GDV Gesamtverband der Versicherer

Publication by the German insurers on the issue of loss prevention

VdS

Photovoltaic systems



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VdS 3145en : 2025-06 (03)

Summary

The guide provides information based on the experience of insurers on the selection, planning, installation and operation of grid-connected photovoltaic systems (PV systems) and aims to avoid or minimise business interruptions and property damage.

This guide deals with fire protection, mechanical, electrical and safety aspects.

This guide was developed jointly by

VDE Renewables GmbH

and

Gesamtverband der Deutschen Versicherungswirtschaft e. V. (German Insurance Association / GDV).

Significant changes compared to VdS 3145: 2017-11 (02):

References to regulations and directives have been updated and information gained in completed research projects and from systems over 20 years old have been included.

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The present publication has no binding force. In particular cases, the insurers may accept other precautions or installers or maintenance services under conditions at their discretion, which do not correspond to these technical specifications or guidelines.

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Photovoltaic systems

Contents

Summary **2**

1 Scope **4**

2 Terms **4**

3 Introduction **5**
3.1 Hazards 5
3.2 Protection concept 5

4 Selection, planning, installation and operation **5**
4.1 Selection of a suitable installation location 6
4.2 PV modules 6
4.3 Mounting systems 9
4.4 Electrical components 10
4.5 Theft protection 19
4.6 Commissioning 19
4.7 Operation 20

5 Literature / sources **23**
5.1 Laws and ordinances 23
5.2 Regulations, rules and information by the statutory accident insurance institutions (DGUV – German social accident insurer) 23
5.3 Technical regulations, standards relating to electrical engineering 23
5.4 Publications by the German insurers on the issue of loss prevention 24
5.5 Publications by VdS Schadenverhütung GmbH (VdS) 25
5.6 Literature 25

Appendix A – Checklist for PV systems **26**

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1 Scope

This publication deals with photovoltaic systems (PV systems). It is primarily intended for planners, installers, inspection engineers for electrical systems, operators and landlords of building spaces and provides information on loss prevention based on the experience of insurers.

2 Terms

Photovoltaic system: Hereafter referred to as a PV system, it converts sunlight into electricity that is fed into the public grid, stored temporarily or used by the producer. In contrast, solar thermal systems convert sunlight into heat. PV systems basically consist of the following components:

(1) PV generator – can consist of one or more interconnected PV modules.

(2) Generator junction box (optional) – is required to connect individual strings, can contain protection technology, e.g. overvoltage protection devices, string fuses.

(3) Cabling on the DC side

(4) Switch disconnector – prescribed by DIN VDE 0100-712 for maintenance work on the inverter; is often integrated in the inverter.

(5) Inverter – converts direct current (DC) and direct voltage into grid-compliant alternating current (AC) and alternating voltage.

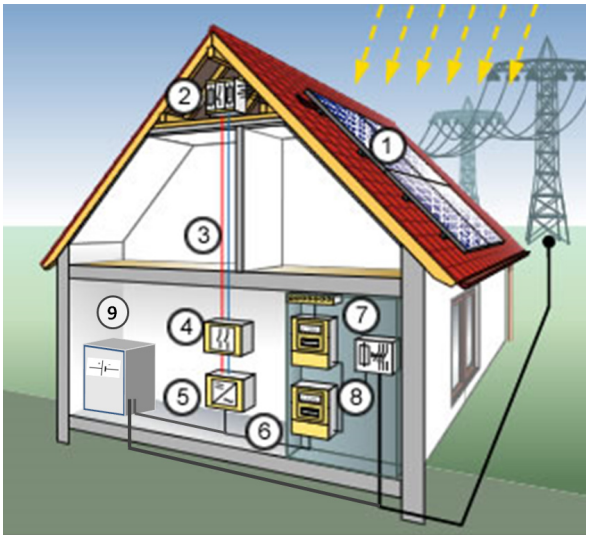
(6) Cabling on the DC side

(7) Inverter sub-distribution – this can also contain the required control technology for the PV system.

(8) Feed-in meter and/or meter for consumption by producer

(9) Energy storage (optional)

Devices for isolation for inverters: Equipment for disconnecting the inverter from the DC and AC side in order to be able to maintain or replace it in de-energised condition. A switch disconnector is to be provided on the DC side in accordance with DIN VDE 0100-712 (see Picture 1, #4).



Picture 1: Basic structure of a PV system

Bypass diodes: They are connected in parallel to the solar cells. In the event of shading, e.g. due to dirt, foliage, trees, lightning protection rods, they are intended to prevent voltage reversal and thus overheating of the cells (hot spots) and possible destruction. Bypass diodes are installed in the module junction box. A combination of frequent shading, insufficient heat dissipation in the junction box, lightning surges and reverse polarity of the module can cause bypass diodes to fail.

Hot spot: Overheating and damage to the cells of a PV module, e.g. due to shading, cell faults or contact problems.

Mounting system: As part of the PV generator, it is designed to permanently connect the PV modules to the substructure, e.g. the roof structure, in a mechanically stable manner.

Hard roofing: Roofing resistant to flying sparks and radiant heat, which prevents the spread of fire on the roof and the spread of fire from the roof to the interior of the building. Typical types of hard roofing are roof tiles made of concrete and standard roof tiles.

Note: Nevertheless, a hard roof could contain combustible building materials in the structure, e.g. polystyrene.

Height above roof: Extension of a fire wall or complex partition wall by at least 30 cm or 50 cm, respectively, above the upper edge of the neighbouring roof structure.

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Arc detectors / arc protection systems in the sense of this document are devices and systems that can detect and interrupt serial arcs on the DC side of the PV system.

Power optimiser: Power optimisers are DC–DC converters on one or more modules that are able to set the optimum operating point for each module, particularly in the event of shading.

The documents below contain further terms:

- DIN VDE 0100–200 – Low-voltage electrical installations – Terms and definitions
- DIN EN ISO 13943 – Fire safety – Vocabulary

3 Introduction

3.1 Hazards

As with any complex technical system, a PV system can involve hazards, e.g. due to errors in planning, execution and production.

In addition, they are exposed to a number of external hazards due to their design and function (see Clause 4.1).

Hazards can also arise if system operators do not meet the requirements for maintenance and upkeep. Hazards can also arise for the building if the building owner can only react indirectly and with a delay to the new hazard situation. If there is a constellation with a rented roof / façade, a provision should be agreed between the system operator and the building owner when the contract is concluded for the event that the system operator does not fulfil his obligations and this results in hazards for the building.

Installing a PV system on a roof with combustible building materials increases the fire risk for the building. Accordingly, further measures are required to reduce the risk of fire spreading to the roof – see GDV publication dealing with photovoltaic systems on roofs (VdS 6023).

3.2 Protection concept

The protection measures for PV systems described in the publication are intended to supplement the existing rules of technology and are aimed in particular at preventing or minimising business interruptions and property damage. This is to be achieved through measures to minimise risks and ensure quality in the planning, installation, commissioning and operation of PV systems. This also aims at ensuring high availability of the PV systems.

Protection measures shall be integrated into a protection concept. The measures are intended to control the property-specific hazards and achieve the relevant protection goals, e.g. to protect people, the environment and the property. The following explanations are intended to provide guidance on determining suitable measures as part of a property-specific protection concept.

The required scope of protection for PV systems can vary depending on the result of a property-specific risk assessment. An inadequate scope of protection can also jeopardise insurability.

To ensure that the necessary protection measures are optimally implemented, experience has shown that it is wise to draw up the protection concept in consultation with all parties involved, especially the insurer.

4 Selection, planning, installation and operation

When commissioning the planning and installation, the operator should ensure

- that planners have the necessary expertise and experience. Otherwise, suitable specialists are to be called in, e.g. structural engineers, roofers, PV experts;
- that the expert companies carrying out the work are sufficiently qualified;
- that detailed documentation is handed over, e.g. PV system log and, if applicable, storage log;
- that an acceptance test is agreed, e.g. by an independent PV expert, such as a VdS-approved expert for photovoltaic systems (https://vds.de/zertifikate/verzeichnis/V3180), VDE Testing Institute or the German Technical Inspection Association TÜV.

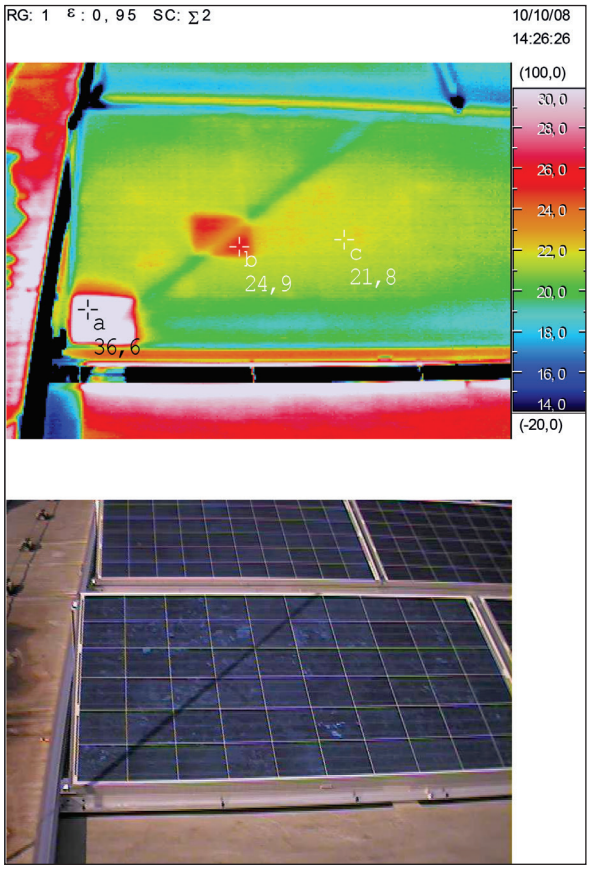
Good coordination of all trades involved is permanently required during planning and execution.

