Uptimax Ni-Cd battery

Technical manual

saft

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. To offer a highly reliable battery of zero or ultra-low maintenance Saft has developed the Uptimax maintenance-free pocket plate battery. The term "maintenance-free" in this publication means that no addition of water is necessary during the lifetime of the product when operated under Saft's recommended conditions.

This publication details the design and operating characteristics of the Saft Nife brand Uptimax battery. When operated in recommended conditions, Uptimax will not require any topping-up during its entire service life. Other regular maintenance checks are still necessary (see section 10 Installation and operating instructions). In addition to all the well-proven advantages of the nickel-cadmium pocket plate battery, Uptimax offers exceptional electrical performance enabling customers to benefit from a smaller battery capacity to suit their specific applications. Saft Uptimax is certified compliant to IEC 60623 / IEC 62259 battery standards.

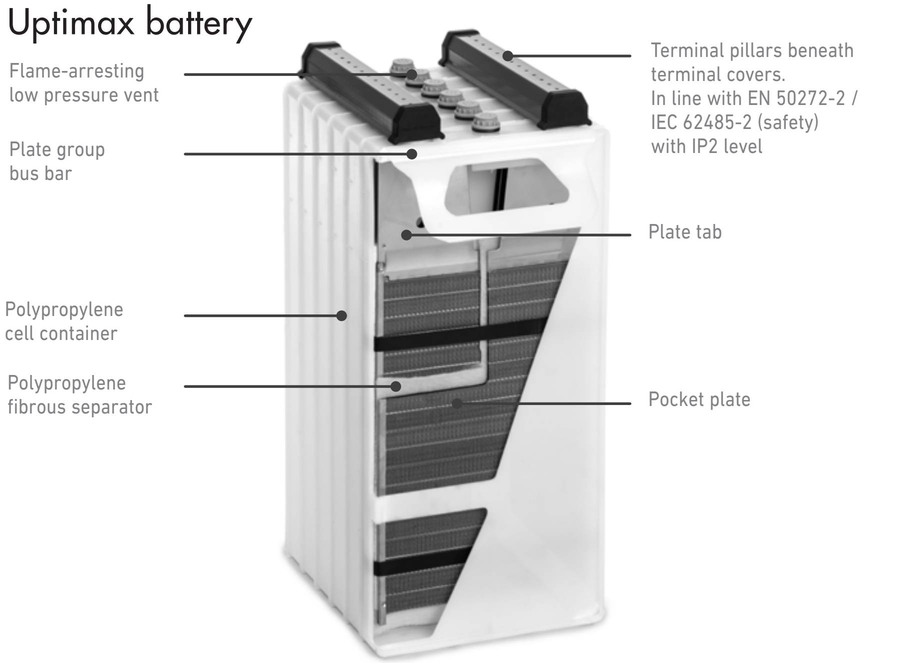
2. Applications

- UPS
- Process control
- Emergency systems
- Security systems
- Offshore oil and gas
- Switchgear

Uptimax batteries are designed to supply the ideal maintenance-free power backup solution for installations that demand maximum reliability and optimum TCO (Total Cost of Ownership) while operating for long periods at high ambient temperatures. Uptimax is especially suited for the oil and gas, utility and electricity industries where availability and reliability of backup power is essential.

3. Construction features

Uptimax battery



Cells are welded together to form rugged blocks up to 10 depending on cell size and type.

Construction of the Saft Nife brand Uptimax cell is based upon Saft pocket plate technology and a new high-tech concept designed to achieve maintenance-free operation in terms of topping-up, improved performance and chargeability.

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 Uptimax pocket plate are retained in pockets formed from nickel-plated steel strips double-perforated by a patented process. These pockets are mechanically linked together, cut to the size corresponding to the plate width and compressed to the final plate dimension. This process leads to a component which is not only mechanically robust but also retains its active material within a steel boundary which promotes conductivity and minimizes electrode swelling.

