Bundesministerium
für Umwelt, Naturschutz,
Bau und Reaktorsicherheit

T R A N S L A T I O N

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for the Environment, Nature Conservation, Building and Nuclear Safety

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General Administrative Provision on the Implementation of the Ordinance on Electromagnetic Fields – 26th Ordinance on the Implementation of the Federal Immission Control Act (26th BImSchVVwV)

of 26 February 2016

Under Article 84(2) of the German Basic Law and on the basis of the second sentence of Section 4(2) of the Ordinance on Electromagnetic Fields in the version promulgated on 14 August 2013 (Federal Law Gazette [*Bundesgesetzblatt, BGBl.*] I, pp. 3266, 3942) in conjunction with Section 48 of the Federal Immission Control Act [*Bundes-Immissionsschutzgesetz]* in the version promulgated on 17 May 2013 (*BGBl.* I, p. 1274), most recently amended by Article 1(11) of the Act of 20 November 2014 (*BGBl.* I, p. 1740), after hearing the parties concerned, the German Federal Government hereby issues the following general administrative provision:

Contents

1 Scope

This general administrative provision gives concrete form to Section 4(2) of the Ordinance on Electromagnetic Fields – hereinafter: 26th BImSchV – in the version promulgated on 14 August 2013.

It describes the requirements placed on low frequency and direct current installations, when such installations are erected and significantly altered, in order to minimise the electrical and magnetic fields generated by the installation in question in accordance with the state-of-the-art, taking into account conditions within the affected area.

It shall apply to low frequency and direct current installations as defined in Section 1(2)(2) and (3) of the 26th BImSchV.

This general administrative provision shall serve the competent authority as a basis for decision-making on whether the minimisation of fields is planned and implemented properly, taking into account conditions within the affected area of the installation in question.

Requirements imposed by the Federal Requirements Plan Act [*Bundesbedarfsplangesetz*], the Power Grid Expansion Act [*Energieleitungsausbaugesetz*], the Energy Industry Act [*Energiewirtschaftsgesetz*] and the Grid Expansion Acceleration Act [*Netzausbaubeschleunigungsgesetz Übertragungsnetz*] shall remain unaffected. Sectoral legal standards, such as provisions concerning nature conservation, in particular site protection and species protection, shall remain unaffected.

2 Definitions

2.1 Traction overhead line installation

The entirety of the equipment for the supply of electrical energy from traction transformer stations to electrical traction units, which include overhead lines and traction energy lines, consisting of bypass lines, supply lines and line feeders.

2.2 Traction current converter installation

Installation for the conversion of three-phase alternating current from public electricity grids into the single-phase alternating current used for railways with the aid of electronic components and input or output transformers, chokes, filters and switching panels.

2.3 Assessment distance

Distance from the installation as of which field strengths decline continuously with increasing distance.

The starting point is in each case the ground projection[1] of the motionless outer conductor of an overhead power line, the outer cable of an underground cable, the centre line of the track for traction overhead line on a single-track railway line, the centre line of the outer electrified track for a traction overhead line on a multi-track railway line and the enclosure for or, where no enclosure is present, the housing of sealing ends, a power converter installation, a traction current converter installation, a transformer or a switching station.

2.4 Reference point

A reference point is a point that is determined for relevant field minimisation locations that are situated outside the assessment distance. It is situated at the assessment distance on the shortest straight line between the relevant field minimisation location in question and the centre point of the installation/route axis in question.

The reference point is chosen so that field strengths are also minimised at greater distances by means of the minimisation of fields with respect to this point.

[1] Where lines run through tunnels or over bridges, the assessment distance is to be analysed radially.

2.5 Affected area

The affected area of an installation is the area within which the installation causes electrical or magnetic fields that deviate significantly from natural and mean anthropogenically induced immissions, irrespective of whether the immissions actually trigger harmful environmental impacts. In the low-frequency range, background exposure is dominated by anthropogenically occurring field strengths that are essentially caused by domestic electrical installations and electrical appliances. In Germany, the mean low-frequency anthropogenic magnetic field strength is 0.1 µT and the electrical field strength is less than 1 V/m.

The starting point is in each case the ground projection[2] of the motionless outer conductor of an overhead power line, the outer cable of an underground cable, the centre line of the track for a traction overhead line on a single-track railway line, the centre line of the outer electrified track for a traction overhead line on a multi-track railway line and the enclosure for or, where no enclosure is present, the housing of sealing ends, a power converter installation, a traction current converter installation, a transformer or a switching station.

2.6 Underground cable

The entirety of an installation for the underground transmission of electricity, consisting of insulated conductors that are laid in the ground, in ducts, tunnels, troughs or in a comparable fashion, including ancillary structures such as, for example, cable pits and sealing ends.

2.7 Overhead power line

Entirety of an installation for the overground transmission of electricity.

2.8 Maximum operational capacity of an installation

An installation’s maximum operational capacity is characterised by technical limits. These are its maximum operational continuous current and its nominal voltage.

2.9 Immission

Electrical and magnetic fields that are generated by one or several installations and occur at a relevant field minimisation location where they may impact humans, animals and plants.

2.10 Line

Short form for overhead power line or underground cable.

2.11 Relevant field minimisation location

A relevant field minimisation location is a building or plot of land within the meaning of Section 4(1) of the 26th BImSchV and situated within the affected area of the installation in question, as well as any building or part of a building intended for purposes involving the not merely temporary presence of human beings.

2.12 Power converter installation, converter station

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[2] Where lines run through tunnels or over bridges, the affected area is to be analysed radially.

Installation for the conversion of direct current into alternating current or vice versa with the aid of electrical components and input or output transformers, chokes, filters and switching panels.

2.13 Transformer

Equipment with one or several windings, with which an alternating voltage and current system is transformed by electromagnetic induction into another alternating voltage and current system that usually has the same frequency, but different voltage and current levels.

2.14 Transformer and switching station

Installation in which electricity is transformed, switched or distributed. In contrast to a switching station, a transformer station contains at least one transformer.

2.15 Effectiveness of a field minimisation measure

The minimisation of fields achieved with a measure that is taken relative to the electrical and magnetic field strengths generated by the installation that would occur in the absence of this measure.

3 Minimisation

3.1 Aim of field minimisation and parameters

The aim of the minimisation requirement set out in Section 4(2) of the 26th BImSchV is to minimise the electrical and magnetic fields generated by low frequency and direct current installations in accordance with the state-of-the.art, taking into account conditions within the affected area, so that immissions are minimised at the relevant field minimisation locations of the installation in question.

Minimisation measures pursuant to Section 4(2) of the 26th BImSchV are to be examined if at least one relevant field minimisation location is situated within the affected area of the installation in question. Should several relevant field minimisation locations be situated within the affected area, all relevant field minimisation locations shall be analysed with equal priority in the procedure of minimisation of fields. A measure shall not come into consideration as a field minimisation measure if it would lead to an increase in immissions at a relevant field minimisation location.

Possible field minimisation measures shall be examined individually for the planned installation, including its planned capacity, and for the specified route. The minimisation requirement does not demand examination in accordance with the ‘NOVA principle’ that is anchored in German energy sector law – grid optimisation takes precedence over grid upgrading takes precedence over grid expansion – or any examination of alternatives, for example underground cables instead of overhead power lines, alternative routing or alternative locations, that may be required under other legal provisions, in particular under the law of planning approvals.

The application of several field minimisation measures may come into consideration. Where their combined application is ruled out, a selection is to be made using the substantive stipulations set out in this general administrative provision. Should one or several field minimisation measures have different impacts on electrical and magnetic fields, the minimisation of the electrical field is to be given precedence when measures are selected for direct current installations and the minimisation of the magnetic field when measures are selected for low frequency installations.

In particular, the principle of proportionality is to be upheld by analysing the level of effort involved in, and benefits of, possible measures. Furthermore, possible disadvantageous impacts on other protected assets are to be taken into account.

Should a new line be suspended from existing overhead structures or should a line that is already suspended from such structures be altered significantly, the minimisation requirement only relates to the additional line, where the existing line is not significantly altered for its part. In this respect, it is irrelevant whether the voltage levels and frequencies of the lines differ. However, the fields from the existing line are to be taken into account as well when fields generated by a new or significantly altered line are minimised.

3.2 Procedure for the implementation of the minimisation requirement

The minimisation requirement shall be implemented in three substeps: a preliminary examination, the determination of field minimisation measures and an assessment of those measures. The context of the individual substeps and the examination process are depicted in a flow chart in Annex I.