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4.1 Selection of a suitable installation location

Irrespective of the considerations regarding yield stability, the following questions have to be clarified in advance:

- What hazards are to be expected from the environment? E.g.:
  - lightning strike, overload;
  - theft, vandalism;
  - wildfires (ground-mounted system);
  - earthquake;
  - landslide;
  - ground subsidence;
  - flooding;
  - ice and snow pressure;
  - avalanche;
  - hail;
  - storm;
  - localised soiling, e.g. bird droppings, leaves;
  - animal browsing;
  - aggressive substances, e.g. vapours, dusts;
  - ground conditions for ground-mounted systems.
- What additional load does the installation place on the building (e.g. static loads on the roof or façade construction due to dead weight, wind and snow load)?
- Can the tightness of the roof be affected by the installation?
- What interactions can arise for the existing technical building equipment, e.g. lightning protection system, exhaust air system?
- Can shading occur due to chimneys, masts, lightning protection rods (see Picture 2), trees, dormers, etc.?
- Are the changes to the existing building structure associated with the installation and attachment of PV modules allowed, and are warranties jeopardised, e.g. tightness of flat roofs?
- Are suitable PV modules for the installation site available?
- Are suitable mounting systems available, and do recommendations by the manufacturer exist?
- Are measures required to restore or maintain the original functions of the building structure, e.g. tightness, thermal insulation and fire protection?
- Is there an increased risk due to the use of the building, e.g. increased fire risk due to agricultural use, wood processing (see premises at risk of fire in VdS 2033)?



Picture 2: Shading through a lightning rod

- Should a PV system be taken into account when drawing up a fire protection concept?
- Are there combustible building materials in the roof structure?
- Are there access points for cleaning, maintenance and inspection?

This analysis can be used to determine whether the planned installation of the PV system is possible and sensible, e.g. with the existing roof or façade construction.

4.2 PV modules

Photovoltaic modules (PV modules) can be either additive, e.g. on the façade or on the roof, or building-integrated, e.g. in the façade or in the roof.

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4.2.1 Planning

To ensure that the PV modules can withstand the weather conditions mentioned in Clause 4.1, only PV modules certified by recognised testing institutes (accredited in accordance with EN 17025) in accordance with DIN EN IEC 61215 and DIN EN IEC 61730 are to be used.

If increased snow and wind loads are to be expected, PV modules with increased mechanical stability are to be selected (e.g. test for proof load: 5400 Pa, according to DIN EN 61215-2 (VDE 0126-31-2)).

PV modules that are listed in the hail protection register in Switzerland (www.hagelregister.ch) and Austria (www.hagelregister.at) with regard to resistance to mechanical and optical damage are to be labelled with a hail resistance class. The hail resistance class is determined by the hailstone size and the impact speed. Here, typical damage, e.g. glass breakage and other damage to the cover, leaks, delamination, opaque cover or detached parts, are taken into account.

4.2.1.1 PV modules on the roof

When installing PV modules and other system components on the roof, care shall always be taken to prevent the outbreak of fire and, should a fire occur, to prevent the spread of fire over a large area. The measures required to this end are illustrated in the VdS 2234en leaflet, e.g.

- spatial separation at a sufficient distance from each other of the modules placed upon supports on both sides of a fire wall;
- subdivision of contiguous module areas;
- arrangement of the PV modules at a sufficient distance from smoke and heat exhaust ventilation systems (SHEVS, see VdS 2098) and dome lights;
- keeping the roof area free for the maintenance of the roof structure as well as roof installations and roof superstructures.

Note: See

- *VdS 2234en Firewalls and complex partition walls, Leaflet for arrangement and construction*

Installing a PV system on a roof with combustible building materials increases the fire risk. The GDV publication VdS 6023 dealing with photovoltaic systems on roofs provides important information on this topic.

To prevent fire propagation and in accordance with the German LBO (federal building regulations), PV modules and unprotected cables (see VdS 2025) must not be laid over a fire wall (see Picture 3). In exceptional cases it may be possible to lay them over a fire wall in a fire-protected manner in accordance with the German Land law (see Picture 4). In the case of building end walls, this is generally only permitted in the case of a deviation requiring authorisation (inspection required by building law). Experience has shown that the use of fire protection sheathing or fire protection bandages in closed cable ducts is a more durable solution than without a duct. In order to maintain the protective function, the building materials used shall be certified for outdoor use and accordingly shall be UV and weather resistant.



Picture 3: Unauthorised laying of cables over a firewall



Picture 4: Cables laid over a firewall in a fire-protected duct

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4.2.1.2 PV modules in the roof or in or as a façade

As part of the building envelope, PV modules in the roof or façade shall also fulfil the protective functions of the roof or façade, e.g. rain protection. Therefore, they shall fulfil the requirements of building regulations. With regard to fire protection, these include:

- Fundamentals: Use of at least building materials of standard flammability (building material class B2 according to DIN 4102-1 or D or E according to DIN EN 13501-1).
- PV modules must not impair the low flammability of the exterior walls.

  Note: See
  - *MIndBauRL – a German model guideline on structural fire protection in industrial buildings*

- PV modules in connected or extended buildings shall show sufficient distance to the firewall. If necessary, the special fire protection requirements for rear-ventilated façades shall also be observed.

  Note: See
  - *VdS 2234en Firewalls and complex partition walls, Leaflet for arrangement and construction*

- In-roof systems:
  - PV modules for installation in the roof structure shall fulfil the requirements for "hard roofing" in accordance with the German LBO (federal building regulations).
  - PV modules in the roof of industrial and functional buildings may have to fulfil additional requirements, e.g. verification of the limitation of fire spread in the roof in the event of an incipient fire from below in accordance with DIN 18234
  - PV modules made of and with glass, which also assume the function of overhead glazing, shall fulfil the relevant requirements in this respect.

    Note: See
    - *MVV TB – a German model administrative regulation for technical building regulations*

- Façade systems:
  - PV modules may only be integrated into roofs and façades if they fulfil the requirements – in particular with regard to stability and fire protection – of the MVV TB, the LBO and, if applicable, the high-rise building guidelines, as amended.

    Note: See
    - *MIndBauRL – a German model guideline on structural fire protection in industrial buildings*
    - *MHHR – a German model guideline for high-rise buildings*

Proof of fire protection properties is provided by a certificate of applicability, e.g. an abZ (German national technical approval) or aBG (German general-type approval) from the DIBt for building materials of low flammability, an abP (German national technical approval certificate) for hard roofing, which should be provided on the construction site and handed over to the client / builder.

4.2.1.3 PV modules in agriculture

PV modules mounted on or near stables should be resistant to aggressive vapours and dusts, e.g. ammonia; so, only modules tested for corrosion in accordance with DIN EN 62716 should be used. Otherwise the modules may age prematurely.

4.2.1.4 PV modules on green roofs

Due to plant growth, also with extensive roof greening, special conditions shall be taken into account when installing PV modules, e.g:

- The green roof shall comply with DIN 4102 against flying sparks and radiant heat.
- To avoid shading by grasses etc., the PV modules should be elevated at a greater distance.
- For the maintenance of the roof, accessible maintenance walkways should be planned between the rows of modules.
- Safety strips along roof penetrations, e.g. dome lights, shall be permanently free of vegetation and no PV modules must cover them. In addition, this safety strip should be covered with non-combustible paving or a gravel layer.
- Plants with a high content of essential oils should not be planted in the area of the PV modules.
- Cables are to be laid at a sufficient distance from the vegetation so that the vegetation cannot penetrate the cable ducts and those are not damaged, e.g. when pruning the vegetation.
- Controlled irrigation of the roof greening is recommended in order to prevent the vegetation from drying out.

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4.2.1.5 Disposal of PV modules

PV modules are subject to the ElektroG (German Electrical and Electronic Equipment Act). Normal household quantities can be handed in at the public waste disposal centres. Larger quantities are disposed of in accordance with the ElektroG, generally via appropriate service providers.

For further information, see www.pvcycle.de.

4.2.2 Assembly

When assembling the solar modules, the functions of neighbouring components (roof, façade) must not be impaired. The special conditions regarding temperature expansion, contact corrosion, etc. shall be taken into account.

