along the section between the anchorage towers, see Figures NO.2 and NO.3 are to be checked.	B+VB
Wind load	The wind load is applied on all conductors and ground wires as well as insulators, accessories and towers.	All
Combined wind and ice load	The wind is applied on ice covered conductors, insulators and towers and the resulting wind load is combined with the ice load.	All
Load at the minimum temperature	The towers shall resist the increased conductor tension at the minimum temperature	VB, F+VF E+VE

Clause National regulation

Table 4.2.10/NO Load cases (2/2)

Load cases	Description of load cases	Valid for tower type
Construction and maintenance loads	It is to be checked that the towers can resist 1,45 times all forces due to the loads as described in 4.2.6 including the Norwegian NNA. The action on members (force or moment) shall be multiplied by 1,45 and checked against yield/buckling of the member.	All
Conductor breakage	The load to be taken into account due to conductor breakage is described in 4.1.7 with the Norwegian NNA. The original conductor tension is taken as the sagging tension at 0 ^{o}C. The breakage is taken to be in the conductor giving the most unfavourable action in the induvidual member.	B+VB
Conductor breakage with full ice load	The load to be taken into account is due to a conductor breakage with an ice load equal to the reference value g_R on all other conductors and ground wires.The reduction of the vertical load and of possible angle tension due to the breakage shall be taken into account.	F+VF
Onesided tension with full ice load	The load to be taken into account is the reference value g_R applied uniformly on all conductors and ground wires on one side of the tower.	E+VE

(snc) NOTE The ruling span method may be used for conductors with rated tensile strength less than 40 kN.

In such cases it shall be documented that the longitudinal strength of the components match either long experience of similar power lines in similar areas, or the longitudinal force caused by unbalanced ice on the attachments in the actual span or in a more unfavourable span in the power line.

4.2.11 *NO.1 Partial factors for actions*
(ncpt) Ref. Table 4.2.11.1 in Part 1.

γ_p = 1,45 for good quality control of design and construction, else = 2,0
Ψ_W=0,25 for wet snow. Ψ_W=0.40 for hard rime ice.

Clause National regulation

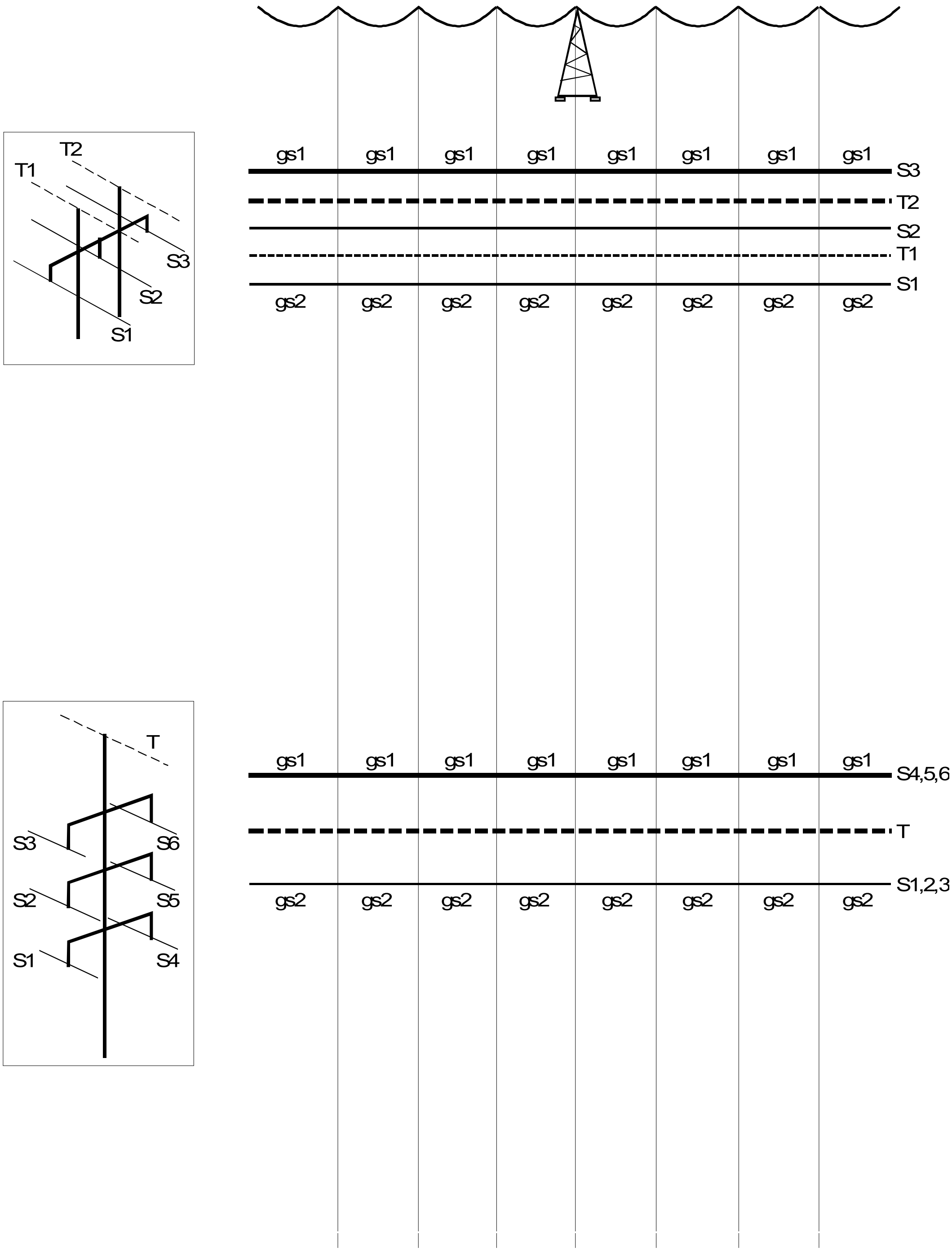


Figure 4.2.10 / NO.1

Ice loads giving transverse bending. The value of the ice loads are:
$g_{s1} = 0,7\ g_R$, $g_{s2} = 0,3\ g_R$ where g_R is the reference value for max. ice load.

Clause National regulation

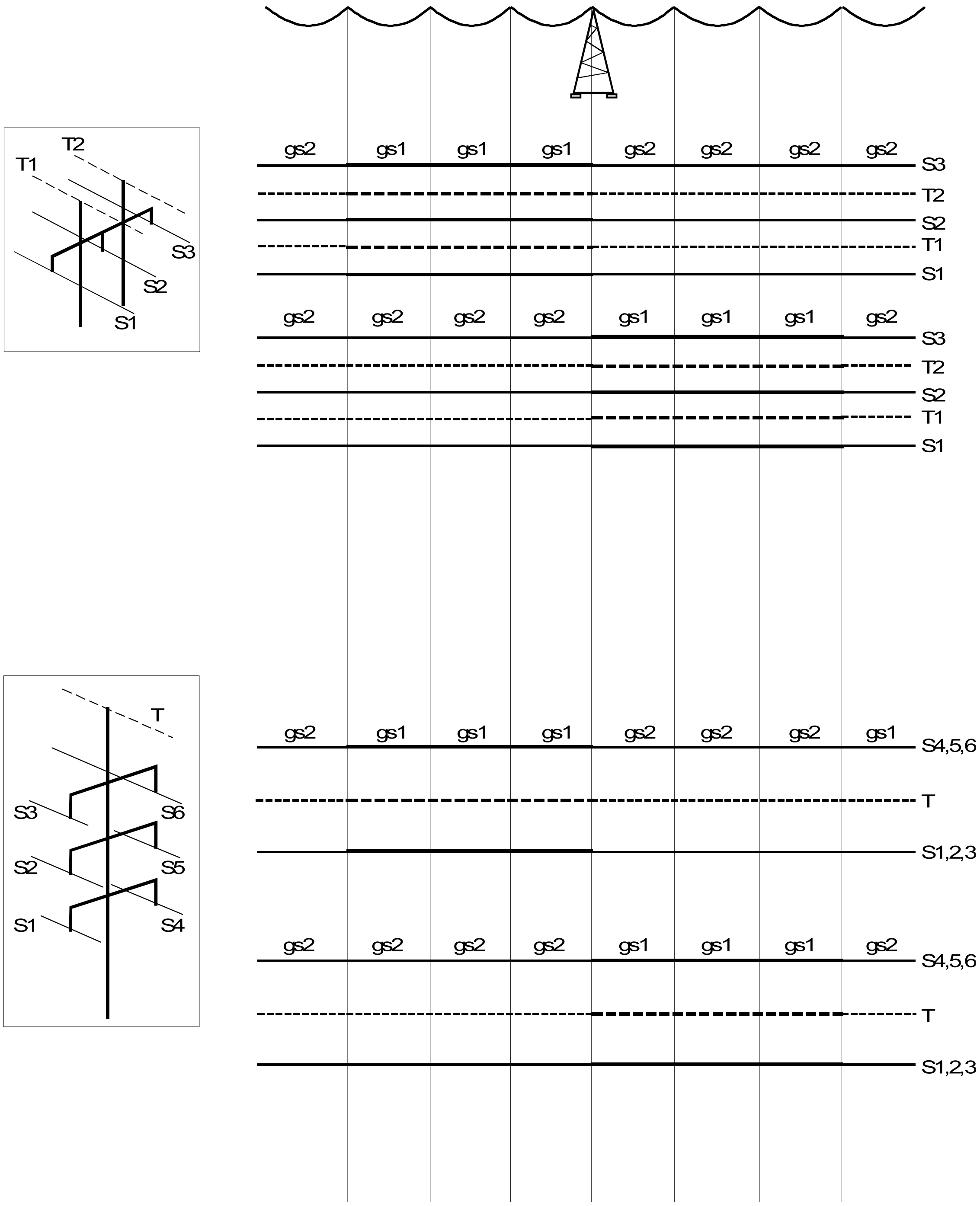


Figure 4.2.10 / NO.2

Unbalanced ice loads giving longitudinale values of the ice loads are:
g_{s1} = 0,7 g_R, g_{s2} = 0,3 g_R where g_R is the reference value for max. ice load.

<u>Clause</u> <u>National regulation</u>

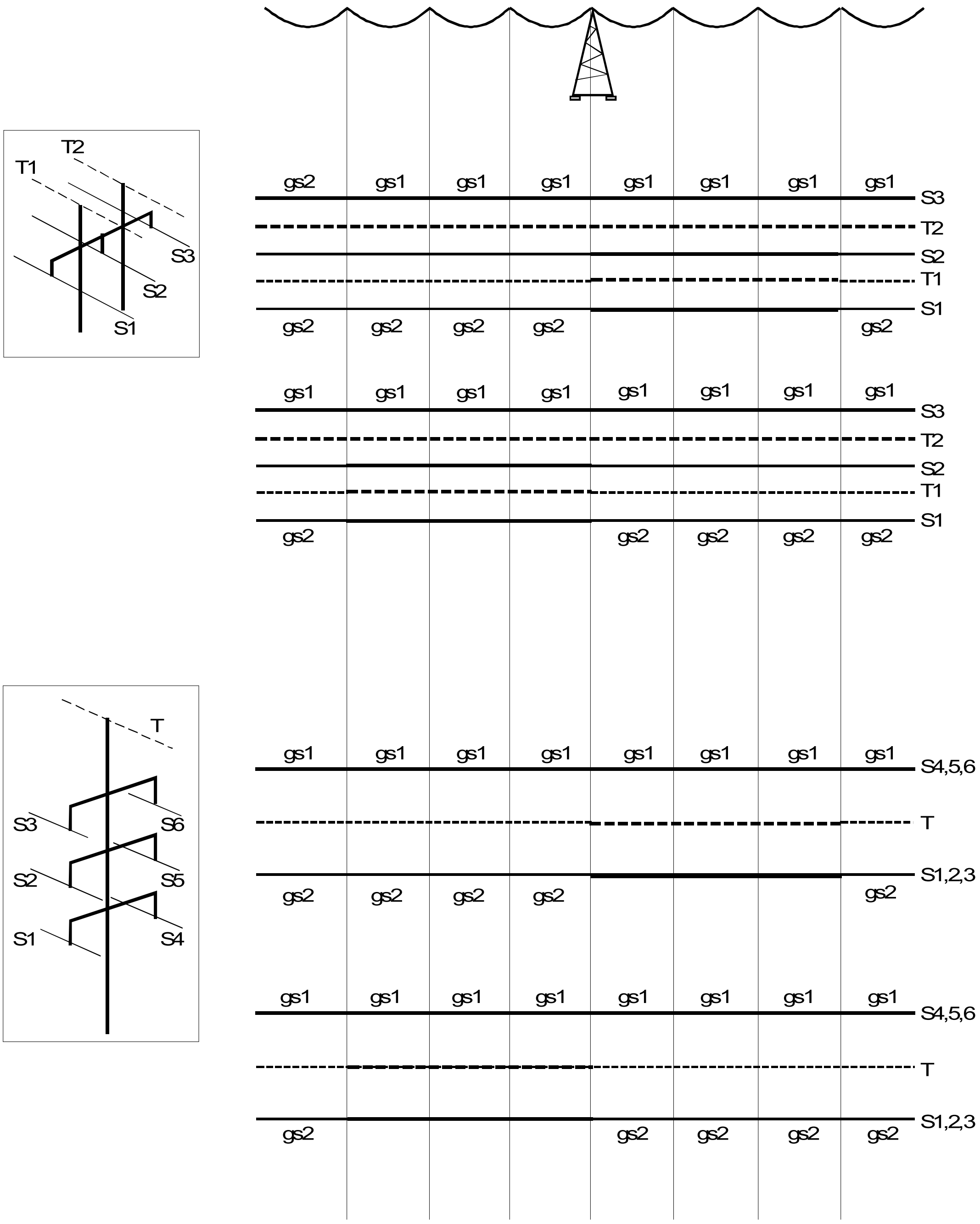


Figure 4.2.10 / NO.3

Unbalanced ice loads giving torsion. The values of the ice loads are:
$g_{s1} = 0{,}7\ g_R$, $g_{s2} = 0{,}3\ g_R$ where g_R is the reference value for max. ice load.

Clause National regulation

5 Electrical requirements

5.2 NO.1 Currents

5.2.1 NO.1 Normal current
(ncpt)

The normal current is dependent on the magnitude of the transmitted power and on the operating voltage. The cross-section of the phase conductors shall be chosen so that the design maximum temperature for the conductor material is not exceeded under the specified conditions defined in the Project Specification.

5.3 NO.1 Insulation co-ordination

5.3.5.2 NO.1 Result of calculation using method in annex E
(A-dev) The last paragraph shall read:
All these minimum electrical clearance distances are solely based on insulation co-ordination requirements. Other requirements may result in substantially larger clearances.

5.4 NO.1 Internal and external clearances

5.4.2.2.1 NO 1.1 Maximum conductor temperature
(ncpt)

The maximum conductor temperature shall be specified in the Project Specification, and shall not be less than 50°C.

5.4.2.2.1.1 NO.1.2 Maximum earth wire temperature
(ncpt)

The maximum earth wire temperature shall be specified in the Project Specification, and shall not be less than 50°C.

5.4.2.2.2 NO.1.3 Ice load for determination of electrical clearances
(ncpt) The return period shall be specified in the Project Specification, but not less than 50 years.

(snc) NOTE The ruling span method may be used for conductors with rated tensile strength less than 40 kN.

When controlling the clearance to ground or other objects it shall be documented that the necessary clearance also includes the effect of sag caused by unbalanced ice load in the actual span or in a more unfavourable span in the power line.

5.4.2.2.3 NO.1.4 Wind load for determination of electrical clearances
(ncpt)

The last sentence in the paragraph beginning with “Under wind loading - - - -“does not apply.

Clause National regulation

5.4.2.2.3 NO.1.5 Wind load for determination of electrical clearances
(A-dev)

The last sentence in paragraph *b)* shall read: National requirements are defined in Table: 5.4.3 Clearances within the span and at the tower.

5.4.2.2.3 NO.1.6 Wind load for determination of electrical clearances
(A-dev)

The last sentence in paragraph *d)* does not apply.

5.4.2.2.3 NO.1.7 Wind load for determination of external electrical clearance
(A-dev) The return period shall be specified in the Project Specification, but not less than 50 years.

5.4.3 NO.1 Clearances within the span and at the tower

5.4.3.1, 5.4.3.2 and 5.4.3.3 NO.1 Recommended clearances within the span
(ncpt)

Conductors in the same horizontal plane should have a minimum clearance within the span of:

$$x = \sqrt{k2 * (b + l_k)} + 0{,}007 * U_S$$

b is the sag (m)
l_k is the insulator length (m) for I-string. For V-chains l_k=0
U_s is the highest system voltage (kV)
k_2 is q_h/2250>=0,25 for strain or post insulators (q_h i N/m^2)
k_2 is q_h/1900>=0,30 for suspension insulators (q_h i N/m^2)

Conductors with a vertical separation should be controlled for a loadcase with ice on the upper conductor and 0°C and no ice on the lower conductor while both conductors also are subjected to wind. The ice- and windload in this case should have a 3-year return period. The vertical separation between earth wire and conductor should be controlled likewise.

(ncpt) NOTE The following abbreviations and voltage limits applies:

Abbreviation	Description	Voltage limits
B	Bare conductors	Exceeding AC 1 kV
Cov	Covered conductors	Exceeding AC 1 kV up to and including AC 45 kV
I	Insulated cable system	Exceeding AC 1 kV up to and including AC 45 kV
C	Conductor	Not relevant
E	Earth wire	Not relevant

(A-dev) NOTE Induction and safety clearances in connection with work near overhead lines
Problems arising by induction and safety clearances in connection with work near overhead lines are not considered in the tables below. All matters concerning these problems shall be dealt with according to national regulations.

Clause National regulation

5.4.3/NO Clearances within the span and at the tower

(A-dev)

Table 5.4.3/NO – Minimum clearances within the span and at the tower

Load Case	Clearance cases												Remarks
	Within the span						At the tower						
	Conductor conductor			Conductor earth-wire			Between phases and/or circuits			Between phase conductors and earthed parts			
Protection system	**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**	
Specified max. Temperature	D_{pp}	D_{pp}	-	D_{el}	D_{el}	-	D_{pp}	D_{pp}	-	D_{el}	D_{el}	-	Load conditions in still air
Specified ice load	D_{pp}	D_{pp}	-	D_{el}	D_{el}	-	D_{pp}	D_{pp}	-	D_{el}	D_{el}	-	Load conditions in still air
Specified wind load Wind load at overvoltage	$K_1 \cdot D_{pp}$	$k_1 \cdot D_{pp}$	-	$k_1 \cdot D_{el}$	$k_1 \cdot D_{el}$	-	$k_1 \cdot D_{pp}$	$k_1 \cdot D_{pp}$	-	$k_1 \cdot D_{el}$ D_{el}	$k_1 \cdot D_{el}$ D_{el}	-	The factor k_1 is dependent on mechanical loading conditions, but should not be less than 0,6

NOTE 1 If the covered conductors are not insulated at the tower, i.e. by use of penetrating clamps, the minimum clearances given in table 5.5 shall be applied.
NOTE 2 The minimum distance between insulated cables is zero. However, if the centre distance is less than twice the cable diameter, the ampacity is reduced.
NOTE 3 Wind load at overvoltage is 30% of specified wind load.

Clause National regulation

5.4.4/NO Clearances to ground in areas remote from buildings, roads, railways, and navigable waterways, and clearance to trees.

(A-dev)

Table 5.4.4/NO - Minimum clearances to the ground in areas remote from buildings, roads, railways and navigable waterways and clearances to trees

Load Case		Clearance to ground in unobstructed countryside (m)						Clearance to trees (m)		
		Normal ground profile			Rockface or steep slope					
Protection system		**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**
Specified max. temperature	C	$5{,}5+D_{el}$ but>6	6	5	$4+D_{el}$ but>4,5	4	3	$2+D_{el}$ but>3	1,5	0,5
	E	>4	4	4	>3	3	3	>1,5	1,5	0,5
Specified ice load	C	$4+D_{el}$ but>4	4	4	$3{,}5+D_{el}$ but>4,5	4	3	$2+D_{el}$ but>3	1,5	0,5
	E	>3	3	3	>3	3	3	>1,5	1,5	0,5
Specified wind load	C	$5{,}5+D_{el}$ but>6	6	5	$2{,}5+D_{el}$ but>3	3	2	$2+D_{el}$ but>3	1,5	0,5
	E	>4	4	4	>2	2	2	>1,5	1,5	0,5
		Note 1: Basic requirements is that a vehicle or person etc. can pass under the line without danger. When that case does not apply (steep slope etc) clearance may be reduced consistent with the requirements that safety of persons shall be ensured.						Note 2: If the risk of causing an earth fault due to a falling tree is unacceptable, then the height of the trees must be reduced or their horizontal proximity to the line shall be limited.		
Note 3		Rockface or steep slope that is not accessible with any kind of vehicle, tractor, snowmobile etc.								
Note 4		If snow depths normally are greater than 1 m, clearances to ground shall be increased accordingly.								