3.2.1 Preliminary examination

The preliminary examination shall serve to establish whether fields are in fact to be minimised at the installation in question, therefore making it necessary to determine minimisation measures.

3.2.1.1 Status of the installation in question

Since the minimisation requirement applies exclusively to low frequency and direct current installations that are either being newly erected or significantly altered, further examination shall only be necessary for such installations.

3.2.1.2 Analysis of the affected area

Field minimisation measures set out in section 3.2.2 are only to be determined if at least one relevant field minimisation location is situated within the affected area of the installation in question.

The affected area shall be dependent both on installation-related factors, for example the mast/pole/pylon height, the number of systems and the voltage level, and factors unrelated to the installation, for example the topography, built structures and vegetation. Consequently, the affected area of each installation is to be identified using conservative standardised values, which are specified as follows:

Affected areas of direct current installations

Overhead power lines

Nominal voltage	**Distance**
≥ 500 kV	400 m

Nominal voltage	Distance
≥ 300 kV to < 500 kV	300 m
< 300 kV	200 m

Underground cables

Nominal voltage	Distance
≥ 500 kV	20 m
≥ 300 kV to < 500 kV	15 m
≥ 100 kV to < 300 kV	10 m
< 100 kV	5 m

Power converter installations

	Distance
All	100 m

Areas affected by low frequency installations

Overhead power lines (including long distance traction current lines)

Nominal voltage	Distance
≥ 380 kV	400 m
≥ 220 kV to < 380 kV	300 m
≥ 110 kV to < 220 kV	200 m
< 110 kV	100 m

Underground cables

Nominal voltage	Distance
≥ 380 kV	100 m
≥ 220 kV to < 380 kV	75 m
≥ 110 kV to < 220 kV	35 m
≥ 50 kV to < 110 kV	25 m
< 50 kV	10 m

Transformer and switching stations

Nominal voltage	Distance
Transformer and switching station > 110 kV	100 m
Transformer and switching station ≤ 110 kV (except local grid transformer stations)	50 m
Local grid transformer station (transformation from medium voltage to low voltage)	10 m

Traction current installations

	Distance
Traction overhead line	100 m
Traction energy line	100 m
Traction current converter installation	20 m
Transformer and switching station	20 m

3.2.2 Determination of field minimisation measures

The examination of field minimisation measures is dependent on the positioning of the relevant field minimisation locations relative to the assessment distance. A distinction is drawn between an examination carried out at the reference points only and an individual field minimisation examination. Assessment distances are specified for low frequency and direct current installations as follows:

Assessment distances for direct current installations

Overhead power lines

Nominal voltage	Distance
All	35 m

Underground cables

Nominal voltage	Distance
All	5 m

Power converter installations

Nominal voltage	Distance
All	5 m

Assessment distances for low frequency installations

Overhead power lines (including long-distance traction current lines)

Nominal voltage	Distance
≥ 380 kV	20 m
≥ 220 kV to < 380 kV	15 m
≥ 110 kV to < 220 kV	10 m
< 110 kV	5 m

Underground cables

Nominal voltage	Distance
≥ 380 kV	10 m
≥ 220 kV to < 380 kV	5 m
≥ 110 kV to < 220 kV	1 m
≥ 50 kV to < 110 kV	1 m
< 50 kV	1 m

Transformer and switching stations

Nominal voltage	Distance
Transformer and switching station > 110 kV	5 m
Transformer and switching station ≤ 110 kV (except local grid transformer stations)	1 m
Local grid transformer station (transformation from medium voltage to low voltage)	1 m

Traction current installations

	Distance
Traction overhead line	10 m
Traction energy line	10 m
Traction current converter installation	5 m
Transformer and switching station	5 m

3.2.2.1 Examination of field minimisation at reference points only

Should no relevant field minimisation location be situated within the area between the centre point of the installation/route axis and the assessment distance, the potential for field minimisation is only to be determined at the reference points. In areas that are densely built up and where there is therefore a large number of reference points, one or several representative reference points may be chosen instead. Schematic examples are depicted in Annex II.

3.2.2.2 Individual field minimisation examination

Should at least one relevant field minimisation location be situated between the centre point of the installation/route axis and the assessment distance, an individual field minimisation examination shall be required. In this respect, two cases are to be distinguished. In Case I, all relevant field minimisation locations are situated within the area between the centre point of the installation/route axis and the assessment distance; in Case II, relevant field minimisation locations are situated both within and outside this area. Schematic examples are depicted in Annex III.

In Case I, the potential for the minimisation of fields is to be determined for the relevant field minimisation locations situated within the assessment distance.

In Case II, the potential for the minimisation of fields is to be determined for the relevant field minimisation locations situated within the assessment distance, and at the reference points for the relevant field minimisation locations situated outside the assessment distance. In densely built-up areas, i.e. where there is a large number of reference points, one or several representative reference points may be chosen instead.

When an individual field minimisation examination is carried out, it is additionally to be examined whether a field minimisation measure would lead to an increase in immissions at relevant field minimisation locations situated within the assessment distance.

3.2.2.3 Examination of field minimisation potential

The potential for the minimisation of the fields generated by the installation in question is to be examined in relation to the minimisation of fields at the specified reference points and relevant field minimisation locations. This examination shall be carried out on the basis of the technical options for the minimisation of fields cited in section 5. The measures in question are to be examined both when a new installation is constructed and when significant alterations are carried out.

The field minimisation potential is to be determined either using measurement and calculation methods or using a standardising analysis, for example by means of comparison with existing installations.

3.2.3 Assessment of measures, specification of minimisation measures

In the last substep, the assessment of measures, the proportionality of the technical options for minimisation that have been determined is to be assessed. For example, the effectiveness of the measures, their impacts on overall immissions at the relevant field minimisation locations, the reduction in immissions to be achieved at the relevant field minimisation locations, the capital and operating costs of the measures, and their impacts on the maintenance and availability of the installations are to be factored into the assessment.

Only measures that may be implemented with generally justifiable economic effort and benefits shall come into consideration. This effort may depend considerably on whether a field minimisation measure is applied to the whole installation or only to part of it, for example a section of a line. When significant alterations are made, the additional effort involved is also dependent on the type and scale of the planned significant alteration itself and may be considerable in comparison to the level of effort involved when a new installation is constructed.

Furthermore, possible disadvantageous impacts on other protected assets are to be taken into account when the minimisation measures that come into consideration are selected. In this respect, firstly, all sectoral legal standards, for example provisions concerning nature conservation, in particular site protection and species protection, the provisions of the Technical Instructions on Noise Abatement [*TA Lärm*] or occupational health and safety provisions, are to be abided by. Secondly, a comprehensive, integrated analysis shall be required with the consequence that minimisation measures may be ruled out on account of the disadvantageous impacts on other protected assets with which they are associated. The reasons and considerations that have led to the decision about the minimisation measures selected are to be documented thoroughly. The documents are to be made available to the competent authority on request.

In conclusion, the minimisation measures shall be finally specified.

4 Method for demonstrating conformity

The fields generated by an installation shall be determined as follows as local maximums outside the installation, at the installation's maximum operational capacity, with currents flowing in the directions that are predominantly to be expected and without taking into account harmonic waves:

a) one metre above the ground, irrespective of whether the detection point is situated in a building or in the open air,

b) directly at the reference point when field minimisation is examined under section 3.2.2.1 or section 3.2.2.2, Case II,

c) in buildings or in the open air at the centre point of the relevant field minimisation location when an individual field minimisation examination is carried out under section 3.2.2.2.

Should conformity be demonstrated using field measurements, it shall be ensured that the undisturbed field is measured. A distance of at least one metre from ferromagnetic or electrically conductive objects that could cause field distortions shall be complied with. In addition to this, it shall be ensured that no distortions occur between different measurements due to domestic electrical installations or other external influences, such as weather conditions. Where this is not guaranteed, demonstration of conformity in the form of a field simulation is to be preferred.

5 Technical options for field minimisation

Measures specific to particular equipment that are intended to minimise the electrical and magnetic fields generated by an installation and the effectiveness of such measures are listed below. The measures cited are to be examined both when a new installation is constructed and when significant alterations are made. Some of the measures may reciprocally influence each other's effectiveness. The installation's operational state may also have an influence on measures' effectiveness. Known interactions are mentioned in connection with the measures in question.

Apart from their effectiveness, the levels of structural and technical effort involved in the implementation of the measures described have also been estimated if possible. These levels of effort may depend considerably on whether a field minimisation measure is applied to the whole installation or only to part of it, for example a section of a line. When significant alterations are made, the level of additional effort involved is dependent on the type and scale of the planned significant alteration itself and may be considerable in comparison to the level of effort involved in the construction of a new installation.

