

technical information on the installation and operation of aleo modules

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Dated: November 2008

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1 Introduction

Thank you for deciding in favor of aleo solar modules. aleo solar is a manufacturer of high-quality solar modules which reflect the state of the art and will supply environmentally friendly solar energy for many years when correctly installed and properly operated. To make it easier for you to install and operate aleo solar modules we have compiled the following important information on how to handle aleo solar modules.

Before you install or operate aleo solar modules, please read all the following information on installation and operation and follow the instructions provided in this publication. Take special note of the safety information!

The information on installation and operation is binding.

Please keep this information on installation and operation in a safe place. You will need this information for care and maintenance activities and if you should ever wish to resell the aleo solar modules.

1.1 Intended use of aleo solar modules

aleo solar offers a wide range of solar modules. Unless further details on the field of application of this particular type of module are given in the product-specification data, the following applies:

aleo solar modules of this type are designed for producing electric energy in grid-connected solar generators. Their use for any other purpose is not recommended. The solar modules of this type must not be installed on vehicles and must not be used for marine or aerospace applications. They must not be used if there is a risk of exposure to strong artificial light or salt water or risk of immersion in water or other liquids. Installing solar modules of this type in coastal locations can have a negative effect on their long-term performance.

aleo solar modules must be used for their intended purpose only.

1.2 Product support

aleo solar is committed to offering high-quality products which are safe and reflect the state of the art in technology – today and in the future. The feedback and ideas we get from installation companies and the users of aleo solar technology can be helpful in this connection. Should you encounter any faults with the solar module after installation or have any problems with the installation work itself, please contact aleo solar:

Tel.: +49 (0)441 219 88-550
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 E-mail: after-sales@aleo-solar.de

2 General information on the handling of aleo solar modules

Installing solar modules requires considerable technical expertise and – given that the DC voltage can exceed 50 volts, e.g. in series circuits – may only be carried out by qualified experts.

Take note of all relevant laws, regulations, directives and safety measures etc. when handling solar modules.

Prevent accidents (e.g. electric shocks) during the installation, operation, maintenance and disposal of solar modules by taking appropriate precautions.

Keep unauthorized persons and animals away from solar energy facilities. Pay particular attention to playing children.

Appropriate safety precautions must be taken for all work on roofs. **Take special note of occupational safety and accident prevention regulations applicable to the work in question.**

Never attempt to modify a solar module or take it apart. Never remove any markings applied or parts fitted by the manufacturer. Do not apply any paint or adhesive to a solar module.

aleo solar modules can be combined with other components to form a photovoltaic (PV) facility. In this case you must also follow the installation and operation instructions issued for these additional components.

2.1 Precautions in connection with the mechanical equipment

Take note in particular of the following instructions when handling solar modules:

- Never leave a solar module standing unattended or not properly secured.
- Never allow a solar module to drop, never jolt it and never allow any objects to fall onto it.
- Do not step on solar modules.
- Although the edges of aleo solar modules have been deburred, there is still a risk of injury in the event of strong contact. It is important therefore to always wear work gloves when handling solar modules.

Solar modules which contain glass panels must be handled with special care. The edges and corners of the glass panels are at particular risk. Broken glass or pieces of glass splintering off increase the risk of injury. Wear suitable protective equipment to prevent injury from flying shards of glass or sharp glass edges should any glass get broken. There is a risk of glass breaking for example due to impact, thermally induced tension, movements in the substructure of the respective solar module and direct contact between the glass and the load-bearing structure. During the installation and operation of a solar module, its glass panel or panels must never impact directly against any other glass, metal or other hard objects.

If a glass panel breaks, there is no longer any guarantee that the solar module in question is insulated. As the result, live parts (e.g. solar cells) may be exposed such that they can be touched. Touching live parts can cause an electric shock.

A solar module with broken glass cannot be repaired and must not be installed. Broken or shattered solar modules must be replaced.

Some aleo solar modules have an insulation back-sheet. Any damage to the insulation back-sheet can have serious consequences. The sheet protects the solar module from weather-related influences and provides electrical insulation. Damage to the insulation back-sheet can cause permanent damage to the solar module (delamination, etc.) and may result in danger to the life and health of persons. It is therefore imperative to ensure that the insulation back-sheet never becomes damaged. All cases of damage must be repaired promptly. Repairs to the insulation back-sheets of aleo solar modules must be left strictly to aleo solar.