<u>Clause</u> <u>National regulation</u>

5.4.5 *NO.1 Clearances to buildings, traffic routes, other lines and recreational areas*

5.4.5.1 (A-dev) *NO.1 General*

Paragraph a) shall read:

Clearances to residential and other buildings when the line is above or adjacent to the buildings or near antenna or similar structures. Crossing over important buildings is not permitted (see Table 5.4.5.2)

5.4.5.1 (A-dev) *NO.2 General*

The note at the end of the clause shall read:

NOTE Due to the increased safety requirements for crossing over buildings, recreational areas, traffic routes, other power lines and telecommunication lines etc., consideration should be given to the use of reinforced suspension such as multiple insulator strings where there is considered to be possibility of mechanical failure in the suspension. Special requirements may be given in regulations.

Clause National regulation

5.4.5.2/NO Residential and other buildings and structures

(A-dev)

Table 5.4.5.2/NO – Minimum clearances to residential and other buildings and structures

Load Case		Clearance cases											
		Direct clearance to less important buildings. (Crossing over important buildings is prohibited) (m)			Horizontal clearance to important buildings, classified areas of petrol stations, storage areas for explosives and particularly flammable goods and other storage areas (m)			Direct clearance to antennas, street lamps, flag poles, advertising signs and similar structures (m)			Direct clearance to permanent cranes, antenna-towers/towers, and other high constructions for which special regulations do not apply (m)		
Protection system		**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**
Specified max. temperature	C	$4{,}5+D_{el}$ but>5	4	3	$5{,}5+D_{el}$ but>6	4	3	$3{,}5+D_{el}$ but>4	2	2	$5{,}5+D_{el}$ but>6	6	6
	E	>3	3	3	>6	4	3	>2	2	2	>5	5	5
Specified ice load	C	$3{,}5+D_{el}$ but>4	4	3	$5{,}5+D_{el}$ but>6	4	3	$2{,}5+D_{el}$ but>3	2	2	$4{,}5+D_{el}$ but>5	5	5
	E	>3	3	3	>6	4	3	>2	2	2	>4	4	4
Specified wind load	C	$2{,}5+D_{el}$ but>3	2	2	$3{,}5+D_{el}$ but>4	2	2	$1{,}5+D_{el}$ but>2	2	2	$3{,}5+D_{el}$ but>4	4	4
	E	>2	2	2	>4	2	2	>2	2	2	>3	3	3
Note 1		Less important buildings are defined as buildings less than approximately 50 m^2 which are not used for living and which only occasionally are used by human beings. (The above applies to small sheds, small barns etc, but also applies to garages for one or two cars at a distance of at least 2 m from other buildings and semi-detached garages contstructed from non-combustible materials not higher than 3 m and situated at least 4 m from other buildings).											
Note 2		The danger of ice falling from overhead lines on buildings shall be considered.											
Note 3		For lines adjacent to or crossing over power stations or substations special regulations apply.											
Note 4		The minimum swing angle of the conductor is 45°.											

Clause National regulation

5.4.5.3/NO Traffic routes

(A-dev)

Table 5.4.5.3.1/NO – Minimum clearances to line crossing roads, railways and navigable waterways

Load Case		Clearance cases								
		To road surface, parking lot, pavement etc., bicycle path and top of rail level (if no electric traction system is used) (m)			To components of el. traction systems of railways or trolley bus lines (m)			To an agreed gauge of a recognised navigable waterway (m)		
Protection system		**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**
Specified max. temperature	C	6,5+D_{el} but>7	7	6	3,5+D_{el} but>4	4	3	2+D_{el}	2	2
	E	>6	6	6	>3	3	3	>2	2	2
Specified ice load	C	6,5+D_{el} but>7	7	6	3,5+D_{el} but>4	4	3	2+D_{el}	2	2
	E	>6	6	6	>3	3	3	>2	2	2
Specified wind load	C	6,5+D_{el} but>7	7	6	3,5+D_{el} but>4	4	3	2+D_{el}	2	2
	E	>6	6	6	>3	3	3	>2	2	2
(SLC1) special load case	C	-	-	-	3,5+D_{el} but>4	4	3	-	-	-
	E	-	-	-	-	3	-	-	-	-
SLC1: Swinging of the over crossing conductors due to varying wind loads at a temperature defined in this NNA and simultaneous loading of the undercrossing conductor of the traction system at it's minimum sag.										
NOTE: For clearances from the rail level, the clearances should be fixed with respect to the gauge of the train rather than the top of the rail.										

Clause National regulation

Table 5.4.5.3.2/NO - Minimum clearances to line near roads, railways, and rope way installations
(A-dev)

Load Case		Horizontal clearance cases									Vertical clearance cases								
		Clearance between nearest part of the overhead line and the centre line of the nearest track of a railway (m)			To outer edge of a carriageway (incl. hard shoulder) of a motorway, highway, country road or of a waterway (m)			To components of a ropeway installation (m)			To components of el. traction systems of rope ways (m)			To pulling ropes of rope ways (m)			To towers or supporting and pulling ropes of a ropeway installation (m)		
Protection system		**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**
Specified max. temperature	C	8	8	8	2+D_{el}	2	2	6+D_{el}	4+D_{el}	4	3,5+D_{el} but>4	4	3	5,5+D_{el} but>6	4	2	3,5+D_{el} but>4	4	4
	E	8	8	8	>2	2	2	5	3	3	>3	3	3	-	3	2	-	3	3
Specified ice load	C	8	8	8	2+D_{el}	2	2	6+D_{el}	4+D_{el}	4	3,5+D_{el} but>4	4	3	5,5+D_{el} but>6	4	2	3,5+D_{el} but>4	4	4
	E	8	8	8	>2	2	2	5	3	3	>3	3	3	-	3	2	-	3	3
Specified wind load	C	5	5	5	2+D_{el}	2	2	4+D_{el}	4+D_{el}	4	3,5+D_{el} but>4	4	3	5,5+D_{el} but>6	4	2	3,5+D_{el} but>4	4	4
	E	5	5	5	>2	2	2	4	3	3	>3	3	3	-	3	2	-	3	3
(SLC1) special load case	C	-	-	-	-	-	-	-	-	-	3,5+D_{el} but>4	4	3	5,5+D_{el} but>6	4	2	-	-	-
	E	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
(SLC2) special load case	C	-	-	-	-	-	-	4+D_{el}	4+D_{el}	4	3,5+D_{el} but>4	4	3	5,5+D_{el} but>6	4	2	-	-	-
	E	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
		Note 1: If this horizontal clearance cannot be met then the vertical clearance in Table 5.4.5.3.1 shall apply.									Note 2: Special protections shall be applied for rope ways crossing over power lines.								

SLC1: Swinging of the over crossing conductors due to varying wind loads at a temperature defined in this NNA and simultaneous loading of the undercrossing conductor of the traction system at it's minimum sag.

SLC2: Swinging of the over crossing conductors due to varying wind loads at a temperature defined in this NNA and maximum tensile stress of the pulling rope increased by 25%.
In evaluating horizontal clearances the following load cases shall be considered:

- Swinging of the conductor due to wind towards fixed components of the ropeway installation.
- Swinging of ropes of the ropeway installation at maximum swing angle of 45° towards part of the overhead line.

Clause National regulation

5.4.5.4/NO Power lines or overhead telecommunication lines

(A-dev)

Table 5.4.5.4/NO – Minimum clearances to other power lines or overhead telecommunication lines

Load Case		Crossing of lines: Vertical clearance between lowest conductor of the upper circuit and live parts or earthed components of the lower line (m)			Crossing of lines: Horizontal clearance between the vertical axis at the swung conductor and components of telecommunication lines (m)			Horizontal clearance between parallel lines of separate utilities on common structures and between parallel or converging lines on separate structures (m)		
Protection System		**B**	**Cov**	**I**	**B**	**Cov**	**I**	**B**	**Cov**	**I**
Specified Max. Temperature	C	$1+D_{pp}$ but>3	2	1	-	-	-	D_{pp} but>1	1	1
	E	>2	2	1	-	-	-	>1	1	-
Specified Ice Load	C	$1+D_{pp}$ but>3	2	1	-	-	-	D_{pp} but>1	1	1
	E	>2	2	1	-	-	-	>1	1	-
Specified Wind Load	C	$1+D_{pp}$ but>3	2	1	$1+D_{pp}$ but>2	2	1	D_{pp} but>1	1	1
	E	>2	2	1	>1	1	-	>1	1	-
					Note 1: If this horizontal clearance cannot be met, the vertical clearance between lowest conductor of the upper circuit an live parts or earthed components of the lower line shall apply					
Note 2		Special care shall be taken with respect to crossing of lines and parallel lines. The clearance shall be greater than 1,1 times the arcing distance (defined as the straight line distance between live and earthed parts) of the insulator string.								
Note 3		When calculating the direct clearance between parallel or converging lines, it is recommended that a difference of 40 percentage points of the specified wind load is applied on the two lines, and that a sufficient number of gradual reductions of the specified wind load is controlled.								
Note 4		When calculating the vertical difference between circuits, the nearest parts of the underlying circuit shall have a minimum temperature as mentioned in this standard.								
Note 5		Clearance between insulated cables with the same nominal voltage may be reduced.								

Clause National regulation

5.4.5.5/NO Recreational areas (playgrounds, sports areas etc.)

(A-dev)

Table 5.4.5.5/NO – Minimum clearances to recreational areas (playgrounds, sports areas etc.)

Load Case		Horizontal clearances					
		To permanent sports facilities and spectator accommodations for these, children's playgrounds, and graveyards (m)			Clearance to camping grounds, public swimming pools (m)		
Protection System		**B**	**Cov**	**I**	**B**	**Cov**	**I**
Specified Max. Temperature	C	$5,5+D_{el}$ but>6	6	6	$2+D_{el}$ but>2,5	2,5	2
	E	>6	6	6	>2,5	2,5	2
Specified Ice Load Load	C	$5,5+D_{el}$ but>6	6	6	$2+D_{el}$ but>2,5	2,5	2
	E	>6	6	6	>2,5	2,5	2
Specified Wind Load	C	$3,5+D_{el}$ but>4	4	4	$0,5+D_{el}$ but>1	1	1
	E	>4	4	4	>1	1	-
Note 1		For sport facilities etc. the above requirements apply to the sports ground itself, start and winning post installations and the spectator areas for these, but not to other areas as greens with trees etc. Crossings are accepted over private tennis courts, golf courses, alpine courses, motorcross, go-cart tracks and tracks for horse riding without spectator accommodation. Crossing of important sports- and recreational areas is prohibited, but excessively high power lines are permitted to cross over othersports facilities where there are no spectator accommodation.					
Note 2		For dangerous areas for shooting ranges there are special regulations issued by the Ministry of Justice					
Note 3		For the crossings of areas as national parks and other preserved areas a special permission is required from the authorities concerned					
Note 4		Crossings of fjords, valleys etc. which may present a hazard to aviation need a permission from the Civil Aviation Administration					

Clause National regulation

5.6 NO.1 Electric and magnetic fields

5.6.3 (A-dev) *NO.1 Interference with telecommunication circuits*

The sentence “Rules for interference on telecommunication circuits are outside the scope of this standard” is to be added before the second paragraph.

6 Earthing systems

6.2 NO.1 Dimensioning of earthing systems at power frequency

6.2.2.2 (snc) *NO.1 Earthing and bonding conductors*

The sentence “Aluminium and aluminium alloys are only permitted above ground” is to be added before the note.

6.2.4.1 (A-dev) *NO.1 Permissible values*

The last paragraph shall be omitted.

6.2.4.4 (A-dev) *NO 1 Measures in systems with isolated neutral or resonant earthing*

Does not apply in Norway

6.3 NO.1 Construction of earthing systems

6.3.2 (A-dev) *NO.1 Transferred potentials*

The first paragraph shall read:

The transfer of potential may occur due to metallic pipes and fences, low voltage cables etc. and general guidelines are difficult to provide. Requirements of limit values of transferred potentials are given in Norwegian regulations and standards.

7 Supports

7.1.1. (ncpt) *NO.1 Structural design resistance of a pole*

This subclause is not applicable in Norway.

7.1.2. (ncpt) *NO.1 Buckling resistance)*

This subclause is not applicable in Norway.

7.2 (ncpt) **NO.1 Materials**

Materials shall be selected according to the Project Specification.

7.3 (ncpt) **NO.1 Lattice steel powers**

Maximum slenderness of members shall be given in the Project Specification.
Minimum thickness of plates shall be given in the Project Specification.

Clause National regulation

Minimum thickness of main members shall be 5 mm and for redundant members 4 mm

Minimum thickness for hollow sections shall be 4 mm.
By hollow sections care shall be taken for drainage.
A bracing bar can be attached by one bolt.
Shaping in cold condition is only permitted when tests show that the material withstands cold forming without developing cracks or dangerous stresses occurs which otherwise in conjunction with subsequent hot dip galvanising can cause inter crystalline crack formation.

Holes for bolts may normally be punched in angles and plates up to 12 mm thickness. The effect of local material conditions shall be taken into account.
The eccentricity of end connections shall be kept as small as possible.

7.3.5 *NO.1 Ultimate limit states*

7.3.5.1 *NO.1 Basis*

7.3.5.1.1 (ncpt) *NO.1 General*

The partial safety factor γ shall be taken as follow:

- resistance of cross sections of members $\gamma_{m1} = 1,10$
- resistance of members to buckling $\gamma_{m1} = 1,10$
- resistance of net section of members at bolt holes $\gamma_{m2} = 1,25$

7.3.5.4 (ncpt) *NO.1 Resistance of lattice members*

Unless otherwise stated in the Project Specification the resistance of cross sections against tension, compression and bending, and the buckling resistance of members shall be determined in accordance with normative annex J.

7.3.6 *NO.1 Connections*

7.3.6.1 *NO.1 Basis*

7.3.6.1.1 (ncpt) *NO.1 General*

The partial safety factor γm shall be taken as follow:

- resistance of bolted connections $\gamma_{mb} = 1,25$
- resistance of riveted connections $\gamma_{mr} = 1,25$
- resistance of welded connections $\gamma_{mw} = 1,25$

7.5 **NO.1 Timber poles**

7.5.5.1 (ncpt) *NO.1 Basis*

The partial safety factor shall be taken as follows:

- resistance of cross sections and elements of timber $\gamma_m = 1,35$
- resistance of cross sections and elements of glulam $\gamma_m = 1,15$
- resistance of bolted connections $\gamma_m = 1,10$

Clause National regulation

7.5.6 (ncpt) *NO.1 Resistance of connections*

The design resistance of bolts in shear or tension are given in NS-EN 1995-1-1: Eurocode 5.

7.7 NO.1 Guyed structures

7.7.1 (ncpt) *NO.1 General*

It shall be controlled that there is no unwanted effects of the elastic elongation of the guys.

7.7.5.1 (ncpt) *NO.1 Basis*

The partial safety factor γ_m for guys regarding resistance to ultimate strength shall be 1,50 unless otherwise stated in the Project Specification.

7.9 NO.1 Corrosion protection and finishes

7.9.2 (ncpt) *NO.1 Galvanising*

Galvanising of steel parts including guys shall be according to the Project Specification.

7.9.7 (A-dev) *NO.1 Protection of timber poles*

Timber poles, glue laminated wood poles and timber sleepers shall be impregnated in accordance with the Project Specification and national regulations.

8 Foundations

8.5 NO.1 Geotechnical design

8.5.1 (ncpt) *NO.1 General*

A geotechnical calculation model may be used to calculate the planting depth in stead of applying 1/7 of the pole length as mentioned in clause 8.5.3 in EN 50341-1. Minimum allowable planting depth is still 1,5 m.

8.5.2 (ncpt) *NO.1 Geotechnical design by calculation*

If not otherwise stated in the Project Specification, separate footings in the form of symmetrical foundations plates and vertical shaft can be designed using the following method:

Uplift:

1) Choose foundation depth (D), and foundation width (B).

2) The uplift bearing resistance factor N_{ul} can be found as:

Clause National regulation

$$N_{ul} = 1 + \tan\rho\,[\frac{2 - \beta/30°}{1+\tan^2\rho} + \frac{\beta/30°}{N + 2\tan^2\rho}]\frac{D}{B}$$

$$N = \frac{1+\sin\rho}{1-\sin\rho}$$

The recommended effective soil strength parameters (a,tanρ) can be found in Table 8.5.2/NO. β is the angle (in degrees) of the inclined load Q_d relative to the vertical axis (see Fig. 8.5.2/NO). Q_d is design load in ULS-condition including a load factor γ_l = 1.3.

3) Calculate the vertical uplift capacity (F_{vd}) for the chosen geometry:

$$F_{vd} = B^2 [N_{ul}\gamma_a' D + 2a(N_{ul} - 1)]$$

4) Increase/decrease either B or D to find new values of N_{ul}, calculate new values of F_{vd} until the requirement $F_{vd} > Q_{vd}$ is satisfied.

Q_{vd}	= vertical component of design load = $Q_d \cdot \cos\beta$	[kN]
γ_a'	= average effective unit weight = $(\gamma \cdot z_w + (\gamma' \cdot (D - z_w)) \cdot (1/D)$	[kN/m³]
D	= depth to foundation level	[m]
z_w	= depth to ground water level (0 ≤ z_w ≤ D)	[m]
γ	= total unit weight of soil	[kN/m³]
γ '	= submerged unit weight of soil	[kN/m³]

NOTE The above procedure can only be applied for β<20°
The height of the foundation shaft above terrain is foreseen to be typically 0,3-0,5 m. If the height is greater than 0,5 m this should be paid special attention.

Compression:

The vertical bearing capacity can be found for B and D determined for uplift as:

$$F_{cd} = \sigma_n' \cdot A_0 = (N_q - 1)(\gamma' C_1 B + \gamma_a' D + a) \cdot A_0$$

The shape factor C_1 can be found as:

$$C_1 = \frac{N_q N_\gamma}{2(N_q - 1)^2}(1 - 2\frac{D}{B}\tan\beta)$$

where
$$N_\gamma \approx (N_q - 1)\frac{1 + 2\tan\rho}{2 - \tan^2\rho}$$

$$N_q = N \cdot e^{\pi \tan\rho}$$

Non-verticality of the loading is taken into account by the reduced area ($A_0 = B_y \cdot B_x$) of the foundation plate.

Clause National regulation

1) Non-verticality in one direction $B_{x(y)} = B(1-2(D/B)\tan\beta_{x(y)})$ (see Fig.8.5.2/NO)

Check that $F_{cd} = \sigma_n'\cdot B_{x(y)}\cdot B > Q_d\cdot\cos\beta_{x(y)}$

2) Non-verticality in both directions $B_y = B(1-2(D/B)\tan\beta_y)$ (see Fig.8.5.2/NO)
$B_x = B(1-2(D/B)\tan\beta_x)$ (see Fig.8.5.2/NO)

Check that $F_{cd} = \sigma_n'\cdot B_y\cdot B_x > Q_d\cdot\cos\beta$

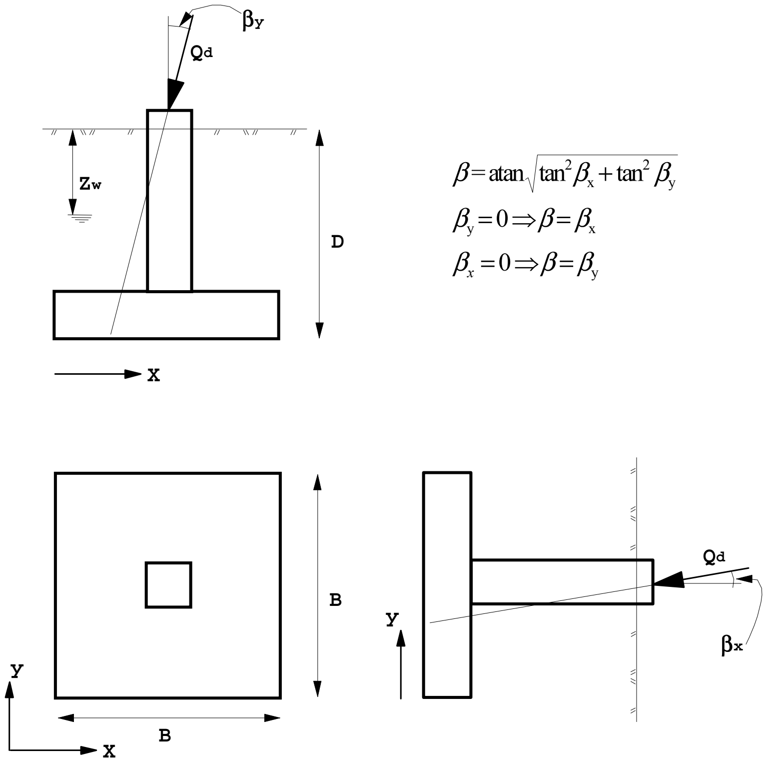
Q_d is design load calculated in ULS-condition including a load factor γ_l = 1,3. The risk of dangerous settlement shall be considered.