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

The alkaline electrolyte does not react with steel, which means that the supporting structure of the Uptimax 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 Uptimax 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 and 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 to provide the level of recombination required. 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 Uptimax, which is a solution of potassium hydroxide and lithium hydroxide, is optimized to give the best combination of performance, life and energy efficiency over a wide operational temperature range.

With the Uptimax, as with all nickel cadmium, the electrolyte concentration does not change significantly between a full charged state and a full discharged state. 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.

There are two types.

a) The standard type concentration is such as to allow the cell to be operated to temperature extremes as low as - 20°C (- 4°F) and as high as + 70°C (+ 158°F). This allows the very high temperature fluctuations found in certain remote regions to be accommodated.

b) For continuous temperatures below - 20°C (- 4°F) an arctic electrolyte is used. It is a special high density electrolyte.

3.4 Terminal pillars

Short terminal pillars are welded to the plate bus bars using a well-proven battery construction method. 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

Uptimax is fitted with a flame-arresting low-pressure vent for each cell of the battery. This vent operates as a one way valve (as defined in IEC 60050-482) which will allow the release of small quantities of hydrogen and non-recombined oxygen. It allows venting if the internal pressure exceeds a fixed safety value. The self-closing vent has an integral porous disk, for flame-arresting function, to prevent an external ignition from spreading into the Uptimax cell.

3.6 Cell container

The Uptimax is built up using the well-proven Saft block battery construction. The tough polypropylene containers are welded together by a heat sealing technique. The assembly of the blocks is completed by a clip-on terminal cover which gives protection to IP2X according to IEC 60529 standard for the conductive parts.

4. Principles of the oxygen recombination cycle

In a conventional flooded electrolyte pocket plate nickel-cadmium battery water is lost from the battery on overcharge due to the following reactions:

At the positive plate

$$4OH^- \longrightarrow 2H_2O + O_2 + 4e^-$$

(Oxygen evolution)

At the negative plate

$$4H_2O + 4e^- \longrightarrow 2H_2 + 4OH^-$$

(Hydrogen evolution)

This corresponds to a theoretical loss of 36 g of water for 107 Ah of overcharge i.e. 0.335 cm^3 per Ah. Hence a conventional cell requires periodic addition of water. The frequency of this operation depends upon the cumulative amount of charge received and the operating temperature.

During the charging process evolution of oxygen begins to occur a little before the positive plate reaches its fully charged state and then becomes the main reaction when the fully charged condition is reached. However, the cadmium negative plate has a better charge acceptance than the positive plate and hydrogen is not evolved until this plate is virtually fully charged.

The oxygen which is produced at the positive plate surface is collected by the special porous separator and thus not allowed to escape from the region between the plates. Some displacement of electrolyte within the separator occurs, thus generating extra unfilled pores for the diffusion of oxygen directly to the adjacent cadmium negative plate.

As soon as the oxygen reaches the negative plate it reacts either chemically or electrochemically. In both cases, the oxygen recombination prevents the negative plate from fully charging and in turn it suppresses the evolution of hydrogen gas. In the Uptimax design, the separator and plate stack are optimized to minimize hydrogen evolution and water usage when operated as recommended. This ensures a long service life without the need to replenish with water. The Uptimax recombination is exceeding the IEC 62259 minimum requirement level of 70 % and achieves more than 95 %.

The Uptimax battery is fitted with a low pressure vent on each cell. On overcharge the cells have an internal pressure above atmospheric pressure. The vent acting as a valve provides an outlet for the release of small quantities of hydrogen and non-recombined oxygen and thus controls the internal pressure. When the pressure falls below the release pressure either on open circuit or on discharge the vent reseals to prevent ingress of air and to minimise self-discharge reactions.

5. Battery features

Complete reliability
Does not suffer from the sudden death failure due to internal corrosion associated with other battery technologies.

Long cycle life
The Uptimax battery has a long cycle life even when the charge/discharge cycle involves 100 % depth of discharge (see section 6.7 Cycling).

Exceptionally long floating lifetime
A lifetime in excess of twenty years is achieved by Uptimax in many applications, and at elevated temperatures it has a superior life when compared to other available battery technologies.

