Sunica.plus

Technical manual





Contents

1. Introduction

The nickel-cadmium battery is the most reliable battery system available in the market today. Its unique features enable it to be used in applications and environments untenable for other widely available battery systems. It is not surprising, therefore, that with the photovoltaic (PV) market and its rigorous requirements, the nickel-cadmium battery has become an obvious first choice for users looking for a reliable, low maintenance, system.

This publication details the design and operating characteristics of the Saft Nife® brand Sunica.plus battery to enable a successful photovoltaic system.

Sunica.plus is built upon solid Saft expertise with more than 20 years field experience. The Sunica.plus is one of the most reliable batteries under the sun. In application, the Sunica.plus operates worry free for years with only occasional and infrequent water topping and performs extended cycling in uncontrolled environments and at partial state of charge.

2. The photovoltaic application

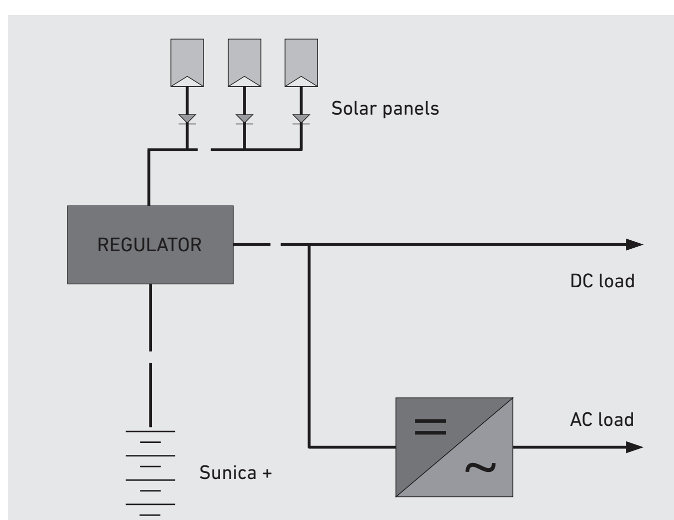
The typical requirements for photovoltaic (PV) applications are ruggedness, environmental flexibility, unattended operation, ease of installation, and reliability.

Photovoltaic applications include:
Navigational Aids: offshore, remote lighthouses, beacons
Telecommunications: emergency telephone posts, radio repeater stations, base stations
Rail Transport: crossing guards lighting, signalling, isolated telephone stations
Oil and Gas: cathodic protection for pipelines, emergency lighting on offshore platforms
Utilities: electrification in remote areas

A photovoltaic system is made up of three distinct parts:
- The photovoltaic array which is built to give up to 20 years of service life
- Electronic components such as blocking diodes and logic circuits, power conditioners, controllers and voltage regulators
- The battery must provide worry free available autonomy, all the time.

Systems are often installed in remote areas, at sites accessible only by foot, helicopter or boat, in good weather conditions and with only limited skilled labour available. Thus, the ideal photovoltaic power system is a reliable installation which requires only infrequent maintenance calls where the battery plays a crucial part. The characteristics of the battery must not result in a failure of the system.

For photovoltaic applications, the most important characteristics required in a battery are:
- ability to withstand cycling, daily and seasonally
- ability to withstand high and low environmental temperatures
- ability to operate reliably, unattended and with minimal maintenance
- ruggedness for transportation to remote sites
- easily installed with limited handling equipment and unskilled labour
- reliability and availability during the 20 years service life of the photovoltaic modules
- resistance to withstand failure of electronic control systems
- no need for refreshing charges
- high charge efficiency during periods of low insolation (typically cold winter seasons)



3. Sunica.plus construction

Protective cover
Prevents external short-circuits. The covers are in line with EN 50272-2 and IEC 60485-2 (safety) with IP2 level.

Flame arresting vent

Handles
Moulded polypropylene handles allow Sunica.plus batteries to be easily manoeuvred and installed.

Plate group bus
Connects the plate tabs with the terminal post. Plate tabs and terminal posts are projection welded to the plate group bus.

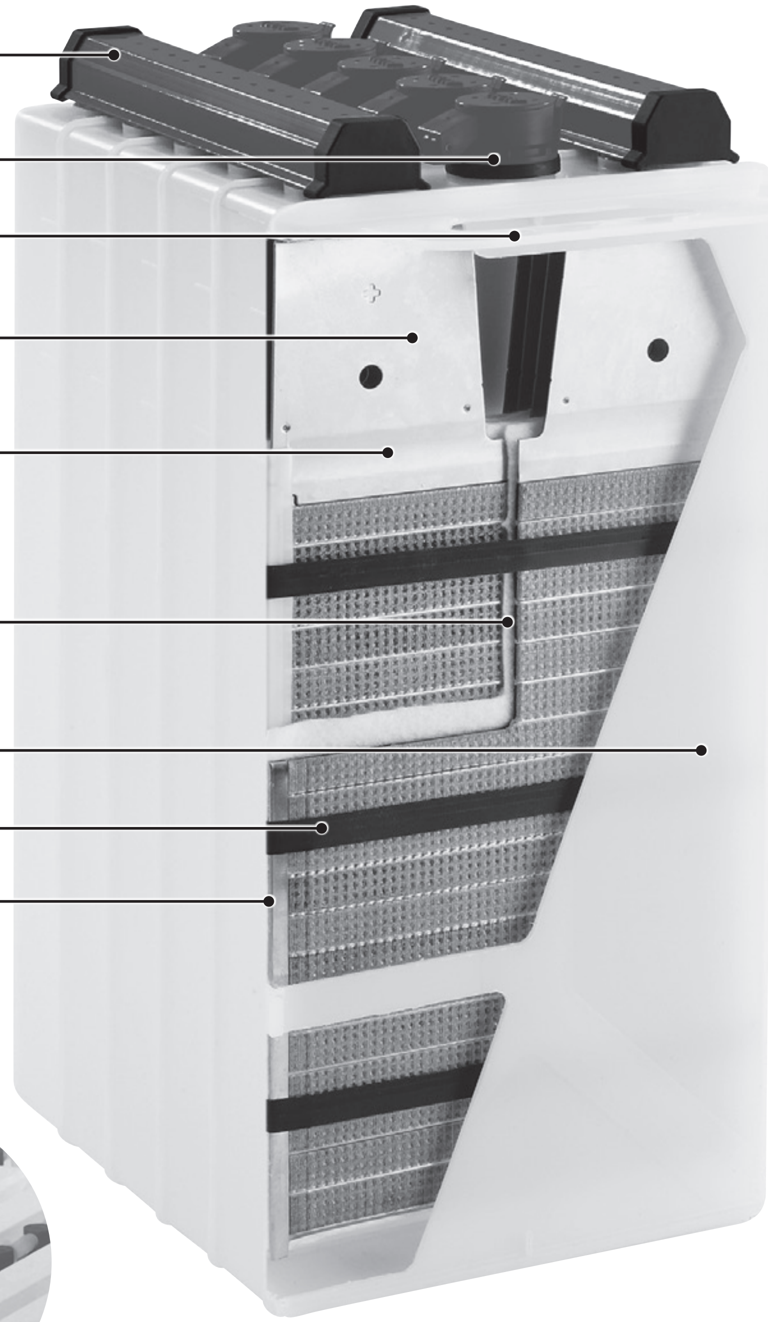
Plate tab
Spot welded to the plate side frames, to the upper edge of the pocket plate and to the plate group bus.

Separators
These separate the plates and insulate the plate frames from each other. This special type of separator improves the internal recombination.