Table 8.5.2/NO - Recommended soil parameters

LOAD TYPE		UPLIFT		COMPRESSION		UNIT WEIGHT	
Soil	Comp.	Attraction a	Friction tanρ	Attraction a	Friction tanρ	Effective γ'	Total γ
		kN/m^2	-	kN/m^2	-	kN/m^3	kN/m^3
Clay	Soft	0	0,25	0	0,25	7,0	17,0
	Medium	5	0,30	5	0,30	7,5	17,5
	Firm	10	0,40	10	0,40	8,0	18,0
Silt	Soft	0	0,40	0	0,40	7,5	17,5
	Medium	0	0,45	5	0,45	8,0	18,0
	Firm	0	0,55	10	0,55	8,5	18,5
Sand	Loose	0	0,45	0	0,45	8,0	18,0
	Medium	0	0,55	5	0,55	8,5	18,5
	Dense	0	0,60	10	0,60	9,0	19,0
Gravel	Loose	0	0,50	0	0,50	9,0	19,0
	Dense	0	0,65	5	0,65	10,0	20,0

The recommended values of effective soil parameters (a, tanρ) are conservatively assumed. It is recommended to perform geotechnical soil investigations to obtain the design soil parameters. In case of no geotechnical investigations the parameters in Table 8.5.2/NO can be used. The adequacy of the back-filled material shall be based on good material handling possibilities, and achieving adequate engineering properties after compaction.

Clause National regulation



$$\beta = \operatorname{atan}\sqrt{\tan^2\beta_x + \tan^2\beta_y}$$
$$\beta_y = 0 \Rightarrow \beta = \beta_x$$
$$\beta_x = 0 \Rightarrow \beta = \beta_y$$

Figure 8.5.2/NO

9 Conductors, earthwires and telecommunication cables

Part 1 applies without change.

10 Insulators

10.7 (ncpt) *NO.1 Mechanical requirements*

Insulators made of glass or porcelain:
-resistance for insulators at installation tension γ_m=4,0
-resistance for insulators at maximum tension γ_m =2,0

Insulators made of composite:
-resistance for insulators at installation tension γ_m =5,0
-resistance for insulators at maximum tension γ_m =2,5

11 Live equipments – Overhead line fittings

11.6 (ncpt) *NO.1Mechanical requirements*

-resistance for overhead line fittings γ_m =1,5
-resistance against slippage for dead-end clamps and splices shall be 90 % of RTS.

The requirement for dead-end clamps may be linearly reduced to 80 % as long as the maximum wire tension is less than 8/9 of the resistance against slippage and the RTS of the wire is greater than 80 kN.

Clause National regulation

12 Checks, taking over and documentation/Quality assurance

Part 1 applies without change.

Annex 1
(informative)

Summary of electrical clearances in tables 5.4.3 to 5.4.5.5.

	Voltages exceeding 1 kV up to and including 45 kV				Voltages exceeding 1 kV	
	Covered conductor		Insulated cable system		Bare conductor	
	Phase	Earth	Phase	Earth	Phase	Earth
Clearance to ground						
Specified wire temperature	6,0	4,0	5,0	4,0	5,5 + D_{el}, but > 6,0	4,0
Ice load	4,0	3,0	4,0	3,0	4,0 + D_{el}, but > 4,0	3,0
Wind load	6,0	4,0	5,0	4,0	5,5 + D_{el}, but > 6,0	4,0
Direct clearance to ground (rockface/steep slope)						
Specified wire temperature	4,0	3,0	3,0	3,0	4,0 + D_{el}, but > 4,5	3,0
Ice load	4,0	3,0	3,0	3,0	3,5 + D_{el}, but > 4,5	3,0
Wind load	3,0	2,0	2,0	2,0	2,5 + D_{el}, but > 3,0	2,0
Direct clearance to trees/vegetation						
Specified wire temperature	1,5	1,5	0,5	0,5	2,0 + D_{el}, but > 3,0	1,5
Ice load	1,5	1,5	0,5	0,5	2,0 + D_{el}, but > 3,0	1,5
Wind load	1,5	1,5	0,5	0,5	2,0 + D_{el}, but > 3,0	1,5
Clearance to road surface, parking lot, pavement etc., bicycle path and top of rail level (if no electric traction system is used)						
Specified wire temperature	7,0	6,0	6,0	6,0	6,5 + D_{el}, but > 7,0	6,0
Ice load	7,0	6,0	6,0	6,0	6,5 + D_{el}, but > 7,0	6,0
Wind load	7,0	6,0	6,0	6,0	6,5 + D_{el}, but > 7,0	6,0
Clearance to components of el. Traction systems of railways, trolley bus lines or rope ways						
Specified wire temperature	4,0	3,0	3,0	3,0	3,5 + D_{el}, but > 4,0	3,0
Ice load	4,0	3,0	3,0	3,0	3,5 + D_{el}, but > 4,0	3,0
Wind load	4,0	3,0	3,0	3,0	3,5 + D_{el}, but > 4,0	3,0
Vertical clearance between lowest conductor of the upper circuit and live parts or earthed components of the lower line						
Specified wire temperature	2,0	2,0	1,0	1,0	1,0+D_{pp}, but > 3,0	2,0
Ice load	2,0	2,0	1,0	1,0	1,0+D_{pp}, but > 3,0	2,0
Wind load	2,0	2,0	1,0	1,0	1,0+D_{pp}, but > 3,0	2,0
Horizontal clearance to outer edge of navigable waterway and to public road including hard shoulder						
Specified wire temperature	2,0	2,0	2,0	2,0	2,0 + D_{el}	2,0
Ice load	2,0	2,0	2,0	2,0	2,0 + D_{el}	2,0
Wind load	2,0	2,0	2,0	2,0	2,0 + D_{el}	2,0
Horizontal clearance to centerline of railway tracks						
Specified wire temperature	8,0	8,0	8,0	8,0	8,0	8,0
Ice load	8,0	8,0	8,0	8,0	8,0	8,0
Wind load	5,0	5,0	5,0	5,0	5,0	5,0
Addition to agreed gauge of a recognised navigable waterway						
Specified wire temperature	2,0	2,0	2,0	2,0	2,0 + D_{el}	2,0
Ice load	2,0	2,0	2,0	2,0	2,0 + D_{el}	2,0
Wind load	2,0	2,0	2,0	2,0	2,0 + D_{el}	2,0

Clause National regulation

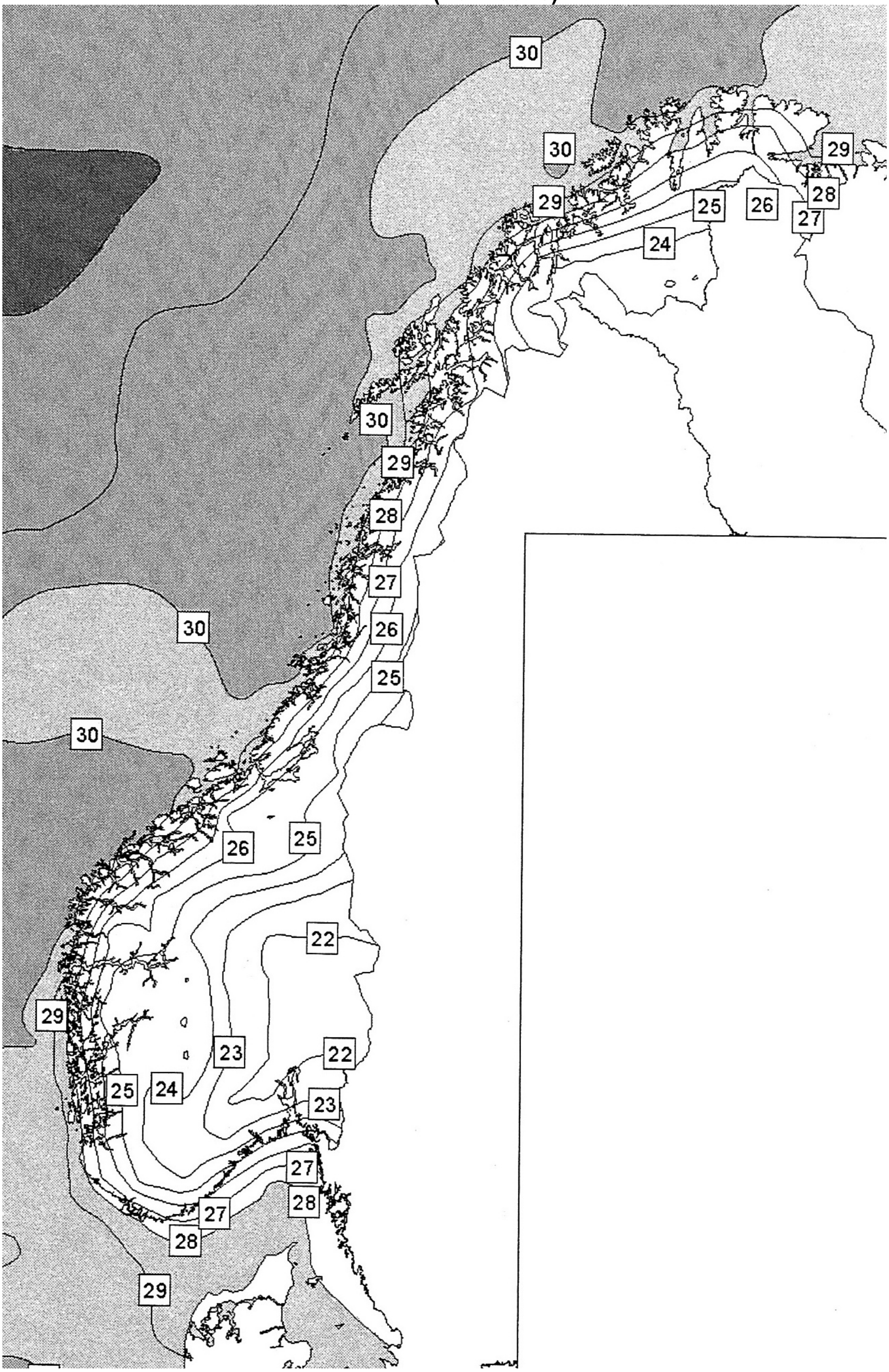
	Voltages exceeding 1 kV up to and including 45 kV				Voltages exceeding 1 kV	
	Covered conductor		Insulated cable system		Bare conductor	
	Phase	Earth	Phase	Earth	Phase	Earth
Horizontal clearance to important buildings, classified areas of petrol stations, storage areas for explosives and particularly flammable goods and other storage areas						
Specified wire temperature	4,0	4,0	3,0	3,0	5,5 + D_{el}, but > 6,0	6,0
Ice load	4,0	4,0	3,0	3,0	5,5 + D_{el}, but > 6,0	6,0
Wind load	2,0	2,0	2,0	2,0	3,5 + D_{el}, but > 4,0	4,0
Direct clearance to less important buildings						
Specified wire temperature	4,0	3,0	3,0	3,0	4,5 + D_{el}, but > 5,0	3,0
Ice load	4,0	3,0	3,0	3,0	3,5 + D_{el}, but > 4,0	3,0
Wind load	2,0	2,0	2,0	2,0	2,5 + D_{el}, but > 3,0	2,0
Horizontal clearance to permanent sports facilities and spectator accommodations for these, children's playgrounds, and graveyards						
Specified wire temperature	6,0	6,0	6,0	6,0	5,5 + D_{el}, but > 6,0	6,0
Ice load	6,0	6,0	6,0	6,0	5,5 + D_{el}, but > 6,0	6,0
Wind load	4,0	4,0	4,0	4,0	3,5 + D_{el}, but > 4,0	4,0
Horizontal clearance to camping grounds, public swimming pools						
Specified wire temperature	2,5	2,5	2,0	2,0	2,0 + D_{el}, but > 2,5	2,5
Ice load	2,5	2,5	2,0	2,0	2,0 + D_{el}, but > 2,5	2,5
Wind load	1,0	1,0	1,0	1,0	0,5 + D_{el}, but > 1,0	1,0
Horizontal clearance between parallel lines of separate utilities on common structures and between parallel or converging lines on separate structures						
Specified wire temperature	1,0	1,0	1,0	1,0	D_{pp}, but > 1,0	1,0
Ice load	1,0	1,0	1,0	1,0	D_{pp}, but > 1,0	1,0
Wind load	1,0	1,0	1,0	1,0	D_{pp}, but > 1,0	1,0
Horizontal clearance between the vertical axis at the swung conductor and components of telecommunication lines						
Ved spesifisert vindlast	2,0	1,0	1,0	1,0	1,0 + D_{pp}, but > 2,0	1,0
Direct clearance to antennas, street lamps, flag poles, advertising signs and similar structures						
Specified wire temperature	2,0	2,0	2,0	2,0	3,5 + D_{el}, but > 4,0	2,0
Ice load	2,0	2,0	2,0	2,0	2,5 + D_{el}, but > 3,0	2,0
Wind load	2,0	2,0	2,0	2,0	1,5 + D_{el}, but > 2,0	2,0
Direct clearance to permanent cranes, antenna-towers/towers, and other high constructions						
Specified wire temperature	6,0	5,0	6,0	5,0	5,5 + D_{el}, but > 6,0	5,0
Ice load	5,0	4,0	5,0	4,0	4,5 + D_{el}, but > 5,0	4,0
Wind load	4,0	3,0	4,0	3,0	3,5 + D_{el}, but > 4,0	3,0
Clearance to pulling ropes of rope ways						
Specified wire temperature	4,0	3,0	2,0	2,0	5,5 + Del, but > 6,0	5,0
Ice load	4,0	3,0	2,0	2,0	5,5 + Del, but > 6,0	5,0
Wind load	4,0	3,0	2,0	2,0	5,5 + Del, but > 6,0	5,0
Clearance to towers or supporting and pulling ropes of a rope way installation						
Specified wire temperature	4,0	3,0	4,0	3,0	3,5 + Del, but > 4,0	3,0
Ice load	4,0	3,0	4,0	3,0	3,5 + Del, but > 4,0	3,0
Wind load	4,0	3,0	4,0	3,0	3,5 + Del, but > 4,0	3,0

Clause National regulation

	Voltages exceeding 1 kV up to and including 45 kV				**Voltages exceeding 1 kV**	
	Covered conductor		**Insulated cable system**		**Bare conductor**	
	Phase	Earth	Phase	Earth	Phase	Earth
Horizontal clearance to components of a rope way installation						
Specified wire temperature	4 + Del	3,0	4,0	3,0	6 + Del	5,0
Ice load	4 + Del	3,0	4,0	3,0	6 + Del	5,0
Wind load	4 + Del	3,0	4,0	3,0	4 + Del	4,0

Clause National regulation

Annex 2
(normative)



Reference wind speeds.

EN 50341-3-18:2001/corrigendum February 2009

National Normative Aspects for Sweden

Replace page 38 by the following:

Clause National regulation

(ncpt) **SE.3 Line adjacent to antenna, street lighting, flag-poles etc.**

(ncpt) **SE.3.1 Clearance to street lighting**

The minimum clearance both horizontal and vertical between the nearest phase conductor and the street lightning pole shall be 4 m. This clearance shall be fulfilled for the following conditions:

- maximum swing-out angle of bare phase conductors at normal wind and at maximum temperature at wind
- maximum swing-out angle of the phase conductor at normal wind and at uniform ice load at 0°C
- at maximum temperature and no wind
- at uniform ice load and no wind at 0°C
- at non-uniform ice load at 0°C
- at conductor temperature at short-circuit conditions, see 9.2.3/SE.1, 9.3.3/SE.1, 9.4/SE.1.2, 9.5.3/SE.1, the minimum clearance shall be 2,0 m.

If the street lighting pole can be hit by a car the clearance between the nearest phase conductor and falling street lighting pole shall be at least 1 + S metres.

Overhead transmission line shall cross above the street lighting installation.

S = a voltage dependent distance in accordance with 5.4.4/SE.1.

5.4.5.3 SE.1 Traffic routes, Line crossing roads, railways and navigable waterways

(A-dev) **SE.1.1 The clearance in crossing of roads and railways**

The clearance shall be in accordance with Table 5.4.5.3/SE.1.1.

Table 5.4.5.3/SE.1.1 - Clearance in crossing of roads and railways

Highest voltage for equipment kV	Type of conductor	Minimum clearance m
Crossing with public roads		
≤ 55	phase	7
	earth wire	6
> 55	phase	7 + S
	earth wire	6
Crossing with not electrified railways		
≤ 55	phase	8
	earth wire	7
> 55	phase	8 + S
	earth wire	7

Clearances given for crossing with public road shall also be valid for private roads with public traffic and private roads where transportation with high vehicles can take place, e.g. roads with traffic from timber-lorries.

National Normative Aspects (NNA)

for

POLAND

based on EN 50341-1:2001

Version circulated with corrigendum February 2009.

Contents

Foreword

1. The address of the Polish National Committee (NC) is as follows:

   Polish Committee for Standardization
   ul. Świętokrzyska 14
   00-050 Warszawa
   Polska
   Tel: +48 22 55 67 581
   Fax: +48 22 55 67 786
   e-mail: intdoc@pkn.pl

2. The Polish National Committee (Polish NC - PKN) and its Technical Committee No. 80 for Overhead lines - General aspects (KT PKN nr 80 ds. Ogólnych w Sieciach Elektroenergetycznych) has prepared this Part 3-22 of EN 50341, listing the Polish National Normative Aspects under its sole responsibility and duly passed this document through the CENELEC and CLC/TC 11 procedures.

   NOTE: The Polish NC and KT No. 80 also take sole responsibility for the technically correct co-ordination of this EN 50341-3-22 with EN 50341-1.

3. This EN 50341-3-22 is normative in Poland and informative for other countries.

4. This EN 50341-3-22 has to be read in conjunction with EN 50341-1, hereafter referred to as Part 1. All clause numbers used in Part 3-22 correspond to those of Part 1. Specific subclauses which are prefixing PL are to be read as amendments to the relevant articles in Part 1. Any necessary clarification regarding the application of Part 3-22 in conjunction with Part 1 shall be referred to the Polish NC who will in co-operation with CLC/TC 11 clarify the requirements. Where no reference is made in Part 3-22 to a specific subclause, then Part 1 shall apply.

5. In the case of “box values” defined in Part 1, amended values (if any) which are defined in Part 3-22 shall be taken into account in Poland.

6. The Polish NC declares in accordance with subclause 3.1 of Part 1 that this Part 3-22 follows the “Empirical Approach” (subclause 4.3), and that consequently subclause 4.2 “General Approach” is not applicable for Poland.

7. The national Polish standards and regulations quoted in Part 3-22 are listed in 2.3 in this Part.

   NOTE: All national standards referred to in this Part 3-22 will be replaced by the relevant European Standards as soon as they become available and are declared by the Polish NC to be applicable and thus reported to the secretary of CLC/TC 11.

Clause National regulation

1 Scope

(ncpt) **PL.1 Field of application**

The NNA specifies the requirements that shall be met for the design and construction of new overhead lines with rated voltages exceeding 45 kV AC.

(ncpt) **PL.2 Overhead lines with insulated conductors**

Design and construction of overhead lines with insulated conductors, where internal and external clearances can be smaller than specified in the NNA are not included.

(ncpt) **PL.3 Optical conductors/wires**

The NNA is also applicable to optical conductors (OPCONs) and optical ground wires (OPGWs) containing optical fibre telecommunication circuits, attached to overhead line supports.

(ncpt) **PL.4 Installation of telecommunication fittings**

The NNA also applies to the installation of telecommunication fittings on supports whose primary structural function is that of overhead line supports.

2 Definitions, symbols and references

2.1 Definitions

(ncpt) **PL.1 design temperature of phase conductors**

the value of the phase conductor temperature used in designing in order to determine the sag of the conductors for calculating clearances of phase conductors to ground and objects crossed.

(ncpt) **PL.2 maximum continuous service temperature**

the conductor temperature at which the conductors may work continuously without deterioration of their mechanical characteristics.

(ncpt) **PL.3 crossing**

a location of the line where the orthogonal projections on a horizontal plane of the outermost conductors of the line and of another object coincide or cross with each other, or the horizontal distance of the line to the object is less than the distance specified in the respective clauses of the NNA.

(ncpt) **PL.4 conductor bouncing**

a sudden momentary change of the position of the conductor as a result of ice falling off from the conductor.

Clause National regulation

(ncpt) **PL.5 line restrictions**

a line restriction is a set of additional protection measures to be implemented on line sections requiring increased safety of the crossed objects. Restriction levels I, II and III are distinguished.

(ncpt) **PL.6 basic tree clearance**

a tree clearance zone on the canopy level with a width calculated using the formula included in 5.4.4/PL.2.

(ncpt) **PL.7 additional clearance of trees**

clearance of trees which may damage the line when falling. The scope of the additional clearance of trees in determined in 5.4.4/PL.2.

2.2 List of symbols

Symbol	Signification	References
A_p	Bouncing amplitude	5.4.3/PL.6
b	Clearance between the conductors of the line	5.4.3/PL.5
k_{el}	Reduction factor for internal clearances between phase conductors and earthed parts of the line	5.4.3/PL.2
k_{pp}	Reduction factor for internal clearances between phase conductors of the line	5.4.3/PL.2
S	Width of the basic tree clearance zone along the line	5.4.4/PL.2
Ψ_G	Combination factor for a permanent action	Table 4.3.10.3/PL.1

2.3 References

References are made to regulations, national standards and international standards (in addition to those included in Part 1). Below is a list of these regulations and standards; the user of the NNA for Poland should check their validity and use their successors, if necessary.