5.1 High-voltage direct current installations, 0 Hertz

5.1.1 HVDC overhead power lines

5.1.1.1 Optimisation of clearances

The aim of this measure is to increase the distance from the conductor wires to relevant field minimisation locations. For example, the distance to the ground is increased by raising pylons or reducing the span length. Should a circuit be suspended from a cross-bar – cantilever arm – oriented away from a relevant field minimisation location, this reduces the immission at that location.

Preconditions: The ground conditions must permit suitable pylon foundations if pylons are raised. The ground clearance of the conductor wires can be specified in the plans when a new installation is constructed.

Effectiveness: In principle, this measure is highly effective close to the route, while its effectiveness declines with increasing distance from the route.

Comments: The level of effort involved is low for the raising of pylons when a new line is to be constructed. The level of effort rises with increasing distance to the ground.

5.1.1.2 Electrical shielding

This measure consists in interposing electrically conductive shielding panels or conductors primarily between voltage-carrying parts of the line and a relevant field minimisation location as components of the installation. This measure includes the parallel suspension of earth wires. In monopolar systems, the parallel suspension of a neutral conductor wire is part of this measure.

Preconditions: The structural preconditions must be fulfilled in order for it to be possible for the additional line components and fittings to be installed. Minimum insulating air gaps between the shields and the voltage-carrying conductor wires, and the minimum distance to the ground must be complied with.

Effectiveness: This measure predominantly has an impact on electrical field strength. The effectiveness of a neutral conductor as a shielding measure is usually low . Earth wires only have a shielding effect if they are installed below or to the side of line systems.

Comments: Due to the ground clearance that is to be guaranteed, the introduction of additional wires demands a raising of the pylons in most cases, this being associated with a review of their structural design and, where relevant, structural adjustments.

5.1.1.3 Minimising wire spacings

The spacings between wires, in particular between voltage- and current-carrying conductor wires, are minimised; this also involves the minimisation of the wire spacings within a circuit and the minimisation of the spacings to other circuits.

Preconditions: This measure is possible on all bipolar lines and can be implemented when new installations are constructed. Whenever conductor arrangements are to be altered, this measure is also possible when significant alterations are made. Minimum insulating air gaps between the wires, between the conductor wires and the pylons, and other earthed parts of the installation or to the ground must be complied with.

Effectiveness: This measure is moderately effective. However, it is influenced by other installation parameters and is dependent on the distance from the conductors.

Comments: Depending on the voltage level, short air gaps may promote noise emissions as a result of corona effects and require special measures when maintenance is carried out if more than one system is suspended from a single pylon, for example to allow pylons to be climbed. This measure is influenced by the swing envelope and minimum insulating air gap for the conductor wires. Minimised wire spacings cause only a low level of additional effort when a new line is to be constructed.

5.1.1.4 Optimising conductor arrangement geometry

Of the possible pylon types, for example the three-level ‘barrel pylon’ with its semi-vertical configuration and the two-level ‘Danube pylon’ with its vertical configuration, the one is selected whose conductor arrangement permits the conductor wires to be suspended in a geometrically favourable arrangement for the cancellation of electrical and magnetic fields. The significant differences between the various pylon types consist in the options for the geometrical configuration of the conductor wires, which may be horizontal, vertical, or triangular. In this respect, a vertical configuration of the outer conductors is generally more favourable for the cancellation of electrical and magnetic fields than a horizontal configuration.

Preconditions: When new installations are constructed, the pylon type and therefore the conductor arrangement geometry can be specified. When new installations are constructed and in particular when significant alterations are made, technical constraints, such as the parallel suspension of several systems, may restrict the possible choices.

Effectiveness: This measure is highly effective.

Comments: The additional effort involved for a pylon type with favourable pylon geometry may be considerable even when new installations are constructed, for example on account of different pylon heights. When significant alterations are made, the choice of a favourable pylon type may often be constrained by technical limits.

5.1.1.5 Optimising pole configuration

When a specified geometrical wire configuration is deployed, the assignment of the positive and negative poles to the wires is chosen so that the electrical and magnetic fields generated by the individual poles cancel each other optimally.

Preconditions: More than one bipolar circuit must be installed on the pylon. This measure can be implemented when new installations are constructed, but only if a longer section of a line or the whole line is affected when significant alterations are made.

Effectiveness: In principle, this measure is highly effective and is influenced by other installation parameters, such as the conductor arrangement or the conductor wire spacing. Low conductor wire spacings increase the effectiveness of this measure. Furthermore, its relative effectiveness is dependent on the distance from the conductor wires. It is highly variable locally, above all within the affected area, and may fluctuate markedly from place to place.

Comments: When the power flow in a circuit is reversed, the installation may be in a non-optimised state in terms of its magnetic field. A low level of additional effort is involved when a new line is to be constructed. An alteration of the pole configuration is mostly associated with a considerable level of effort along short sections of a line.

5.1.2 HVDC underground cable

5.1.2.1 Minimising cable spacings

Cables are laid with the smallest possible spacing between them; this also involves the minimisation of the cable spacings within a circuit and the spacings to other circuits.

Preconditions: This measure is possible on all bipolar circuits and can be implemented when new installations are constructed. Minimum cable spacings may be required in order to limit the thermal loads of the cables.

Effectiveness: This measure is highly effective. However, it is influenced by other installation parameters and is dependent on the distance from the conductors.

Comments: The reduction of cable spacings may lead to heating in the ground. The level of additional effort involved is low where a new line is to be constructed.

5.1.2.2 Optimising pole configuration

When a specified geometrical conductor configuration is deployed, the sequence in which the positive and negative poles are connected to the underground cable is chosen so that the magnetic fields generated by the cables are cancelled optimally.

Preconditions: This measure can be implemented if more than one bipolar circuit is laid along a route. It can be implemented when new installations are constructed, but only if a longer section of a line or the whole line is affected when significant alterations are made.

Effectiveness: In principle, this measure is highly effective. However, it is influenced by other installation parameters, such as the geometrical configuration of the individual cables or the conductor spacing. Small conductor spacings increase this measure’s effectiveness.

Comments: When the power flow in a circuit is reversed, the installation may be in a non-optimised state in terms of its magnetic field. A low level of additional effort is involved when a new line is to be constructed. An alteration of the pole configuration is mostly associated with a considerable level of effort along short sections of a line.

5.1.2.3 Optimising laying depth

Underground cables are laid deep in the ground.

Preconditions: The ground conditions and the infrastructure in place at the location must be suitable for deep cable laying. This measure is possible on all underground direct-current cables. This measure can generally be implemented when new installations are constructed.

Effectiveness: This measure’s effectiveness depends on the laying depth. It is highly effective close to the route, while its effectiveness declines with increasing distance from the route.

Comments: Heat dissipation worsens at greater laying depths, with possible consequences for the cables and the ground. The additional effort involved is dependent on the conditions in the individual case.

5.1.3 Power converter installations

5.1.3.1 Optimising spacing

Parts of an installation that generate fields are erected within the facility site or facility building at the greatest possible distance from relevant field minimisation locations; this also involves raising the gantries for incoming and outgoing overhead power lines.

Preconditions: This measure can be implemented when new installations are constructed and significant alterations are made.

Effectiveness: This measure is highly effective.

Comment: When significant alterations are made, the level of effort involved may rise considerably in comparison to the level of effort involved in the construction of a new installation, depending on the scale of the planned alteration.

5.1.3.2 Minimising spacings between equipment with different polarities

Equipment or elements of equipment that carry voltages and currents with different polarities are assembled as close together as possible so that their electrical and magnetic fields cancel each other optimally.

Preconditions: This measure can be implemented when new installations are constructed, subject to compliance with technical constraints. The spatial conditions and the scale of the envisaged alterations are decisive when significant alterations are made. Minimum insulating air gaps between equipment or elements of equipment with different electrical potentials must be complied with.

Effectiveness: This measure's effectiveness is dependent on its scale. It is influenced by other installation parameters and is dependent on the distances of the conductors.

Comments: Small spacings between equipment or elements of equipment that are assigned to different circuits may have disadvantageous impacts on availability. The level of additional effort involved is low when new installations are constructed. The level of additional effort involved when significant alterations are made is dependent on the scale of the planned alteration and the spatial conditions. No practical experience of this measure is available.