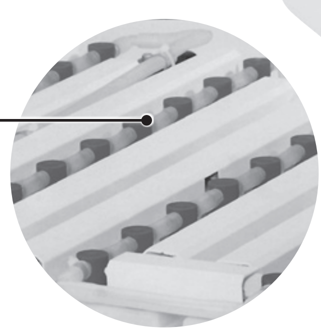
Cell container
Made of tough polypropylene.

Plate
Horizontal pockets of double-perforated steel strips.

Plate frame
Seals the plate pockets and serves as a current collector.



Automated integral water filling system
Saft's automated integral water filling system is available as an option for the Sunica.plus range.



The construction of the Saft Nife® brand Sunica.plus cell is based upon the proven Saft pocket plate technology. Special features are included to enhance its use in the specialised photovoltaic application.

3.1 Plate assembly

The nickel-cadmium cell consists of two groups of plates, one containing nickel hydroxide (the positive plate) and the other containing cadmium hydroxide (the negative plate).

The active materials of the Saft Sunica.plus pocket plate have been specially developed and formulated to improve its cycling ability, a specific need for photovoltaic applications. These active materials are retained in pockets formed from nickel plated steel which is double perforated by a patented process. The pockets are mechanically linked together, cut to the size corresponding to the plate length and compressed to the final plate dimension. This process leads to a component which is not only mechanically very strong but also retains its active material within a steel boundary which promotes conductivity and minimises electrode swelling.

These plates are welded to a current carrying bus bar assembly which further ensures the mechanical and electrical stability of the product.

Nickel-cadmium batteries have an exceptionally good cycle life because their plates are not gradually weakened by repeated cycling since the structural component of the plate is steel. The active material of the plate is not structural, only electrical. The alkaline electrolyte does not react with steel, which means that the supporting structure of the Sunica.plus battery stays intact and unchanged for the life of the battery. There is no corrosion and no risk of "sudden death".

3.2 Separator

The separator is a key feature of the Sunica.plus battery. It is a polypropylene fibrous material which has been used and proven by Saft in the Ultima ultra-low maintenance product over more than 20 years. It has been further optimized for this product to give the features required. Using this separator, the distance between the plates is carefully controlled to give the necessary gas retention for an optimum level of recombination. By providing a large spacing between the positive and negative plates and a generous quantity of electrolyte between plates, the possibility of thermal runaway is eliminated.

3.3 Electrolyte

The electrolyte used in Sunica.plus is a solution of potassium hydroxide and lithium hydroxide. It is optimised to give the best combination of performance, life, cycling ability and energy efficiency while operating in a wide operational temperature range. The concentration allows the cell to operate in extremely low and high temperatures, i.e., -20°C (-4°F) to +50°C (+122°F). For temperatures below -20°C (-4°F) a special high density electrolyte can be used to improve its charge and discharge performance. An important consideration of Sunica.plus, and indeed all nickel-cadmium batteries, is that the electrolyte does not change during charge and discharge. It retains its ability to transfer ions between the cell plates irrespective of the charge level. In most applications the electrolyte will retain its effectiveness for the life of the battery and will never need replacing.

3.4 Terminal pillars

Terminal pillars are welded to the plate bus bars using a well-proven block battery construction. They are constructed of nickel-plated steel and are internally threaded. The pillar to lid seal uses a compressed visco-elastic sealing method. The pillars are held in place by compression lock washers. This assembly is designed to provide satisfactory sealing throughout the life of the product.

3.5 Venting system

Sunica.plus is fitted with a flame arresting flip-top vent to simplify topping-up and is supplied with a transportation plug to ensure safe transportation. There is also an option of a water filling system which has been proven by Saft in railway applications over many years. This gives semi-automatic filling and an effective and safe gas venting system.

3.6 Cell container

Sunica.plus is built using the well-proven block battery construction. The tough polypropylene containers are welded together by heat sealing and the assembly of the blocks are completed by a clip-on terminal cover which gives protection to IP2 X according to IEC 60529 standard for the conductive parts.

4. Sunica.plus benefits

Complete reliability

The Sunica.plus does not suffer from the sudden death failure associated with other battery technologies.

Long cycle life

Sunica.plus has a long cycle life and delivers up to 10000 cycles at 15 % depth of discharge during a twenty year life (see section 5.7 Cycling).

Exceptional long life

Sunica.plus incorporates all the design features associated with the conventional Saft twenty year life products to ensure that, in many applications, it can achieve or exceed this lifetime compared to available battery technologies.

Low maintenance

With its special recombination separator and generous electrolyte reserve, Sunica.plus reduces the need for topping-up with water. It can be left in remote sites for long periods and will, depending upon application demands, give up to 6 years without the need for topping-up.

Charge efficiency

Good charge efficiency at normal temperatures and excellent charge efficiency at low temperatures ensure that the battery is charged during the winter period.

Wide operating temperature range

Sunica.plus has a special optimised electrolyte which allows it to have a normal operating temperature of from -20°C to +50°C (-4°F to +122°F), and accept extreme temperatures, ranging from as low as -50°C to up to +70°C (-58°F to up to +158°F).

Resistance to mechanical abuse

Sunica.plus is designed with a high mechanical strength. It withstands all the harsh treatment associated with transportation over difficult terrain (see section 7.2 Mechanical abuse).

High resistance to electrical abuse

While the use of a voltage regulator is recommended to obtain maximum overall efficiency of the system, the failure of this component will not damage the battery. It will simply cause an overcharging of the battery and so use extra water. The Sunica.plus battery is resistant to overcharge and over-discharge conditions compared to the other battery technologies (see section 7.1 Electrical abuse).

Well-proven pocket plate construction

Saft has nearly 100 years of manufacturing and application experience with respect to the nickel-cadmium pocket plate product and this expertise has been built into the twenty plus years design life of the Sunica.plus product (see section 3 Sunica.plus construction)

Low installation costs

Sunica.plus can be used with a wide range of photovoltaic systems as it produces no corrosive vapours, uses corrosion-free polypropylene containers and has a simple bolted assembly system.

Extended storage

When stored in the filled and charged state in normal condition (0°C to +30°C / +32°F to +86°F), Sunica.plus can be stored for up to 2 years (see section 9 Installation and operating instructions).

Environmentally safe

Saft operates a dedicated recycling center to recover the nickel, cadmium, steel and plastic used in the battery (see section 11 Disposal and recycling).

5. Operating features

5.1. Capacity

The Sunica.plus battery capacity is rated in ampere hours (Ah) at the C_{120} discharge rate. It is the quantity of electricity supplied for a 120 hour discharge period to a cut-off voltage of 1.0 volt per cell after being fully charged. This nominal value of capacity is regarded as the most useful for sizing photovoltaic applications.

5.2. Cell voltage

The cell voltage of Sunica.plus like all nickel-cadmium cells results from the electrochemical potentials of the nickel and the cadmium active materials in the presence of the potassium hydroxide electrolyte. The nominal voltage for this electrochemical couple is 1.2 volts.

5.3. Internal resistance

The internal resistance of a cell varies with the type of service and the state of charge. It is difficult to define and measure accurately.

In the fully charged state and at high temperature, the internal resistance is the lowest. The internal resistance is characterized by measuring the response in discharge voltage with a change in discharge current.

The internal resistance of a Sunica.plus cell has the values given in the product literature for fully charged cells at normal temperature.

For lower states of charge the values increase. At 50 % discharged, the internal resistance is about 20 % higher, and at 90 % discharged, it is about 80 % higher. When the temperature decreases below 20°C, the internal resistance increases. At 0°C (+32°F), the internal resistance is about 40 % higher.

Table 1 shows typical values for a 100 Ah cell (values in mΩ).