Maintenance-free
With its special recombination separator combined with its low pressure vent and generous electrolyte reserve, Uptimax eliminates the need for topping-up with water under recommended operating instructions – from - 20°C (- 4°F) to + 40°C (+ 104°F) at 1.39 V/cell. Note that it is possible to add water if required.

Simple installation
Uptimax can be used with a wide range of stationary and mobile applications as it produces no corrosive vapors, uses corrosion-free polypropylene containers and has a simple bolted connector assembly system (see section 10 Installation and operating instructions).

Wide operating temperature range
Uptimax employs an electrolyte which allows a normal operating temperature of from - 20°C to + 40°C (- 4°F to + 104°F) and accepts extreme temperatures, ranging from as low as - 40°C with arctic electrolyte to + 70°C (- 40°F to + 158°F) (see section 3.3 Electrolyte).

Fast recharge/improved chargeability
Uptimax can be recharged at high currents which allow very fast recharge times to be achieved (see section 7.4 Charge efficiency).

Resistance to mechanical abuse
Uptimax is designed with a high mechanical strength. It withstands all the harsh treatment associated with transportation over difficult terrain (see section 8.2 Mechanical abuse).

High resistance to electrical abuse
Uptimax will survive abuse which would destroy other battery technologies. For example, it can withstand overcharging, deep discharging, and high ripple currents without damage (see section 8.1 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. This expertise has been built into the twenty-plus years' design life of the Uptimax product (see section 3 Construction features of the Uptimax battery).

Extended storage
When stored in the filled and charged state in normal condition (0°C to + 30°C / + 32°F to + 86°F), Uptimax can be stored for up to 2 years (see section 10 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 12 Disposal and recycling).

Low life-cycle cost
When all the factors of lifetime, low maintenance requirements, simple installation and storage and resistance to abuse are taken into account, Uptimax becomes the most cost effective solution for many professional applications.

6. Operating characteristics

6.1 Capacity

The Uptimax battery capacity is rated in ampere-hours (Ah). Its rated Ah is the quantity of electricity at + 20°C (+ 68°F) which it can supply for a 5 hours runtime to 1.0 V/cell after being fully charged. This is in accordance with both IEC 62259 and IEC 60623 standard.

In accordance with these IEC standards, the current can be expressed as a function of this 5 hours capacity or the C_5 capacity. For example, the expression 0.2 C_5 A is equal to 20 % of the C_5 capacity in Amps. The expression follows the IEC specification since the declared nominal capacity (C_n) is the runtime of 5 hours. So in that case, 100 % of the Ah is delivered in 5 hours of runtime at C_5/5 A or 0.2 C_5 A. When the discharge current deviates from 0.2 C_5 A so will the delivered capacity or runtime.

In practice, Uptimax is used in floating conditions and so the tabular data is based upon cell performance after several months of floating. This eliminates certain correction factors which need to be used when sizing batteries with constant current charged cell data (see section 9 Battery sizing principles).

6.2 Cell voltage

The cell voltage of 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 cell voltage is 1.2 V.

6.3 Internal resistance

The internal resistance of a cell varies with the temperature and the state of charge.

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 an Uptimax 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.

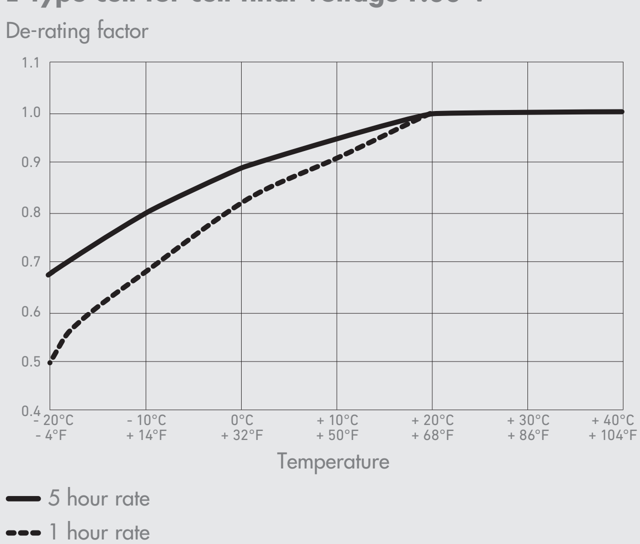
6.4 Effect of temperature on performance

Variations in ambient temperature affect the performance of Uptimax and this needs to be taken into account when sizing the battery.