(ncpt) **Standards**

PN-B-02482:1983
Fundamenty budowlane − Nośność pali i fundamentów palowych
Building foundations -- Capacity of piles and pile foundations

Clause National regulation

(ncpt) **Standards**

PN-B-02483:1978
Pale wielkośrednicowe wiercone − Wymagania i badania
Large diameter bored piles -- Specifications and tests

PN-B-03200:1990
Konstrukcje stalowe − Obliczenia statyczne i projektowanie
Steel structures -- Static calculation and design

PN-B-03205:1996
Konstrukcje stalowe − Podpory linii elektroenergetycznych − Projektowanie i wykonanie
Steel structures -- Transmission lines supports -- Design and execution

PN-B-03264:2002
Konstrukcje betonowe, żelbetowe i sprężone − Obliczenia statyczne i projektowanie
Plain, reinforced and prestressed concrete structures -- Analysis and structural design

PN-B-03322:1980
Elektroenergetyczne linie napowietrzne − Fundamenty konstrukcji wsporczych − Obliczenia statyczne i projektowanie
Electric overhead lines -- Foundations of supporting structures -- Static calculations and design

PN-B-04452:2002
Geotechnika − Badania polowe
Geotechnics -- Field tests

PN-E-05115:2002
Instalacje elektroenergetyczne prądu przemiennego o napięciu wyższym od 1 kV
Power installations exceeding 1 kV a.c.

PN-E-05118:1977
Przemysłowe zakłócenia radioelektryczne – Elektroenergetyczne linie i stacje wysokiego napięcia – Dopuszczalny poziom zakłóceń – Ogólne wymagania i badania terenowe
Industrial radio interference -- Power lines and high-voltage stations -- Limit of interference -- General requirements and tests

PN-E-06303:1998
Narażenie zabrudzeniowe izolacji napowietrznej i dobór izolatorów do warunków zabrudzeniowych
Exposure of outdoor insulation to pollution and selection of insulators under polluted conditions

Clause National regulation

(ncpt) **Standards**

PN-E-08501:1988
Urządzenia elektryczne – Tablice i znaki bezpieczeństwa
Electrical equipment -- Plates and safety signs

PN-M-34501:1991
Gazociągi i instalacje gazownicze – Skrzyżowania gazociągów z przeszkodami terenowymi – Wymagania
Gas pipelines -- Gas pipelines and ground obstacles crosses – Requirements

PN-EN 1991-1-4:2005
Eurokod 1: Oddziaływania na konstrukcje – Część 1-4: Oddziaływania ogólne – Oddziaływania wiatru
Eurocode 1: Actions on structures -- Part 1-4: General actions -- Wind actions

PN-EN 1992-1-1:2005
Eurokod 2: Projektowanie konstrukcji z betonu -- Część 1-1: Reguły ogólne i reguły dla budynków
Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings

PN-EN 1993-1-1:2006
Eurokod 3: Projektowanie konstrukcji stalowych -- Część 1-1: Reguły ogólne i reguły dla budynków
Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings

PN-EN 1993-3-1:2006
Eurokod 3 -- Projektowanie konstrukcji stalowych -- Część 3 -1: Wieże, maszty i kominy -- Wieże i maszty
Eurocode 3 - Design of steel structures - Part 3-1: Towers, masts and chimneys - Towers and masts

PN-EN 1993-1-11:2006
Eurokod 3 -- Projektowanie konstrukcji stalowych -- Część 1-11: Konstrukcje cięgnowe
Eurocode 3 - Design of steel structures - Part 1-11: Design of structures with tension components

PN-EN 1997-2:2007
Eurokod 7 -- Projektowanie geotechniczne -- Część 2: Badania podłoża gruntowego
Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing

PN-EN 10020:2003
Definicja i klasyfikacja gatunków stali
Definition and classification of grades of steel

Clause National regulation

(ncpt) **Standards**

PN-EN 10025-1:2007
Wyroby walcowane na gorąco ze stali konstrukcyjnych -- Część 1: Ogólne warunki techniczne dostawy
Hot rolled products of structural steels - Part 1: General technical delivery conditions

PN-EN 10025-2:2007
Wyroby walcowane na gorąco ze stali konstrukcyjnych -- Część 2: Warunki techniczne dostawy stali konstrukcyjnych niestopowych
Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels

PN-EN 10025-3:2007
Wyroby walcowane na gorąco ze stali konstrukcyjnych -- Część 3: Warunki techniczne dostawy spawalnych stali konstrukcyjnych drobnoziarnistych po normalizowaniu lub walcowaniu normalizującym
Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels

PN-EN 60445:2002
Zasady podstawowe i bezpieczeństwa przy współdziałaniu człowieka z maszyną, oznaczanie i identyfikacja − Oznaczenia identyfikacyjne zacisków urządzeń i zakończeń żył przewodów oraz ogólne zasady systemu alfanumerycznego
Basic and safety principles for man-machine interface , marking and identification – Identification of equipment terminals and of termination of certain designated conductors, including general rules for an alphanumeric system (IEC 60445:1999)

PN-IEC 815:1998
Wytyczne doboru izolatorów do warunków zabrudzeniowych
Guide for the selection of insulators in respect of polluted conditions

PN-EN ISO 14688-1:2006
Badania geotechniczne -- Oznaczanie i klasyfikowanie gruntów – Część 1: Oznaczanie i opis
Geotechnical investigation and testing - Identification and classification of soil - Part 1: Identification and description (ISO 14688-1:2002)

PN-EN ISO 14688-2:2006
Badania geotechniczne – Oznaczanie i klasyfikacja gruntów – Część 2: Zasady klasyfikowania
Geotechnical investigation and testing – Identification and classification of soil – Part 2: Principles for classification

Clause National regulation

National laws and regulations

- Rozporządzenie Ministra Środowiska, z dnia 14 czerwca 2007 r. w sprawie dopuszczalnych poziomów hałasu w środowisku (Dz. U. Nr 120, poz.826)

  Regulation of the Minister of Environment of 14 June 2007 on permissible noise levels in the environment

- Rozporządzenie Ministra Środowiska z dnia 30 października 2003 r. w sprawie dopuszczalnych poziomów pól elektromagnetycznych w środowisku oraz sposobów sprawdzania dotrzymania tych poziomów (Dz. U. Nr 192. poz.1883)

  Regulation of the Minister of Environment of 30 October 2003 on permissible electric and magnetic field limits in the environment and on methods of verifying compliance with these limits

- Rozporządzenie Ministra Infrastruktury z dnia 28 kwietnia 2003 r. w sprawie przepisów żeglugowych na śródlądowych drogach wodnych (Dz. U. Nr 212, poz.2072)

  Regulation of the Minister of Infrastructure of 28 April 2003 on the rules of navigation on inland waterways

- Rozporządzenie Ministra Transportu i Gospodarki Morskiej z dnia 10 września 1998 r. w sprawie warunków technicznych, jakim powinny odpowiadać budowle kolejowe i ich usytuowanie (Dz. U. Nr 151, poz.987)

  Regulation of the Minister of Transport and Marine Economy of 10 September 1998 on the technical conditions for railway structures and their location

- Rozporządzenie Ministra Infrastruktury z dnia 25 czerwca 2003 r. w sprawie sposobu zgłaszania oraz oznakowania przeszkód lotniczych (Dz. U. Nr 130, poz.1193)

  Regulation of the Minister of Infrastructure of 25 June 2003 on the notification and markings of air obstacle

- Ustawa z dnia 21 marca 1985 r. o drogach publicznych (tekst jednolity) (Dz. U. z 2004 r. Nr 204, poz.2086)

  Public Roads Law of 21 March 1985 (Consolidated version)

- Ustawa z dnia 18 lipca 2001 r. Prawo Wodne (Dz. U. Nr 115, poz.1229)

  Water Law of 18 July 2001

Clause National regulation

3 Basis of design

Part 1 applies without change.

4 Actions on lines

4.3 Actions, Empirical approach

(ncpt) **PL.1 The Empirical approach**

The Empirical approach as described in 4.3 is used in this NNA, with due regard, however, for certain relationships described in the General approach in 4.2.
Detailed values of wind and ice loads are given in 4.3.2 and 4.3.3 of this NNA, respectively.

4.3.2 Wind loads

(ncpt) **PL.1 Wind zones map**

Wind load zones in Poland are shown in Figure 4.3.2/PL.1.

(snc) **PL.2 Wind speeds**

According to Part 1, the mean wind speed V_{mean} or the gust wind speed V_g may be used as the basis for calculating extreme wind speed.

In this NNA, the mean wind speed V_{mean}, allowing to calculate the gust wind load, is used to determine the wind load.
It is assumed that the terms ”extreme wind” and “maximum wind” are interchangeable.

(a) Mean wind speed V_{mean}

The values of the mean wind speed should be determined using Table 4.3.2/PL.1.

Table 4.3.2/PL.1 – Mean wind speed

Zone	V_{mean} [m/s]
I	$22 \cdot c_{ALT}$
II	$26 \cdot c_{ALT}$
III	$22 \cdot c_{ALT}$

Clause National regulation

where:

c_{ALT} — altitude factor calculated using the following formula:

$c_{ALT} = 1{,}0$ for $H \leq 300$ m

$c_{ALT} = 1 + 0{,}0006\,(H - 300)$ for $H > 300$ m

H – altitude above sea level

(b) Reference wind speed V_R

The reference wind speed V_R calculated using the following formula:

$$V_R = k_T \ln\frac{10}{z_0} V_{mean}$$

where:

The terrain factor k_T and the ground roughness parameter z_0 are given in Table 4.3.2/PL.2.

NOTE: Terrain category II is assumed for overhead lines in non-mountainous areas, unless otherwise specified in the Project Specification.

(c) Wind speed V_h at arbitrary height *h* above ground

For overhead line elements more than 10 m above ground, a wind speed shall be calculated using the following formula:

$$V_h = k_T \cdot \ln\frac{h}{z_0} \cdot V_{mean}$$

(d) Wind forces on conductors

For individual conductors and sub-conductors, the value of the perpendicular force Q_{Wc} on the conductors, caused by the wind blowing horizontally, is calculated using the following formula:

$$Q_{Wc} = q_c \cdot G_q \cdot G_c \cdot C_c \cdot d \cdot L \cdot \cos^2\phi \quad \text{[N]}$$

where: $q_c = q_h$

G_c – is the span factor, to be determined according to 4.3.2,

C_c – is the drag factor, to be determined according to 4.2.2.4.1; usually, for conductors $C_c = 1{,}0$, and for iced conductors: $C_c = C_{cI} = 1{,}1$,

d – is the diameter [m] of conductor or sub-conductor, or the diameter of iced conductor, D [m], calculated as described in 4.3.4/PL.2, if ice covers the conductor,

L – is span length,

ϕ – is the angle of incidence of the wind.

Clause National regulation

Table 4.3.2/PL.2 − Terrain factor k_T and ground roughness parameter z_0 for different terrain categories

Terrain category	k_T	z_0 [m]
0 Sea and coastal areas exposed to onshore wind	0,16	0,003
I Lakes or flat, horizontal areas with little vegetation and without obstacles	0,17	0,01
II Areas with low vegetation, such as grasses, and with occasional obstacles (trees, buildings) scattered at intervals equal to at least twenty times their height	0,19	0,05
III Areas evenly covered with vegetation, buildings or isolated obstacles, scattered at intervals equal to at least twenty times their height (such as villages, suburban areas, permanent forests)	0,22	0,3
IV Areas in which at least 15 % of the surface is covered with buildings with mean height exceeding 15 m	0,24	1,0
V Mountainous and more complex terrain where the wind may be locally strengthened or weakened	Data from local observation stations shall be used	
The terrain categories are shown in standard PN-EN 1991-1-4:2005 (Subclause 4.3.2 and Annex A.1)		

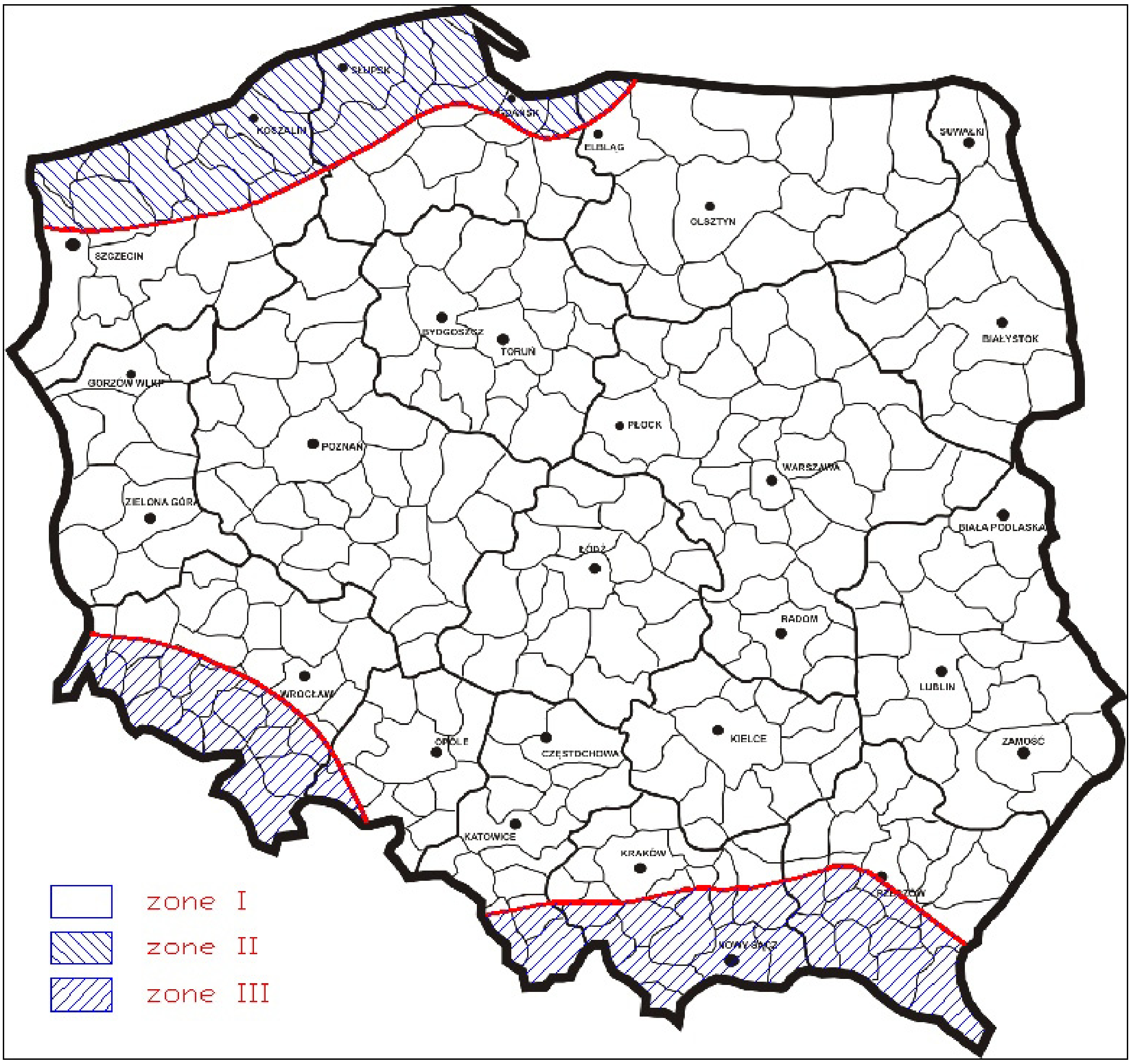


Figure 4.3.2/PL.1. – Wind load zone map

4.3.3 Ice loads

(snc) **PL.1 Characteristic ice loads on conductors**

Characteristic ice loads on conductors per unit length I_k (N/m) are shown in Table 4.3.3/PL.1.

The value of the characteristic ice load depends on the zone in which the considered line is located.

Clause National regulation

Table 4.3.3/PL.1 – Characteristic ice loads per unit length of the conductor

Ice load zone	Characteristic ice load I_K [N/m]
S1	4,1 + 0,41 *d* or according to the Project Specification
S2	8,2 + 0,82 *d* or according to the Project Specification
S3	16,4 + 0,82 *d* or according to the Project Specification
S_{spec}	Only on the basis of meteorological data for the area where the line is located or according to the Project Specification

where:

d – is the external diameter of the conductor in mm

The ice load zones in Poland are shown in Figure 4.3.3/PL.1.

Only ice loads on conductors, insulators and elements mounted on conductors (e.g. warning spheres) are considered. Ice density $q_I = 700$ kg/m^3 should be used. The Project Specification may, however, specify a different value for ice density. The impact of icing on the support structure on support loading is not considered. Characteristic ice loads are used as input data for determining design loads on supports, conductors, insulators and equipment.

(snc) **PL.2 Ice loads on insulator sets**

Ice loads on insulator sets are calculated as follows:

S1 zone – 150 N per 1 m of the length of each insulator string

S2 zone – 200 N per 1 m of the length of each insulator string

S3 zone – 250 N per 1 m of the length of each insulator string

S_{spec} zone – the load value should be specified in the Project Specification

(snc) **PL.3 Ice loads on elements mounted on conductors**

Ice loads on elements mounted on conductors are calculated on the assumption that thickness of a layer of ice is equal to the thickness of a layer of ice on conductors on which the considered elements are mounted.

Clause National regulation

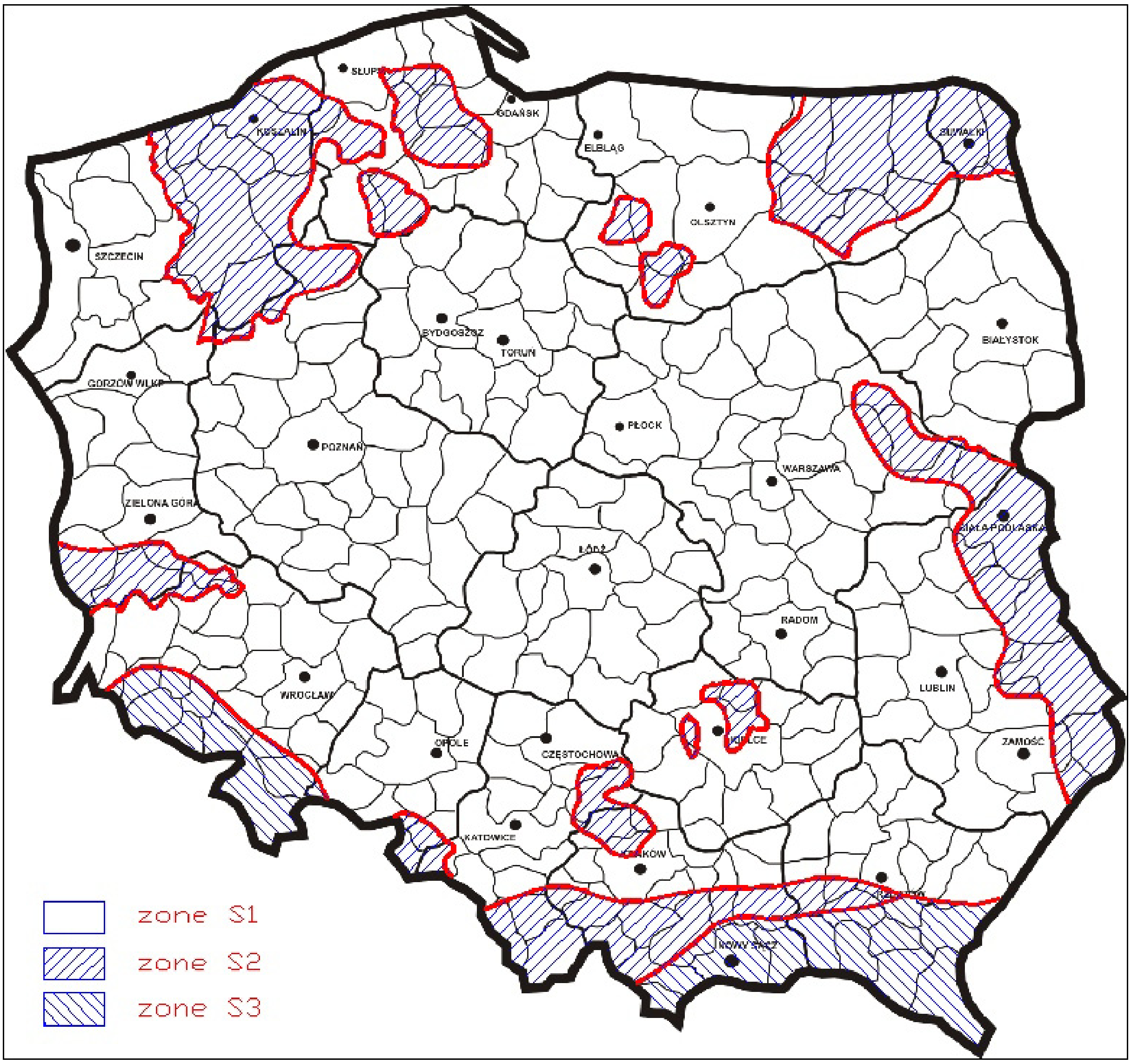


Figure 4.3.3/PL.1. – Ice load zone map

4.3.4 Combined wind and ice loads

(ncpt) **PL.1 Combined wind and ice loads**

Combined wind and ice loads shall be considered for the following combinations:

a) a high ice load equal to $\psi_I \cdot Q_{IK}$ combined with a moderate wind load $\psi_W \cdot Q_{WK}$

b) a moderate ice load $\psi_I \cdot Q_{IK}$ combined with a high wind load $\psi_W \cdot Q_{WK}$

(ncpt) **PL.2 Drag factor and ice density**

The following drag factor and ice density should be used:
C_{cI} =1,1 and ρ_I =700 kg/m^3.