Table 1 - Internal resistance for a 100 Ah cell (in mΩ) for different conditions

Temperature	Fully charged	50 % discharged	90 % discharged
+ 20°C (+ 68°F)	3.0	3.6	5.4
0°C (+ 32°F)	4.2	5.0	7.6

5.4. Effect of temperature on performance

Variations in ambient temperature affect the performance of Sunica.plus and this must be accounted for when sizing the Sunica.plus battery for a minimum expected autonomy.

Low temperature operation reduces the discharge performance and at high temperature, the discharge performance is only slightly affected. The effect of temperature impacts the performance more significantly at higher rates of discharge.

The temperature de-rating factors used for sizing a Sunica.plus battery are given for cells with standard electrolyte in Figure 1. At temperatures below +20ºC (+68°F), the ability to discharge is impacted by the ability to deliver charged capacity with an increased resistance. At temperatures above +20ºC (+68°F), the ability to charge is impacted by a reduced efficiency.

When the special high density electrolyte is used, for operating temperatures below -20ºC (-4ºF) use the temperature de-rating factors given in Figure 2.

Figure 1. Temperature de-rating: standard electrolyte for operating temperatures from -20°C to +40°C (-4°F to +104°F)

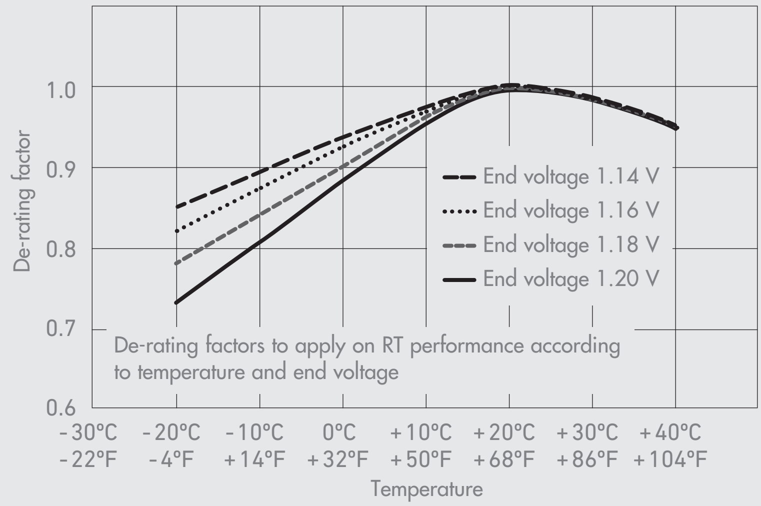
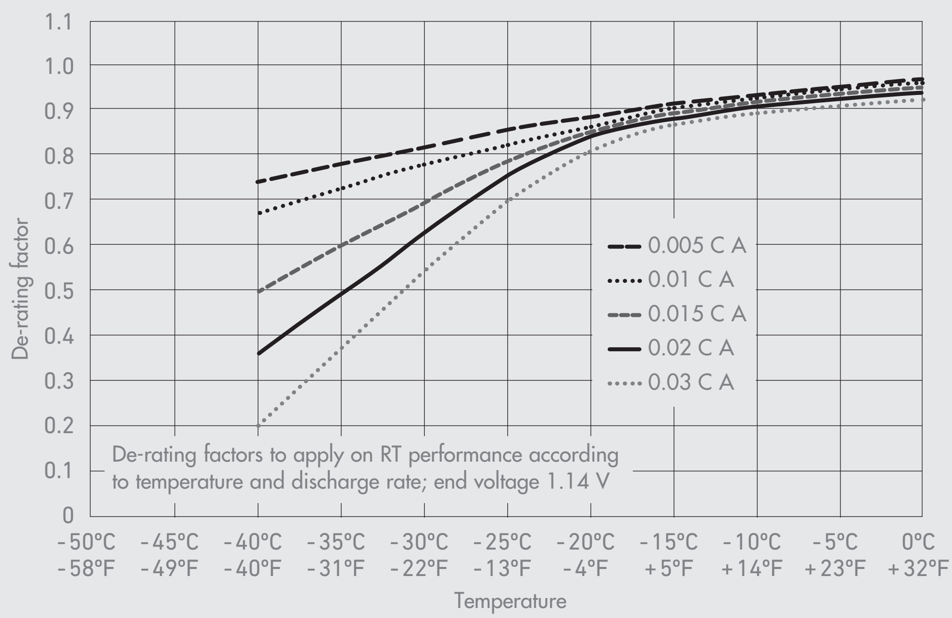


Figure 2. Temperature de-rating: special electrolyte for operating temperatures down to -40°C (-40°F).



5.5. Short circuit values

The typical short circuit value in amperes for a Sunica.plus cell is approximately 6 times the C_{120} capacity, e.g. for a 100 Ah cell the short circuit value would be 600 amperes. The Sunica.plus battery is designed to withstand a short circuit current of this magnitude for many minutes without damage.

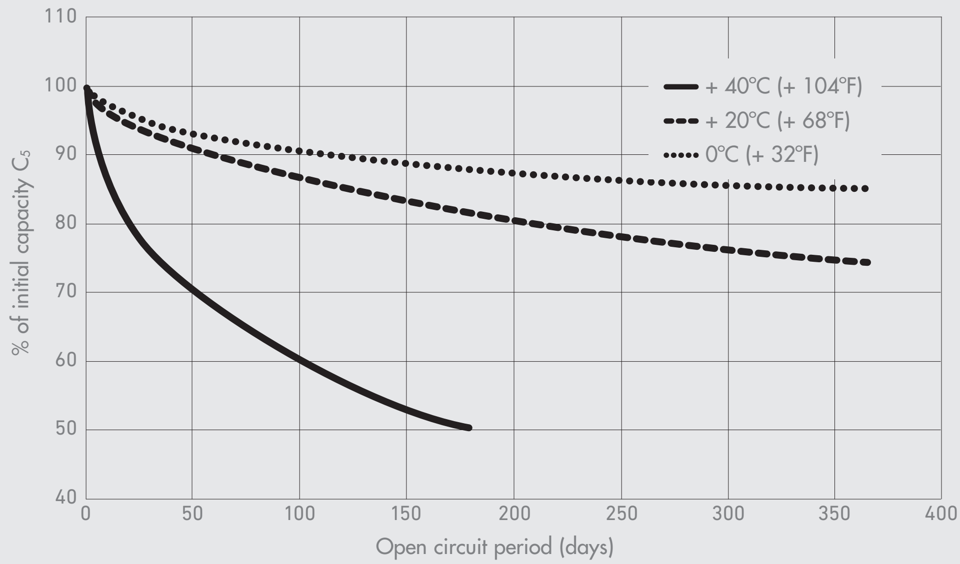
5.6. Open circuit loss

The state of charge of the Sunica.plus cell on open circuit stand slowly decreases with time due to self-discharge. At +20°C (+68°F), this decrease is relatively rapid during the first two weeks but then stabilises to about 2 % per month.

The self-discharge is affected by the temperature. At low temperatures, the charge retention is better and the open circuit loss is reduced. At high temperature the self-discharge is increased and the open circuit loss is also increased.

The open circuit loss for Sunica.plus is shown in Figure 3. For up to 2 years of storage time, storing Sunica.plus in a high state of charge is required.

Figure 3. Typical open circuit loss variation with time



5.7. Cycling

Sunica.plus is designed to withstand the daily cycling encountered in photovoltaic applications. It can operate at a partial state of charge without detriment.

The available cycling life depends on the Depth Of Discharge (DOD) each day. A shallow cycle (say 15 %) will give more than 10000 cycles, whereas a deep cycle (say 80 %) will give about 1000 cycles. The available cycling life also depends on the operating temperature of the Sunica.plus. At higher temperatures, the number of expected cycles will decrease.