Low temperature operation reduces the discharge performance but at the high temperature, the discharge performance is similar to those at normal temperatures.

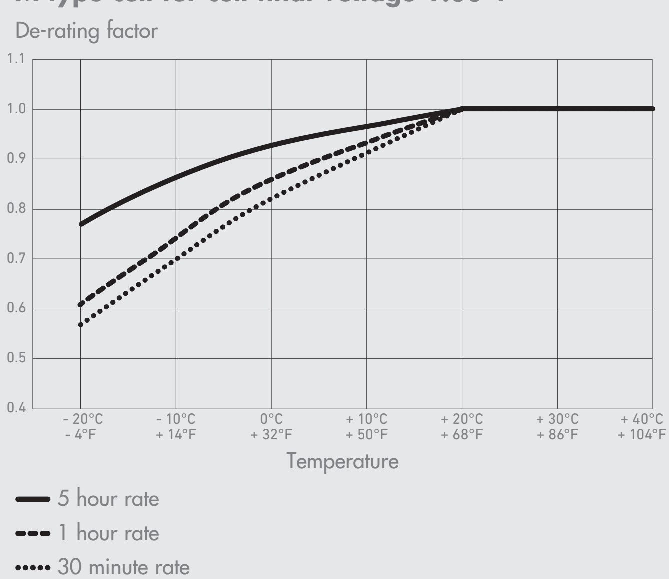
Temperature de-rating factors for L and M type cells are given in Figure 1(a) and Figure 1(b) for operating temperature - 20°C to + 40°C (- 4°F to + 104°F).

Figure 1(a): Temperature de-rating factors for L type cell for cell final voltage 1.00 V



Typical de-rating factors for published performance data for cells in floating applications

Figure 1(b): Typical de-rating factors for M type cell for cell final voltage 1.00 V



Typical de-rating factors for published performance data for cells in floating applications

6.5 Short-circuit values

The typical short-circuit value of an Uptimax cell is given in Table 1. The Uptimax battery is designed to withstand a short-circuit current of this magnitude for many minutes without damage.

Table 1: Short-circuit currents at + 20°C (+ 68°F) for fully charged cells

Type	Amperes
L	6 * C_5 A
M	11* C_5 A

6.6 Open circuit loss

The state of charge of Uptimax on open circuit slowly decreases with time due to self-discharge. In practice this decrease is relatively rapid during the first two weeks but then stabilizes to about 2 % per month at + 20°C (+ 68°F).

The self-discharge is affected by the temperature. At low temperatures the self-discharge decreases and so 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 Uptimax is shown in Figure 2 for a one year period.

6.7 Cycling

Uptimax is a maintenance-free product when used under recommended conditions in stationary and not continuous cycling applications. Nevertheless, it is designed using conventional pocket plate electrode technology and has therefore an equivalent cycling capability.

If Uptimax is used in a continuous cycling application, the water consumption may be significantly increased. In that case, watering the cells during their useful life will be necessary. However, there are cycling applications where Uptimax can be beneficial. This will depend on the frequency and depth of discharge involved. For example, in a poor power quality stationary application, the Uptimax battery can provide superior cycling duty with infrequent or no watering intervals (see section 8).

6.8 Water consumption

The Uptimax battery works on the oxygen recombination principle and therefore has a reduced water consumption. The Uptimax recombines at least at a level of 95 % when float charging (as per IEC 62259 methodology). It has a water usage reduced by a factor of up to 10 times of that of an open flooded cell. When operated as recommended, the Uptimax will not need topping-up during its entire service life.