The Project Specification may define other requirements.

Clause National regulation

4.3.5 Temperature effects

(ncpt) **PL.1 Minimum and maximum temperatures**

Unless otherwise specified in the Project Specification, minimum and maximum temperatures, as well as the temperature for icing conditions, shall be selected from Table 4.3.10.3/PL.1.

4.3.6 Construction and maintenance loads

(ncpt) **PL.1 Construction and maintenance loads**

Supports shall be designed for assembly loads in line with the adopted working procedures for erecting supports and installing conductors.

Cross-arms and earthwire peaks on which assembly works are planned, involving linesmen climbing onto the cross-arm, suspending a man-basket, etc., shall be designed for assembly loads including an additional vertical force acting on the axis of the outermost conductor and equal to:

2 kN for support earthwire peaks of all lines and for support cross-arms of lines with a nominal voltage of up to 110 kV

3 kN for support cross-arms of lines with a nominal voltage exceeding 110 kV

The Project Specification may specify other load values.

4.3.7 Security loads

(ncpt) **PL.1 Security loads**

Security loads shall be determined according to case 5, Table 4.3.10.4/PL.1.

4.3.8 Forces due to short-circuit currents

(ncpt) **PL.1 Short-circuit currents**

Requirements concerning forces due to short-circuit currents may be given in the Project Specification.

4.3.9 Other special forces

(ncpt) **PL.1 Other special forces**

Requirements concerning other special forces according to 4.2.9 may be given in the Project Specification

Clause National regulation

4.3.10 Load cases

4.3.10.3 Conductor tension load cases

(ncpt) **PL.1 Conductor tensile forces**

Unless otherwise stated in the Project Specification, the conductor tension load cases are given in Table 4.3.10.3/PL.1

Table 4.3.10.3/PL.1 − Conductor tension load cases

No	Load case	Conductor temperature ºC	Load	Note
1.	Normal	−5	Conductor self-weight + 50 % of characteristic ice load	(1)
2.	Normal	−5	Conductor self-weight + characteristic ice load	(1)
3.	Normal	−25	Conductor self-weight	
4.	Normal	+10	Conductor self-weight + maximum wind load	(2)
5.	Normal	+40	Conductor self-weight	(3)
6.	Normal	−5	Conductor self-weight (ψ_G =1,0) with high ice load (ψ_I =1,0) + moderate wind load (ψ_W= 0,4)	(4)
7.	Normal	−5	Conductor self-weight (ψ_G =1,0) with moderate ice load (ψ_I = 0,35) + high wind load (ψ_W = 0,7)	(4)

Notes: (1) – characteristic ice loads I_K are given in Table 4.3.3/PL.1

(2) – mean wind speeds for calculating the maximum wind load are given in Table 4.3.2/PL.1.

(3) – higher conductor temperature may be considered; the maximum temperature should be given in the Project Specification.

(4) – for combined wind and ice loads refer to 4.3.4/PL.1.

4.3.10.4 Standard load cases

(ncpt) **PL.1 Load cases**

Load cases are given in Table 4.3.10.4/PL.1.

Clause National regulation

Table 4.3.10.4/PL.1 – Load cases

Load case	Design situation	Load case description	Conductor temperature [ºC]	Applies to
1	Normal	Maximum wind load	+10	All supports
2a	Normal	Uniform ice loading of all conductors and insulators in all spans	−5	
2b	Exceptional	Transversally unbalanced ice loads: ice load on all conductors on one side of the support reduced by the factor α=0,5; ice load on the conductors on the other side of the support not reduced (transverse bending)		
2c		Longitudinally unbalanced loads: ice load on all conductors in one direction of the line reduced by the factor α_1=0,35; ice load in the other direction of the line reduced by the factor α_2=0,70 (longitudinal bending)		
2d		Torsionally unbalanced loads: ice load on conductors on one side of the support and in one direction of the line reduced by the factor α_3=0,35; ice load on all other conductors of the line reduced by the factor α_4=0,70 (torsional bending)		
3	Normal	Combined ice and wind loads, with the effect E_d determined for two combinations: I. Conductor self-weight with high ice load + moderate wind load $E_d = E_d\,(\psi_G \cdot Q_{GK}, \psi_I \cdot Q_{IK}, \psi_W \cdot Q_{WK})$; ψ_G = 1,0; ψ_I = 1,0; ψ_W = 0,4 II. Conductor self-weight with moderate ice load + high wind load $E_d = E_d\,(\psi_G \cdot Q_{GK}, \psi_I \cdot Q_{IK}, \psi_W \cdot Q_{WK})$; ψ_G = 1,0; ψ_I = 0,35; ψ_W = 0,7	−5	
4a	Normal	Action with a value equal to 2/3 of one-side conductor tension with uniform ice loads on all spans	−5	Tension supports
4b		Action of total one-side conductor tension with ice load		cross-arms, earthwire peaks, and other structural elements on which less than three conductors are tensile fixed
4c		Construction and maintenance loads		All supports

Clause National regulation

Load case	Design situation	Load case description	Conductor temperature [ºC]	Applies to
5	Exceptional	Action caused by the breaking of a phase conductor (single or an entire bundle) or earth wire at an ice load reduced by the factor α_5=0,70 (no wind load)	−5	Tension supports

Notes:
1. In each load case, permanent actions, i.e. the weight of structures, conductors, insulators and equipment, and tension components representing conductor self-weight, should be considered. In addition, tension components representing wind and ice loads should be considered in the appropriate load cases.
2. The wind load should be considered for winds blowing perpendicular, parallel and at an angle of 45º to the longitudinal plane of the support. The longitudinal plane of the support is the plane perpendicular to the axis of the cross-arms.
3. For branched supports, combined loads occurring simultaneously should be considered, depending on the support's function in the line.
4. Other special load cases or requirements may be included in the Project Specification.

4.3.11 Partial factors for actions

(ncpt) **PL.1 Partial factors for actions**

Partial factors for actions are given in Table 4.3.11/PL.1.

Table 4.3.11/PL.1 − Partial factors for actions

Design situation	Symbol	Factor γ_F
Normal: permanent actions variable actions	 γ_G γ_Q	 1,1 (0,9)$^{*)}$ 1,3
Exceptional:	γ_A	1,0

$^{*)}$ when the actions are favourable (i.e. decrease the usage)

NOTE: The above mentioned partial factors on actions should be considered in conjunction with the partial factors on material properties.

(ncpt) **PL.2 Applying of the partial factors**

According to the adopted empirical approach, partial factors shall be applied to the effects of action (e.g. vertical, transversal, longitudinal forces which arise from the conductor reaction) and not to the characteristic values of actions.

The only exceptions are load cases involving load combinations; in these cases partial factors are included in combination factors ψ.

Clause National regulation

5 Electrical requirements

5.2 Currents

5.2.1 Normal current

(ncpt) **PL.1 Design maximum temperature**

The owners of the overhead lines shall determine the design maximum temperature at their discretion, depending on the magnitude of power transmission in normal and emergency conditions, on the mode of operation of the line and on economic considerations.

(ncpt) **PL.2 Recommended design temperature**

For overhead lines of 110 kV and more, it is recommended to use a design maximum temperature of at least + 60 ºC. The Project Specification may define other recommendations.

5.3 Insulation co-ordination

5.3.3 Determination of the co-ordination withstand voltage (U_{cw})

5.3.3.5 Lightning performance of overhead lines

(ncpt) **PL.1 Atmospheric discharge protection**

Atmospheric discharge protection of overhead lines shall be ensured by installing an earth wire(s), adequate tower earthing or by installing surge arresters. Overhead electrical lines with nominal voltage of 110 kV and more shall be protected using earth wires extending along their entire length.

The angle of the lightning protection cone for the outermost phase conductor (wind pressure on the conductors not considered) should not be greater than:

30º in 110 kV lines

20º in 220 kV and 400 kV lines

The angle of the lightning protection cone for an inner phase conductor, i.e. conductor located between two other conductors (wind pressure on the conductors not considered) should not be greater than:

60º in 110 kV lines

45º in 220 kV and 400 kV lines

The earth wires shall be earthed at each tower. The earthing resistance of any tower with an earth wire(s) shall not exceed the values given in Tables 6.4.1/PL.3 and 6.4.2/PL.3

At the substation entry, earth wires should be connected with the support structures and earth electrode of the station.

Clause National regulation

5.3.4 Determination of the required withstand voltage (U_{rw})

(ncpt) **PL.1 The required withstand voltages**

The required withstand voltages are given in PN-EN 60071-1. The Project Specification may specify other values than the maximum values of withstand voltages as given in PN-EN 60071-1.

5.3.5 Electrical clearance distances to avoid flashover

5.3.5.3 Empirical method

(ncpt) **PL.1 Clearances D_{el} and D_{pp}**

Clearances D_{el} and D_{pp} are given in Table 5.5/PL.1. Calculation of these values according to Annex E is also permitted.

Table 5.5/PL.1 – Clearances D_{el} and D_{pp}

Highest system voltage [kV]	D_{el} [m]	D_{pp} [m]
123	0,85	0,96
245	1,70	2,00
420	2,80	3,20

5.4 Internal and external clearances

5.4.1 Introduction

(ncpt) **PL.1 Distance to the crossed objects**

Where external objects are crossed, it shall be verified that the distance to the crossed object, calculated in accordance with this standard, is greater than 110 % of a_{som} at three towers before and three towers past the crossing. The above requirement does not apply when D_{el} is calculated according to Annex E.

(ncpt) **PL.2 Minimum internal clearances**

Minimum internal clearances between the live parts and the earthed structure (in still air conditions) shall be as follows:

- 110 % of a_{som} for 110 kV lines
- 105 % of a_{som} for 220 and 400 kV lines,

unless otherwise specified in the Project Specification.

The above requirement does not apply when D_{el} is calculated according to Annex E.

Clause National regulation

(ncpt) **PL.3 Applicable restriction levels**

Depending on the importance of the object crossed by the overhead electrical line, more strict requirements, hereafter referred to as restrictions, apply to the line components at the crossing. There are three restriction levels, I, II and III, level III being the most strict. The applicable restriction levels are given in Table 5.4.1/PL.4.

Table 5.4.1/PL.4 − Restriction levels applicable at crossings of overhead electrical lines with external objects

No	Object	Restriction level for electrical lines exceeding 45 kV at crossings
1	Motorway, express road	III
2	Voivodship, national and city road	II
3	Industrial, district, municipal road	I
4	Bus station	III for 400 kV lines, crossings are not permitted
5	Tourist sailing routes	I
6	Navigable water bodies accessible by passenger ships, tugs, pusher tugs, barges; water sports centres and swimming pools	III
7	Arterial and primary railroads, ropeways	III
8	General purpose, secondary and urban railroads	II
9	Outbuildings, greenhouses, garages	I
10	Residential buildings, public buildings	II 1)
11	Public gardens, marketplaces, garden plots, cemeteries, industrial buildings, developed industrial areas (work places), military barracks	II
12	Designated car parks	II 2)
13	a) Designated operating zones of cranes or loading equipment	III refer to Table5.4.5.3/PL.9
	b) Non-designated operating zones of cranes or loading equipment	not permitted

Clause National regulation

No	Object	Restriction level for electrical lines exceeding 45 kV at crossings
14	Buildings, stores, process plant and permanent storage areas with explosives or explosion hazard zones; filling stations	Crossing not permitted; proximity and, in exceptional cases, crossing, permitted according to requirements given in 5.4.5.2/PL.3
15	Electric traction system wires (trolley wires, carrying and strengthening wires, feeder wires)	II
16	Electric lines of any voltage and telecommunication lines	I
17	Over-ground pipelines for transporting fire hazardous material, including gas pipelines	II

Explanatory notes:

I – restriction level I applies,

II – restriction level II applies,

III – restriction level III applies.

1) Crossing not permitted in the case of 400 kV overhead lines and new 220 kV overhead lines.

2) Crossing not permitted in the case of 400 kV overhead lines. Minimum clearance between the outermost conductor and designated car parks is 20 m.

Crossings with objects not listed in Table 5.4.1/PL.4 shall be designed on a case by case basis.

(ncpt) **PL.4 Additional requirements**

Where restrictions apply, there are additional requirements for conductors and insulators.

The restrictions involve the following:

For restriction level I:

- conductor tension – refer to 9.2.4/PL.1; 9.3.4/PL.1; 9.5.4/PL.1
- increased mechanical security of insulator sets and insulator cross-arms on the towers encompassing the crossing.

For restriction level II:

- conductor tension – refer to 9.2.4/PL.1; 9.3.4/PL.1; 9.5.4/PL.1

increased mechanical security of insulator sets and insulator cross-arms on the towers of the entire section in which crossing of objects listed in Table 5.4.1/PL.4 takes place.

NOTE: With regard to lines with bundle conductors, restriction level II is the same as restriction level I.

Clause National regulation

For restriction level III:

- conductor tension – refer to 9.2.4/PL.2; 9.3.4/PL.2; 9.5.4/PL.2
- increased mechanical security of insulator sets and insulator cross-arms on the towers of the entire section in which crossing of objects listed in Table 5.4.1/PL.4 takes place.

Increased mechanical security of insulator sets composed of one string is achieved by increasing the number of insulator strings by one more than it results from mechanical load calculations.

In case of multi-string insulator sets, increasing the number of insulator strings is not required, unless specified otherwise by a Project Specification.

Increased mechanical security of rigid insulator cross-arms is achieved by adding an upper bar to the cross-arm. In self aligning cross-arms, increased mechanical security concerns the upper bar of the cross-arm and is achieved in accordance with the rules applicable to insulator sets.

(ncpt) **PL.5 Restriction for connecting of conductors**

Connecting of conductors is not permitted in spans in which crossing with objects listed in Table 5.4.1/PL.4 takes place.

5.4.2 General considerations and load cases

5.4.2.2 Load cases for calculation of clearances

5.4.2.2.1 Maximum conductor temperature

(ncpt) **PL.1 Design maximum temperature of phase conductors**

For phase conductors, the design maximum temperature should be determined according to 5.2.1/PL.1 and 5.2.1/PL.2.

(ncpt) **PL.2 Design maximum temperature of earth wires**

With regard to earth wires and other wires not designed to transmit power, the design maximum temperature should be +40 ºC.

5.4.2.2.2 Ice load for determination of electrical clearance

(ncpt) **PL.1 Uniform ice load case**

Conditions for checking clearances for uniform characteristic ice loads I_k, according to 4.3.3/PL.1:

- conductor temperature: –5 ºC;
- no wind load

Clause National regulation

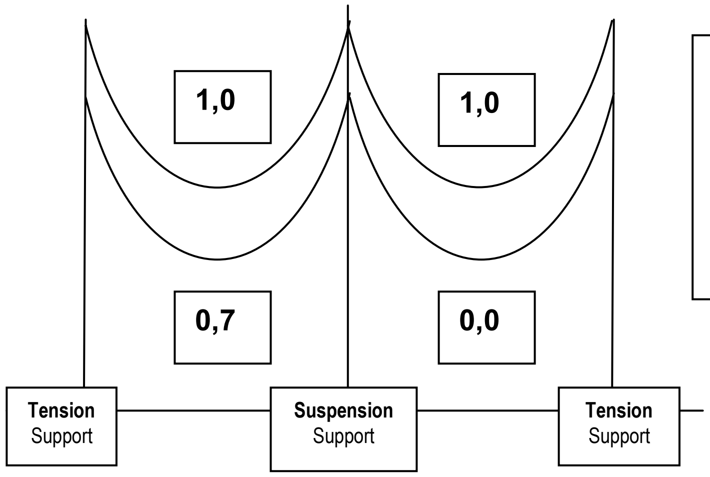
(ncpt) **PL.2 Non-uniform ice load case**

Conditions for checking clearances for non-uniform characteristic ice loads occurring after uneven drop of ice loads in adjacent spans of a section :

- conductor temperature: −5 ºC;
- no wind load;

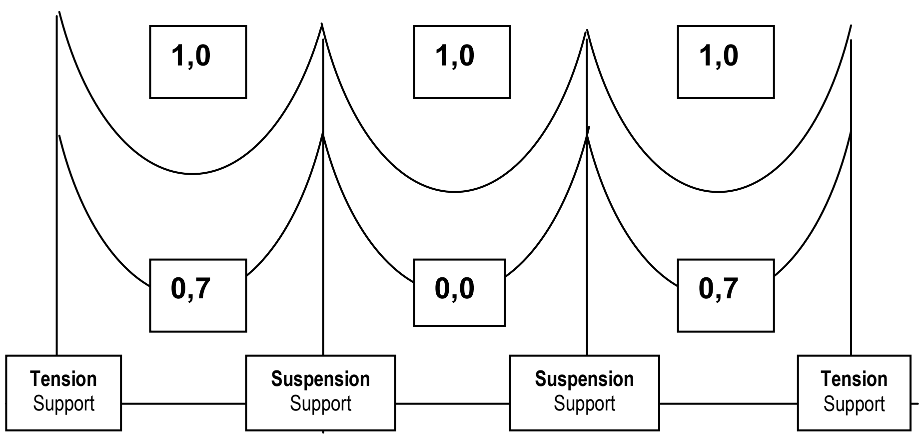
70 % of the ice load I_k determined as described in 4.3.3/PL.1 in a span and no ice load in an adjacent span, with full ice load I_k remaining on the upper conductors (see ice load diagram below)

For two-span tension sections:



Where:
the box values are ice loads on the individual conductors relative to the characteristic ice load I_K for these conductors.

For tension sections with more spans:



Clause National regulation

The above recommendations apply to clearances between phase conductors as well as clearances between phase conductors and earth wires.

For non-uniform ice loads, dislocation of conductor clamping points (swinging of insulator sets or suspension fittings on suspension supports) should be considered.

5.4.2.2.3 Wind load for determination of electrical clearances

(ncpt) **PL.1 Wind load with the exception of extreme wind load**

Clearances shall be checked for the following conditions:

- conductor temperature: +40 ºC;
- wind load corresponding to 58 % of wind load with no gusts according to 4.3.2/PL.2.

(ncpt) **PL.2 Extreme wind load case**

Clearances shall be checked for extreme winds with gusts under the following conditions:

- conductor temperature: +40 ºC;
- extreme wind load on conductors according to 4.3.2/PL.2 (d) and extreme wind load on insulator sets according to 4.2.2.4.2.

This case is used to check internal clearances as described in 5.4.3.

5.4.2.2.4 Combined wind and ice loads

(ncpt) **PL.1 Combined wind and ice loads**

Combined wind and ice loads are not considered when calculating clearances, unless the Project Specification requires otherwise.

If it is required to consider the combined wind and ice loads when calculating clearances, the Project Specification shall determine in detail the load values and the required clearances.

5.4.3 Clearances within the span and at the tower

(ncpt) **PL.1 Minimum clearances**

Minimum clearances in the middle of the span and at the tower are included in Table 5.4.3/PL.1.

Clause National regulation

Table 5.4.3/PL.1 – Minimum clearances in the middle of the span and at the tower

	Clearance cases: in the middle of the span and at the tower				
	In the middle of the span		At the tower		
Load Case	Phase conductor – phase conductor	Phase conductor – earth-wire	Between phases and/or circuits	Between phase conductors and earthed parts	Remarks
Conductor temperature equal to +40 ºC	b_1 1)	b_2 1)	D_{pp}	refer to 5.4.1/PL.2	Still air and ice-free load conditions
Ice load	refer to 5.4.3/PL.6 2)	refer to 5.4.3/PL.6 2)	D_{pp}	refer to 5.4.1/PL.2	Load conditions in still air
Wind load except extreme wind load	—	—	$k_{pp}\ D_{pp}$	$k_{el}\ D_{el}$	k_{pp} and k_{el} according to 5.4.3/PL.2
Extreme wind load	—	—	$D_{50\ Hz\_p\_p}$	$D_{50\ Hz\_p\_e}$	refer to Table 5.4

1) refer to 5.4.3/PL.5 to calculate the values of b_1 and b_2

2) in addition, the requirement of 5.4.3/PL.4 must be met, if so stated in the Project Specification.

(ncpt) **PL.2 Reduction factor for minimum internal clearances**

The reduction factors are as follows:

$$k_{el} = 0{,}9$$

$$k_{pp} = 0{,}8$$

The Project Specification may specify other values of the factors within the range 0,6÷1.

(ncpt) **PL.3 Jumper rigidity factor**

The swinging of the jumpers shall be calculated using the jumper rigidity factor which reduces the effect of wind load.

The values of this factor are as follows:

- for lines up to 110 kV: 0,3
- for 220 kV lines: 0,5
- for 400 kV lines: 0,7

Clause National regulation

(ncpt) **PL.4 Clearances between conductors within the span for non-uniform ice loads**

Load cases for checking clearances between the conductors for non-uniform ice loads are given in Table 5.4.2.2.2/PL.2.