2.2 Precautions in connection with the electrical equipment and with the optical equipment

Take note in particular of the following instructions when handling solar modules:

- Solar modules generate voltage immediately in response to light on their front, whatever the incidence of the light. The voltage of a single solar module is sufficient for an electric shock.
- If the solar modules are connected in series, the voltage is cumulated; if the modules are connected in parallel, the current is cumulated. Consequently, a system with several solar modules connected together will generate high voltages and/or amperages which may pose a major risk to life and health if the installation and operation instructions are not observed.
- **Never touch the electrical connections or other live parts of a solar module! There is a risk of a flow of current which can be fatal!**
- Pulling the contacts apart under load can produce an electric arc.
- To prevent as far as possible the generation of electric energy when handling and wiring up the solar modules, carefully cover the complete front of the module in question with a material which is impervious to light.
- Use only electricians' tools which are sufficiently insulated.
- Prevent sunlight being concentrated or reflected artificially onto a solar module. In particular do not use any lenses or mirrors.

3 Information on planning, installation and operation

The following sections contain important information on the planning, installation and operation of solar modules.

3.1 Planning phase

Contact the relevant authorities and – in the case of grid-connected PV generators – your local electric power grid operator in order to clarify the situation regarding permits and any conditions relating to installation and operation. Observe all the laws, regulations, directives and conditions etc. applicable to the photovoltaic facility you want to install. Make sure in particular that the information at your disposal is up to date.

3.1.1 Determining the location and orientation of the solar modules, selecting the solar modules and power inverters

Select a location with the best possible solar radiation for the photovoltaic facility you want to install. Your choice of location should take account of the seasonal changes in light conditions. You should choose a location where even on the shortest day of the year the solar modules are not in the shade between 9 hours and 15 hours solar time. Avoid areas in the shade to prevent lost output and to prevent the photovoltaic generator from failing.

In the northern hemisphere (southern hemisphere) the solar modules should be positioned so that they face south (north) at an angle of at least 15 degrees to the horizontal. The optimum pitch angle depends in particular on the latitude of the location and on the desired main use-phase of the PV facility. Typical values for the pitch angle vary, e.g. in Europe from between approx. 30° in the Mediterranean area to approx. 40° in Northern Europe. Tables and calculation programs are available for determining a more exact value for your specific location.

Solar modules which have no module-integrated circuit for performance optimization (e.g. an MPP tracker) require at least an external performance optimization circuit (e.g. an external MPP tracker) in order to optimize the energy output from these modules. External MPP trackers are often found in power inverters. The following aspects must be considered when using solar modules without an internal MPP tracker:

- Only solar modules of the same type and the same output class are allowed to be connected to a given external MPP tracker.
- The solar modules which you want to connect to a given external MPP tracker must be aligned in the same direction and at the same angle to the sun (same azimuth and same elevation).

Failure to observe these basics can greatly decrease the performance of a photovoltaic facility while increasing the risk of damage. Several MPP trackers should be used if necessary. In this case it may also be necessary to allow for several power inverters or for the type of power inverter which can control several module lines independently of each other. In many cases a parallel arrangement of modules is more cost-effective than the use of several power inverters or the use of power inverters with several MPP trackers.

The power inverters used must be coordinated with the solar modules used.

Short-circuits or switching operations in photovoltaic facilities can cause sparks or electric arcs. Therefore, do not install solar modules in close proximity to readily inflammable materials of a solid, liquid or gaseous nature.

If solar modules are to be installed on a roof or facade, a special support frame will be required to enable the solar modules to be properly fastened. Make sure that the frame structure and all components used for fastening the solar modules in place comply with all relevant laws, regulations and directives etc.

Such additional structures and the solar modules themselves can have an impact on the fire resistance of the building in question. Incorrect or improper installation poses a risk in the event of a fire and when extinguishing a fire. Additional parts such as ground-fault detectors, fuses and interrupters may be required. Observe in particular the conditions required by authorities, power supply companies and insurance companies.

The solar modules must be secured in such a way that they resist all possible expected loads and weather conditions. In particular, the load-bearing structure must be capable of withstanding all snow loads, ice loads and wind forces to be expected in the location. In areas with high snow loads it is strongly recommended that support be provided at the back of the module. We are always pleased to provide advice.

3.1.2 Structural stability calculations

Structural safety calculations and load-bearing/deflection calculations must be made for each specific building or project. These calculations must be undertaken by the installer of the facility (installation firm) or by the owner/user.