6.9 Gas evolution

Gas is generated during overcharge through electrolysis when gas doesn't recombine, it will eventually exhaust from the cell. The electrolysis of 1 cm^3 of water produces about 1865 cm^3 of gas mixture and this gas mixture is in the proportion of 2/3 hydrogen and 1/3 oxygen. Thus the electrolysis of 1 cm^3 of water produces about 1243 cm^3 of hydrogen.

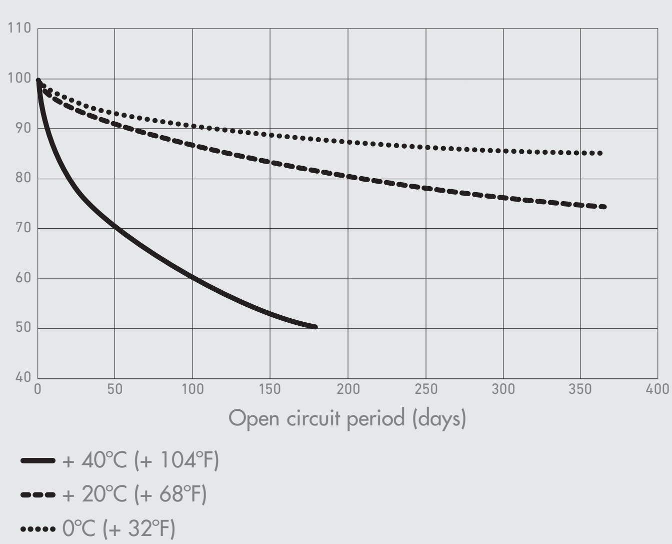
Table 2 gives the values for I_{gas} used to estimate ventilation needs in accordance with IEC 62485-2 / EN 50272-2.

Table 2: Values for current I_{gas} producing gas when charging at constant current or potential

	I_{gas} (mA/Ah)
Under float charge conditions 1.39 V/cell	1.5
Under float charge conditions 1.42 V/cell	2
Under boost charge conditions 1.45 V/cell	5
Under all commissioning charge conditions Constant current charge and constant potential charge	200

Figure 2: Typical open circuit loss variation with time

Percentage of initial capacity %



7. Battery charging

In order to ensure that the maintenance-free properties of the Uptimax battery are achieved, it is necessary to control the charge input to the battery to optimize the rate of water loss during the life of the product.

The Uptimax battery must be properly commissioned (see section 10) before putting in service and applying the following charging methods.

It is important therefore that the recommended charge conditions are complied with.

7.1 In service – charging methods

Uptimax can be charged with a single level or a two level charge method.

The single level charging method is adequate to maintain the Uptimax in a good state of operation over its useful life. This charge method is sufficient when Uptimax is used in stationary power applications with occasional discharges and the installation, commissioning and operation is done in accordance with Saft Installation and Operating instructions (see section 10).

The two level constant potential charging method is used when a fast recharge is important.

Two options of charging voltages are possible for float and single level charging: either 1.39 V/cell or 1.42 V/cell.

The first one is particularly adapted to narrow voltage windows and the second one is used when the charger and the load accept a wider voltage window to reach faster a high State Of Charge .

a) Single level charging

Uptimax batteries are float charged at 1.39 ± 0.01 V/cell or 1.42 ± 0.01 V/cell from a fully discharged condition to a high state of charge.

See section 7.2 regarding temperature compensation.

b) Two level constant voltage charging

The two level constant voltage charging consists of a first high rate (boost) charging stage to a maximum voltage of 1.45 ± 0.01 V/cell for up to 12 hours.

After a prolonged mains failure the first stage can be initiated manually or automatically. After this first stage the charger should be switched to float charge at a voltage of 1.39 ± 0.01 V/cell or 1.42 ± 0.01 V/cell.

See section 7.2 regarding temperature compensation.