5.2 16.7-Hertz traction current installations

5.2.1 Traction current overhead power lines

5.2.1.1 Optimisation of clearances

The aim of this measure is to increase the distance of the conductor wires from the relevant field minimisation locations. For example, the distance to the ground is increased by raising masts or reducing the span length. Should a circuit be carried on a cross-bar – cantilever arm – oriented away from a relevant field minimisation location, this reduces the immission at that location.

Preconditions: The ground conditions must permit suitable pylon foundations if pylons are raised. The ground clearance of the conductor wires can be specified in the plans when new installations are constructed.

Effectiveness: In principle, this measure is highly effective close to the route, while its effectiveness declines with increasing distance from the route.

Comments: The effectiveness of raising the ground clearance may be highly variable along the route, depending on other installation parameters, such as the phase configuration for pylons with more than one circuit, and have a locally limited contrary effect. The level of additional effort involved in the raising of pylons is estimated between low and moderate when a new line is to be constructed. The level of effort rises with increasing ground clearance.

5.2.1.2 Electrical shielding

Electrically conductive shielding panels or conductors are primarily interposed between voltage-carrying parts of the line and a relevant field minimisation location as components of the installation; this also involves the parallel suspension of earth wires.

Preconditions: The structural preconditions must be fulfilled in order for it to be possible for the additional line components and fittings to be installed. Minimum insulating air gaps between the shields and the voltage-carrying conductor wires, and the minimum ground clearance must be complied with.

Effectiveness: This measure presominantly has impact on electrical field strength. Its effectiveness is dependent on the design of the shielding, but usually low. Earth wires only have a shielding effect if they are installed below or to the side of line systems.

Comments: Due to the ground clearance that is to be guaranteed, the introduction of additional cables demands a raising of the pylons, this being associated with a review of their structural design and, where relevant, structural adjustments along the route. The level of additional effort involved when new installations are constructed and significant alterations are made is dependent on the planned design and the length of the part of a line to be shielded.

5.2.1.3 Minimising wire spacings

The spacings between wires, in particular between voltage-carrying and current-carrying conductor wires, are minimised. This measure includes the minimisation of wire spacings within a circuit and the spacings to other circuits.

Preconditions: This measure is possible on all lines. It can be implemented when new installations are constructed. Whenever conductor arrangements are to be altered, the measure is also possible when significant alterations are made. Minimum insulating air gaps between the wires, between the conductor wires and the pylons, and other earthed parts of an installation or to the ground must be complied with. A clear reduction of the spacing between the conductor wires and circuits may be achieved by means of special pylon designs and spans with low sag.

Effectiveness: This measure is highly effective. However, it is influenced by other installation parameters and is dependent on the distance from the conductors.

Comments: Depending on the voltage level, short air gaps may promote noise emissions due to corona effects and require special measures when maintenance work is carried out, for example to allow pylons to be climbed, if more than one system is suspended from a pylon. This measure is influenced by the swing envelope and minimum insulating air gap of the conductor wires. When a new line is to be constructed, minimised wire spacings entail only low levels of additional effort.

5.2.1.4 Optimising conductor arrangement geometry

Of the possible pylon types, for example one, two and three-level pylons, the one is selected whose conductor arrangement permits the conductor wires to be suspended in a geometrically favourable arrangement for the cancellation of electrical and magnetic fields. The significant differences between the various pylon types consist in the geometrical options for the configuration of the conductor wires, primarily horizontal or vertical. In this respect, a vertical configuration of the outer conductor wires is in principle more favourable for the cancellation of electrical and magnetic fields than a horizontal configuration.

Preconditions: The pylon type and therefore the conductor arrangement geometry can be specified when new installations are constructed. Technical constraints, such as the parallel suspension of several systems, may restrict the possible choices when new installations are constructed and in particular when significant alterations are made.

Effectiveness: This measure is highly effective.

Comments: The level of additional effort involved for a pylon type with favourable pylon geometry may be considerable even when new installations are constructed, for example on account of different pylon heights. When significant alterations are made, the choice of a more favourable pylon type may often be constrained by technical limits.

5.2.1.5 Optimising conductor configuration

When a specified geometrical wire configuration is deployed, the sequence in which the single-phase alternating-current conductors are connected to the wires is chosen so that the electrical and magnetic fields generated by the individual conductor wires cancel each other optimally.

Preconditions: There must be more than one circuit installed on the pylon. This measure can be implemented when new installations are constructed; it is possible when significant alterations are made if a longer section of a line or the whole line is affected.

Effectiveness: This measure is highly effective and is influenced by other installation parameters, such as the conductor arrangement or the conductor wire spacing. Small conductor spacings increase its effectiveness. Furthermore, the measure's relative effectiveness is dependent on the distance from the conductor wires. Its effectiveness is highly variable locally, above all within the affected area, and may fluctuate markedly from place to place.

Comments: The optimal conductor configuration may be different for the near and far-fields. Depending on other installation parameters such as the ground clearance of the conductor wire height along the route, an optimal phase configuration for the far-field may have locally limited contrary effects. A low level of additional effort is involved for a new line that is to be constructed. An alteration of the conductor configuration is mostly associated with a considerable level of effort along short sections of a line.

5.2.2 Traction current underground cables

5.2.2.1 Minimising cable spacing

Cables are laid at the smallest possible spacing from one another; this also involves the minimisation of the cable spacings within a circuit and the spacings to other circuits.

Preconditions: This measure is possible on all underground cable systems. Should a circuit be carried in a single cable, the spacing to other circuits may be minimised. This measure may generally be implemented when new installations are constructed. Minimum cable spacings may be required in order to limit the thermal loads of the cables.

Effectiveness: This measure is highly effective. However, it is influenced by other installation parameters and is dependent on the distance from the conductors.

Comments: The reduction of the cable spacings may lead to heating in the ground. A low level of additional effort is involved when a new line is to be constructed. The level of additional effort involved when significant alterations are made depends on the type and scale of the planned alteration, and is therefore to be examined in the individual case.

5.2.2.2 Optimising conductor configuration

When a specified geometrical configuration of the individual cables is deployed, the sequence in which the single-phase alternating-current conductors are connected to the underground cables is chosen so that the magnetic fields generated by the cables cancel each other optimally.

Preconditions: This measure can be implemented if more than one current system is laid along a route and the geometrical configuration of the individual cables remains the same, as when single conductor cables are laid. This measure can be implemented when new installations are constructed; it is possible when significant alterations are made if a longer section of a line or the whole line is affected.

Effectiveness: This measure is highly effective and is influenced by other installation parameters, such as the geometrical configuration of the individual cables or the conductor spacing. Small conductor spacings increase the effectiveness of this measure.

Comments: A low level of additional effort is involved when a new line is to be constructed. An alteration of the conductor configuration is mostly associated with a considerable level of effort along short sections of a line.

5.2.2.3 Optimising laying geometry

Cables are laid so that the relative positions of the individual cores permit the best-possible cancellation of the magnetic fields. The cores of a system may be run jointly in one cable or individually in separately laid cables. Running them in a shared cable or the vertical configuration of individual cables is advantageous with a view to the cancellation of fields. Additionally, cables may be transposed with smaller cable cross-sections.

Preconditions: This measure is possible above all with single-conductor cables and may be specified when new installations are constructed. When significant alterations are made, the choice of an alternative laying geometry may be constrained by technical limits.

Effectiveness: The choice of a favourable laying geometry may markedly reduce the immission within the affected area compared to the immission that would occur were an unfavourable geometry to be chosen. Transposition contributes to the minimisation of fields, depending on the lay length. The effectiveness of this measure is therefore to be estimated as high. However, it is influenced by other installation parameters, for instance by the conductor spacing when conductors are deployed that have not been transposed.

Comments: Cables that have been laid on top of one another or transposed may require special measures for fault clearance. The additional effort involved for a specific laying geometry may be considerable even when new installations are constructed. When significant alterations are made, the choice of a favourable geometry is often constrained by technical limits, depending on the voltage level.

5.2.2.4 Optimising laying depth

Underground cables are laid deep in the ground.

Preconditions: The ground conditions and the infrastructure in place at the location must be suitable for deep laying. This measure is possible with all traction current underground cables. It can be implemented when new installations are constructed.

Effectiveness: This measure's effectiveness depends on the depth at which the cables are laid. In principle, it is highly effective close to the route, while its effectiveness declines with increasing distance from the route.

Comments: Heat dissipation worsens at greater laying depths, with possible consequences for the cables and the ground. The level of additional effort involved is dependent on the conditions in the individual case.