Figure 4 shows the number of expected cycles as a function of Depth Of Discharge (DOD) and operating temperature. The number of cycles given are after a 30 % capacity loss where 70 % of the beginning of life capacity is still available for use.

In practice, in photovoltaic applications, the battery is exposed to a large number of relatively shallow cycles. The cycles are normally operated at different states of charge due to the variation of sun insolation each day. In order to simulate this, the IEC Standard 61427-1 specifies an accelerated cycling test. The procedure replicates a photovoltaic energy system operating in very severe conditions. It consists of a period of operation with a high state of charge, to simulate the effect of overcharge on the lifetime of the battery, and a period of operation with a low state of charge, to simulate the effect of a poor state of charge on a battery. The cycling is done at +40°C (+104°F). With this extreme scenario, the test results should demonstrate the survivability of a battery when used in a worst case photovoltaic operating regime.

Figure 4. Typical cycle life values at different temperatures

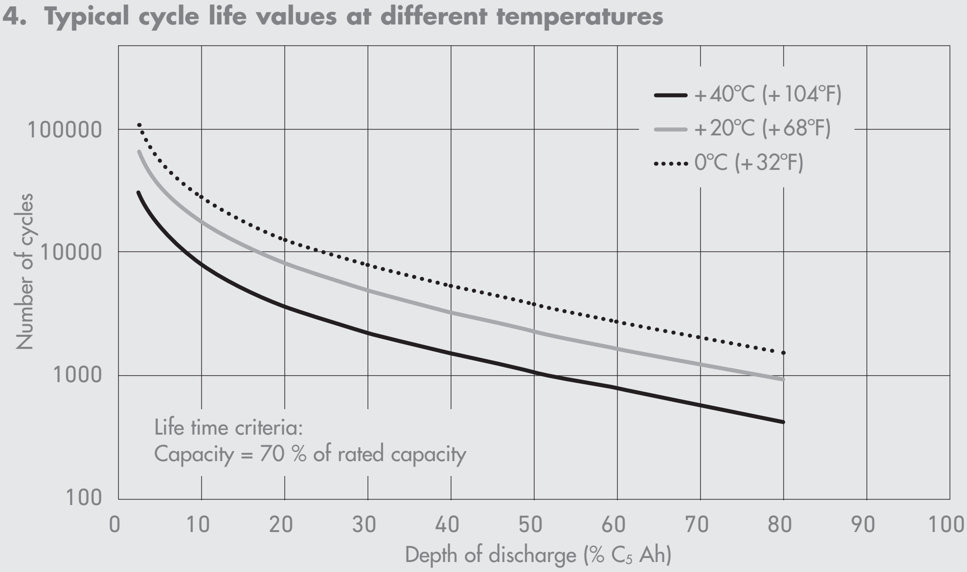
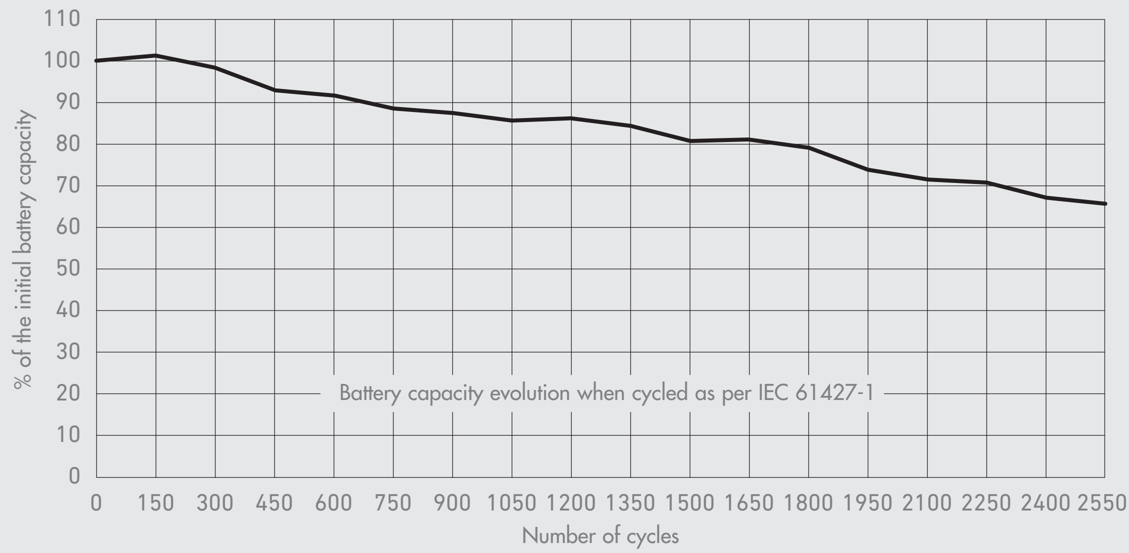


Figure 5. Sunica.plus cycling to IEC Standard 61427-1



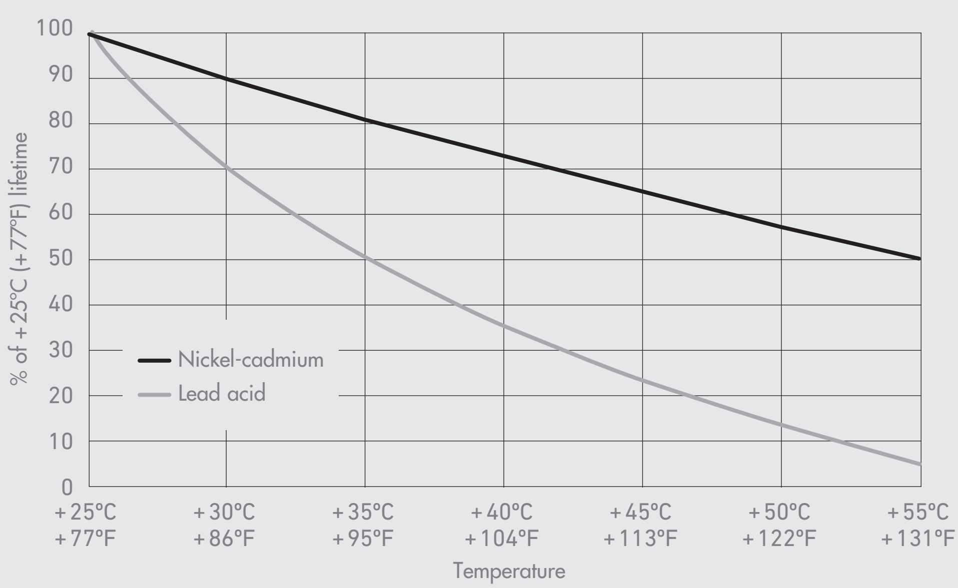
The Sunica.plus delivered 1800 cycles according to IEC 61427-1 (see Figure 5). The test results demonstrate its superior cycling ability after being subjected to continuous cycling at a partial state of charge (low and high) and at a fixed +40°C (+104°F).

5.8. Effect of temperature on lifetime

Sunica.plus is designed as a twenty year life product but, as with every battery system, increasing temperature reduces the expected life. However, the reduction in lifetime with increasing temperature is much lower for the Sunica.plus when compared to the lead acid battery. As referenced in IEEE 1106 standard, the general rule of thumb when considering the aging characteristic of nickel-cadmium is that is will lose approximately 1% of its capacity per year at temperatures less than or equal +25°C (+77°F).

The available calendar life as a function of temperature of Sunica.plus is compared with a lead acid battery in Figure 6. In sizing calculations, it is common to predict the lifetime of the Sunica.plus to be the same at +25°C to +30°C (+77°F to +86°F). This is normal since the actual observed lifetimes in the field often exceed the general rule of thumb.