The additional loads generated by the photovoltaic facility must be taken into consideration in the structural calculations for the building as a whole.

3.2 Storing, transporting and unpacking solar modules

Whenever the aleo solar modules are stored or transported, care must be taken to ensure that they are stood upright in the packing units and that there is a big enough area to support each solar module. Each module must also be secured against tipping over. When solar modules are transported they must always be in an upright position. Transporting in horizontal position is not allowed.

Packing units must never be stacked as this may cause damage to the solar modules. The same applies to the stacking of individual solar modules and to the stacking of pallets on which there are (packed) solar modules.

We recommend that the solar modules be stored indoors in their original packaging until ready for final installation. Dry storage conditions are important in particular for modules whose original packaging is made of non-impregnated cardboard.

Loose solar modules must only ever be stored standing upright on wedge-shaped supports with suitable padding. Adequate padding must also be placed between the individual solar modules. The solar modules must also be secured against tipping over.

Check each solar module before installation to ensure that it is in perfect mechanical condition. Check in particular for damage to the insulation of cables, plugs and junction boxes as well as for damage to glass panels and insulation back-sheets (where the respective module types are fitted with the components in question).

Solar modules with visible damage to glass panels, insulation back-sheets or the insulation of electrical connections must not be used. Cables and plugs with visible damage to their insulation must not be integrated in a photovoltaic facility.

3.3 Installation

aleo solar modules must be installed strictly by authorized specialist firms or restrictions will be applied to the performance guarantee. Be sure to observe all the laws, regulations and directives etc. applicable to the installation of solar modules. Take special note of the occupational safety and accident prevention regulations.

Carry out your work in dry conditions as far as possible. The electrical connections of the solar modules must be dry and so must the tools used.

When solar modules are installed on roofs and in other elevated positions there is a risk of objects falling during the installation work and injuring people or animals. It is important therefore to cordon off the danger area before beginning with the installation work and to remove sensitive objects from the danger zone.

It is strongly recommended for a photovoltaic facility to be installed by at least two qualified specialists.

3.3.1 Installing the mechanical equipment

A photovoltaic facility must be installed such that when finished it displays high resistance to the environmental influences (wind, rain, hail, snow, etc.) acting on it. Make sure in particular that the solar modules of the PV facility cannot be damaged by other parts of the facility or by any other objects. Solar modules normally remain in use for several decades, so even minor sources of error can lead to major damage to the PV facility in the course of time.

Use only stable and corrosion-resistant installation material. Do not use any material which can cause corrosion on the solar modules which you want to integrate in the PV facility. If you have any questions about support frames for solar modules and other installation material, ask your supplier or aleo solar.

Never drill additional mounting holes in solar modules under any circumstances.

Unless stated otherwise in the product-specification data issued for the module type in question, the following applies:

aleo solar modules must be installed on end or cross-wise, i.e. with rectangular modules there must be two module edges vertical to the perpendicular. The modules must be orientated such that no water can collect in any junction boxes at the rear. With solar modules which are installed on end and have one connection cable or two connection cables secured to the same side of the box this means that the modules have to be fitted such that their connection cables leave the boxes on the sides facing the ground. Modules which are installed on end and do not have their own connection cables are usually fitted so that their electrical connections (connection sockets or the like) lie on the sides facing the ground.

Framed aleo solar modules usually have four mounting holes. Solar modules of this type must be fitted so that their frames rest with the areas of the mounting holes on the corresponding sub-structures. A drawing showing the positions of the holes can be found in the respective data sheets. Be sure not to mistake the mounting holes with the holes for draining the hollow frames of the solar modules. The solar modules must be fitted such that the drainage holes are not covered and water can run out through these openings unhindered.

Alternatively to this standard installation arrangement it is also possible to install most aleo solar modules on their narrow sides provided they both rest full-length on suitable supports. This fitting method is required in particular in connection with various insertion systems. In this case you must provide generous support surfaces so that the solar modules cannot slip when loaded. Here too you must make sure that the drainage holes are not covered and water can run out through the openings unhindered. For very high loads (e.g. in locations noted for extreme winds or snow falls) you must use the previously described conventional fitting method because solar modules display the greatest resistance when mounted this way.

Information about fitting aleo solar modules with other systems of installation points is available from aleo solar. Similarly, aleo solar is glad to provide information about which types of solar modules are suitable for fitting by their short sides.