5.2.3 Traction current overhead lines

5.2.3.1 Optimisation of clearances

Parts of installations that generate fields, such as line feeders or supply lines, are to be erected within the facility site at the greatest possible distance from relevant field minimisation locations. For example, the raised installation and suitable orientation of cross-bars are possible.

Preconditions: This measure can generally be implemented when new installations are constructed and when significant alterations are made.

Effectiveness: This measure is moderately effective.

Comments: The level of effort involved may rise considerably, depending on the scale of the measure. The measure may lead to markedly higher masts. Increased effort may be incurred when maintenance is carried out (maintenance vehicles potentially not deployable), which may lead to a reduction of the installation's availability.

5.2.3.2 Minimising distances between incoming and returning currents by deploying autotransformers

The greatest possible proportion of the return current is kept away from the track and ground, and carried at the least possible distance from the parts of the installation that conduct the highest incoming currents, such as supply lines, line feeders and contact wires.

Preconditions: This measure can be implemented when new installations are constructed. All measures may be limited to parts of railway lines.

Effectiveness: This measure generally is highly effective. It has no effect along sections where a train is present. The overall effect is therefore dependent on the levels of traffic on the railway line and the length of the sections with autotransformers.

Comments: A –15-kV supply line is required additionally when autotransformer systems are deployed. The complexity of the system is markedly increased by the introduction of an additional voltage level. As a result of this, the level of technical effort involved rises for additionally required parts of an installation, as well as due to the autotransformer switching stations at both ends of the section of line. The additional lines may make maintenance more difficult and reduce availability. The additional effort involved, for instance in more stable masts and larger foundations, may be considerable.

5.2.3.3 Minimising distances between incoming and returning currents by deploying booster transformers without insulated rail joints

The greatest possible proportion of the return current is kept away from the track and ground, and carried at the least possible distance from the parts of the installation that conduct the highest incoming currents, such as supply lines, line feeders and contact wires.

Preconditions: This measure can be implemented when new installations are constructed. All measures may be limited to parts of railway lines.

Effectiveness: This measure generally is highly effective. It has no effect along sections where a train is present. The overall effect is therefore dependent on the levels of traffic on the railway line and the length of the sections with booster transformers.

Comments: The booster leads to a raising of impedances and therefore to a shortening of the distances between traction transformer stations and additional insulated overlaps, thus incurring the effort that is associated with them.

5.2.3.4 Minimising distances between incoming and returning currents by installing a return conductor wire without insulated rail joints

The greatest possible proportion of the return current is kept away from the track and ground, and carried at the least possible distance from the parts of the installation that conduct the highest incoming currents, such as supply lines, line feeders and contact wires.

Preconditions: This measure can be implemented when new installations are constructed. All measures may be limited to parts of railway lines.

Effectiveness: This measure is highly effective.

Comments: The effort involved in the parallel suspension of return conductor wires rises with the length of the distance for which they are installed, but is estimated as moderate on sections of railway line of up to one kilometre. When significant alterations are made, the additional effort involved is dependent on the scale and type of the planned alteration, the spatial conditions and the existing type of installation. For instance, shifting existing return wires close to the parts of the installation with the highest incoming currents may entail a low level of additional effort if the existing mast design is suitable.

5.2.3.5 Minimising traction current

Sections of railway line are fed from two sides.

Preconditions: This measure can always be implemented when new installations are constructed or significant alterations are made. What are required are connections to traction transformer stations or switching stations on both sides.

Effectiveness: This measure is highly effective.

Comments: In the case of a spur railway line, the level of additional effort involved is high because an additional traction transformer station or switching station has to be constructed, depending on whether 110 kV or 15 kV traction energy is available.

5.2.4 Traction current ancillary installations

Note: Traction current ancillary installations include, for example, traction transformer stations and converter stations.

5.2.4.1 Optimisation of clearances

Parts of an installation that generate fields are erected within the facility site or facility building at the greatest possible distance from relevant field minimisation locations; this also involves raising gantries for incoming and outgoing overhead power lines.

Preconditions: This measure can be implemented when new installations are constructed and significant alterations are made.

Effectiveness: This measure's effectiveness is dependent on its type and scale.

Comment: The level of effort involved when significant alterations are made may rise considerably in comparison to the level of effort involved in the construction of new installations, depending on the scale of the planned alteration.

5.2.4.2 Minimising spacings between equipment

Equipment or elements of equipment are assembled compactly as close together as possible so that their electrical and magnetic fields cancel each other optimally.

Preconditions: This measure can be implemented when new installations are constructed, subject to compliance with technical constraints. The spatial conditions and the scale of the envisaged alterations are decisive when significant alterations are made. Minimum insulating air gaps between equipment or elements of equipment with different electrical potentials must be complied with.

Effectiveness: This measure's effectiveness is dependent on its scale. It is influenced by other installation parameters and is dependent on the distance of the conductors.

Comments: Small spacings between equipment or elements of equipment that are assigned to different circuits may have disadvantageous impacts on availability. The level of additional effort involved is low when new installations are constructed. When significant alterations are made, the level of additional effort involved is dependent on the scale of the planned alteration and the spatial conditions.

5.3 50-Hertz energy transmission installations

5.3.1 Three-phase alternating-current overhead power lines

5.3.1.1 Optimisation of clearances

The aim of this measure is to increase the distance of the conductor wires from relevant field minimisation locations. For example, the distance to the ground is increased by raising pylons or reducing span lengths. Should a circuit be suspended from a cross-bar – cantilever arm – oriented away from a relevant field minimisation location, this reduces the immission at that location.

Preconditions: The ground conditions must permit suitable pylon foundations if pylons are raised. The ground clearance of the conductor wires may be specified in the plans when new installations are constructed.

Effectiveness: In principle, this measure is highly effective close to the route, while its effectiveness declines with increasing distance from the route.

Comments: The effectiveness of raising the ground clearance may be highly variable along the route, depending on other installation parameters, such as the phase configuration on pylons with more than one circuit, and have locally limited contrary effects. The level of additional effort involved depends on the measure implemented in each case. For example, it is low for the raising of pylons when a new line is to be constructed. The level of effort involved rises sharply with increasing ground clearances.

5.3.1.2 Electrical shielding

Electrically conductive shielding panels or conductors are primarily interposed between voltage-carrying parts of the line and a relevant field minimisation location as components of the installation; this also involves the parallel suspension of earth wires.

Preconditions: The structural preconditions must be fulfilled in order that it is possible for the additional line components and fittings to be installed. Minimum insulating air gaps between the shields and the voltage-carrying conductor wires, and the minimum ground clearance must be complied with.

Effectiveness: This measure predominantly has an impact on electrical field strength. Its effectiveness is dependent on the type and design of the shielding, but is usually low . Earth wires only have shielding effects when they are installed below or to the side of line systems.

Comments: Due to the ground clearance that is to be guaranteed, the introduction of additional wires requires the raising of pylons in most cases, this being associated with a review of their structural design and, where relevant, structural adjustments. The level of additional effort involved when new installations are constructed and significant alterations are made is dependent on the planned design and the length of the part of a line to be shielded.

5.3.1.3 Minimising wire spacings

The spacings between conductor wires are minimised; this also involves the minimisation of wire spacings within a circuit and the spacings to other circuits.

Preconditions: This measure is possible on all lines and can be implemented when new installations are constructed. Whenever conductor arrangements are to be altered, this measure is also possible when significant alterations are made. Minimum insulating air gaps between the wires, between the conductor wires and the pylons, and other earthed parts of the installation or to the ground must be complied with. A clear reduction in the spacings between conductor wires and circuits may be achieved by means of special pylon designs and spans with a low sag.

Effectiveness: This measure is highly effective. However, it is influenced by other installation parameters and is dependent on the distance from the conductors.

Comments: Depending on the voltage level, short air gaps may promote noise emissions due to corona effects and require special measures when maintenance is carried out, for example to allow pylons to be climbed, if more than one system is suspended from a pylon. This measure is influenced by the swing envelope and minimum insulating air gap of the conductor wires. Minimised wire spacings cause only minor additional effort when a new line is to be constructed.

5.3.1.4 Optimising conductor arrangement geometry

Of the possible pylon types, for example the three-level ‘barrel pylon’ with its semi-vertical configuration and the two-level ‘Danube pylon’ with its vertical configuration, the one is selected whose conductor arrangement permits the conductor wires to be suspended in a geometrically favourable arrangement for the cancellation of electrical and magnetic fields. The significant differences between the various pylon types consist in the options for the geometrical configuration of the conductor wires, which may be horizontal, vertical or triangular. In this respect, a vertical configuration of the outer conductor wires is generally more favourable for the cancellation of electrical and magnetic fields than a horizontal configuration.