Clearances between phase conductors and between phase conductor and earth-wire are not checked for this case unless otherwise required in the Project Specification.

If such a check is required, minimum internal clearances should be determined according to Table 5.4. The Project Specification may specify greater values.

(ncpt) **PL.5 Checking the minimum clearance between the conductors in the middle of the span using the empirical approach**

The clearance between the conductors of an electrical line should be at least:

- for conductors made of the same material and with the same cross-sectional area and stress

  $b_1 = k \cdot \sqrt{f_{+40} + l_i} + k_{pp} \cdot D_{pp}$ (phase conductor - phase conductor)

  $b_2 = k \cdot \sqrt{f_{+40} + l_i} + k_{el} \cdot D_{el}$ (earth-wire - phase conductor)

- for conductors made of the different materials or with the different cross-sectional areas or stresses

  $b_1 = k' \cdot \sqrt{f'_{+40} + l_i'} + k'' \cdot \sqrt{f''_{+40} + l_i''} + k_{pp} \cdot D_{pp}$ (phase conductor- phase conductor)

  $b_2 = k' \cdot \sqrt{f'_{+40} + l_i'} + k'' \cdot \sqrt{f''_{+40} + l_i''} + k_{el} \cdot D_{el}$ (earth-wire - phase conductor)

where:

$b_1; b_2$ - minimum permissible clearance between the conductors in still air, in the middle of the span, in the vertical plane perpendicular to the span axis

k - coefficient depending on the material and cross-sectional area of the conductor, to be selected using Table 5.4.3/PL.4

k' and k'' - coefficients, each of which is equal to a half of the respective coefficient *k* for the specific conductor, selected using Table 5.4.3/PL.4

f_{+40} - sag in m of the conductor at +40 ºC,

f'_{+40} and f''_{+40} - respective sag in m of each of the two conductors at +40 ºC,

l_i - vertical length in m of suspension insulator sets, measured from the point of attachment of the set to the conductor:
for tension insulator sets and line post insulators, the value l_i = 0 should be used.

Clause National regulation

For spans with a tension insulator set on one end and a suspension insulator set on the other end, in formula b, the value equal to half of the vertical length l_i of the suspension insulator set should be used instead of l_i.

l_i' l_i'' - respective vertical lengths in m of the insulator sets of the two conductors.

NOTE: When "high-temperature" conductors are used, the Project Specification may recommend that the sag of the conductor at a temperature exceeding +40 ºC is used.

Table 5.4.3/PL.4 − *k* coefficients depending on material and cross-sectional area for various conductor arrangements

Conductor material	Cross-sectional area in mm^2	*k* coefficient for the following clearances between the horizontal projections of the conductors			
		for phase conductors		for phase conductor and earth-wire	
		clearance at least equal to $k_{pp} D_{pp}$	clearance less than $k_{pp} D_{pp}$	clearance at least equal to $k_{el} D_{el}$	clearance less than $k_{el} D_{el}$
1	*2*	*3*	*4*	*5*	*6*
Aluminium-steel with a steel to aluminium ratio exceeding 0,1 and steel conductors	from 50 to 150 150 and more	0,7 0,65	0,85 0,75	0,7 0,65	0,85 0,75
Aluminium and its alloys and aluminium-steel with a steel to aluminium ratio below 0,1	from 50 to 150 150 and more	0,75 0,7	0,95 0,85	0,75 0,7	0,95 0,85

(ncpt) **PL.6 Clearances for conductor bouncing**

For lines with conductors arranged vertically or almost vertically, when the clearance between the horizontal projections of neighbouring conductors is smaller than $k_{pp} D_{pp}$ (for phase conductors) or k_{el} D_{el} (for phase conductor and earth-wire), the greater one of the following distances should be used as the minimum permissible clearance between the conductors:

a) clearance determined as described in 5.4.3/PL.5

b) clearance for which the distance between these conductors shall not be smaller than k_{pp} D_{pp} (for phase conductors) or k_{el} D_{el} (for phase conductor and earth-wire) when the upper conductor is under characteristic ice load I_K and a sudden bouncing of the lower conductor occurs as a result of drop of characteristic ice load from the lower conductor.

Clause National regulation

The bouncing amplitude A_p in m, from the position under the characteristic ice load I_K, in the middle of the span, is calculated using the following formula:

$$A_p = 2c\ (f_R - f_{-5})$$

where:

c - is a coefficient equal to 1,0 for a single conductor and 0,5 for a bundle of conductors

f_R - is the sag in m with the characteristic ice load on the conductor I_K at conductor temperature of -5 °C

f_{-5} – is the sag in m at conductor temperature of −5 °C with no ice load

If a separator(s) is(are) installed within the span, the values f_R and f_{-5} should be determined for the sub-spans between the insulator sets on the tower and the separator, and between the separators.

5.4.4 Clearances to ground in areas remote from buildings, roads, railways and navigable waterways

(ncpt) **PL.1 The minimum clearances to ground**

The minimum clearances to ground shall be determined using Table 5.4.4/PL.1.

Table 5.4.4/PL.1 − Minimum clearances to ground in areas remote from buildings, roads, railways and navigable waterways

Load case	**Clearance to ground in unobstructed countryside**		**Clearance to trees**	
	Normal ground profile	Rockface or steep slope	**Under the line**	**Beside the line**
Maximum conductor temperature	5 m + D_{el}	2 m + D_{el} but greater than 3 m	2,5 m + D_{el}	2,5 m + D_{el}
Ice load	5 m + D_{el}	2 m + D_{el} but greater than 3 m	D_{el}	2,5 m + D_{el}
NOTE: These clearances are based on a 5 m high vehicle.				

Clause National regulation

(ncpt) **PL.2 Lines running through forests and near trees**

Clearances between conductors and trees are specified in Table 5.4.4/PL.1.

In justified cases, these clearances should be increased by at least 1 m, e.g. where the conductors run near fruit trees or ornamental trees subject to pruning, trimming, etc., the length of the garden tools should be considered.

The width of the basic tree clearance zone along the line is calculated using the following formula:

$$S = B + 2\,(2{,}5 + D_{el}) \quad [\mathrm{m}]$$

where:

B – is the width of the line in m (the distance between the outermost phase conductors)

In addition, when determining the width of the basic tree clearance zone, tree growth and periodical clearing of the zone, as required in the Project Specification, should be allowed for.

The Project Specification may require additional clearance of trees along the line, whose height H_d is such that they may damage the line if they fall. The tree height H_d is calculated using the following formula:

$$H_d \geq \sqrt{l^2 + \Delta h^2} - D_{el}$$

where:

H_d – is the tree height in m,

l – is the horizontal distance in m between the tree trunk at the ground and the outermost conductor of the electrical line,

Δh – is the level difference in m between the conductor at +10 ºC and the ground at the tree trunk, in the plane perpendicular to the line direction

Clearance of trees with a height H_d or more may not be required if they are isolated trees growing in an open area, and as such, are more resistant to breaking or falling. This does not apply to sick trees.

The Project Specification may allow for additional contingencies when specifying the clearances between trees and conductors for lines running through forest areas.

(ncpt) **PL.3 Lines running above forests**

When overspanning forests to avoid lopping, the maximum future height of the trees should be allowed for when determining conductor height.

5.4.5 Clearances to buildings, traffic routes, other lines and recreational areas

5.4.5.1 General

(ncpt) **PL.1 General**

The following cases are considered in the NNA for Poland:

a) Clearances to residential and other buildings, when the line is above or adjacent to the buildings or near antennas or similar structures (see Table 5.4.5.2/PL.1).

b) Clearances to line crossing roads, railways and navigable waterways (see Table 5.4.5.3.1/PL.1 in conjunction with 5.4.5.3/PL.4).

c) Clearances to line adjacent to road, railway or navigable waterways (see Table 5.4.5.3.2/PL.1 in conjunction with 5.4.5.3/PL.4).

d) Vertical and horizontal clearances to overground pipelines and pipeline support structures, at crossings (see 5.4.5.3/PL.5 and Table 5.4.5.3./PL.5).

e) Vertical and horizontal clearances to underground pipelines (see 5.4.5.3/PL.6).

f) Vertical and horizontal clearances to designated operation zones of cranes and loading equipment, such as hoisting and transport equipment and earthwork machinery and equipment (see 5.4.5.3/PL.7 and Table 5.4.5.3/PL.6).

g) Clearances to line crossing or parallel to other power lines or overhead telecommunication lines (see 5.4.5.4/PL.1, PL.2, PL.3 and Table 5.4.5.4/PL.1).

h) Clearances to recreational areas, line above and in close proximity (see 5.4.5.5/PL.1 and Table 5.4.5.5/PL.1).

5.4.5.2 Residential and other buildings

(ncpt) **PL.1 General recommendations**

It is recommended that:

a) the span located above the building be as short as possible;

b) conductors do not run over chimneys and buildings with non-fire resistant roofs, e.g. roofs covered with thatch, wood or roofing paper placed on wood.

Clause	National regulation

Lines with a nominal voltage 400 kV and new lines with a nominal voltage 220 kV are not permitted to cross residential buildings, schools and public buildings where people may stay on a permanent basis.

Where electrical lines cross, or are in close proximity to, residential buildings, schools, boarding houses, hospitals, sanatoriums, etc., where people stay on a permanent basis, the electric and magnetic field intensities and noise levels caused by the line must not exceed the values given in 5.5.1.3/PL.1 and 5.6.1/PL.1.

For the electrical line restrictions levels applicable to crossings with residential buildings, refer to Table 5.4.1/PL.4.

Clearances to residential buildings, fire sensitive installations, fuel stations as well as antennas, street lamps, flag poles and advertising signs are included in Table 5.4.5.2/PL.1.

(ncpt) **PL.2 Recommendations for gas fuel stations**

Overhead electrical lines should not cross liquid or gas fuel stations, buildings with fire hazardous materials and explosion hazard zones.

As an exception, crossings of the above facilities with lines with a nominal voltage of up to 110 kV are permissible.

In such cases, the crossing span shall be limited by tension supports and restriction level III shall apply. The distance of the support from the liquid fuel station (buildings housing fire-hazardous materials, tanks, pumps) shall be at least 30 m.

(ncpt) **PL.3 Other recommendations**

The routing of overhead electrical lines adjacent to factory buildings, permanent storage areas, tanks and other process facilities with explosives or explosion hazard zones, or to fuel stations, should be in accordance with the special regulations on the construction of such installations and upon approval of the competent administrative bodies.

If such regulations are not in place, the line should be routed so that the distance between the outermost conductor and the considered facility is equal to at least 1,5 times the height of the point of attachment of the highest phase conductor on the support.

If the line must be routed closer than 1,5 times the height of the point of attachment of the highest phase conductor on the support, restriction level III shall apply.

Clause National regulation

Table 5.4.5.2/PL.1 – Minimum clearances to residential and other buildings

	Clearance cases: Residential and other buildings					
	Line above buildings			**Line adjacent to buildings**	**Antennas, street lamps, flag poles, advertising signs and similar structures**	
Load Case	With fire resistant roofs where the slope is greater than 15º to the horizontal	With fire resistant roofs where the slope is less than 15º to the horizontal	With non fire resistant roofs and fire sensitive installations such as fuel stations, etc.		Antennas and lightning protection facilities	Street lamps, flag poles, advertising signs and similar structures which cannot be stood on
Maximum conductor temperature	2 m + D_{el}, but greater than 3 m	4 m + D_{el}, but greater than 5 m	10 m + D_{el}	2 m + D_{el}, but greater than 3 m (horizontal clearance)	2 m + D_{el}	2 m + D_{el}
Ice load	2 m + D_{el}, but greater than 3 m	4 m + D_{el}, but greater than 5 m	10 m + D_{el}	2 m + D_{el}, but greater than 3 m (horizontal clearance)	2 m + D_{el}	2 m + D_{el}
Wind load according to 5.4.2.2.3/PL.1	2 m + D_{el}, but greater than 3 m	4 m + D_{el}, but greater than 5 m	10 m + D_{el}	2 m + D_{el}, but greater than 3 m (horizontal clearance)	2 m + D_{el}	2 m + D_{el}
Remarks	It is considered that it is reasonable for a person to stand on the roof for maintenance and to use a hand tool.	It is considered that it is reasonable for a person to stand on the roof for maintenance and to use a small ladder.	The clearance shall be sufficient to remove the possibility that induced voltages could lead to ignition.	If this horizontal distance cannot be met the vertical clearances in the case of a line above buildings shall be met.	The clearance D_{el} shall be maintained even when the structure falls towards the line conductors.	

Clause National regulation

5.4.5.3 Traffic routes

(ncpt) **PL. 1 Overhead electrical lines crossing and adjacent to roads**

The positioning of the electrical line supports should conform with the respective road regulations. (Public Roads Law of 21 March 1985).

Where the electrical line crosses the road, restriction levels according to Table 5.4.1/PL.4 shall apply.

Clearway traffic signs shall be installed at crossings of 400 kV lines with national, voivodship and district roads. The signs shall be placed at the road side, 20 m from the outermost line conductor. The minimum clearances to roads at crossings are included in Table 5.4.5.3.1/PL.1.

The clearances required for lines adjacent to roads are given in Table 5.4.5.3.2/PL.1.

(ncpt) **PL.2 Overhead electrical lines crossing and adjacent to public railways**

The conditions for the construction of the crossing and the positioning of the supports shall be agreed with the owner of the railway, with due regard for the relevant regulations.

Restriction levels according to Table 5.4.1/PL.4 apply to lines crossing railways.

It is forbidden to:

a) cross overhead 110 kV and higher voltage electrical lines with semaphores and barriers,
b) use rails or other railway equipment as earthing.

The following regulations are applicable: Regulation of the Minister of Transport and Marine Economy of 10 September 1998 on the technical conditions for railway structures and their location.

The minimum clearances to lines crossing and adjacent to railways are included in Table 5.4.5.3.1/PL.1 and 5.4.5.3.2/PL.1, respectively.

Clause National regulation

Table 5.4.5.3.1/PL.1 – Minimum clearances to line crossing roads, railways and navigable waterways

	Clearance case: Line crossing roads, railways and navigable waterways						
Load case	To road surface or top of rail level (if no electric traction system is used)	To components of electric traction systems or railways, trolley bus lines or rope ways	To pulling ropes of rope ways	To an agreed gauge of a recognised navigable waterway	To fixed points of a ropeway or fixed components of an el. traction system of a railway	To towers or supporting and pulling ropes of a ropeway installation	To rope way installation in the case of undercrossing
Maximum conductor temperature	7 m + D_{el}	2 m + D_{el}	2 m + D_{el}	2 m + D_{el}	2 m + D_{el}	4 m + D_{el}	2 m + D_{el}
Ice load	7 m + D_{el}	2 m + D_{el}	2 m + D_{el}	2 m + D_{el}	2 m + D_{el}	4 m + D_{el}	2 m + D_{el}
Wind load according to 5.4.2.2.3/PL.1	7 m + D_{el}	2 m + D_{el}	2 m + D_{el}	2 m + D_{el}	2 m + D_{el}	4 m + D_{el}	2 m + D_{el}
Remarks	For field roads clearances can be reduced by 2 m	—	—	—	Horizontal clearance	Vertical clearance	—

Table 5.4.5.3.2/PL.1 – Minimum clearance to line adjacent to roads, railways and navigable waterways

	Clearance case: Line adjacent to roads, railways and navigable waterways			
Load case	To loading gauges or the components of an electric traction system wire installation of a railway or trolley bus line	To components of a ropeway installation	To outer edge of a carriageway (incl. hard shoulder) of a motorway, highway, country road or of a waterway	Horizontal clearance between nearest part of the overhead line and the outer edge of the nearest track of a railway
Maximum conductor temperature	0,5 m + D_{el}, but greater than 1,5 m	5 m + D_{el}	0,5 m + D_{el}, but greater than 1,5 m	5 m + D_{el}
Ice load	0,5 m + D_{el}, but greater than 1,5 m	5 m + D_{el}	0,5 m + D_{el}, but greater than 1,5 m	5 m + D_{el}
Wind load according to 5.4.2.2.3/PL.1	0,5 m + D_{el}, but greater than 1,5 m	5 m + D_{el}	0,5 m + D_{el}, but greater than 1,5 m	5 m + D_{el}

Clause National regulation

(ncpt) **PL.3 Overhead electrical lines crossing and adjacent to ropeways**

Crossing of overhead electrical lines with ropeways is not recommended. If the overhead electrical line is adjacent to the ropeway, the falling of the electrical line support must not result in the damage of any element of the ropeway.

Metal components of the ropeway, such as supporting and pulling ropes, drives, bridges, galleries, supports, protective nets etc., should be earthed at the crossings and points of close proximity with the overhead electrical line.

The minimum clearances to lines crossing and adjacent to ropeways are included in Table 5.4.5.3.1/PL.1 and 5.4.5.3.2/PL.1, respectively.

(ncpt) **PL.4 Overhead electrical lines crossing and adjacent to waterways**

The conditions for crossing waterways or routing lines in close proximity to waterways should be agreed with the competent waterway authorities within the framework of the Water Law.

The maximum extent of inundation and the highest water level shall be determined on the basis of specifications provided by the competent waterways authority. In addition, the height of vessels necessary to determine the clearance to navigable waterways shall also be agreed with the competent waterways authority.

The required minimum clearance between the phase conductors and the surface of any water body shall in no case be smaller than

$$4 + D_{el} \qquad [m]$$

from the highest known water level (for load cases included in Table 5.4.5.3.1/PL.1).

The above requirement supplements the value of 2 m + D_{el} included in Table 5.4.5.3.1/PL.1, which is the clearance to the agreed gauge of a recognised navigable waterway.

Restriction levels according to Table 5.4.1/PL.4 shall apply to overhead electrical lines crossing waterways.

The crossing of a navigable waterway with an overhead electrical line shall be marked with clear distinct and permanent warning signs, well visible from the middle of the waterway, so that they signal the crossing to the approaching ships.

The navigation signs should meet the requirements of Regulation of the Minister of Infrastructure of 28 April 2003 on the rules of navigation on inland waterways. (See Annex 7).

Annex 8 of the Regulation of the Minister of Infrastructure of 28 April 2003 specifies methods of additional marking of overhead electrical lines crossing waterways suited for radar navigation.

Clause National regulation

If the line is adjacent to a navigable waterway, the horizontal clearance of the overhead electrical line from the waterfront shall be agreed with the waterway user. However, the minimum clearance between the outermost conductor of the electrical line and the waterfront, equal to 5 + D_{el} [m] for still air conditions, shall be maintained.

(ncpt) **PL.5 Overhead electrical lines crossing and adjacent to overground pipelines**

Appropriate restriction levels according to Table 5.4.1/PL.4 shall apply to overhead electrical lines crossing overground pipelines transporting fire hazardous material.

It is recommended that the angle, on a plan view, between the line and the pipeline be in the range from 30º to 90º.

Crossing of inspection chambers and manholes of pipelines transporting explosive or fire hazardous material is not permitted.

The horizontal clearance between the suspension support of the overhead electrical line and the crossed pipeline transporting explosive or fire hazardous material shall be at least equal to the height of the support. If it is not possible to meet this requirement, a tension support shall be used.

The vertical clearance between the conductors of the overhead electrical line and the overground pipeline, as well as the pipeline support structure, should meet the requirements specified in Table 5.4.5.3/PL.5. Compliance with these requirements should be checked when the horizontal clearance between the pipeline and the outermost conductor of the line is less than:

- 4 + D_{el} [m] for pipelines with non-flammable materials
- 10 + D_{el} [m] for pipelines with fire hazardous materials

under still air conditions

Table 5.4.5.3/PL.5 − Minimum vertical clearances to overground pipeline and pipeline support structures

Load Case	**Vertical clearance between the conductors and the pipeline**	
	Pipelines with non-flammable material	Pipelines with fire hazardous material
	[m]	
Maximum conductor temperature	4 + D_{el}	10 + D_{el}
Ice load	4 + D_{el}	10 + D_{el}

Clause National regulation

(ncpt) **PL.6 Overhead electrical lines crossing and adjacent to underground pipelines**

The requirements for crossings of electrical lines with gas pipelines are defined in PN-M-34501:1991.

With regard to pipelines transporting other flammable materials, it is recommended that the same requirements as for lines crossing and adjacent to gas pipelines be fulfilled.

Furthermore, the horizontal distance between underground pipelines and the foundations should not be less than 20 m. Minimum clearance between electrical lines and underground pipelines transporting non-flammable materials is not specified. Relevant regulations on pipeline construction, if in place, shall apply to crossings and close proximity cases.

(ncpt) **PL.7 Overhead electrical lines crossing and adjacent to permanent operating zones of cranes or loading equipment**

Crossings of electrical lines with operating zones of cranes or loading equipment such as hoisting and transport equipment, minerals mining and loading machinery and equipment, etc. and routing lines in close proximity to such zones is only permissible for lines specified below if the operating zone of the equipment and machinery is a designated zone. However, such crossings are not recommended.

If it is necessary for the electrical line to run in proximity of, or to cross, the designated operating zone of such machinery or equipment, the clearance between the line and the zone shall not be less than specified in Table 5.4.5.3/PL.6, and appropriate restrictions according to Table 5.4.1/PL.4 shall apply.