The installation and fastening instructions by the manufacturers of modules are to be observed. The working space required to maintain neighbouring components or existing systems is to be taken into account, as well.

4.3 Mounting systems

The mounting system can consist of the following elements:

- Attachment to load-bearing building structures (roof / exterior wall), e.g. roof hooks, clamps, clips, installation on surfaces with loads to weight them down or with anchors in the ground;
- substructure, e.g. rail support system, frame for elevation on the roof or installation on open spaces (wood / metal);
- system-specific module fastening (point / linear mounting/bracket).

4.3.1 Selection

The mounting system shall

- be suitable for damage-free mounting of the intended PV modules (see also Clause 4.1);
- ensure adequate anti-theft protection if necessary;
- comply with the specifications of the module manufacturer; and
- be comprehensively documented with all individual components and relevant mechanical properties.

4.3.2 Planning

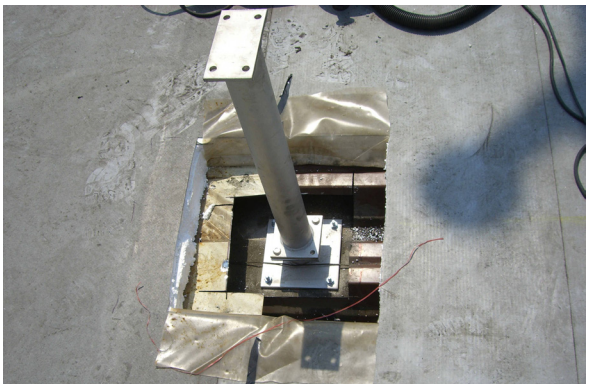
Depending on the installation location (façade, on or in the roof or on open spaces), the following aspects shall be taken into account when selecting and dimensioning the mounting system, in particular the attachment to building structures or installation on open spaces:

- Effects from dead loads (weight of modules and mounting system) and live loads (wind, snow according to DIN EN 1991-1-3 and -1-4 and thermal stresses) as well as other atmospheric influences (corrosion protection), (see Picture 7);
- interactions with neighbouring building components, e.g. roof tiles or fire protection-approved lightweight construction with trapezoidal steel profiles (see Pictures 5 and 6).

The building owner shall ensure through the planner and installer that the stability of the building is not impaired by the installation of the PV modules.

Further information:

- *German regulations for flat roofs by the roofing industry (Flachdachrichtlinie des Dachdeckerhandwerks)*
- *Information paper on bearing pressure by BSW*



Picture 5: Integrated mounting system



Picture 6: Poor planning/execution

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4.3.3 Installation

When installing mounting systems, always ensure that

- suitable elements according to the manufacturer's specifications are used;
- the manufacturer's installation instructions are followed; and
- the neighbouring components are not damaged or impaired in their structural and structural-physical functions.

Note: Guideline VDI 6012, Sheet 1.4 has been published on the subject of the attachment of PV systems.



Picture 7: Storm damage due to non-compliance with the system statics

Note: The installation of PV systems on asbestos-cement roofs (corrugated fibro-cement roofs) is prohibited under the GefStoffV (German Hazardous Material Ordinance).

4.4 Electrical components

The following technical application rules are to be observed for PV systems and energy storage systems:

- VDE-AR-N 4100 "Technical rules for the connection and operation of customer installations to the low voltage network (TCR low voltage)"
- VDE-AR-N 4105 "Generators connected to the low-voltage distribution network – Technical requirements for the connection to and parallel operation with low-voltage distribution networks"
- VDE-AR-4110 "Technical requirements for the connection and operation of customer installations to the medium voltage network (TCR medium voltage)"
- VDE-AR-N 4120 "Technical requirements for the connection and operation of customer installations to the high voltage network (TCR high voltage)"

The installation regulations of the DIN VDE 0100 series, in particular the standard for PV power supply systems DIN VDE 0100-712, are to be observed.

In accordance with the preliminary standard DIN VDE V 0100-551-1 (VDE V 0100-551-1), it is permissible to install feed-in sockets in final circuits or to permanently connect plug-in solar devices with a maximum AC power of 800 VA.

4.4.1 Inverter

To ensure safe operation, inverters shall be certified in accordance with the standard DIN EN 62109-2 (VDE 0126-14-2).

In order to achieve a sufficiently long service life of the inverters with high efficiency, they shall be properly dimensioned and correctly installed.

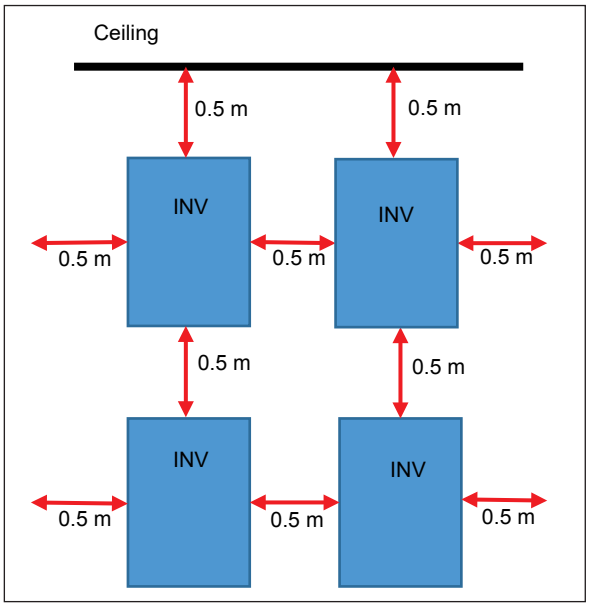
Planner and installer shall observe the following instructions when selecting the inverter and its installation location:

- The manufacturer's specifications shall be observed, e.g.:
  - the limits of the specified ambient temperatures;
  - minimum distances to combustible materials and to ensure sufficient air flow; Picture 8 shows examples of such manufacturer specifications. Should no manufacturer specifications be available, a minimum distance of 0.5 m to combustible materials is to be maintained;
  - assembling layout, permissible inclination;
  - weather protection.
- Suitable place of installation:
  - Due to the possible risk of fire in the event of a fault, inverters shall be mounted on a non-combustible surface (see Picture 9); if the substructure is combustible, a non-combustible mounting plate is to be used; a metal plate with good thermal conductivity is unsuitable; e.g. fibre silicate plates would be preferable;
  - the coolest possible location is to be selected, as high operating temperatures shorten the service life;

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- an installation location that is protected from vapours and aggressive ambient air is to be selected; preferably dry and dust-free to avoid corrosion and the formation of leakage currents and the associated damage;
- the inverters and module electronics in the outdoor area shall be protected from direct sunlight;
- these are not to be installed in potentially explosive atmospheres;
- the installation location shall be suitable for the weight and dimensions of the inverter;
- the PV power supply system and the inverters should be installed above a possible flooding area (e.g. high water risk);
- installation in areas with special fire risks in accordance with DIN VDE 0100-420, e.g. operating sites at risk of fire (see VdS 2033), is not permitted. Examples of such premises are hay or straw stores, fodder stores, paint stores, timber stores, sawmills;
- the installation of inverters in a separate room that is at least fire-retardant (F30) and separated from other rooms and equipped with a fire detection and alarm system (FDAS) is recommended.

- A suitable type of protection is to be selected:
  - indoor area at least IP 20;
  - outdoor area at least IP 44.
- Measures shall be taken during installation (e.g. protective roof), and a suitable installation site is to be selected to reduce weather-related stresses and prevent the deposition of highly flammable substances. The air circulation must not be impaired by covers or similar.
- When installing outdoors, the risk of freezing is be taken into account.
- Condensation can form depending on humidity and temperature gradients. To avoid condensation, additional measures such as ventilation may be necessary.
- The maximum no-load voltage of the interconnected PV modules (string) must not exceed the permissible voltage limit of the inverter.
- The requirements of the network operators shall be observed.
- Inverters should be equipped with an arc protection system. This is to be activated so that arcing faults in the string circuit are recognised and eliminated.



Picture 8: Safe distances for inverters



Picture 9: Inverters on non-combustible surface

4.4.2 Energy storage

More and more photovoltaic systems are supplied or retrofitted with an energy storage system.

The most commonly used energy storage systems are lithium-ion batteries. Due to the flammable electrolyte and the largely varying material composition, they pose a particular challenge for fire protection. It is therefore recommended that only certified energy storage systems are used.

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The systems can be certified according to the following standards:

- For lead-acid and NiCd batteries:
  - Safety requirements for secondary batteries and battery installations – Part 1: General safety information – DIN EN IEC 62485-1 (VDE 0510-485-1)
  - Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries – DIN IEC 62485-2 (VDE 0510-485-2)
- For lithium-ion batteries:
  - Stationary energy storage systems with lithium batteries – Safety requirements – VDE AR-E 2510-50
  - Safety guidelines for lithium-ion home storage systems (prepared by BSW, BVES, DGS, StoREgio, ZVEH)
  - Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications DIN EN IEC 62619 (VDE 0510-39)
- Energy storage systems shall be integrated into the building's overvoltage protection concept (see VDE 0100-443). If there is no overvoltage protection concept, the energy storage system shall be protected against overvoltage.