Figure 6. Available calendar life as a function of temperature



In general terms for every +10°C (+18°F) increase above +25°C (+77°F), the calendar life of the Sunica.plus is reduced by 20 %. The lead acid battery is reduced by 50 % in the same case.

5.9. Water consumption

Water in the electrolyte is consumed when the Sunica.plus is overcharged. It is necessary to overcharge each cycle to maintain a high state of charge since the charge efficiency is less than unity.

This overcharge, breaks down the water of the electrolyte into oxygen and hydrogen gas. Gas that is not recombined will exhaust from the cell. As a result, distilled water has to be added periodically.

Water loss is associated with the current used for overcharging. A battery which is constantly cycled i.e. is charged and discharged daily, will consume more water than a battery on standby operation.

A recombination separator is used in the Sunica.plus and it reduces the water usage considerably by enhancing the internal recombination of gas.

The consumption of water varies according to the voltage, temperature and the level of cycling.

Table 2 summarizes the minimum expected watering interval of the Sunica.plus.

Table 2 - Typical watering interval of Sunica.plus

Charge voltage	1.5 V	1.55 V	1.6 V
Daily DOD	5 % to 10 %	10 % to 15 %	15 % to 25 %
Topping-up interval at + 20°C (+ 68°F)	6 years	4 years	2 years
Topping-up interval at + 40°C (+ 104°F)	3 years	2 years	1 year

6. Battery charging

6.1. Charging generalities

The photovoltaic array converts solar irradiance into dc electrical power.

Unlike a mains connected system, the output from a photovoltaic array is variable. To obtain the best efficiency from the system, it is normal for the photovoltaic array to include some form of charge control.

When the solar panels are sized in such a way that they can provide the needed energy to the load during the season of low solar radiation, the Sunica.plus will operate at a partial state of charge. In the high solar radiation season, the extra energy is then available for recovering full battery capacity.

In practice, the charge voltage is the main parameter which can be used to optimise the state of charge of the Sunica.plus for a given solar application.

The optimised charge voltage is linked to the daily Depth Of Discharge (DOD) which depends on the sized autonomy. The optimized charge voltage is set to maintain a high state of charge cycle after cycle with low water consumption.

6.1.1 The daily Depth Of Discharge (DOD)

In order to define the optimised charge voltage, it is necessary to define the daily DOD. This daily DOD is determined from the fact that the Sunica.plus is charging during the day and is discharging during the night. For example, with a Sunica.plus sized to deliver between 2 to 5 days of autonomy, the daily DOD will range from 5 to 20 % DOD.

The following example illustrates a typical daily DOD.

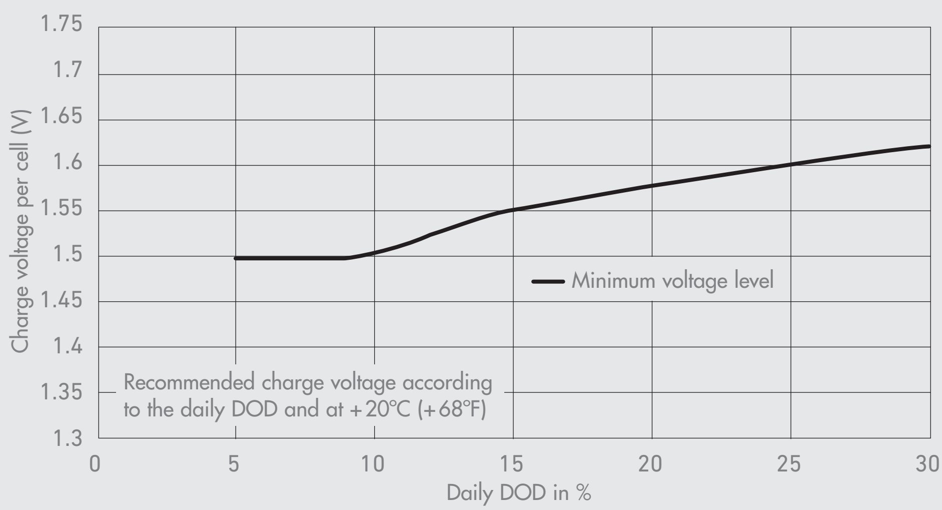
The Sunica.plus was sized for 5 days of autonomy with a load of 50 W. It follows that the needed energy is, 5 x 24 x 50 W = 6000 Wh
The energy discharged during the night is 50 W for about 12 h. So, each day the Sunica.plus has to supply 50 W x 12 h = 600 Wh.
From this the daily DOD is 600 Wh / 6000 Wh i.e. 10 %. The daily DOD varies due to the actual hours of discharge required each night.

6.1.2 Optimum charge voltage

The needed charge voltage to maintain a high state of charge depends on the daily DOD. Deeper daily DOD, the higher the charge voltage is needed with a given amount of sun insolation each day.

The charge voltage values are optimized in order to keep the high state of charge at the same level regardless of the daily DOD. Figure 7 illustrates the recommended charge voltage as a function of daily DOD.

Figure 7. Charge voltage required for high state of charge



When cycling with this recommended charge voltage, the Sunica.plus will stabilize at greater than 95 % state of charge. The solar panels should be sized to provide a minimum needed energy to maintain this high state of charge. Values for the minimum needed charge energy is provided in the Saft sizing outputs.

6.2. Charge efficiency

The charge efficiency of Sunica.plus is dependent on the state of charge of the battery and the temperature. At states of charge lower than 80 % and temperatures between +10°C to +25°C (+50°F to +77°F), it is recharged at a high level of efficiency. When cycling at +20°C (+68°F), at the recommended value of charge voltage, the Ah efficiency is close to 100 % at a 50 % state of charge. The efficiency is better than 90 % at 95 % state of charge. At higher temperatures the Ah efficiency is reduced. At +40°C (+104°F), the charge efficiency ranges between 96 % to 82 % between 50 % and 95 % state of charge. When the charge voltage is less than or more than the recommended value, the stabilised state of charge and the charge efficiency will vary up or down accordingly.

The relationship between the charge efficiency and the daily Depth Of Discharge (DOD), autonomy and charge voltage for +20°C (+68°F) is shown in Table 3.

Table 3 - Typical Ah efficiencies under different application conditions

Daily DOD	Typical autonomy	Charge voltage per cell	Expected SOC	Ah efficiency at H SOC	Ah efficiency at 50 % SOC
5 to 10 %	5 days or +	1.5 V	95 %	>90 %	≈100 %
10 to 15 %	3 to 5 days	1.55 V	95 %	>90 %	≈100 %
15 to 25 %	2 to 5 days	1.6 V	95 %	>90 %	≈100 %

It is important to note that the charging efficiency of Sunica.plus is not reduced with time and so this does not have to be taken into account in battery sizing.

In practice, a photovoltaic system's battery normally has a state of charge between 20 % and 80 % and in this case the charging efficiency of Sunica.plus remains high.

6.3. Temperature effects

As the temperature increases, the electrochemical behaviour becomes more active and so, for the same charge voltage, the current at the end of charge increases. This current increase compensates for the variation in charge efficiency at high temperatures. For this reason, it is not recommended to use temperature compensation of the charge voltage at ambient temperatures above 0°C (+32°F). In terms of water loss, this is not increased significantly at these higher temperatures due to the effectiveness of the partial gas recombination features of Sunica.plus.

As the ambient temperature is reduced, then the reverse occurs. In that case, when the ambient temperature falls below 0°C (+32°F), using temperature compensation of the charge voltage is recommended. This is particularly useful to maintain a high state of charge in the critical period of the year.

The temperature compensated charge voltage should be equivalent to -3.0 mV per °C and per cell (-1.68 mV per °F per cell) when the ambient falls below 0°C (+32°F).