If the horizontal clearance between the crane or loading equipment and the line is less than the distance given in Table 5.4.5.3/PL.6, the crane/loading equipment shall be earthed. (Contact between steel wheels and earthed steel rails is considered sufficient earthing connection). Machines on rubber tyre wheels shall be equipped with antistatic chains.

Clause National regulation

Table 5.4.5.3/PL.6 − Minimum horizontal and vertical clearances to designated operating zones of cranes and loading equipment, such as hoisting and transport equipment and earthwork machinery and equipment, etc.

Nominal voltage of the electrical line [kV]	Clearance between conductors and designated operating zones		
	Horizontal clearance between the line's outermost phase conductor and the designated operating zone of cranes or loading equipment	Vertical clearance between the overhead line's conductors and the designated operating zone of cranes or loading equipment	
		with rope transmission	without rope transmission
	[m]		
2	*3*	*4*	*5*
Higher than 45, up to 110	10	6 + D_{el}	3 + D_{el}
Higher than 110, up to 400	20	8 + D_{el}	4 + D_{el}

NOTE: The above clearances should be maintained for the maximum sag of the conductor in the span where crossing takes place.

5.4.5.4 Other power lines or overhead telecommunication lines

(ncpt) **PL.1 Requirements**

Conductors of the line with higher nominal voltage should cross over the conductors of the line with lower nominal voltage.

Departure from this requirement is permissible if the Project Specification specifies other requirements.

It is recommended that:

a) the angle between the horizontal projections of the crossing lines be in the range from 30º to 90º
b) one tower of the crossing span of the higher line be near the lower line.

Requirements concerning clearances to other lines are included in Table 5.4.5.4/PL.1.

Clause National regulation

Table 5.4.5.4/PL.1 − Minimum clearances to other power lines or overhead telecommunication lines

Load case	**Crossing of lines**		**Parallel lines on common structures**	**Parallel or converging lines on separate structures**
	Vertical clearance between the lowest conductor of the upper circuit and live parts or earthed components of the lower line [m]	Horizontal clearance between the vertical axis of the swung conductor and components of telecommunication lines [m]	Clearance between conductors of lines of separate utilities [m]	Clearance between conductors of lines [m]
Maximum conductor temperature	$2 + D_{pp}$ [1)]	—	Clearance between the conductors of the higher voltage line determined as described in 5.4.3/PL.1 [2)]	Clearance between the conductors of the higher voltage line determined as described in 5.4.3/PL.5 [2)]
Ice load	D_{pp} for the higher voltage line (for conditions defined in 5.4.3/PL.6)	—	D_{pp} for the higher voltage line (for conditions defined in 5.4.3/PL.6) [2)]	—
Wind load according to 5.4.2.2.3/PL.1	—	2	D_{pp}	D_{pp}

1) When checking the clearance between the conductors of the crossing lines, the design maximum temperature and the temperature of +10 ºC should be used for the upper and the lower line, respectively, unless otherwise stated in the Project Specification.

2) Higher values can be given in Project Specification .

Clause National regulation

(ncpt) **PL.2 Requirements for clearances to telecommunication lines**

If an overhead electrical line with a voltage of 45 kV or more is adjacent to an overhead telecommunication line with metal wires, the clearance between the supports or support earth electrodes of the two lines shall be at least 15 m.

If it is not possible to maintain this clearance, calculations for harmful galvanic effects shall be made. If the permissible values of the effects are exceeded, appropriate measures shall be used to protect the telecommunication line against the harmful impact of the electrical line.

The protection measures shall be agreed with the user of the telecommunication line.

(ncpt) **PL.3 Installation of telecommunication wires**

Installation of telecommunication wires on electrical line supports is only permissible upon agreement with the user of the electrical line and on conditions defined in the Project Specification.

5.4.5.5 Recreational areas (playgrounds, sports areas, etc.)

(ncpt) **PL.1 Minimum clearances**

Minimum clearances to recreational areas are given in Table 5.4.5.5/PL.1.

Clause National regulation

Table 5.4.5.5/PL.1 – Minimum clearances to recreational areas

	Line above				**Line in close proximity**
Load case	To general sport areas	To highest level of swimming pools	To agreed gauge of sailing facilities	To permanently installed sports facilities like starting and winning post installations, camping installations as well as structures which can be erected or climbed on	Horizontal clearance to all recreational installations
Maximum conductor temperature	7 m + D_{el}	8 m + D_{el}	2 m + D_{el}	3 m + D_{el}	3 m + D_{el}
Ice load	7 m + D_{el}	8 m + D_{el}	2 m + D_{el}	3 m + D_{el}	3 m + D_{el}
Wind load according to 5.4.2.2.3/PL.1	7 m + D_{el}	8 m + D_{el}	2 m + D_{el}	3 m + D_{el}	3 m + D_{el}

Clause National regulation

5.5 Corona effect

5.5.1 Radio noise

5.5.1.3 Noise limits

(ncpt) **PL.1 The permissible value**

Noise shall not exceed the permissible value given in PN-E-05118:1977 which is 57,5 dB when clearance to horizontal projection of the nearest conductor is 20 m.

If the value given in PN-E-05118:1977 is exceeded, it is recommended that the receivers be readjusted accordingly.

5.5.2 Audible noise

5.5.2.3 Noise limit

(ncpt) **PL.1 Maximum permissible levels**

Maximum permissible levels of audible noise emitted by the electrical line to the environment are determined in separate regulations.

Regulation of the Minister of Environment of 14 June 2007 on permissible noise levels in the environment defines noise limits. The Regulation defines limits for noise emitted by electrical lines depending on land use and on the time of day or night.

5.6 Electric and magnetic fields

5.6.1 Electric and magnetic fields under a line

(ncpt) **PL.1 Electric and magnetic field intensities**

Electric and magnetic field intensities near the electrical line shall not exceed the values given in the relevant national regulations, i.e. in Regulation of the Minister of Environment of 30 October 2003 on permissible electric and magnetic field limits in the environment and on methods of verifying compliance with these limits.

Clause National regulation

6 Earthing systems

6.2 Dimensioning of earthing systems at power frequency

6.2.1 General

(ncpt) **PL.1 Requirement**

Conductive supports of lines with a voltage of 110 kV and more must always be earthed.

6.2.2 Dimensioning with respect to corrosion and mechanical strength

6.2.2.2 Earthing and bonding conductors

(ncpt) **PL.1 Using aluminium and aluminium alloys**

Aluminium and aluminium alloys cannot be used for earth rods or earthing and bonding conductors.

6.2.4 Dimensioning with regard to human safety

6.2.4.1 Permissible values

(ncpt) **PL.1 Permissible touch voltages U_{TP}**

Permissible touch voltages U_{TP} are given in Table G.8 of Annex G. Interpolation is recommended for fault durations t_F not included in Table G.8.

The voltage difference U_D acting as a source voltage in the touching circuit with a limited value that guarantees the safety of a person when using additional known resistance may be determined using calculation methods described in G.4.2 of Annex G.

ncpt) **PL.2 Duration of the fault current**

The duration of the fault current (shock duration) shall mean the tripping time of the basic protection systems interrupting the fault current circuit and the trip-out time of the interrupting device.

6.2.4.2 Measures for the observance of permissible touch voltages

(ncpt) **PL.1 Electric shock hazard criteria**

It is considered that shock hazard does not exist if, for a given duration of the fault current t_F, the touch voltage U_T does not exceed the highest permissible value $U_{Tp} = U_{D1}$

Clause National regulation

$$U_T \leq U_{Tp} = U_{D1}$$

The above condition may be considered fulfilled if the earth potential rise U_E does not exceed double the value of the expected voltage difference U_D

$$U_E \leq 2\, U_D$$

(ncpt) **PL.2 Earthing of conductive parts on non conductive poles or towers**

Earthing of poles made of non-conductive material is necessary if an earth wire or surge arresters are installed on such a pole.

With regard to poles or towers made of wood or other non conductive materials (e.g. reinforced concrete with an appropriate thickness of the outer concrete layer), hazards may be caused by parts which are installed on these poles/towers, are freely accessible to people and where permissible touch voltage may be exceeded. In such cases, the hazardous parts shall be earthed or insulated from the voltage source.

(ncpt) **PL.3 Towers at frequently visited locations**

Towers in the following locations shall be checked for the risk of excessive touch voltage: play grounds, stadiums and sports fields, bathing areas, beaches, campsites and other recreational areas, camping sites, industrial plants, town squares, garden plots and parks, car parks, designated pedestrian areas and areas near buildings, public roads and streets, etc. i.e. areas likely to be frequented by people.

(ncpt) **PL.4 Supplementary measures for the observance of permissible touch voltages**

If reduction of touch voltages by means of reducing the earth potential rise and using the appropriate configuration of the earth electrode system, comprising support foundations and earth rods, is difficult due to cost considerations or technical problems, supplementary measures shall be used.

Potential grading earth electrode in the form of ground rings arranged in steps in the ground is a recommended supplementary measure. Partial coating of supports with insulating coats is permissible on condition that the coating is renewed before the end of the guarantee period for the insulation properties of the coating.

6.3 Construction of earthing systems

6.3.2 Transferred potentials

(ncpt) **PL.1 Hazards posed by potentials transferred by cables**

Electrical cables connecting the overhead line with other electrical objects may pose an electric shock hazard if only one end of their armouring and shields or return conductors is connected to the earth electrode. If shock hazard on non-earthed cable ends exist, measures preventing access to the hazardous cable ends shall be implemented.

6.4 Earthing measures against lightning effects

(ncpt) **PL.1 Earth wires**

Lines with a voltage of 110 kV and more shall be protected using earth wires along their whole length. The earth wires shall be earthed at each support of the line.

(ncpt) **PL.2 Protection against backflashovers**

Lines should be protected against backflashovers by earthing earth wires and all metal supports of the line.

Unless otherwise provided for in the Project Specification, a line is considered adequately protected against backflashovers if it meets the requirements described below.

The resistance to earth of an earth electrode of each support (without the earth wire) shall not exceed the values given in Table 6.4.1/PL.3.

The resistance to earth of surge arresters and spark gaps installed on the line supports shall not exceed the values given in Table 6.4.1/PL.3

Table 6.4.1/PL.3 − Maximum resistance to earth of an earth electrode for soil resistivity of less than 1000 Ωm

Nominal voltage of the line [kV]	Resistance to earth [Ω]
110 and less	10
more than 110	15

For high resistivity soil ($\rho \geq$ 1000 Ωm), resistance to earth of the earth electrode as provided for in Table 6.4.2/PL.3 is permissible.

Table 6.4.2/PL.3 − Maximum resistance to earth of an earth electrode for soil resistivity exceeding 1000 Ωm

Nominal voltage of the line [kV]	Resistance to earth [Ω]
110 and less	15
more than 110	20

If it is difficult or impossible to achieve the resistance to earth of the earth electrode as provided for in Table 6.4.2/PL.3, greater values of the resistance to earth of the earth electrode are permissible on condition that the effectiveness of the line shielding is not compromised.

Table 6.4.2/PL.3 does not refer to the earthing of supports on the last 0,5 km or 1 km of the line immediately preceding the high voltage substation, for lines of up to 110 kV and over 110 kV, respectively.

At the entrance to the high voltage substation, the earth wires shall be connected with the earthed supports (line gantries).

6.6 Site inspection and documentation of earthing systems

(ncpt) **PL.1 Inspection of electric shock protection measures**

In addition to the measurements referred to in 6.5, inspection of the following should be carried out:

- condition of the connections between the earthing conductors and earthing parts;
- condition of anti-corrosion and electric insulation coatings of the visible components of the earthing system.

7 Supports

7.1 Initial design considerations

(ncpt) **PL.1 Design considerations**

The process of adopting of parent Eurocodes (EN) to their application as Polish Standards has not been completed in Poland. Until the establishment of these standards, parallel application of PN-EN and PN is allowed, as mentioned in the following sub-clauses of Clause 7.

Clause National regulation

7.2 Materials

(ncpt) **PL.1 Requirements**

Materials used in the fabrication of transmission line supports shall comply with PN-EN 10025-1:2007, PN-EN 10025-2:2007, PN-EN 10025-3:2007:2007 and PN-EN 10020:2003.

7.2.5 Concrete and reinforcing steel

(ncpt) **PL.1 Concrete and reinforcing steel**

Concrete and reinforcing steel shall be specified in conformity with the requirements of PN-EN 1992-1-1:2005. By march 2010 application of PN-B-03264:2002 is allowed..

7.3 Lattice steel towers

7.3.1 General

(ncpt) **PL.1 Lattice steel towers**

When designing lattice steel towers, the requirements of PN-EN 1993-1-1:2006 and PN-EN 1993-3-1:2006 shall apply. By march 2010 application of PN-B-03200:1990 and of PN-B-03205:1996 (excluding Tables 1 and 2 of the latter) is allowed.

7.4 Steel poles

7.4.1 General

(ncpt) **PL.1 Requirements for steel poles**

When designing steel poles, the requirements of PN-EN 1993-1-1:2006 and PN-EN 1993-3-1:2006 shall apply. By march 2010 application of PN-B-03200:1990 and of PN-B-03205:1996 is allowed, excluding Tables 1 and 2 of the latter and deflection limits for poles determined in 4.8. For steel pole with height H the deflection limit, for suspension poles shall be $H/40$, for tension poles shall be $H/50$ instead of $H/25$. These deflections shall be fulfilled for normal and construction condition work of structure.

Clause National regulation

7.6 Concrete poles

(ncpt) **PL.1 Requirements**

Concrete poles shall be designed in accordance with PN-EN 1992-1-1:2005. By march 2010 application of PN-B-03264:2002 is allowed.

7.7 Guyed structures

(ncpt) **PL.1 Requirements**

Guyed structures shall be designed in accordance with PN-EN 1993-1-1:2006 and PN-EN 1993-3-1:2006 and PN-EN 1993-1-11:2006. By march 2010 application of PN-B-03200:1990 is allowed.

7.10 Maintenance facilities

7.10.1 Climbing

(ncpt) **PL.1 Access steps**

Access steps are the basic means of safe access to supports by authorised personnel. Lattice towers shall be equipped with access steps with maximum spacing of 400 mm.

7.10.3 Safety requirements

(ncpt) **PL.1 Warning plates**

Each support of an overhead electrical line exceeding AC 45 kV shall be equipped with warning plates according to PN-E-08501:1988, placed 1,5 m to 3,0 m above the ground.

Lattice towers shall be equipped with at least two warning plates installed on opposite sides of the tower so that they are visible when approaching the tower crosswise to the line.

For single-pole supports, it is acceptable to install just only one warning plate.

For multi-pole supports, it is recommended that one warning plate be installed on each pole.

Guy wires attached in the ground more than 10 m from the support shall be equipped with a warning plate placed on the guy wire or near the guy wire so that it is visible when approaching the support along the line connecting the point of attachment of the wire in the ground with the support axis.

The Project Specification may define additional safety requirements.

(ncpt) **PL.2 Number plates**

All supports of the transmission line shall be equipped with durable number signs or plates.

Each support shall have at least one number sign or plate placed 1,5 m to 3,0 m above the ground.

If line inspection and maintenance operations using air transport are envisaged, at least every fifth support shall be equipped with two number plates attached to the upper parts of the support on opposite sides of the structure. The digits comprising the support number on these plate shall be legible, at least 20 cm high and contrasting with the plate background.

(ncpt) **PL.3 Line designation plates**

It is recommended that supports of lines with a voltage of 110 kV and more be equipped with plates with the line symbol. The line designation plates shall be placed in the same manner as the number plates in the lower parts of the supports.

The line symbol may be placed on the number plates. It is up to the line user to define the line symbol.

(ncpt) **PL.4 Circuit plates**

Each circuit of a double or multi circuit line shall be marked with a circuit plate on each support.

The circuit plate shall bear a Roman numeral indicating the number of the circuit. It is recommended that the colour of the plate be circuit-specific. The plate should be visible when approaching the support along the line axis. The point of attachment of the circuit plates should be such that each plate can be unmistakably assigned to the proper line circuit.

(ncpt) **PL.5 Phase plates**

Tension supports shall be equipped with phase marking plates. Phase marking shall conform with the marking of alternating current conductors given in PN-EN 60445:2002; the symbols: L1, L2 and L3 should be black against a yellow background. The place of attachment of the phase plates shall be such that the plates clearly indicate respective phases.

Clause National regulation

7.12 Assembly and erection

(ncpt) **PL.1 Requirements for assembly**

The assembly shall be in conformity with PN-EN 1993-3-1:2006 and with the Project Specification. By march 2010 application of PN-B-03205:1996 is allowed.

8 Foundations

8.3 Soil investigation

(ncpt) **PL.1 Soil investigation**

Soil investigation shall be carried out in conformity with the requirements of PN-EN 1997-2. By march 2010 application of PN-B-04452:2002 is allowed.

8.4 Loads acting on foundations

(ncpt) **PL.1 Loads acting on foundations**

Loads acting on foundations shall be assessed taking into account the required combinations of applied loading cases as stated in Table 4.3.10.4/PL.1.

(ncpt) **PL.2 Loads acting on the ground**

Loads acting on the ground shall be assessed taking into account the load on the support together with forces acting on the support, dead weight of the foundation, dead weight of the soil, ground water uplift pressure, loads from neighbouring heaps or embankments and relief caused by excavations. Calculations of the ground water uplift pressure should be made for the most unfavourable water table conditions.

8.5 Geotechnical design

(ncpt) **PL.1 Geotechnical design**

Geotechnical design shall be according to PN-EN 1997-1. By march 2010 application of PN-B-03322:1980, PN-B-02482:1983 or PN-B-02483:1978 is allowed.

Clause National regulation

8.7 Structural design

(ncpt) **PL.1 Foundations**

Foundations shall be designed according to PN-EN 1992-1-1:2005. By march 2010 application of PN-B-03264:2002 is allowed.

8.8 Construction and installation

(ncpt) **PL.1 Requirements**

By march 2010 application of PN-B-06050:1999 and PN-B-03205:1996 is allowed. These standards provide construction and installation criteria for foundations.

9 Conductors and overhead earthwires (ground wires) with or without telecommunication circuits

9.2 Aluminium based conductors

9.2.1 Characteristics and dimensions

(ncpt) **PL.1 The design and calculations of the conductor**

When determining the diameter of a phase conductor and the structure of a bundle of conductors, the audible noise level, corona and noise (interference) level shall be considered.

The nominal cross-sectional area of the conductor must not be less than 50 mm^2. It is recommended that the diameter of the outer layer round wires be at least 2,33 mm.

9.2.3 Conductor service temperatures and grease characteristics

(ncpt) **PL.1 Maximum conductor service temperatures**

The maximum continuous service temperature of aluminium based conductors must not be higher than +80 ºC.

The Project Specification may specify other value.

The maximum temperature of aluminium based conductors due to a specified power system fault (short-circuit) must not exceed +200 ºC. The Project Specification may specify a lower temperature value or other requirements.

Clause National regulation

Unless otherwise stated in the Project Specification, +40 ºC shall be used as the initial conductor temperature for calculating maximum temperature due to a specified power system fault (short-circuit).

(ncpt) **PL.2 Maximum service temperatures of special conductors**

If a special aluminium alloy is used and the conductors and the equipment accessories are of appropriate design, the Project Specification may specify higher conductor service temperatures than those specified in 9.2.3/PL.1.

(ncpt) **PL.3 Grease characteristics**

The grease used shall comply with PN-EN 50326 across the entire range of conductor temperatures, i.e. from −35 ºC to the maximum conductor service temperature.

9.2.4 Mechanical requirements

(ncpt) **PL.1 Limit state of the conductor for line sections without restrictions and with restriction levels I and II**

The partial factor γ_{M} for aluminium based conductors, for load cases 2, 4, 5, 6 and 7 given in Table 4.3.10.3/PL.1 is

$$\gamma_{M} = 1,25$$

which represents 80 % of the rated tensile strength (RTS) of the conductor. This means that the tensile load in the conductor must not in any point of the span exceed 80 % of the conductor strength.

With regard to load cases 1 and 3 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the span exceed 52 % of the rated tensile strength (RTS) of the conductor. The partial factor γ_{M} for these cases is $\gamma_{M} = 1,92$.

The Project Specification may specify a higher value of γ_{M} .

(ncpt) **PL.2 Limit state of the conductor for line sections with restriction level III**

With regard to load cases 2, 4, 5, 6 and 7 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the span exceed 56 % of the rated tensile strength (RTS) of the conductor. The partial factor γ_{M} for these cases is $\gamma_{M} = 1,79$.

With regard to load cases 1 and 3 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the span exceed 36 % of the rated tensile strength (RTS) of the conductor. The partial factor γ_{M} for these cases is $\gamma_{M} = 2,78$.

Clause National regulation

(ncpt) **PL.3 Protection against conductor damage due to wind-induced vibrations**

Protection of conductors against vibration shall be determined depending on the tensile load in the conductor, conductor weight and diameter, span length and terrain category.

9.2.5 Corrosion protection

(ncpt) **PL.1 Grease application**

In steel-aluminium conductors, grease shall always be applied to the steel core. The Project Specification shall specify whether it is necessary to apply grease to the aluminium layers.