Compliance with VDE-AR-E 2510-50 is intended to ensure, among other things, that a fire caused by a fault in a battery cell or in the stationary energy storage system is limited to neighbouring or surrounding cells or components by means of design measures (propagation test).

For lithium batteries, compliance with the operating window resulting from the permissible cell voltage and the permissible cell temperature has top priority. Leaving this safe operating range of the cell can lead to serious defects or even a fire (thermal runaway) in the cell (see Picture 10).

According to the application rule VDE-AR-E 2510-2 dealing with stationary electrical energy storage systems intended for connection to the low-voltage grid, batteries shall be housed in protected areas, e.g. a battery room or battery cabinet. The requirements for the installation of batteries described in VDE-AR-E 2510-2 are to be complied with, e.g.

- the manufacturer's installation conditions and safety regulations as well as the local building regulations are to be observed;
- the energy storage system must not be installed in areas subject to a risk of fire or explosion (DIN VDE 0100-420 or standards in the DIN EN 60079 series);
- the installation location should offer protection against extreme environmental influences (e.g. sunlight, extreme temperatures, extreme temperature fluctuations, soiling, etc.);
- the installation location should not be near highly flammable materials;
- the energy storage systems are to be certified in accordance with VDE 0100-600 (for the first time) and VDE-AR-E 2510-2, Section 6. 600.

The following recommendations for installation should be observed:

- at least fire-retardant separation of the energy storage systems (e.g. enclosure of the energy storage system or the installation room);
- living spaces are unsuitable for installation;
- installation of networked smoke alarms.

Energy storage systems should be installed above a level to be defined to protect them against flooding. For flooded / humidified systems, the safety instructions for users of energy storage systems in the event of water damage and flooding by BVES are helpful.

The SPEISI research project "Safety and Reliability of PV Plants with Storage Systems with Special Consideration of Fire Risks and Extinguishing Strategies" – https://www.ise.fraunhofer.de/en/research-projects/speisi.html – has shown that the proper planning and installation of qualified storage systems, taking into account the manufacturer's specifications, enables the safe operation of energy storage systems.

It should be noted that, according to the MElt-BauVo – a German model building regulation for the construction of operating rooms for electrical systems – there are additional requirements for the place of installation for energy storage systems with a total battery capacity of more than 20 kWh designed for the general power supply in buildings.

A separate room partitioned in a fire-resistant manner (F90, T30 RS) on the outside of the building with pressure relief / ventilation to the outside is particularly suitable for housing the energy storage system. Integration into an existing fire detection and fire alarm system is recommended, otherwise smoke alarm devices should be installed.

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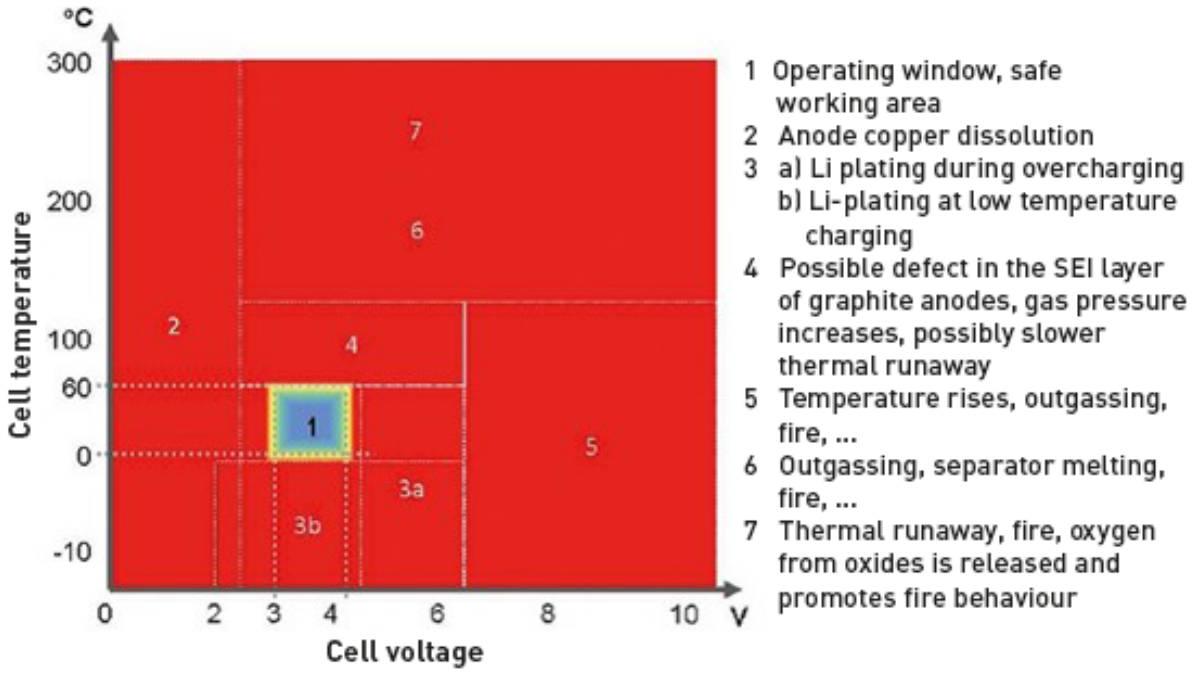


Figure 1: Schematic operating window for an example of a lithium-ion cell (NMC) with graphite anode. (Real values may deviate from this)

The numbered fault areas 2–7 are subdivided for a better overview only.
In practice, they are not demarcated, but merge into one another or overlap.

Picture 10: Operating window of a lithium-ion battery

Note:

In the case of PV systems featuring energy storage, it makes sense for these systems to supply energy even if the public power supply fails. In addition to the energy storage, the inverter used also has to be capable to operate off-grid.

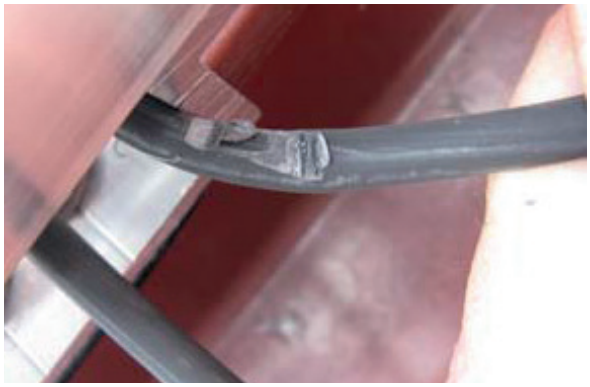
If a PV system is operated in "off-grid mode", special care is to be taken to ensure that protection is provided by automatically switching off the power supply (personal protection) and that protection against overcurrent is also ensured in off-grid mode; see also the application rule VDE AR-E 2510-2 dealing with stationary electrical energy storage systems intended for connection to the low-voltage grid. This is to be checked and documented.

4.4.3 Wiring systems

The selection and laying of cables on the direct current and alternating current side is to be carried out in accordance with the recognised rules of technology. Please refer to the GDV publication VdS 2025 dealing with electrical wiring systems.

On the DC side, this is to be done with particular care, as the usual short-circuit protection with overcurrent protection devices, e.g. circuit breakers, is not effective here. This is the reason why they shall be selected and installed in such a way that the risk of an earth fault or short circuit is minimised, e.g. by the safe installation of single-core cables or single-core sheathed cables. The risk of damage to the cables is to be avoided, e.g. they must not be laid and pulled over sharp edges (see Pictures 11 and 12).

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Pictures 11 and 12: Damage to cables



Picture 13: Improper cable routing

When dimensioning the cables for PV systems, continuous operation and thus a load factor of g=1.0 is generally to be assumed.





Picture 14: Proper cable routing

The following shall be observed in order to reduce the hazards posed to DC cables by external environmental influences:

- The induction of lightning currents in the direct current lines can be reduced or avoided by:
  - avoiding large conductor loops; the equipotential bonding conductors are to be routed in parallel and in as close contact as possible to the DC and AC cables;
  - routing cables in metal pipes or ducts (see Picture 14), whereby these are to be included in the equipotential bonding on both sides (in the case of earthed active DC conductors, special requirements are to be observed with regard to their mechanical load capacity).
- DC cables are to be designed for the existing DC voltage, i.e. the maximum permissible DC voltage of the cable is to be observed.
- Cables are to be laid in accordance with DIN VDE 0100-520 (see Picture 14). Particular attention is to be paid to mechanical stresses so that solid foreign bodies or friction do not cause gradual insulation damage to cables.