Preconditions: The pylon type and therefore the conductor arrangement geometry can be specified when new installations are constructed. Technical constraints such as the parallel suspension of multiple systems may restrict the possible choices when new installations are constructed and in particular when significant alterations are made.

Effectiveness: This measure is highly effective.

Comments: The additional effort involved for a pylon type with favourable pylon geometry may be considerable even when new installations are constructed, for example on account of different pylon heights. The choice of a more favourable pylon type may often be constrained by technical limits when significant alterations are made.

5.3.1.5 Optimising conductor configuration

When a specified geometrical wire arrangement is deployed, the sequence in which the three-phase alternating-current conductor is connected to the wires is chosen so that the electrical and magnetic fields generated by the individual conductor wires cancel each other optimally.

Preconditions: There must be more than one circuit installed on the pylon. This measure can be implemented when new installations are constructed; it is possible when significant alterations are made if a longer section of a line or the whole line is affected.

Effectiveness: This measure is highly effective and is influenced by other installation parameters, such as the conductor arrangement or conductor wire spacing. Small conductor spacings increase its effectiveness. Furthermore, the measure’s relative effectiveness is dependent on the distance from the conductor wires. It is highly variable locally, above all within the affected area, and may fluctuate markedly from place to place.

Comments: The optimal conductor configuration may be different for electrical and magnetic fields, and for the near and far-fields. Since it also depends on the load flow directions in the individual systems, the line may be in a non-optimised state after the flow of current in a circuit has reversed. A low level of additional effort is involved when a new line is to be constructed. An alteration of the conductor configuration is mostly associated with a considerable level of effort along short sections of a line.

5.3.2 Underground three-phase alternating-current cables

5.3.2.1 Minimising cable spacings

Cables are laid with the smallest possible spacings between them; this also involves the minimisation of the cable spacings within a circuit and the spacings to other circuits.

Preconditions: This measure is possible on all underground cable systems. Should a circuit be run in a single cable, the spacings to other circuits may be minimised. This measure can generally be implemented when new installations are constructed. Minimum cable spacings may be required in order to limit the thermal loads of the cables.

Effectiveness: This measure is highly effective and is influenced by other installation parameters and is dependent on the distance from the conductors.

Comments: The reduction of cable spacings may lead to warming in the ground. A low level of additional effort is involved when a new line is to be constructed.

5.3.2.2 Optimising conductor configuration

When a specified geometrical configuration of the individual cables is deployed, the sequence in which the three-phase alternating-current conductors are connected to the underground cable is chosen so that the magnetic fields generated by the cables cancel each other optimally.

Preconditions: This measure can be implemented if more than one circuit is laid along a route and the geometrical configuration of the individual cables remains the same, as when single-conductor cables are laid. The measure may can implemented when new installations are constructed; it is possible when significant alterations are made if a longer section of a line or the whole line is affected.

Effectiveness: This measure is highly effective and is influenced by other installation parameters, such as the geometrical configuration of the individual cables or the conductor spacing. Low conductor spacings increase the effectiveness of this measure.

Comments: The installation may be in a non-optimised state in terms of its magnetic field if the power flow direction in a circuit is reversed. A low level of additional effort is involved when a new line is to be constructed. An alteration of the conductor configuration is mostly associated with an enormous level of effort along short sections of a line.

5.3.2.3 Optimising laying geometry

Cables are laid so that the relative positions of the individual cables permit the best-possible cancellation of magnetic fields. They can be laid in one – horizontal or vertical – plane or in a triangular configuration. A configuration in a triangular pattern is favourable with a view to the cancellation of fields. Additionally, cables with smaller cable cross-sections may be transposed.

Preconditions: The optimisation of the laying geometry is possible above all with single-conductor cables. The optimal laying geometry can be specified when new installations are constructed; the choice of an alternative laying geometry may be constrained by technical limits when significant alterations are made. Requirements concerning heat dissipation may require cables to be laid with shallow cover.

Effectiveness: The choice of a favourable laying geometry may markedly reduce the immission within the affected area compared to the immission that would occur were an unfavourable geometry to be chosen. This measure's effectiveness is therefore to be estimated as high. However, it is influenced by other installation parameters, e.g. the conductor spacing where cables are not transposed. Transposition contributes to field minimisation, depending on the lay length.

Comments: Cables that are laid on top of each other or transposed may require a special level of effort for fault clearance. Apart from this, the spacings between the underground cables are dependent on the capacity of the surrounding ground or the replacement backfill to dissipate heat. The level of additional effort involved for a specific laying geometry may be considerable even when a new installation is constructed. When significant alterations are made, the choice of a more favourable geometry is often constrained by technical limits, depending on the voltage level.

5.3.2.4 Optimising laying depth

Underground cables are laid deep in the ground.

Preconditions: The ground conditions and the infrastructure present at the location must be suitable for deep laying. This measure is possible with all underground three-phase alternating-current cables and can be implemented when new installations are constructed.

Effectiveness: This measure’s effectiveness depends on the laying depth. It is highly effective close to the route, while its effectiveness declines with increasing distance from the route.

Comment: Heat dissipation worsens at greater laying depths, with possible consequences for the cables and the ground.

5.3.3 Medium and higher-voltage three-phase alternating-current transformer and switching stations, converter stations and compensation installations

5.3.3.1 Optimisation of clearances

Parts of installations that generate fields are erected within the facility site or facility building at the greatest possible distance from relevant field minimisation locations; this also involves raising gantries for incoming and outgoing overhead power lines.

Preconditions: This measure can be implemented when new installations are constructed and significant alterations are made.

Effectiveness: This measure’s effectiveness is dependent on its scale.

Comments: The level of effort involved when significant alterations are made may rise considerably in comparison to the level of effort involved when a new installation is constructed, depending on the scale of the planned alteration. No practical experience is available.

5.3.3.2 Minimising spacings between equipment with different phase configurations

Equipment or elements of equipment that carry voltages and currents with different phases, such as third rails and switching panels, are assembled compactly as close together as possible, so that their electrical and magnetic fields cancel each other optimally.

Preconditions: This measure can be implemented when new installations are constructed, subject to compliance with technical constraints. When significant alterations are made, the spatial conditions and the scale of the envisaged alterations are decisive. Minimum insulating air gaps between equipment or elements of eqipment with different electrical potentials must be complied with.

Effectiveness: This measure’s effectiveness is dependent on its scale. It is influenced by other installation parameters and is dependent on the spacing between the equipment.

Comments: Small spacings between equipment or elements of eqipment that are assigned to different circuits may have disadvantageous impacts on availability. A low level of additional effort is involved when new installations are constructed.

5.3.4 Local grid transformer stations

5.3.4.1 Optimisation of clearances

Parts of installations that generate fields are erected within the facility space at the greatest possible distance from relevant field minimisation locations; this involves the orientation of the low-voltage side of transformers towards a side of the facility space that faces away from relevant field minimisation locations, as well as the laying of lines via the shortest-possible path along the walls furthest away from relevant field minimisation locations or along the floor of the installation. At pole-mounted substations, these measures include the raising of the pole.

Preconditions: This measure can be implemented when new installations are constructed and significant alterations are made.

Effectiveness: Since higher magnetic fields are generated by conductors on the low-voltage side than by conductors on the medium-voltage side, measures that increase the distances between parts of installations on the low-voltage side and relevant field minimisation locations are usually more effective.

Comments: When significant alterations are made, the level of effort involved may rise considerably, depending on the scale of the planned alteration in comparison to the level of effort involved in the construction of a new installation. Additionally, the level of effort involved in the fault clearance and maintenance may rise as a result of the rearrangement of equipment.

5.3.4.2 Minimising spacings between equipment with different phase configurations

Equipment or elements of equipment that carry voltages and currents with different phases are assembled compactly as close together as possible so that their electrical and magnetic fields cancel each other optimally.

Preconditions: This measure can be implemented when new installations are constructed, subject to compliance with technical constraints; the spatial conditions and the scale of the envisaged alterations are decisive when significant alterations are made. Minimum insulating air gaps between equipment or elements of equipment with different electrical potentials must be complied with.

Effectiveness: This measure is highly effective in the immediate environs of the installation.

Comments: The level of additional effort involved is low when new installations are constructed. The level of effort involved may rise considerably when significant alterations are made.

5.3.4.3 Optimising feed-in to and outputs from low-voltage distribution units

The connection for the line from the transformer is placed on the low-voltage distribution unit so that currents that generate magnetic fields are minimised on the low-voltage distribution unit. The centre of the low-voltage distribution unit is a more favourable feed-it location than its sides.