9.3 Steel based conductors

9.3.1 Characteristics and dimensions

(ncpt) **PL.1 Conductor specification**

The nominal cross-sectional area of the conductor must not be less than 50 mm^2.

(ncpt) **PL.2 Application range of the conductors**

Steel based conductors may only be used as earth wires.

9.3.3 Conductor service temperatures and grease characteristics

(ncpt) **PL.1 Maximum conductor service temperature**

The maximum temperature of steel based conductors due to a specified power system fault (short-circuit) must not exceed +300 ºC.

The Project Specification may specify a lower temperature or other requirements. Unless otherwise stated in the Project Specification, +40 ºC shall be used as the initial conductor temperature for calculating maximum temperature due to a specified power system fault (short-circuit).

(ncpt) **PL.2 Grease characteristics**

The grease used shall comply with PN-EN 50326 across the entire range of conductor temperatures, i.e. from −35 ºC to the maximum conductor service temperature.

Clause National regulation

9.3.4 Mechanical requirements

(ncpt) **PL.1 Limit state of the conductor for line sections without restrictions and with restriction levels I and II**

The partial factor γ_M for aluminium based conductors, for load cases 2, 4, 5, 6 and 7 given in Table 4.3.10.3/PL.1 is

$$\gamma_M = 1,25$$

which represents 80 % of the rated tensile strength (RTS) of the conductor. This means that the tensile load in the conductor must not in any point of the span exceed 80 % of the conductor strength.

With regard to load cases 1 and 3 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the span exceed 52 % of the rated tensile strength (RTS) of the conductor. The partial factor γ_M for these cases is $\gamma_M = 1,92$.

The Project Specification may specify a lower value of γ_M .

(ncpt) **PL.2 Limit state of the conductor for line sections with restriction level III**

With regard to load cases 2, 4, 5, 6 and 7 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the span exceed 56 % of the rated tensile strength (RTS) of the conductor. The partial factor γ_M for these cases is $\gamma_M = 1,79$.

With regard to load cases 1 and 3 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the conductor exceed 36 % of the rated tensile strength (RTS) of the conductor. The partial factor γ_M for these cases is $\gamma_M = 2,78$.

(ncpt) **PL.3 Protection against conductor damage due to wind-induced vibrations**

Protection of single conductors against vibration shall be determined depending on the tensile load in the conductor, conductor weight and diameter, span length and terrain category.

Clause National regulation

9.5 Conductors (OPCON's) and ground wires (OPGW's) containing optical fibre telecommunication circuits

9.5.1 Characteristics and dimensions

(ncpt) **PL.1 Conductor specification**

It is recommended that the diameter of the outer layer wires be at least 2,33 mm.

The nominal cross-sectional area of the conductor must not be less than 50 mm^2.

9.5.3 Conductor service temperatures

(ncpt) **PL.1 Maximum conductor service temperatures**

The maximum continuous service temperature of OPCON's must not be higher than +80 ºC.

The Project Specification may specify the maximum short duration temperature of the OPCON. Neither the optical characteristics of the optical fibres nor the mechanical characteristics of the conductor may deteriorate at this temperature.

The maximum temperature of OPCON's and OPGW's due to a specified power system fault (short-circuit) must not exceed +200 ºC. The Project Specification may define a different temperature or other requirements.

Unless otherwise stated in the Project Specification, +40 ºC shall be used as the initial conductor temperature for calculating maximum temperature due to a specified power system fault (short-circuit).

(ncpt) **PL.2 Maximum service temperatures of special conductors**

The Project Specification may set higher temperatures than those given in 9.5.3/PL.1 provided that special materials are used and the conductor and hardware are of appropriate design

Clause National regulation

9.5.4 Mechanical requirements

(ncpt) **PL.1 Limit state of the conductor/wire for line sections without restrictions and with restriction levels I and II**

The partial factor γ_M for OPCON's and OPGW's, for load cases 2, 4, 5, 6 and 7 given in Table 4.3.10.3/PL.1 is

$$\gamma_M = 1,40$$

which represents 71 % of the rated tensile strength (RTS) of the conductor. This means that the tensile load in the conductor must not in any point of the span exceed 71 % of the conductor strength, unless the manufacturer specifies a lower value.

With regard to load cases 1 and 3 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the span exceed 52 % of the rated tensile strength (RTS) of the conductor. The partial factor γ_M for these cases is $\gamma_M = 1,92$.

The Project Specification may specify a different value of γ_M .

(ncpt) **PL.2 Limit state of the conductor for line sections with restriction level III**

With regard to load cases 2, 4, 5, 6 and 7 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the span exceed 56 % of the rated tensile strength (RTS) of the conductor. The partial factor γ_M for these cases is $\gamma_M = 1,79$.

With regard to load cases 1 and 3 given in Table 4.3.10.3/PL.1, the tensile load in the conductor must not in any point of the span exceed 36% of the rated tensile strength (RTS) of the conductor. The partial factor γ_M for these cases is $\gamma_M = 2,78$.

(ncpt) **PL.3 Protection against conductor damage due to wind-induced vibrations**

Protection of conductors against vibration shall be determined depending on the tensile load in the conductor, conductor weight and diameter, span length and terrain category.

Particular attention should be paid to anti-vibration protection of the telecommunication part.

9.5.5 Corrosion protection

(ncpt) **PL.1 Corrosion protection of steel wires**

The use of zinc coated steel wires in OPGW's and OPCON's is not permitted.

9.6 General requirements

9.6.2 Partial factor for conductors

(ncpt) **PL.1 Partial factor for conductors**

Partial factors for limit states are given in 9.2.4/PL.1, 9.3.4/PL.1 and 9.5.4/PL.1, where, in addition, the permissible tensile load in the conductor expressed as the percentage of the rated tensile strength (RTS) is also shown for other conductor states.

9.7 Test reports and certificates

(ncpt) **PL.1 Scope of conductor tests**

The required scope of conductor tests shall be agreed by the manufacturer and the purchaser.

10 Insulators

10.1 General

(ncpt) **PL.1 Requirements for insulator units**

Insulator units shall comply with the respective product standards, i.e. ceramic long rod insulators shall comply with PN-EN 60433, and composite insulators shall comply with PN-IEC 61109.

10.2 Standard electrical requirements

(ncpt) **PL.1 Electrical requirements for insulators**

The electrical requirements for insulators regarding withstand voltages are included in 5.3.4/PL.1.

Clause National regulation

10.3 RIV requirements and corona extinction voltage

(ncpt) **PL.1 Levels for radio interference**

For all types of insulators for overhead lines, the levels of radio interference shall not exceed the permissible values determined in accordance with CISPR 18-2.

Tests shall be carried out in accordance with PN-EN 60437.

If required, the minimum corona extinction voltage shall be determined by testing the complete insulator set. The value of the corona extinction voltage shall be included in the Project Specification.

10.4 Pollution performance requirements

(ncpt) **PL.1 Requirements for pollution level**

Guidance on the selection of insulators in respect of polluted conditions is given in PN-E-06303:1998. The pollution level (pollution zone) in the area through which the line runs should be specified in the Project Specification.

Standard PN-E-06303 includes selection of porcelain and glass insulators according to their characteristic pollution curve or creepage distance (Table 10.4/PL.1). Criteria of composite insulators selection, according to minimal unitary creepage distance, given in Annex E. These criteria are compatibile with PN-IEC 815:1998 (IEC/TR 60815:1986).

Table 10.4/PL.1 – Selection of insulators according to their nominal creepage distance [mm]

Highest system voltage [kV]	Nominal voltage of line [kV]	Pollution zone			
		I	II	III	IV
123	110	2 100	2 700	3 400	4 300
245	220	4 200	5 400	6 800	8 600
420	400	7 200	9 200	11 600	14 700

Clause National regulation

10.5 Power arc requirements

(ncpt) **PL.1 Insulator sets**

Insulator sets shall be power arc resistant. If so required by the Project Specification, power arc resistance shall be verified by a power arc test carried out in accordance with IEC 61467. Insulator sets shall have arcing fittings. The short-circuit strength of the arcing fittings shall match the envisaged short-circuit currents for the considered line, which should be determined in the Project Specification.

10.7 Mechanical requirements

(ncpt) **PL.1 Mechanical strength of insulator units**

The rated mechanical strength of insulator units shall comply with PN-EN 60383-1 (for glass or ceramic insulators) and of PN-IEC 61109 (for composite insulators).

String insulator units and line post insulators which are part of insulator sets and insulator cross-arms shall carry loads associated with load cases included in Table 4.3.10.3/PL.1, allowing for the partial factors for actions.

(ncpt) **PL.2 Multiple insulator strings**

Multiple insulator strings shall be designed so as to ensure even distribution of the mechanical load transferred to the individual insulator strings.

Where multiple insulator strings are used, it is required that the mechanical load is distributed evenly to the remaining strings if one string is damaged. Insulators from the remaining strings should withstand the additional loading resulting from the new operating conditions in static state of the string irrespective of the partial factors.

The damaged insulator should not cause damage to insulators of the neighbouring string by mechanical impact.

It is recommended that the correctness of multiple insulator string design be confirmed by mechanical tests. The requirement to carry out the tests, testing method and evaluation criteria should be included in the Project Specification.

Clause National regulation

11 Line equipment - Overhead line fittings

11.3 RIV requirements and corona extinction voltage

(ncpt) **PL.1 Fittings**

Fittings for high voltage overhead lines shall be designed so that their contribution to the line's impact on the environment as concerns radio interference complies with the requirements of 10.3/PL.1.

11.5 Short-circuit current and power arc requirements

(ncpt) **PL.1 Insulator fittings**

The short-circuit strength of insulator set fittings shall match the line service conditions. Increased temperature of the fittings caused by the highest envisaged short-circuit current shall not result in deterioration of the performance characteristics of the fittings.

Considering the short-circuit strength requirements for fitting connections, the use of connections with point contacts is not recommended.

11.6 Mechanical requirements

(ncpt) **PL.1 Partial factor for a material property in the ultimate limit state**

A value of the partial factor higher than given in 11.6 may be specified in the Project Specification.

(ncpt) **PL.2 Additional requirements for suspension clamps**

The minimum slide-out force of typical suspension clamps shall not be less than the difference between the tensile loads in the conductors for a load case in which on one side of the clamp all ice has fallen off while on the second side of the clamp there is still an ice load equal to 0,7 of the characteristic ice load I_K. This condition should be checked if so stated in the Project Specification.

12 Quality assurance, checks and taking-over

Part 1 applies without change.

Clause National regulation

Annex G (normative) - Earthing systems

G.3 Current rating calculation

(ncpt) **PL.1 Minimum cross-section of earthing conductors and earth electrodes with regard to the heat action of the fault current**

For fault currents with a t_F of less than 5 seconds, the minimum cross-section A_{min} of the earthing conductors or earth electrodes of an earthing system for temperatures θ_i = 20 ºC and θ_F = 300 ºC or 150 ºC, depending on the anti-corrosion coating, may be calculated using the permissible short-circuit current density, taken from Figure G.4:

$$A_{min} = \frac{I}{G} \quad [mm^2]$$

where

I – is a part of the short-circuit current flowing through a component of the earthing system, for which the minimum cross-section is calculated (in amperes; rms value)

G – is a short-circuit current density taken from Figure G.4 (in A/mm^2)

The minimum cross-section A_{min} of earthing conductors and earth electrodes of an earthing system designed for t_F of more than 5 seconds and temperatures specified above, may be determined using data from Figure G.5 and assuming that I_d=I (I as defined above).

G.4 Touch voltage and body current

G.4.2 Calculation taking into account additional resistances

(ncpt) **PL.1 Method of calculation of the voltage difference U_D**

The voltage difference for various fault duration t_F values and various additional touch resistances R_a (R_a = R_{a1} + R_{a2}) may be calculated as described below:

1) Determine the function $U_T = f\ (Z_{B1})$ (where Z_{B1} is the total human body impedance for a hand to both feet current path) using data from Table G.7. Z_{B1} is calculated by multiplying the values of Z_B by a correction factor equal to 0,75 for current paths other than the one for which the Z_B values are given.

2) Determine the function $U_{\mathrm{Tp(tF)}} = f\,(Z_{\mathrm{B1}})$ by reading the values of $U_{\mathrm{Tp(tF)}}$ for each fault duration from Table G.8 or D_1 curve from Figure 6.2, and then determining the respective Z_{B1} values using the function $U_{\mathrm{T}} = f\,(Z_{\mathrm{B1}})$.
3) Determine the current $I_{\mathrm{B(tF)}}$ by dividing $U_{\mathrm{Tp(tF)}}$ by respective impedance Z_{B1} determined on the basis of the function $U_{\mathrm{Tp(tF)}} = f\,(Z_{\mathrm{B1}})$ ($I_{\mathrm{B(tF)}} = U_{\mathrm{Tp(tF)}}/\,Z_{\mathrm{B1}}$).
4) Calculate the values of $U_{\mathrm{D(tF)}}$ for each value of t_{F}, using the following formula:

$$U_{\mathrm{D\,(tF)}} = U_{\mathrm{Tp(t_F)}} + R_{\mathrm{a}} \cdot I_{\mathrm{B(t_F)}} = U_{\mathrm{Tp(t\ )}} + \frac{R_{\mathrm{a}} \cdot U_{\mathrm{Tp(t_F)}}}{Z_{\mathrm{B1}}} = U_{\mathrm{Tp(t_F)}}(1 + \frac{R_{\mathrm{a}}}{Z_{\mathrm{B1}}})$$

G.5 Measuring touch voltages

(ncpt) **PL.1 Measurement of the voltage difference U_{D} using a vertical probe**

When measuring the voltage difference using a vertical probe, the probe shall be driven 10 cm into the earth (as described in Annex N of PN-E-05115:2002 and in G.5.1).

Annex H (informative) - Earthing systems

H.4 Measurements for and on earthing systems

H.4.2 Measurement of resistances to earth and impedances to earth

(ncpt) **PL.1 Measurements of resistance to earth of line supports**

It is recommended that the resistance to earth of a line support be measured by means of the fall-of-potential method using purpose-built earth testers (measuring instruments). The probe and auxiliary electrode shall be driven into the earth, in a line perpendicular to the electrical line axis.

Clause National regulation

Annex M (informative) - Typical values of geotechnical parameters of soils and rocks

M.2 Definitions

(snc) **PL.1 Soil classification with regard to particle size according to PN EN-ISO 14688-1:2006 and PN-EN ISO 14688-2:2006**

Table M.2/PL.1 – Fractions, particle size

Soil	Fractions	Symbols	Particle size [mm]
Very coarse grained	Large boulder	LBo	> 630
	Boulder	Bo	> 200 – 630
	Cobble	Co	> 63 – 200
Coarse grained	Gravel Coarse gravel Medium gravel Fine gravel	Gr CGr MGr FGr	> 2,0 – 63 > 20 – 63 > 6,3 – 20 > 2,0 – 6,3
	Sand Coarse sand Medium sand Fine sand	Sa CSa MSa FSa	> 0,063 – 2,0 > 0,63 – 2,0 > 0,2 – 0,63 > 0,063 – 0,2
Fine grained	Silt Coarse silt Medium silt Fine silt	Si CSi MSi FSi	> 0,002 – 0,063 > 0,02 – 0,063 > 0,0063 – 0,02 > 0,002 – 0,0063
	Clay	Cl	≤ 0,002

(snc) **PL.2 Soil classification according to compaction and consistency, according to PN-EN-ISO 14688-1:2006**

Table M.2/PL.2 – Soil compaction classification

Name	Compaction I_D [%]
Very loose	0 to 15
Loose	15 to 35
Semi-compact	35 to 65
Compact	65 to 85
Very compact	85 to 100

Clause National regulation

Table M.2/PL.3 – Silt and clay consistency index

Silt and clay consistency	Consistency index I_C
Quick	< 0,25
Soft	0,255 to 0,50
Stiff	0,50 to 0,75
Rigid-flexible	0,75 to 1,00
Firm and very firm	> 1

(snc) **PL.3 Classification of mineral soils**

Table M.2/PL.4 – Mineral soil classification depending on the approximate content of different size fractions

Fraction	Fraction content in % of the material mass ≤ 63 mm	Fraction content in % of the material mass ≤ 0,063 mm	Soil name	
			modified	basic
Gravel	20 to 40		gravelly	
	> 40			gravel
Sand	20 to 40		sandy	
	> 40			sand
Silt+ clay (fine grained soils)	5 to 15	< 20	slightly silty	
		≥ 20	slightly clayey	
	15 to 40	< 20	silty	
		≥ 20	clayey	
	> 40	< 10		silt
		10 to 20	clayey	silt
		20 to 40	silty	clay
		>40		clay

Clause National regulation

(snc) **PL.4 Soil descriptions and names**

Table M.2/PL.5 – Fraction content, symbols and names of soils

<table>
<tr><th rowspan="2">No</th><th rowspan="2" colspan="2">Soil type</th><th rowspan="2">Symbol</th><th colspan="4">Fraction content [%]</th></tr>
<tr><th>Cl (f_i)</th><th>Si (f_π)</th><th>Sa (f_p)</th><th>Gr ($f_ż$)</th></tr>
<tr><td>1</td><td colspan="2">Gravel</td><td>Gr</td><td>up to 3</td><td>0 – 15</td><td>0 – 20</td><td>80 – 100</td></tr>
<tr><td>2</td><td colspan="2">Sandy gravel</td><td>saGr</td><td>up to 3</td><td>0 – 15</td><td>20 – 50</td><td>50 – 80</td></tr>
<tr><td>3</td><td colspan="2">Gravelly sand</td><td>grSa</td><td>up to 3</td><td>0 – 15</td><td>50 – 80</td><td>20 – 50</td></tr>
<tr><td rowspan="3">4</td><td colspan="2">Fine sand</td><td>F Sa</td><td rowspan="3">up to 3</td><td rowspan="3">0 – 15</td><td rowspan="3">85 – 100</td><td rowspan="3">0 – 20</td></tr>
<tr><td colspan="2">Medium sand</td><td>M Sa</td></tr>
<tr><td colspan="2">Coarse sand</td><td>C Sa</td></tr>
<tr><td rowspan="2">5</td><td colspan="2">Silty gravel</td><td>siGr</td><td rowspan="2">up to 3</td><td rowspan="2">15 – 40</td><td rowspan="2">0 – 20</td><td rowspan="2">40 – 85</td></tr>
<tr><td colspan="2">Clayey gravel</td><td>clGr</td></tr>
<tr><td rowspan="2">6</td><td colspan="2">Sandy and silty gravel</td><td>sasiGr</td><td rowspan="2">up to 3</td><td rowspan="2">15 – 40</td><td rowspan="2">20 – 45</td><td rowspan="2">40 – 65</td></tr>
<tr><td colspan="2">Silty and sandy gravel</td><td>sisaGr</td></tr>
<tr><td>7</td><td colspan="2">Silty sand with gravel</td><td>grsiSa
grclSa</td><td>up to 3</td><td>15 – 40</td><td>40 – 65</td><td>20 – 40</td></tr>
<tr><td>8</td><td colspan="2">Silty (clayey) sand</td><td>siSa
clSa</td><td>up to 3</td><td>15 – 40</td><td>40 – 85</td><td>0 – 20</td></tr>
<tr><td rowspan="2">9</td><td colspan="2">Gravelly silt</td><td>grSi
grclSi</td><td rowspan="2">0 – 8</td><td rowspan="2">40 – 80</td><td rowspan="2">0 – 20</td><td rowspan="2">20 – 60</td></tr>
<tr><td colspan="2">Silty gravel</td><td>siGr</td></tr>
<tr><td rowspan="2">10</td><td rowspan="2">Loam</td><td>Sandy-clay loam</td><td>saclSi</td><td>8 – 17</td><td>33 – 72</td><td colspan="2">20 – 60</td></tr>
<tr><td>Sandy-silt loam</td><td>sasiCl</td><td>8 – 31</td><td>25 – 65</td><td colspan="2">20 – 60</td></tr>
<tr><td>11</td><td colspan="2">Silt</td><td>Si</td><td>0 – 10</td><td>72 – 100</td><td colspan="2">0 – 20</td></tr>
<tr><td>12</td><td colspan="2">Clayey silt</td><td>clSi</td><td>8 – 20</td><td>65 – 90</td><td colspan="2">0 – 20</td></tr>
<tr><td>13</td><td colspan="2">Clay</td><td>Cl</td><td>25 – 60</td><td>0 – 60</td><td colspan="2">0 – 40</td></tr>
<tr><td>14</td><td colspan="2">Silty clay</td><td>siCl</td><td>20 – 40</td><td>48 – 80</td><td colspan="2">0 – 20</td></tr>
<tr><td>15</td><td colspan="2">Various soils</td><td></td><td>10 – 30</td><td>20 – 40</td><td>30 – 40</td><td>20 – 40</td></tr>
<tr><td rowspan="2">16</td><td rowspan="2" colspan="2">Symbols for regoliths</td><td rowspan="2"></td><td></td><td>20 – 40</td><td>20 – 40</td><td>30 – 40</td></tr>
<tr><td>10 – 30</td><td>40 – 60</td><td colspan="2">30 – 60</td></tr>
<tr><td>17</td><td colspan="2">Organic soils</td><td>Or</td><td></td><td></td><td colspan="2"></td></tr>
</table>