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- Cables must not be laid directly on the roof surface (see DIN VDE 0100-712); laying cables as shown in Picture 13 is therefore not permitted.
- Cables must not come into permanent contact with water.
- They must not be laid in water-bearing layers.
- Damage to cables due to inadequate fastening are to be avoided.
- Cables are to be fixed or laid in cable routing systems.
- Cable ties are not suitable for vertical fastening of cables, as there is a risk that the punctual load causes damage to the insulation.
- This also applies to horizontal routing if the weight of the cables is held by cable ties.
- Exposed DC cables shall be resistant to UV radiation and ozone and be designed for the ambient temperatures that occur.
- When connecting aluminium cables, the following instructions are to be observed unless other suitable methods are used:
  - The terminals shall be suitable for aluminium conductors.
  - The oxide layer shall be removed from the conductor ends with a knife, for example.
  - Immediately after removing the oxide layer, the conductor ends are to be rubbed with an acid- and alkali-free grease, e.g. technical Vaseline, and the clamp connection is to be made immediately.

Cables are to be protected from animal browsing, e.g. by:

- avoiding sagging cables ("swings"), i.e. lay the cable as close as possible to the mounting system;
- using open cable support systems, e.g. cable trays, mesh cable trays;
- using cables with metal braiding or sheathing.

Where there is a risk of aggressive vapours, gases, e.g. ammonia or dusts being released by e.g. liquid manure, cables shall be resistant to these risks.

Note: Cables in accordance with the standard "Electric cables for photovoltaic systems", DIN EN 50618 (VDE 0283-618) are particularly suitable for PV systems (type H1Z2Z2-K).

Due to the risk of electric arcs, DC cables must not be routed through rooms in which highly flammable materials are stored, e.g. straw.

Note: See

- *Information sheet for planners and installers – Reducing arc risks on PV systems*

To avoid fire hazards due to plug connections, these are to be installed in accordance with the manufacturer's instructions and must not be installed under mechanical tension. Plug connections with plugs and sockets from different manufacturers are not permitted (see DKE announcement on the compatibility of plug connectors for the DC voltage side, VDE 0100-712 and DIN VDE 0126-23-1). Only plug connectors (coupling and plug) in accordance with DIN EN 62852 (VDE 0126-300) may be used.

Inadequate crimping of plugs and sockets can also lead to serious damage. For this reason, crimp connections are to be made only in an expert manner and with the appropriate tools.

4.4.4 Generator junction boxes and other enclosures

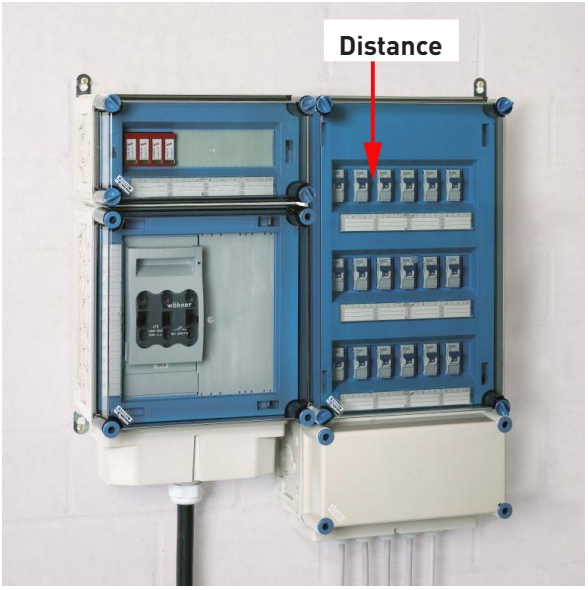
Generator junction boxes and other enclosures shall be selected according to the ambient conditions.

According to DIN VDE 0100-712, generator junction boxes and distributors for PV systems shall comply with the series of standards DIN EN 61439 (VDE 0660-600) or the standard DIN EN 60670-24 (VDE 0606-24).

Generator junction boxes are to be designed in protection class II (featuring protective insulation). They are to be labelled with a warning that active parts may remain live even after disconnection from the PV inverter.

In order to comply with the permissible limit temperatures, a simultaneity factor of g = 1.0 is to be taken into account when dimensioning generator junction boxes and distributors. Also ambient temperatures higher than 35 °C are to be taken into account for outdoor installations. In most cases, it is sufficient to install the built-in devices at a distance of 1 to 2 HP (horizontal pitch) from each other (see Picture 15). The exact selection can be found in the installation instructions of the equipment manufacturer.

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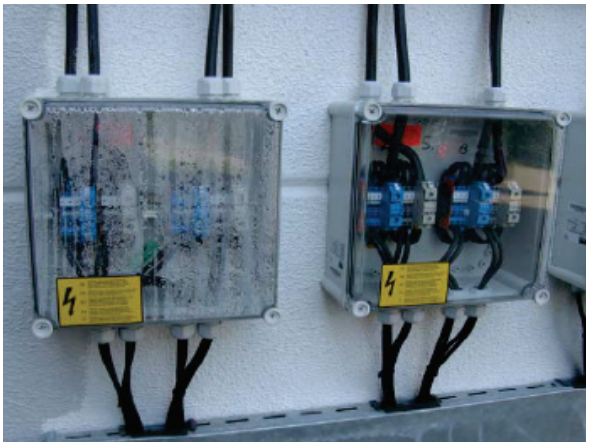
Picture 15: Distributor for PV system

Indoor installation:

- Protection class IP 20 has to be met as a minimum.
- Enclosures should be installed in dry rooms where possible.
- Depending on air humidity and temperature fluctuations (day/night changes), condensation can form (see Picture 16). To avoid condensation, additional measures such as ventilation may be necessary.

Outdoor installation:

- Protection class IP 44 has to be met as a minimum.
- To avoid excessive heating of the housing, it should not be exposed to direct sunlight. If necessary, e.g. ventilation is to be provided or less devices are to be installed.
- Measures shall be taken during installation (e.g. protective roof), and a suitable installation site is to be selected to reduce weather-related stresses.
- Attention shall be paid to the UV resistance of the housing.
- Depending on air humidity and temperature fluctuations (day/night changes), condensation can form. Condensation can be avoided with ventilation or other measures.



Picture 16: Condensation in the generator junction box

4.4.5 Devices for isolation

4.4.5.1 Device for DC isolation according to DIN VDE 0100-712

DIN VDE 0100-712 requires a switch disconnector on the DC voltage side. The device for DC isolation enables disconnection from the DC voltage side in the event of a fault and during maintenance or repair work on the inverter.

Please note that the switch disconnector has to be suitable for disconnecting DC voltages. This switch is often integrated in the inverter already.

4.4.5.2 Isolation for DC lines (fireman's switch)

The term "fireman's switch" refers to a device in which the DC side of a PV system can be disconnected by an additional DC switching point close to the modules.

The application rule "Measures for the DC range of a PV installation for the maintenance of safety in the case of firefighting or technical assistance" (VDE-AR-E 2100-712) is to be observed.

The DFV (German association of firefighters) and the AGBF (German working group of the heads of the professional fire brigades) do not consider fireman's switches to be necessary. (See: https://www.agbf.de/downloads-fachausschuss-vorbeugender-brand-und-gefahrenschutz/category/28-fa-vbg-oeffentlich-empfehlungen?download=397:2023-04-photovoltaikanlagen)

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If there are fireman's switches in the system, they have to be serviced regularly in accordance with the manufacturer's instructions. This can include, for example, regular switching to remove oxide layers on the switching contacts.

4.4.5.3 Protective devices on the AC voltage side according to DIN VDE 0100-712

Cables on the AC voltage side are to be protected by overcurrent protection devices, e.g. circuit breaker, switch fuse.

The use of residual current devices (RCDs) is recommended for fire protection reasons. In other areas, e.g. in agriculture and in certain network systems (such as TT systems), they are to be provided for.

If a residual current device (RCD) is to be provided and no information is available from the manufacturer as to whether smooth DC residual currents may occur in the electrical system via the inverter in the event of a fault, a residual current device (RCD) of type B or type B+ is required.

A residual current monitoring unit (RCMU), which is usually integrated in the inverter, does not replace a residual current device (RCD).

4.4.6 Lightning and surge protection

4.4.6.1 Lightning protection

According to scientific findings, the installation of a PV system does not increase the probability of lightning striking a building.

However, a PV system must not impair an existing lightning protection system. Therefore, arresters and the PV system are to be matched.

Table 1 shows the possible variants that can arise with regard to lightning protection and a PV system on the roof of a building.

In order not to impair existing lightning protection, the PV modules preferably are to be mounted completely in the protected area of the arresters (see Table 1, Variant c). A sufficient separation interval is to be observed (see VdS 2031) (see Pictures 17 and 18). To ensure this, appropriately trained specialists, e.g. VdS-approved EMC experts, are to be called in.

If the separation interval cannot be maintained for technical reasons (see Table 1, Variant b), a connection capable of carrying lightning current has to be established between the external lightning protection and the PV substructure (e.g. NYY-O 1x16 mm², round wire AlMgSi 8 mm). To prevent partial lightning currents from entering the building, all cables entering the building are to be included in the lightning equipotential bonding via a type 1 surge protective device (SPD) at the building entrance. The SPD is to be connected to the earthing installation via the shortest possible route.

For more complex systems, it is advisable to consult a specially trained expert, e.g. a VdS-approved EMC expert or an equivalent lightning protection expert (https://vds.de/zertifikate/verzeichnis/V2832).