6.4 Regulators

6.4.1 A pulse width modulator (PWM) type regulator

For a PWM type regulator the advised charge voltage should be based on the daily Depth Of Discharge (DOD) according to the values in Table 4.

Table 4 - PWM regulator recommended charge voltages for different conditions

Voltage system	12 V	24 V	48 V
Typical number of Ni-Cd cells	9	18	36
Daily DOD	**Typical autonomy**	**Charge voltage per cell**	
5 to 10 %	5 days or +	1.5 V	
10 to 15 %	3 to 4 days	1.55 V	
15 to 25 %	2 to 3 days	1.6 V	

6.4.2 A battery regulator based on the switching principle

For this type of regulator it is useful to define the boost threshold (not mandatory), the float threshold and the charge reconnect threshold.

Typical threshold values for a battery system with Sunica.plus defined for 5 days or more autonomy is shown in Table 5.

Table 5 - Typical threshold values for switching type regulator

Voltage system	12 V	24 V	48 V
Typical number of Ni-Cd cells	9	18	36
Boost threshold (not mandatory or 1.65 V per cell)	14.7 V	29.4 V	58.8 V
Float threshold (by 1.55 V per cell)	14.1 V	28.2 V	56.4 V
Battery reconnect threshold (by 1.45 V per cell)	13 V	26 V	52 V
End of discharge threshold (not mandatory or 1 V per cell)	9 V	18 V	36 V

6.4.3 Recommendation for choosing the voltage regulators

The charge voltages shall be adjustable due to the wide charge voltage range of Sunica.plus. The low voltage disconnect shall be adjustable or inhibit due to the deep discharge possible of the Sunica. plus. Regulators with voltage regulation using PWM systems are recommended due to the need of maintaining the charge voltage on the battery during the daily charge process.

7. Special operating factors

7.1. Electrical abuse

7.1.1. Ripple effects

The nickel-cadmium battery is tolerant to high ripple and the only effect is that of increased water usage. In general, any commercially available charger or generator can be used for commissioning or maintenance charging of Sunica.plus.

7.1.2. Over-discharge

If more than the designed capacity is taken out of a battery then it becomes over-discharged. This is considered to be an abuse situation for a battery and should be avoided.

The Sunica.plus battery can be recovered from an over-discharge without any detrimental effects.

7.1.3. Overcharge

Overcharge is the effect of forcing current through a battery after it is fully charged. For Sunica.plus, with its generous electrolyte reserve, an increase in overcharge will not significantly alter the maintenance period. In the case of excessive overcharge, more frequent water replenishment is required but there will be no significant effect on the life of the battery.

7.2. Mechanical abuse

7.2.1. Shock loads

The Sunica.plus block battery concept complies with both IEC 60068-2-29 (bump tests at 5 g, 10 g and 25 g) and IEC 60068-2-77 (shock test 3 g), where g = acceleration.

7.2.2. Vibration resistance

The Sunica.plus block battery concept was tested to IEC 77 for 2 hours at 1 g and demonstrated compliance.

7.2.3. External corrosion

Sunica.plus nickel-cadmium cells are manufactured in durable polypropylene, all external metal components are nickel plated and these components are protected by a rigid plastic cover.

8. Battery sizing principles

8.1 Introduction

The photovoltaic systems type of use and the required reliability are the main factors when sizing the Sunica.plus battery.

Professional applications (emergency systems, sea-lights, radio beacons etc.) are generally oversized according to their importance and it is necessary to take into account the working conditions of the system.

It is not the purpose of this manual to give sizing methods for complete photovoltaic systems. However, it is useful to discuss the different factors which can affect the design of the system and the battery sizing. The array and battery size are related since the photovoltaic system must have array and battery sizes which are sufficient for the load to operate at all the required times throughout the year. The system could have a small array and a large battery or vice versa. However, there are limits to these sizes as, while the minimum array size is that which can deliver the annual daily load in the average daily insolation, the minimum battery size is that which can supply the overnight load.

8.2 The basic principles

The basic rules controlling the calculation of the correct battery for an application require the calculation of the following parameters:

Unadjusted capacity

This is the average daily load (in Ah per day) multiplied by the number of days of battery reserve. This capacity has to be adjusted according to the battery characteristics and operating conditions.

Discharge adjustment

This is the capacity adjusted for life. It is obtained by dividing the unadjusted capacity by the required capacity at the end of life (expressed as a percentage of the rated capacity). Figure 4 shows the number of cycles before reaching a capacity of 70 %.

Charge adjustment

It is recommended to use a charge voltage optimised for the daily DOD and temperature. With an optimized charge voltage, a high state of charge is optimized with the lowest water consumption. As a guideline, an optimized charge voltage will allow to keep a state of charge at 95 % in its daily cycling.

Temperature adjustment

Cell capacity ratings are defined at +20°C to +25°C (+68°F to +77°F). For temperatures outside this range, it is necessary to use the temperature correction factor (see Figures 1 and 2).

Design margin adjustment

It is a common practice to provide a design margin to allow for uncertainties in the load. This is usually in the range of 10 to 25 % (or a factor of 0.90 to 0.75).

Load current calculation

An equivalent load current is calculated. This makes it possible to use the performance table data at +20°C to +25°C (+68°F to +77°F).

The unadjusted energy can be determined by multiplying the load (watts/amps) by the hours of needed autonomy. This unadjusted energy/capacity can now be adjusted by the necessary adjustment factors to eventually determine the adjusted load to look up in the standard performance tables. The performance tables allow performance lookup based on anticipated end of discharge voltage.

8.3 Battery sizing example

In this example, a telecom application is considered.

Requirements

The average load current = 5 A / 8 days or 192 h of autonomy.

There is no information concerning the performance requirement at the battery end of life but we will assume that full autonomy is required. The average temperature is considered to be +40°C (+104°F) and the voltage window: 41.8 V to 54.4 V.

The expected load growth which has to be allowed for in the design is 10 %.

Unadjusted capacity

Calculating a simple unadjusted capacity we have 5 A x 192 = 960 Ah.

Discharge adjustment

As we anticipate achieving the full 8 days autonomy at the end of life, then, as described in 8.2 above, we will use a factor of 0.7 (70 % of initial capacity).

Charge adjustment

If the charge voltage is in accordance with the recommended value corresponding to the daily Depth Of Discharge (DOD), then the charge adjustment used is 0.95.

Temperature adjustment

The temperature adjustment value = 0.95 (Figure 1: + 40°C/+ 104°F)

Design margin

The design margin adjustment value is 0.9 as allowance for a load growth of 10 % is required.

Load current calculation

From this data, the calculated battery capacity is 960 Ah / (0.7 x 0.95 x 0.95 x 0.9) = 1688.4 Ah.

And the equivalent load current is 1688.4 Ah / 192 h = 8.8 A.

End voltage is 41.8 V / 36 cells = 1.16 V.

Battery selection in the performance table becomes 8 A / 192 h / 1.16 V = SUN+ 1830 (1 string is required).

Charge voltage calculation

The daily Depth Of Discharge (DOD) is calculated according to the methodology given in paragraph 6.1.1.

If we assume that the daily night duration during the critical month is 18 hours, then the daily DOD is 5 A x 18 h x 100/1830 Ah = 4.9 %. Thus the charge voltage to be used is 1.5 V per cell (see the table in paragraph 6.4.1) and the voltage at the battery terminals is 1.5 V x 36 = 54 V which is compatible with the load voltage window.

9. Installation and operating instructions

9.1 Receiving the shipment

Do not overturn the package. Check the packages and cells for transport damage.

The battery is shipped filled and charged, and is ready for immediate use. Transport seals are located under the lid of each vent; they must be removed prior to mounting.