Framed aleo solar modules must be fastened in place with suitable tensioning clamps (or size M8 screws in the case of modules with installation holes) which clamp the solar module securely to the sub-structure and distribute the load over the frame. When nuts and round or cornered washers are tightened they can exert high spot loads on the upper side of the frame, causing in particular glass panels to break. You should therefore never use these methods of fastening for aleo solar modules. Nor should you use any other fastening elements which lead to additional loading of the glass panels.

When solar modules are installed at an angle of more than approx. 45° to the horizontal it may be necessary to use an anti-slip arrangement which prevents the modules from sliding out of their original position. Make sure that there is sufficient space between the frame of each solar module and the respective installation surface so that heat can effectively dissipate from the solar module and water – in particular condensation water – can evaporate. You should therefore never cover solar modules with any kind of seal-

ing material against the installation surface. A low ambient temperature can have a positive impact on a solar module's output and on its useful life.

aleo solar modules are generally tested with an elevated load of 5400 Pa (see e.g. IEC 61215 Ed. 2). This equates to an area load of approx. 540 kg/m² on the module surface. More details about the various module types can be found in the data sheets issued for the specific product types.

3.3.2 Installing the electrical equipment

All the electrically relevant components of a solar power facility (modules, cables, plugs, power inverters etc.) must be approved for the voltages and currents which can arise in the facility in question.

All wiring work must comply with valid regulations. The cables must be protected against damage. All connections must be in faultless condition, both in mechanical and electrical terms. Never clean or lubricate the junction boxes or plug-and-socket connections with oil, grease or any substances containing alcohol. This may cause the plastic material to become brittle. Soiled connections and plug-and-socket connections should be cleaned mechanically with a soft material, compressed air or the like.

Do not exert any strong tension or pressure on solar module junction boxes and the cables leading to them. Broken junction boxes and damaged cable inlets can destroy the protective insulation of the solar module in question and pose a risk of electric shock. Never attempt to press plugs with force into the corresponding sockets.

Before you connect or disconnect electric contacts you must check that the complete front sides of all the solar modules which are connected together or which you want to connect together are covered with material that is impervious to light.

aleo solar modules generally come with permanently installed junction boxes and flexible connection cables with pre-fitted plugs and sockets. These solar modules can be connected in series by connecting the positive (+) connection on one solar module to the negative (-) connection on another solar module. An arrangement of several solar modules which are connected together in this way is referred to as a "module string" or "array".

For the rest of the wiring of a module string (e.g. with a power inverter) you should use copper cable with a minimum cross-section of 4 mm² and a sheath which is resistant in particular to ultraviolet light and ozone and which also displays sufficient heat resistance. The cable insulation must be approved for the system's maximum open-circuit voltage (usually 1000 V DC). If cables of over 100 meters in length are used they must have a cross-section of at least 6 mm² in order to minimize conduction losses. The use of cables with cross-sections of more than 4 mm² may also be required for module strings in parallel circuits. Be sure to observe the laying regulations for the respective types of cable!

Take care not to confuse the polarity on the power inverter connections! The cable leading to the positive (+) connection of a module string must be connected to the related positive DC connection on the corresponding power inverter and the cable leading to the negative (-) connection of a module string to the related negative DC connection of the power inverter.

The load-bearing structure must be connected to the equipotential bonding.

3.3.2.1 Separate grounding of solar module frames

In order to prevent the risk of electric shock in the event of any damage or installation errors, every solar module frame belonging to a PV facility can be separately connected to the facility's ground. Such a grounding arrangement may be compulsory depending on where the photovoltaic facility is located. It is recommended to configure the grounding such that when one solar module is removed from a system of modules, the other modules are still connected to ground. You must also observe the recommendations issued by the power inverter manufacturer and the insurance companies.

3.3.2.2 Diodes and fuses

When individual solar cells or solar modules are covered by shade this can result in the shaded area heating up because electric energy produced by other parts of the PV facility will be consumed in the shaded module region. The use of a bypass diode or other technical means to bridge shaded areas will reduce the extent to which these areas heat up and therefore also the amount of lost output. aleo solar

modules come with factory-fitted bypass diodes or other components which provide efficient protection for the cells.