The selection of surge protective devices (SPD) (see Picture 19) depends on whether external lightning protection is present and should this be the case on whether the required separation interval is maintained.

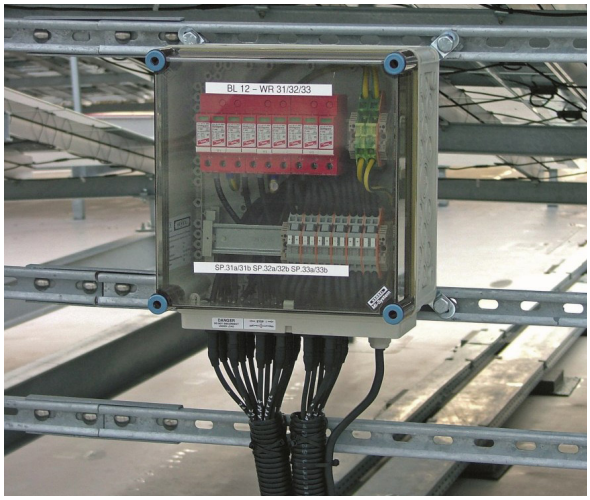


Picture 17: Distance between DC cables and lightning protection system not maintained (separation interval)



Picture 18: Distance between DC cables and lightning protection system not maintained (separation interval)

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Picture 19: Generator junction box with surge protection devices

4.4.6.2 Surge protection for PV systems

Surge protection for power and information technology cables on the inverter or storage system is required to prevent damage to property and interruptions to operation (see DIN EN 62305-3 Supplement 5 (VDE 0185-305-3 Supplement 5)).

4.4.6.3 Functional equipotential bonding

Regardless of the external lightning protection, functional equipotential bonding is always to be provided between the mounting frame of the PV modules and the main earthing rail, taking into account the manufacturer's specifications (see Table 1, Variant a).

4.4.6.4 Earthing concept for ground-mounted systems

Ground-mounted systems are to be earthed and meshed in accordance with DIN EN 62305-3 (VDE 0185-305-3) Supplement 5, Appendix D. This significantly reduces overvoltage.

For tracked systems, external lightning protection in accordance with DIN EN 62305-3 (VDE 0185-305-3) Supplement 5, Appendix B is recommended.

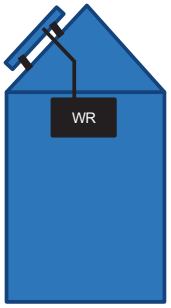
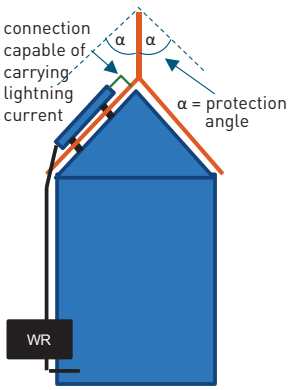
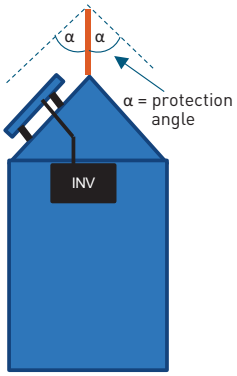
Building	**Without lightning protection system**	**With lightning protection system**	
	Damage by lightning is accepted	Damage by lightning is not accepted	
PV system	Damage by lightning is accepted If applicable, the PV system is connected to the main earthing rail of the building (functional equipotential bonding).	Damage by lightning is accepted, but it must not cause a fire or endanger persons The separation interval between the lightning protection system, and the PV system cannot be maintained	Damage by lightning is not accepted The PV system is located in the protected area of the lightning protection system, and the separation interval between the two systems is maintained.
Variant	a) 	b) 	c) 

Table 1: Variants of PV systems and lightning protection

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4.5 Theft protection

The theft protection concept should be agreed with the insurer during the planning phase. Please find below some suggestions for this concept.

Many system operators present their PV system on the Internet. For those interested in and users of PV systems, the many information pages of PV operators with presentations of system types and sizes, locations and yields etc. are popular websites. Gangs of fraudsters and thieves have used these reports for targeted robberies.

Particularly at risk are:

- PV systems on uninhabited or remote buildings, e.g. agricultural buildings, schools, administrative buildings,warehouses;
- ground-mounted systems;
- stored system components.

To make the sale of stolen PV modules and inverters more difficult, they should be labelled with irremovable serial numbers. The system owner should keep a list of the serial numbers in the system documentation.

When operating personnel are absent, any access aids for rooftop installations are to be blocked or inaccessible.

Ground-mounted systems are often located in remote areas with a large number of easily accessible modules.

The following additional measures are recommended to secure such systems:

- stable fencing with a minimum height of 2 m as well as climb-over and crawl-under protection;
- electronic perimeter security with alarm activation, e.g. pull-wire system, surveillance camera.

  Note: The necessary overvoltage protection must not be forgotten here (see Clause 4.4.6).

Further details can be found in the publications "Security Manual Perimeter" (VdS 3143en).

4.6 Commissioning

The generator side of a PV system cannot be switched off without installed switching devices. After connecting the connection cables to the modules, a DC voltage is immediately applied. There is the risk of a flow through the body and arcing. The commissioning of a PV system therefore represents a particular hazard for the installer. In accordance with the standard for the operation of electrical systems (VDE 0105-100), only a qualified electrician may carry out commissioning. The necessary work steps and measurements are to be specified in writing before commissioning.

The scope and procedure for the initial verification of an electrical installation is defined in the standard for verification (VDE 0100-600). In this context, the external lightning protection is to be checked, as well.

In addition, special features are to be observed for PV systems, which are described in the standard "Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance – Part 1: Grid connected systems – Documentation, commissioning tests and inspection" (DIN EN 62446-1 VDE 0126-23-1):

- Complete visual inspection of the structure, the cable routing and the fastening of the mechanical construction, visual inspection of all electrical connections and cable routing (see Picture 20);
- testing by measurement of the open-circuit voltage and of the polarity before connecting the inverter, and comparing the results with the specifications;
- isolation measurement with sufficient test voltage, see standard DIN EN 62446-1 (VDE 0126-23-1) Table 2;
- short-circuit current measurement of all strings;
- function tests.

In addition, the examination using a thermographic camera may reveal fault-related heat sources due to short-circuited cells, soldering faults, cracks with heat development, electrical connections, etc., which can cause a fire. These inspections are to be carried out by a certified thermographer, e.g. VdS-approved expert for electrical thermography (https://vds.de/zertifikate/verzeichnis/V2861) or an equivalent expert.

In contrast, the electroluminescence method is suitable for analysing the efficiency of a PV module. Electroluminescence (EL) can be used to detect microcracks and grid finger interruptions (interruption of contact strips), for example. Together with a power measurement, this inspec-

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tion should be carried out before the PV system is handed over to the operator in order to document the condition of the system.

Both procedures can be carried out on site at the PV system using modern equipment. Thermographic and EL inspections complement each other but do not replace the testing of electrical systems in accordance with DIN VDE 0100-600 and DIN EN 62446-1 (VDE 0126-23-1).

After commissioning, a complete documentation of the PV system with the planning and device documents, including all measurement logs, is to be handed over to the operator. A sample verification report is attached to the standard DIN EN 62446-1 (VDE 0126-23-1).

The ZVEH (central association of the German electrical and information technology trades) offers a PV system report for complete documentation.

In addition to commissioning, acceptance by an appropriate expert, e.g. VdS-approved expert for photovoltaic systems (https://vds.de/zertifikate/verzeichnis/V3180), a VDE testing institute, the TÜV or an equivalent expert should be agreed.

4.7 Operation

4.7.1 Maintenance and verification

According to the German LBO (federal building regulations), buildings have to be maintained in such a way that health, life and the natural basis of life are not jeopardised. This also applies to PV systems and their components that are installed on top of, on and in the building and are therefore part of the building. The system operator/owner is always responsible for maintenance and verification as well as safe operation.

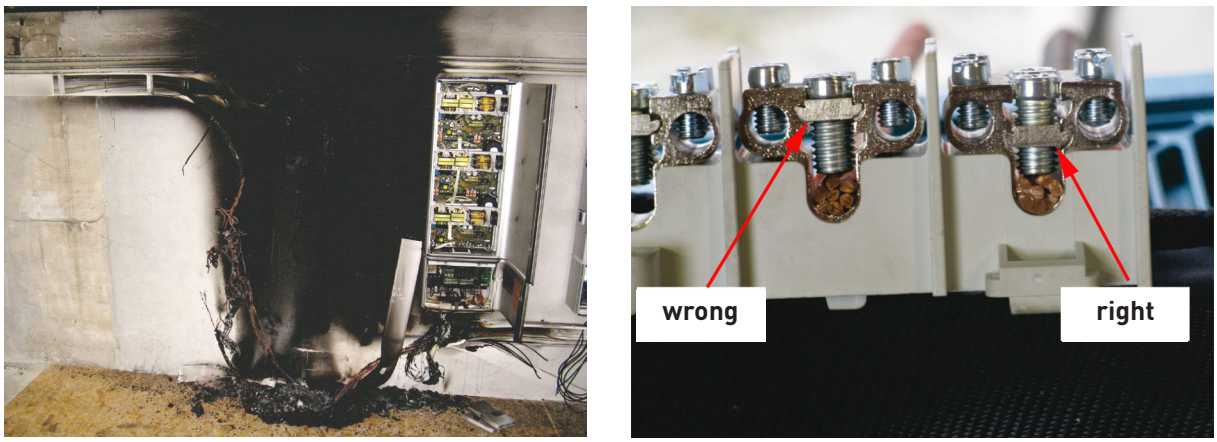
The operator of the PV system can do a lot to ensure that the system can be operated safely and satisfactorily for many years.