The battery must never be charged with the plastic transport seals in place as this is dangerous and can cause permanent damage.

9.2. Storage

Store the battery indoors in a dry, clean, cool location (0°C to + 30°C /+ 32°F to + 86°F) and well-ventilated space on open shelves. Storage of a filled battery at temperatures above + 30°C (+ 86°F) can result in loss of capacity. This can be as much as 5 % per 10°C (18°F) above + 30°C (+ 86°F) per year. Do not store in direct sunlight or expose to excessive heat. Sunica.plus batteries are supplied filled with electrolyte and charged, they can be stored in this condition for a maximum of 24 months from date of shipment. Never drain the electrolyte from the cells. Store without opening the boxes.

9.3. Installation

9.3.1. Location

Install the battery in a dry and clean room. Avoid direct sunlight and heat.

The battery will give the best performance and maximum service life when the ambient temperature is between +10°C to +30°C / +50°F to +86°F.

9.3.2. Ventilation

During the last part of charging, the battery is emitting gases (oxygen and hydrogen mixture). At normal float charge, the gas evolution is very small but some ventilation is necessary.

Note that special regulations for ventilation may be valid in your area depending on the application.

9.3.3. Mounting

Verify that cells are correctly interconnected with the appropriate polarity. The battery connection to load should be with nickel plated cable lugs.

Recommended torques for terminal bolts are:

- M6=11 ± 1.1 N.m (97.4 ± 9.8 lbf.in)
- M8=20 ± 2 N.m (177.0 ± 17.7 lbf.in)
- M10=30 ± 3 N.m (265.0 ± 26.6 lbf.in)

The connectors and terminals should be corrosion-protected by coating with a thin layer of anti-corrosion oil. Remove the transport seals and close the vent caps.

If a central water filling system is used as an option, refer to the corresponding installation and operating instructions sheet.

9.3.4. Electrolyte

When checking the electrolyte levels, a fluctuation in level between cells is not abnormal and is due to the different amounts of gas held in the separators of each cell. The level should be at least 15 mm above the minimum level mark and there is normally no need to adjust it.

Do not top-up prior to initial charge.

After commissioning, when the level is stabilized, it should be not less than 5 mm below the maximum level mark.

9.4. Commissioning

Verify that the ventilation is adequate during this operation.

A good commissioning is important.

Charge at constant current is preferable. If the current limit is lower than indicated in Table 6, charge for a proportionally longer time.

Table 6

Cell type	Rated capacity 5 h - 1.00 V C_5 Ah (Ah)	Nominal capacity 120 h - 1.00 V C_{120} Ah (Ah)	Charging current 0.1 C_5 A (A)	Max. quantity of water to be added in cc	Cell connection bolt per pole
SUN+ 100	95	100	9.5	280	M8
SUN+ 150	140	150	14	380	M10
SUN+ 200	185	200	19	500	M10
SUN+ 250	235	250	24	590	M10
SUN+ 305	280	305	28	700	M10
SUN+ 355	325	355	33	880	2xM10
SUN+ 405	375	405	38	1000	2xM10
SUN+ 455	420	455	42	1100	2xM10
SUN+ 505	470	505	47	1200	2xM10
SUN+ 555	515	555	52	1300	2xM10
SUN+ 610	560	610	56	1400	2xM10
SUN+ 660	610	660	61	1600	3xM10
SUN+ 710	650	710	65	1700	3xM10
SUN+ 760	700	760	70	1800	3xM10
SUN+ 810	750	810	75	1900	3xM10
SUN+ 860	800	860	80	2000	3xM10
SUN+ 910	840	910	84	2100	3xM10
SUN+ 960	890	960	89	2300	4xM10
SUN+ 1015	940	1015	94	2400	4xM10
SUN+ 1065	980	1065	98	2500	4xM10
SUN+ 1115	1030	1115	103	2600	4xM10
SUN+ 1170	1080	1170	108	2700	5xM10
SUN+ 1215	1120	1215	112	2800	4xM10
SUN+ 1270	1170	1270	117	3000	5xM10
SUN+ 1320	1220	1320	122	3100	5xM10
SUN+ 1370	1260	1370	126	3200	5xM10
SUN+ 1420	1300	1420	130	3300	5xM10
SUN+ 1470	1350	1470	135	3400	5xM10
SUN+ 1520	1400	1520	140	3500	5xM10
SUN+ 1570	1450	1570	145	3700	6xM10
SUN+ 1620	1500	1620	150	3800	6xM10
SUN+ 1670	1550	1670	155	3900	6xM10
SUN+ 1720	1600	1720	160	4000	6xM10
SUN+ 1775	1650	1775	165	4100	6xM10
SUN+ 1830	1700	1830	170	4200	6xM10

9.4.1. Cells stored up to 6 months:

A commissioning charge is normally not required and the cells are ready for immediate use. If full performance is necessary immediately, a commissioning charge as mentioned in section 9.4.2. is recommended.

9.4.2. Cells stored more than 6 months and up to 2 years:

A commissioning charge is necessary:

- Commissioning at ambient temperature between +10°C to +30°C (+50°F to +86°F)
  - Constant current charge: 20 h at 0.1 C_5 A recommended (see Table 6).

  Note: At the end of charge, the cell voltage will reach about 1.75 V, thus the charger shall be able to supply such a voltage.

When the charger maximum voltage setting is too low to supply constant current charging, divide the battery into two parts to be charged individually at constant current.

- Constant potential charge: 1.55 V/cell for a minimum of 24 h after current limited to 0.1 C_5 A (see the current in Table 6).

If these methods are not available, then charging may be carried out at lower voltages, 1.50 V/cell for 36 hours minimum.

• Commissioning at ambient temperature above +30°C (+86°F)
  - Only constant current charge: 20 h at 0.1 C_5 recommended.

The electrolyte temperature is to be monitored during charge. If the temperature exceeds +45°C (+113°F) during charging, then it must be stopped to reduce the temperature. The charging can be resumed when electrolyte temperature drops below +40°C (+104°F).

In the case of remote areas, where the only charger available is the photovoltaic array, the battery should be connected to the system with no connected load and no voltage limit.

The battery should then be charged in good sunshine conditions. During this operation, the Ah charged shall be in the magnitude of 1.6 times the rated capacity, and, in order to limit the risk of electrolyte overflow, it is recommended not to exceed the charge current value specified in Table 6.

9.4.3. Cell electrolyte after prolonged float charge:

Check the electrolyte level and adjust it to the upper level mark by adding distilled or deionized water.

Note: When full battery performance is required for capacity test purposes, the battery has to be charged in accordance with IEC 62259 section 7 (7.1 & 7.2).

9.5 Charging in service

The photovoltaic array converts solar irradiance into DC electrical power at a pre-determined range of voltages whenever sufficient solar radiation is available. Unlike a main connected system, the output from a photovoltaic array is variable and, to obtain the best efficiency from the system, it is quite normal to have some form of charge control.

Two main techniques for charging the batteries are generally used in photovoltaic systems. These are those which have a constant voltage limitation based on the PWM technics and those with several voltage steps charging where the battery, by switching means, is charging up to a high pre-set voltage (boost or float threshold), then drops to a lower voltage level (battery reconnect threshold) and then back to the high pre-set voltage and so on.

Recommended charging voltages for a typical photovoltaic application sized for 5 days or more back-up time:
a) case of constant voltage limitation (PWM regulator system or similar)
• float: 1.50 V/cell
• boost (not mandatory): 1.65 V/cell
b) case of regulators based on the switching principle:
• boost threshold (not mandatory): 1.65 V/cell
• float threshold: 1.55 V/cell
• battery reconnect threshold: 1.45 V/cell

For lower back-up time, the values have to be increased depending of the load requirement. Consult the manufacturer.