Table 3: Temperature Compensated Voltage (TCV) control

T (°C)	T (°F)	1.39 V/ cell -3 mV / °C / Cell (-1.68 mV / °F / Cell)	1.42 V/ cell -2.5 mV / °C / Cell (-1.4 mV / °F / Cell)
-20	-4	1.510	1.520
-10	14	1.480	1.495
0	32	1.450	1.470
10	**50**	**1.420**	**1.455**
20	68	1.390	1.420
30	86	1.390	1.395
40	104	1.390	1.370

7.2 Temperature compensation

The recommended float and single level charge voltage for Uptimax is 1.39 V/cell or 1.42 ± 0.01 V/cell.

a) 1.39 V/cell charging voltage

Temperature Compensated Voltage (TCV) is mandatory from -20°C to +20°C (-4°F to +68°F) to avoid under charging of the battery.

If the average temperature is above +20°C (+68°F), TCV shall not be used. The electrolyte reserve of Uptimax is sufficient to last during the service life of the battery.

Table 3 gives the TCV values according to the operating temperature. If no TCV control is available, adjust manually the charging voltage to the value that corresponds to the operating temperature.

Short periods with temperatures below +20°C (+68°F) do not have to be considered. For example, if there is a daily variation of the temperature, with a minimum temperature below +20°C (+68°F), and a daily average temperature at or above +20°C (+68°F), there is no need to compensate the charge voltage.

b) 1.42 V/cell charging voltage

TCV is mandatory from -20°C to +40°C (-4°F to +104°F). A charge voltage of 1.42 V/cell and the use of TCV allow Uptimax to operate without the need of watering maintenance over its useful life.

Table 3 gives the TCV values according to the operating temperature. If no TCV control is available, adjust manually the charging voltage to the value that corresponds to the operating temperature.

7.3 Charge acceptance

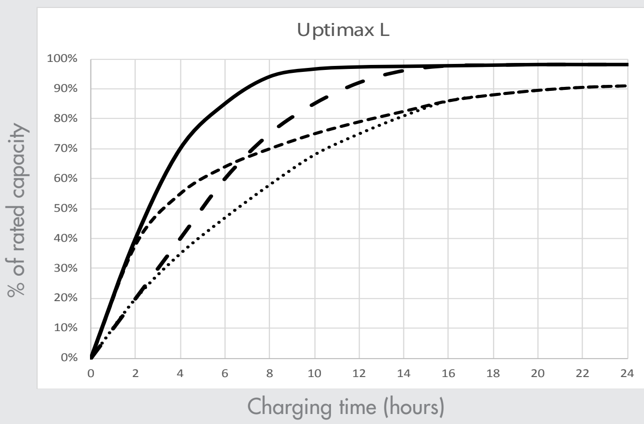
The performance data sheets for Uptimax are based upon several months' floating and so are for fully float charged cells. A discharged cell will take a certain time to achieve the state of charge. Figure 3 gives the available capacity during charge. For stationary application, the recommended charge voltage is 1.39 ± 0.01 V for floating and 1.45 ± 0.01 V for the first stage of a two step charge. Up to $0.2C_5$ A of recharge current can be used. A full state of charge will be reached in 1 to 3 months.

7.4 Charge efficiency

The charge efficiency of Uptimax is dependent on the state of charge of the battery and the temperature. For much of its charge profile it is recharged at a high level of efficiency. In general, at states of charge less than 80 % the charge efficiency remains high. When the battery approaches a fully charged condition, the charging efficiency decreases rapidly until fully charged when overcharge begins.

Figure 3(a): Available capacity after constant voltage charge

Available charge current 0.1 C_5A or 0.2 C_5A at +20°C (+68°F)