Preconditions: This measure can be implemented when new installations are constructed and significant alterations are made.

Effectiveness: Since higher magnetic fields are generated by conductors on the low-voltage side than by conductors on the medium-voltage side, measures that increase the distance of parts of installations on the low-voltage side from relevant field minimisation locations are more effective as a rule.

Comments: If consumption or feed-in alters in the connected low-voltage circuits, the installation may be in a non-optimised state. The level of additional effort is low.

6 Transitional rule

This general administrative provision shall not apply to planning approval and planning consent procedures applied for up to 4 March 2016 for which a complete application had been submitted at this point in time.

7 Entry into force

This general administrative provision shall enter into force on the day following its publication.

The Federal Council [*Bundesrat*] has given its consent.

Berlin, 26 February 2016

The Federal Chancellor

Dr Angela Merkel

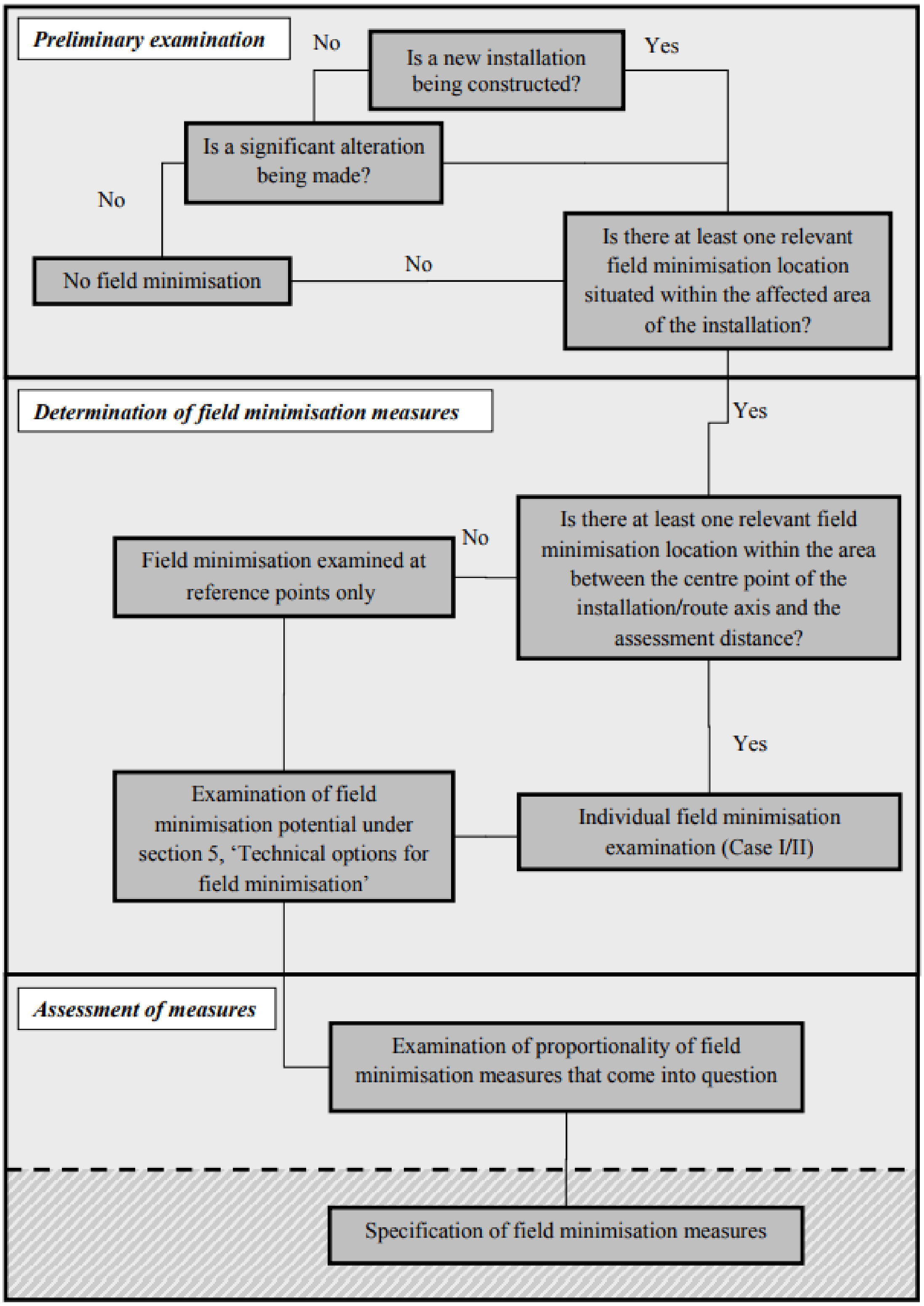
The Federal Minister
for the Environment, Nature Conservation, Building and Nuclear Safety