For use in warm areas, a temperature compensation on the charge voltage is not recommended.
For use in cold areas, a temperature compensation is recommended to increase the charge acceptance.
The recommended value is: -3.0 mV/°C/cell (-1.68 mV/°F/cell) starting from +20°C (+68°F).

10. Maintenance

In a correctly designed standby application, Sunica.plus requires the minimum of attention.

However, it is good practice with any system to carry out an inspection of the system once per year or at the recommended topping-up interval period to ensure that the charging system, the battery and the ancillary electronics are all functioning correctly.

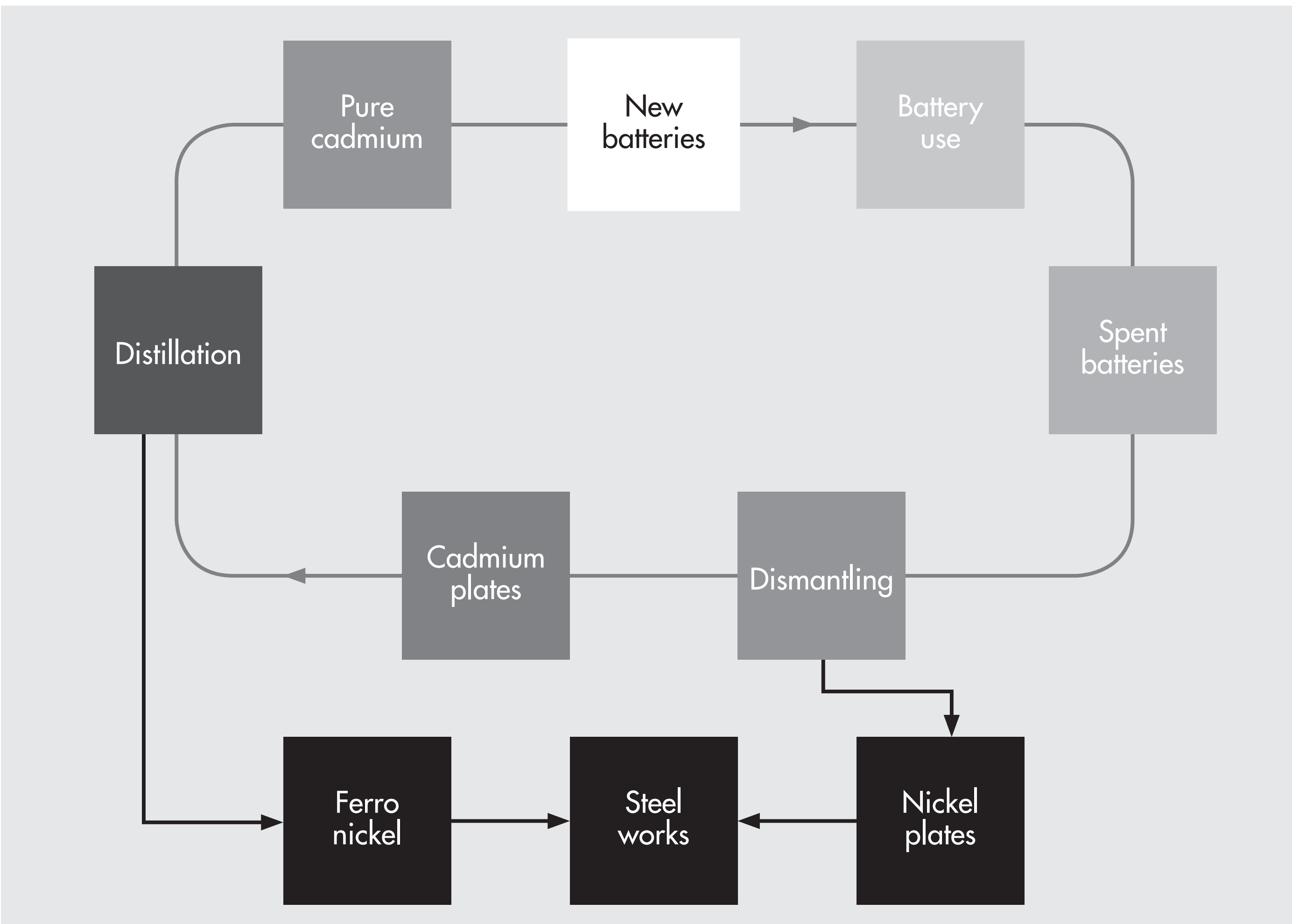
When this system service is carried out, it is recommended that the following actions should be taken:

- Keep the battery clean using only water. Do not use a wire brush or solvents of any kind.
- Check the charging voltage. In parallel operation, it is of great importance that the recommended charging voltage remains unchanged. The charging voltage should be checked at least once yearly. If a cell float voltage is found below 1.35 V, high rate charge is recommended to apply to the cell concerned.
- Check visually the electrolyte level. Never let the level fall below the minimum level mark. Use only distilled or de-ionized water to top-up. Topping-up of the Sunica.plus battery shall be carried out when battery is fully charged.
  Note: There is no need to check the electrolyte density periodically. Interpretation of density measurements is difficult and could be misleading.
- Check every two years that all connections are tight. The connectors and terminal bolts should be corrosion-protected by coating with a thin layer of anti-corrosion oil.
- High water consumption is usually caused by improper voltage setting of the charger.

11. Disposal and recycling

In a world where autonomous sources of electric power are ever more in demand, Saft batteries provide an environmentally responsible answer to these needs. Environmental management lies at the core of Saft's business and we take care to control every stage of a battery's life cycle in terms of potential impact. Environmental protection is our top priority, from design and production through end-of-life collection, disposal and recycling.

Our respect for the environment is complemented by an equal respect for our customers. We aim to generate confidence in our products, not only from a functional standpoint, but also in terms of the environmental safeguards that are built into their life cycle. The simple and unique nature of the battery components make them readily recyclable and this process safeguards valuable natural resources for future generations.



Standards list:

§ Certified IEC 62259 - Secondary cells and batteries containing alkaline or other non-acid electrolytes - Nickel-cadmium prismatic secondary single cells with partial gas recombination. Sunica.plus exceeds gas recombination requirements.

§ Certified IEC 60623 - Secondary cells and battery containing alkaline and other non-acid electrolytes - Vented nickel-cadmium prismatic secondary single cells

§ IEC 60068-2-29 - Environmental testing - Part 2: Tests. Test Eb and guidance: Bump

§ IEC 60068-2-77 - Environmental testing - Part 2-77: Tests - Test 77: Body strength and impact shock

§ Complies with EN 50272-2 / IEC 62485-2 - Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries - The protective covers for terminals and connectors, the insulated cables are compliant with IP2 level protection against electrical shocks according to safety standard.

§ Complies with IEC 61427-1 - Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 1: Photovoltaic, off-grid application.

Saft is committed to the highest standards of environmental stewardship

As part of its environmental commitment, Saft gives priority to recycled raw materials over virgin raw materials, reduces its plants' air and water releases year after year, minimizes water usage, reduces fossil energy consumption and associated CO_2 emissions, and ensures that its customers have recycling solutions for their spent batteries.

Regarding industrial nickel-based batteries, Saft has had partnerships for many years with collection companies in most EU countries. This collection network receives and dispatches our customers' batteries at the end of their lives to fully approved recycling facilities, in compliance with the laws governing trans boundary waste shipments.

This collection network meets the requirements of the EU batteries directive. A list of our collection points is available on our web site. In other countries, Saft assists users of its batteries in finding environmentally sound recycling solutions. Please contact your sales representative for further information.

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