When the PV system is handed over after installation, the operator should have the exact function explained to him/her. In their technical documentation, component manufacturers generally point out measures that can also be carried out by laypersons. These should be discussed with the installer of the system. These are for instance:

- regular visual inspections;
- regular yield and function checks;
- event-dependent visual inspections;
- keeping the outside of inverter systems clean;
- keeping free of vegetation, e.g. in case of green roofs or ground-mounted systems.

Regular visual inspections allow obvious damage to be recognised at an early stage, such as damage to cable insulation, damage to the enclosures of distributors and inverters, PV generators, etc.

Event-dependent visual inspections are to be carried out after a storm or a thunderstorm. It is important to check whether, for example, objects such as branches fell onto the roof and possibly caused damage. Did the storm damage or deform PV system mounts? Is lightning damage visible?



Picture 20: Fire damage caused by a loose clamping point on a PV distributor due to a threaded plate inserted incorrectly – picture on the right

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Regular cleaning of a PV system prevents heat build-up, for example in inverters, and ensures optimum ventilation through free ventilation grilles, thus ensuring that the system continues to function, extending the service life of the electronics and reducing the risk of fire. In addition, reduced yields are to be expected with dirty PV modules. The cleaning intervals required depend on the ambient conditions. For example, it may make sense to clean the PV system twice a year due to the high level of dust pollution on a farm.

In the case of PV systems on green roofs, the vegetation has to be cut back regularly to avoid shading and resulting hotspots.

If damage is detected, the insurer is to be informed and a specialised company called in. If possible, pictures of the damage should be sent in advance.

The report IEA-PVPS T13-23:2021 "Quantification of Technical Risks in PV Power Systems" contains many illustrations that show various defects in PV systems, which on the one hand constitute hazards and on the other hand cause lower performance or output.

A PV system, like any technical system, has to be checked and maintained at regular intervals. Only a trained expert is able to carry out technically correct maintenance, inspection and any necessary repair of a PV system. Regular inspections ensure that technical faults, defects and soiling are detected, thus safeguarding the yield. Faulty components shall be repaired or replaced promptly in order to rule out an increased risk of subsequent faults.

The following deadlines for periodic verifications are recommended:

- Annual visual inspection by a qualified electrician:
  - check of all system components for damage caused by e.g. weather conditions, animals;
  - dirt, deposits, build-up, fouling;
  - roof penetrations, sealing;
  - stability, corrosion of the mounting system;
  - check of the protective devices.
- At least every 4 years: periodic verification in accordance with DIN EN 62446-1 (VDE 0126-23-1).

  Note: During periodic verifications, e.g. in accordance with DGUV Regulation 3, PV systems (as part of the electrical system) are to be included in the inspection. DGUV Information 203-080 regarding the installation and maintenance of photovoltaic systems also provides information on occupational health and safety and fire protection measures.

- Lightning protection systems on buildings with PV systems should be checked at least every 5 years (see VdS 2010).

It is recommended to conclude a maintenance contract with the installer of the PV system.

It is to be confirmed that the system complies with the acknowledged rules of technology.

4.7.2 Handling of old PV systems (older than 20 years)

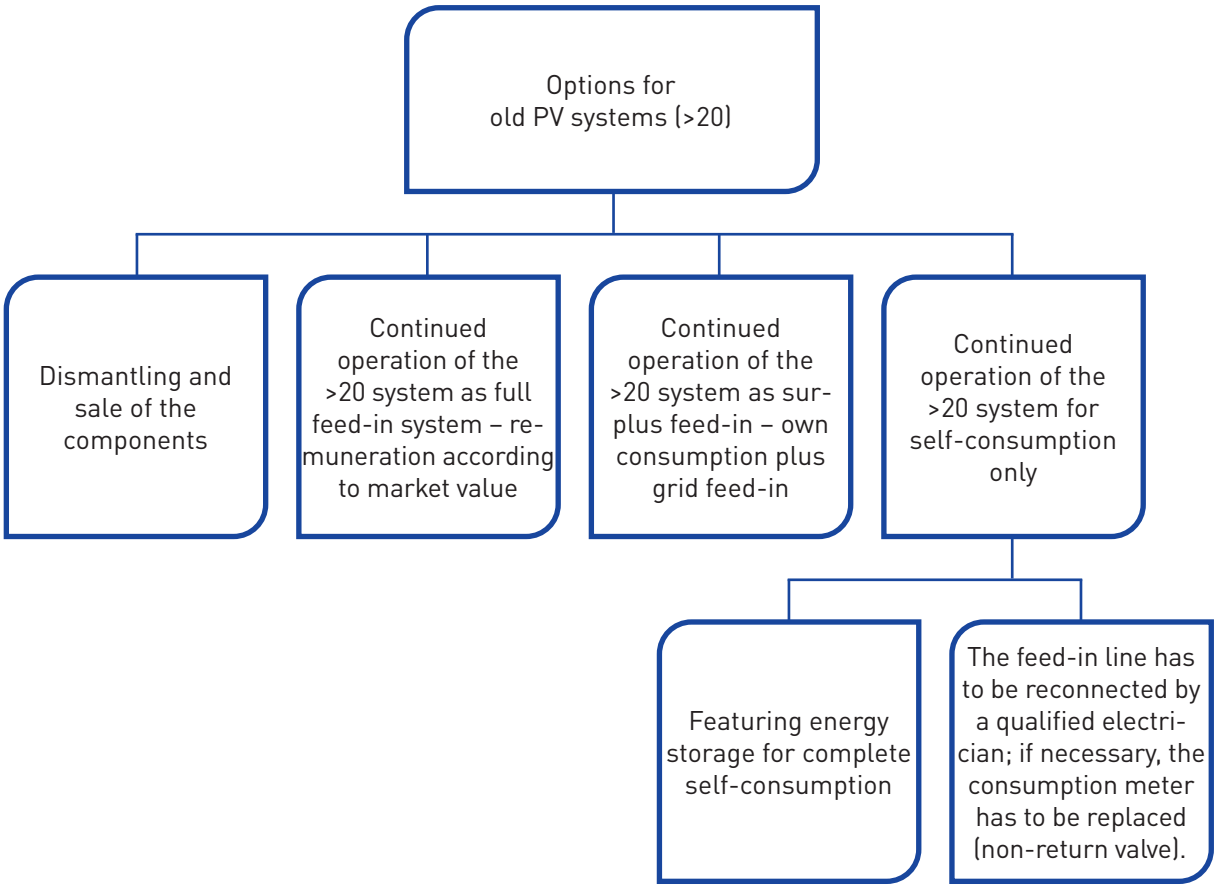
PV systems are planned for an operating time of 20 years and more. The following section explains how to deal with PV systems that are older than 20 years (>20).

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Due to their age, the risks of these systems increase or problems arise:

- There is an increased risk of fire due to wear and tear as well as component failure. In the case of commercially used buildings, a higher risk assessment effort is required.
- A classification of age-related defects versus external influences is not always possible.
- Yield losses due to degradation cannot be calculated.
- Spare parts are no longer available, conversions may be necessary – loss adjustment for property damage and loss of earnings.
- Conversions and extensions of old systems (e.g. adding an energy storage system) are technically more demanding and more prone to errors than the construction of a new system – liability risks for the specialised electrical contractor.

Due to the expected wear and tear caused by ageing, e.g. on cables, a particularly extensive inspection of the PV system is required when converting it after 20 years.