Barbara Hendricks

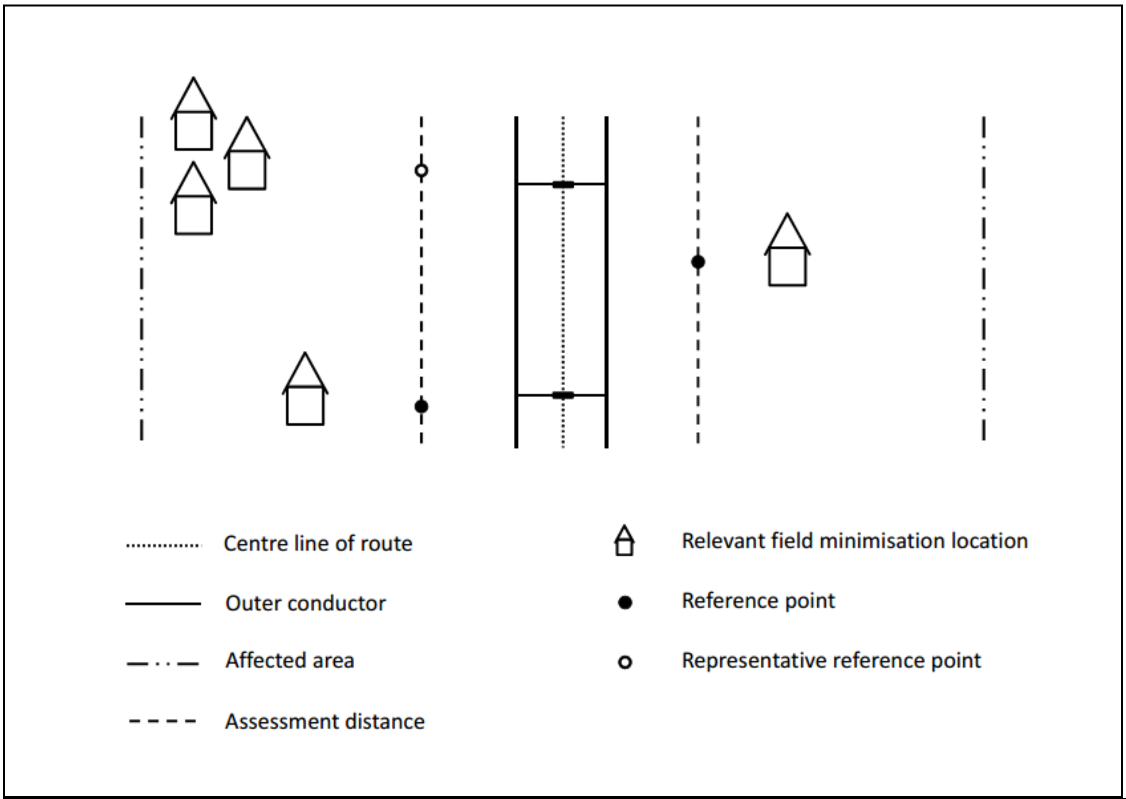
Annex I

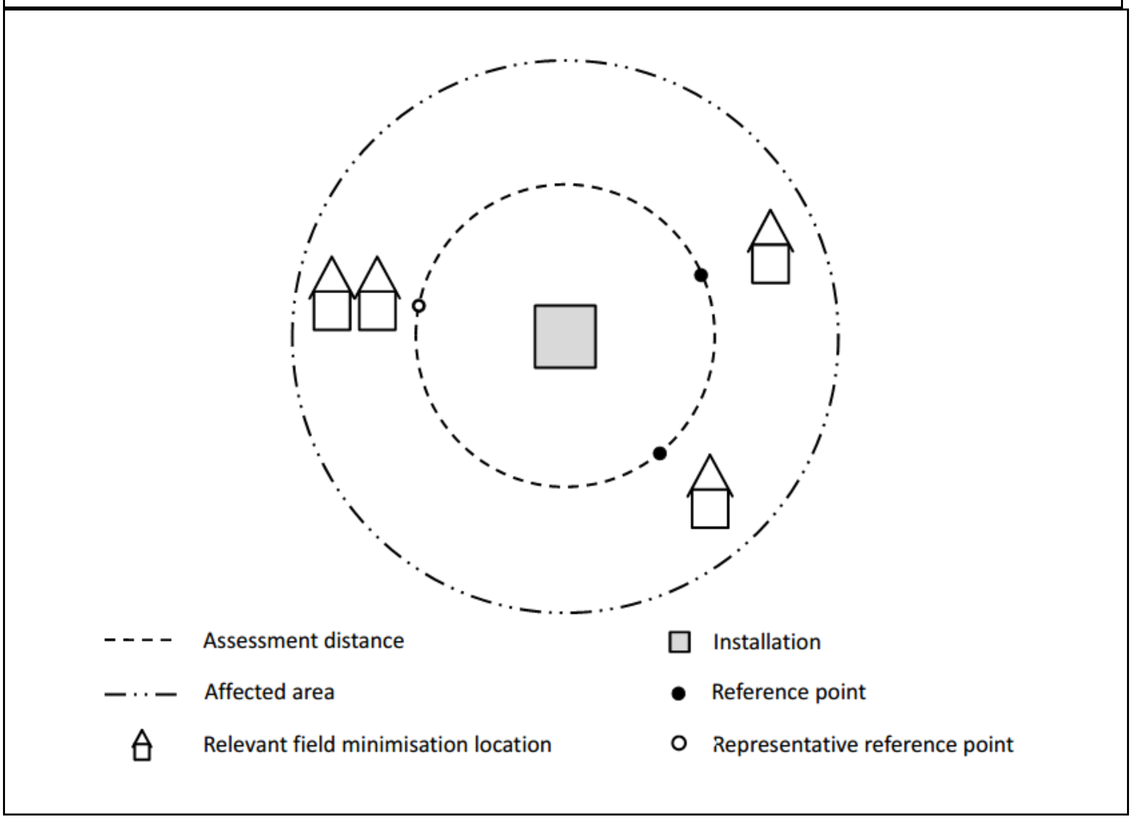
Re section 3.2

Flow chart



Examples of the determination of reference points

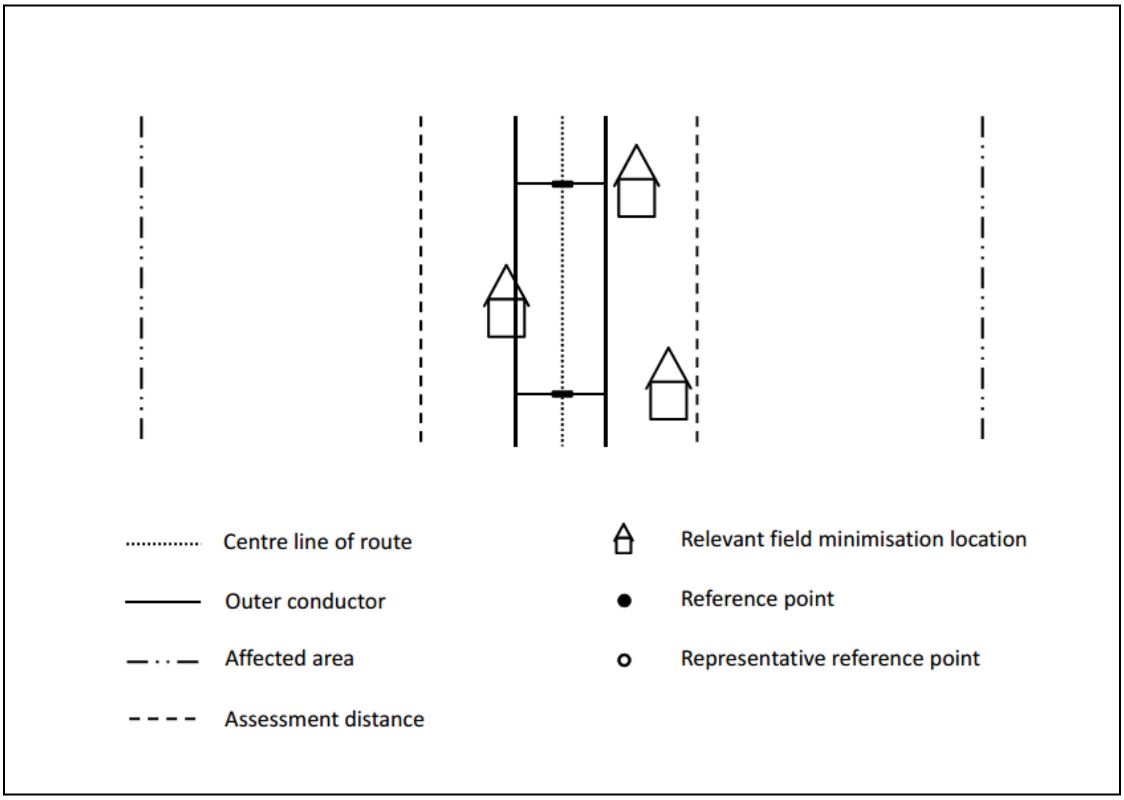


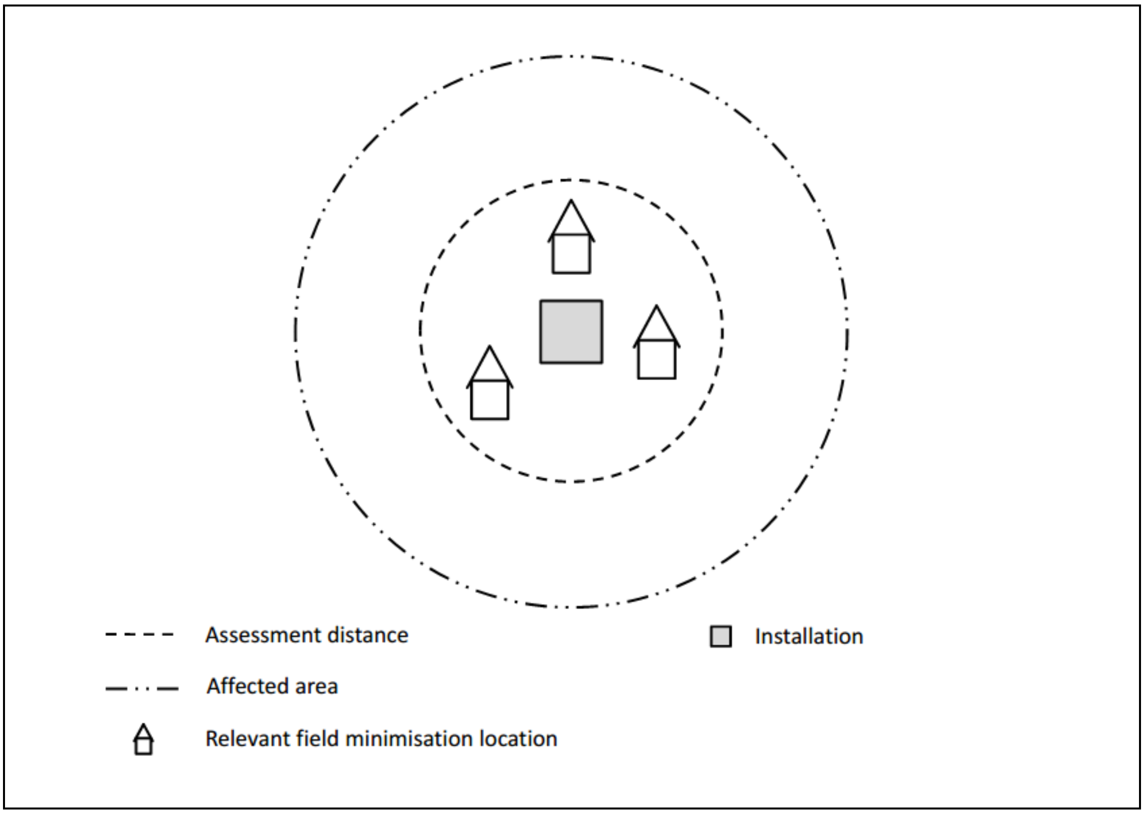


Annex III

Re section 3.2.2.2

Examples of Case I





Examples of Case II