Should it be necessary to connect module strings in parallel, proceed as follows:

- Select a module string which you want to connect in parallel.
- Install a suitably dimensioned protective diode in one of the two connecting leads leading to this string such that it lies in conducting direction when electric energy is generated properly in this string, i.e. it lets the electric current pass. This requires the anode of the diode to be connected to the positive (+) terminal of this string and the cathode of the diode to the negative (-) terminal.
- When you are finished with the first module string, repeat these steps on all the other strings which are to be switched in parallel and then make the connections required for the parallel switching of these strings. Instead of additional diodes you can install DC line fuses. These must have a rating which is appropriate for the maximum reverse current (I_R) specified in the data sheet issued for the modules in question. If there is a likelihood of individual module strings in a parallel connection being covered by shade, preference should be given to diodes.

The installation of additional diodes or fuses is necessary for parallel circuits of module strings because the internal protective measures adapted to the module output (e.g. bypass diodes) are unable to regulate the flow of current adequately if individual module strings in parallel circuits are covered by shade. Non-compliance with this point may lead to damage to the solar modules in question (and the electronic components installed in them).

aleo solar recommends that line fuses (DC) always be installed for both series and parallel circuits in order to protect the solar modules in the event of a fault (e.g. a defective power inverter). The fuses must have a rating which is appropriate for the maximum reverse current (I_R) specified in the data sheet issued for the modules in question.

3.4 Care and maintenance

The solar modules require very little care and maintenance to provide high performance. We recommend that the solar modules be inspected every six months, when they should be cleaned and examined.

The solar modules may become soiled to varying degrees depending on surrounding conditions, and this can reduce their performance. To clean the glass surfaces of the modules we recommend the use of water which is adjusted to the temperature of the module and a soft cloth or sponge. To remove stubborn dirt you can use a mild, non-abrasive cleaning agent or alcohol. The glass surfaces of some aleo solar modules have microscopic structures. You must take care not to destroy these surfaces (no abrasion of projecting structures, no clogging of pores etc.).

Experience with the use of dirt- or water-repellent coatings is still inconclusive. The subsequent application of such coatings can have a negative impact on the efficiency of the solar modules in question. We recommend therefore not to use these coatings.

When carrying out the inspection you must also check that the electrical and mechanical connections are clean, secure and undamaged. Be sure to take precautions against electric shock in the event of any defects. All irregularities must be rectified promptly.

aleo solar modules must be serviced strictly by specialist firms which are authorized by aleo solar, otherwise restrictions will be applied to the performance guarantee.

Should any repairs become necessary on an aleo solar module, it is essential that you contact aleo solar. Never under any circumstances attempt to repair the solar module yourself! Improper repairs can result for example in damage which not until several years later may lead to electrical insulation failure. Inadequate insulation can put lives at risk! To reduce the risk of consequential damage and reduced output you should notify aleo solar promptly about any defects and arrange for them to be rectified.

Before carrying out any maintenance or repair work you must take suitable steps to block out the solar modules as much as possible. This is necessary in order to block the generation of electric current during the maintenance or repair work. On PV facilities which are equipped with isolating devices in the DC circuit, you must also disconnect the solar modules electrically from the other parts of the PV facility by actuating the isolating device in question.

It is recommended that the owner/user checks the yields of his solar energy facility at regular intervals.

The regulations governing fires in electrical facilities also apply.

3.5 Disposal

When solar modules reach the end of their service life they must be disposed of in accordance with the regulations. They must never be disposed of as household waste. Contact your local waste disposal center for advice or contact aleo solar to return the modules.

4 Characteristic values of solar modules

Detailed type-related information about the electrical and mechanical characteristics of aleo solar modules can be found in the respective data sheets. Important electrical characteristic values under standard test conditions (STC) are listed on the back of aleo modules. Under certain circumstances a solar module may generate more current or voltage than under STC. To determine the minimum ratings of other PV system components (power inverter, connection cables, etc.) you must therefore multiply the open-circuit voltage and short-circuit current under STC by a suitable safety factor. For solar modules comprising monocrystalline or polycrystalline cells this factor is ≥ 1.25 .

Between the characteristics of an individual solar module and the values listed in the corresponding type data sheet there may be deviations which can vary over the module's life. In terms of current (I) and voltage (U) these deviations are usually no more than ± 10 per cent upon delivery of the modules. For the rated outputs P_{MPP} under standard test conditions (1000 W/m², radiation spectrum AM 1.5 global, cell temperature of 25 °C) the tolerance ranges are far smaller with most module types. As a rule a maximum output of between P_{MPP} and $P_{MPP} + 4.99$ W was determined with a measuring accuracy of ± 3 per cent for a module with a rated output P_{MPP} in the as-delivered state. Deviating allocations to power classes and deviating tolerance ranges can be found in the respective product data sheets.