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5 Literature / sources

5.1 Laws and ordinances

-

5.2 Regulations, rules and information by the statutory accident insurance institutions (DGUV – German social accident insurer)

-

5.3 Technical regulations, standards relating to electrical engineering

DIN VDE 0100 Low-voltage electrical installations

- Part 200 Terms
- Part 410 Protection for safety – Protection against electric shock
- Part 420 Protection for safety – Protection against thermal effects
- Part 430 Protection for safety – Protection against overcurrent
- Part 443 Protection for safety – Protection against voltage disturbances and electromagnetic disturbances – Clause 443: Protection against transient overvoltages of atmospheric origin or due to switching
- Part 444 Protection for safety – Protection against voltage disturbances and electromagnetic disturbances
- Part 520 Selection and erection of electrical equipment – Wiring systems
- Part 530 Selection and erection of electrical equipment – Switchgear and controlgear
- Part 534 Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring
- Part 540 Selection and erection of electrical equipment – Earthing arrangements and protective conductors
- Part 551 Low-voltage generating sets – Installation of generating sets for parallel operation with other energy sources including a public distribution network
- Part 600 Verification
- Part 712 Solar photovoltaic (PV) power supply systems

DIN VDE 0105-100 Operation of electrical installations – General requirements

DIN VDE 0105-100/A1 Operation of electrical installations - General requirements – Amendment A1: Periodic verification

DIN EN 62109-1 (VDE 0126-14-1) Safety of power converters for use in photovoltaic power systems – Part 1: General requirements

DIN EN 62109-2 (VDE 0126-14-2) Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters

DIN EN 62446-1 (VDE 0126-23-1):2019-04 Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance, Part 1: Grid-connected systems – Documentation, commissioning test and inspection

DIN EN IEC 62446-2 (VDE 0126-23-2):2021-08 Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance, Part 2: Grid connected systems – Maintenance of PV systems

DIN EN IEC 63027 (VDE 0126-27) Photovoltaic power systems – DC arc detection and interruption

DIN EN 61215 (VDE 0126-31) Terrestrial photovoltaic (PV) modules – Design qualification and type approval

DIN EN 61646 (VDE 0126-32) Terrestrial thin-film photovoltaic (PV) modules – Design qualification and type approval

DIN EN 62108 (VDE 0126-33) Concentrator photovoltaic (CPV) modules and assemblies – Design qualification and type approval

DIN EN 61730-1 (VDE 0126-30-1) Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction

DIN EN 61730-2 (VDE 0126-30-2) Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing

DIN EN 62446-1 (VDE 0126-23-1) Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance – Part 1: Grid connected systems – Documentation, commissioning tests and inspection

DIN EN 50618 (VDE 0283-618) Electric cables for photovoltaic systems

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DIN EN 62716 (VDE 0126-39) Photovoltaic (PV) modules – Ammonia corrosion testing

DIN EN IEC 62619 (VDE 0510-39) Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications

DIN EN 50272-1 (VDE 0510-1) Safety requirements for secondary batteries and battery installations – Part 1: General safety information

DIN EN 50272-2 (VDE 0510-2) Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries

DIN EN 61439-1 (VDE 0660-600-1) Low-voltage switchgear and controlgear assemblies – Part 1: General rules

DIN EN 61439-2 (VDE 0660-600-2) Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies

DIN EN 62305-3 (VDE 0185-305-3) Protection against lightning – Part 3: Physical damage to structures and life hazard

DIN EN 62305-3 (VDE 0185-305-3) Suppl. 5 Protection against lightning – Part 3: Physical damage to structures and life hazard – Supplement 5: Lightning and overvoltage protection for photovoltaic power supply systems

Application rules

VDE-AR-N 4100 Technical rules for the connection and operation of customer installations to the low voltage network (TCR low voltage)

VDE-AR-N 4105 Generators connected to the low-voltage distribution network – Technical requirements for the connection to and parallel operation with low-voltage distribution networks

VDE-AR-4110 Technical requirements for the connection and operation of customer installations to the medium voltage network (TCR medium voltage)

VDE-AR-4120 Technical requirements for the connection and operation of customer installations to the high voltage network (TCR high voltage)

VDE-AR-E 2100-712 Measures for the DC range of a PV installation for the maintenance of safety in the case of firefighting or technical assistance

VDE-Verlag GmbH, Berlin-Offenbach Bismarckstr. 33, 10625 Berlin / Germany www.vde-verlag.de/

DIN standards

DIN EN 1991-1-3 Actions on structures – Part 1-3: General actions – Snow loads

DIN EN 1991-1-4 Actions on structures – Part 1-4: Wind actions

DIN 4102 Fire behaviour of building materials and building components

DIN EN 13501 Fire classification of construction products and building elements according to their fire behaviour

DIN 18008 Glass in Building – Design and construction rules

DIN 18234 Fire safety of large roofs for buildings – Fire exposure from below

DIN EN 14449 Glass in building – Laminated glass and laminated safety glass

DIN EN ISO 13943 – Fire safety – Vocabulary

DIN MEDIA

5.4 Publications by the German insurers on the issue of loss prevention

VdS 2010 dealing with risk-orientated lightning and overvoltage protection

VdS 2025 dealing with electrical wiring systems

VdS 2031 dealing with lightning and overvoltage protection in electrical equipment

VdS 2033 dealing with electrical installations in operating sites at risk of fire and equivalent risks

VdS 2234en Firewalls and complex partition walls, Leaflet for arrangement and construction

VdS 3143en Security Manual Perimeter

VdS 6023 dealing with photovoltaic systems on roofs

VdS Schadenverhütung Verlag Amsterdamer Straße 174, 50735 Cologne / Germany www.vds-shop.de

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Brochure regarding renewable energies (www.gdv.de)

5.5 Publications by VdS Schadenverhütung GmbH (VdS)

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5.6 Literature

RAL-GZ 966 Solarenergieanlagen von RAL Güte Gemeinschaft (solar energy systems from RAL Güte Gemeinschaft)

MBO – the German model building regulation

MIndBauRL – a German model guideline on structural fire protection in industrial buildings, version March 2014

MHHR – a German model guideline for high-rise buildings, version April 2008

VDI 6012 Sheet 1.4 Fixing of solar modules and solar collectors on buildings

Rules for sealing German regulations for flat roofs by the roofing industry (Flachdachrichtlinie des Dachdeckerhandwerks), editor: Zentralverband des Deutschen Dachdeckerhandwerks e. V. – ZVDH –, Fachverband Dach-, Wand- und Abdichtungstechnik e. V.

MVV TB – a German model administrative regulation for technical building regulations with reference to the series of standards DIN 18008 "Glass in Building – Design and construction rules"

Technical book: Photovoltaik Strom aus Sonnenlicht für Verbundnetz und Inselanlagen (photovoltaic electricity from sunlight for interconnected grids and off-grid systems) (H. Häberlin; VDE-Verlag; 2nd edition)

Leitfaden Photovoltaische Anlagen (guide to photovoltaic systems) (Ralf Haselhuhn, Uwe Hartmann, Udo Siegfriedt et. al.; 4th edition 2010; editor: DGS – German Solar Energy Society)

Information sheet for planners and installers – Reducing arc risks on PV systems; 1st edition, July 2017, editor: Bundesverband Solarwirtschaft e. V.

IEA PVPS Task 13 Performance, Operation and Reliability of Photovoltaic Systems – Quantification of Technical Risks in PV Power Systems Report IEA-PVPS T13-23:2021

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Appendix A – Checklist for PV systems

1. A verification report in accordance with VDE 0126-23-1 and DIN VDE 0100-600 is on hand, i.e. a written report of the initial verification with the results of the visual inspection, measurement and performance testing (note: an installer declaration is not a verification report).	
2. The load-bearing capacity of the building has been tested by a qualified expert and is sufficient for the additional load transfer. The distribution of load (e.g. according to the ballasting plan) was also taken into account during the load capacity test.	
3. The system statics of the load-bearing system for the ambient conditions (snow load, wind, etc. in accordance with DIN EN 1991-1-3 and -1-4) has been verified and complied with!	
4. No modules are installed across fire compartments!	
5. No direct current cables are routed in an unprotected manner across fire compartments!	
6. An existing lightning protection system has been professionally adapted to the new situation (written confirmation from the responsible specialist company for lightning protection on hand).	
7. Cables have been properly laid (see Clause 4.4.3, DIN VDE 0100-520 and DIN VDE 0100-712). DC plugs and sockets of the same type from the same manufacturer have been used and arranged and fastened so that they are protected from the weather.	
8. The module frame is equipped with functional equipotential bonding, and all metal structures are interconnected.	
9. DC cables in the building have been properly laid and marked in the ground plan (for fire brigade use).	
10. Inverters have been installed on a non-combustible surface.	
11. The minimum distance between the inverters has been observed (see Picture 9) and the manufacturer's specifications have been followed.	
12. The distance between the inverters and combustible materials is at least 0.5 m.	
13. The PV system is checked in accordance with the manufacturer's specifications and regularly in accordance with Clause 4.7 (e.g. maintenance contract).	
14. The fault-free function of the system is checked regularly (see Clause 4.7).	
15. The roof membrane of the building is undamaged and not overaged. In case of PV systems on stands, measures have been implemented to protect the roof membrane.	
16. For roof systems containing combustible materials, the instructions of VdS 6023 have been observed and measures to minimise the fire risk have been implemented.	
17. Sufficient distances to roof penetrations, such as dome lights or SHEVS, are maintained. The instructions of VdS 2098 have been observed.	
18. The mounting system is designed by its manufacturer for use on the respective roof membrane. An approval from the manufacturer of the roof membrane is on hand.	
19. The requirements of VdS 2234en regarding the arrangement and installation of PV systems (Chapter 9) have been met.	
20. The AC and DC sides of the inverter are protected by surge protective devices.	
21. Cross-building communication lines of the inverters are protected by suitable surge protective devices.	
22. Direct current arc detection and interruption (AFPE, Arc Fault Protection Equipment) is present and has been activated.	

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