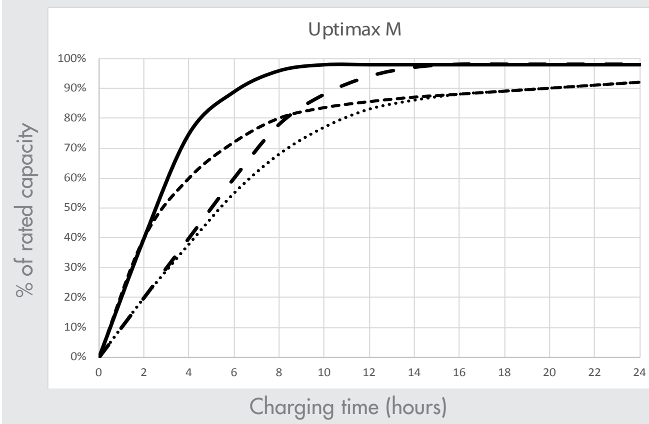


- 1.45 Vpc at + 20°C (+ 68°F), 0.2 C_5A
- 1.45 Vpc at + 20°C (+ 68°F), 0.1 C_5A
- 1.39 Vpc at + 20°C (+ 68°F), 0.2 C_5A
- 1.39 Vpc at + 20°C (+ 68°F), 0.1 C_5A

**For charging voltages higher than 1.45 V/cell, a current limit of 0.1 C_5A is recommended*

Figure 3(b): Available capacity after constant voltage charge

Available charge current 0.1 C_5A or 0.2 C_5A at +20°C (+68°F)



- 1.45 Vpc at + 20°C (+ 68°F), 0.2 C_5A
- 1.45 Vpc at + 20°C (+ 68°F), 0.1 C_5A
- 1.39 Vpc at + 20°C (+ 68°F), 0.2 C_5A
- 1.39 Vpc at + 20°C (+ 68°F), 0.1 C_5A

**For charging voltages higher than 1.45 V/cell, a current limit of 0.1 C_5A is recommended*

8. Special operating factors

8.1 Electrical abuse

8.1.1 Ripple effects

The nickel-cadmium battery is tolerant to high ripple from standard charging systems. Uptimax accepts ripple currents up to 0.2 C_5 A I_{eff}. In general, any commercially available charger or generator can be used for commissioning or maintenance charging of Uptimax.

8.1.2 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. However, the Uptimax battery is designed to recover from this situation.

8.1.3 Overcharge

Overcharge is the effect of forcing current through a battery when it is fully charged.

In the case of Uptimax, with its generous electrolyte reserve, a small degree of overcharge will not significantly alter the maintenance period. In the case of excessive overcharge or excessive cycling, water replenishment may be required but there will be no significant effect on the life of the battery.

8.2 Mechanical abuse

8.2.1 Shock loads

The Uptimax block battery concept complies with 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.

8.2.2 Vibration resistance

The Uptimax block battery concept complies with IEC 60068-2-77 where it was subjected to 2 hours at 1 g, where *g* = acceleration.

8.2.3 External corrosion

Uptimax nickel-cadmium cells are manufactured in durable polypropylene, all external metal components are nickel-plated and these components are protected by an anti-corrosion oil and a rigid plastic cover.

9. Battery sizing principles in stationary applications

There are a number of methods which are used to size nickel-cadmium batteries for standby floating applications. The method employed by Saft is the IEEE 1115 recommendation which is accepted internationally. This method takes into account multiple discharges, temperature de-rating, performance after floating and the voltage window available for the battery.

A significant advantage of the nickel-cadmium battery is that it can be fully discharged without a significant impact in terms of life or recharge. Thus, to obtain the most cost efficient battery, it is an advantage to discharge the battery to the lowest practical value in order to obtain the maximum energy from the battery.

The principle sizing parameters are:

9.1 The voltage window

This is the maximum voltage and the minimum voltage at the battery terminals acceptable for the system. In battery terms, the maximum voltage gives the voltage which is available to charge the battery, and the minimum voltage gives the lowest voltage acceptable to the system to which the battery can be discharged. In discharging the nickel-cadmium battery, the cell voltage should be taken as low as possible in order to find the most economic and efficient battery.

9.2 Discharge profile

This is the electrical performance required from the battery for the application. It may be expressed in terms of amperes for a certain duration, or it may be expressed in terms of power (watts or kW) for a certain duration. The requirement may be simply a one step discharge or a many step profile. In order to utilize all of the charged capacity, it's recommended to discharge the battery until 1.00 V/Cell.

9.3 Temperature

The maximum and minimum temperatures and the normal ambient temperature will have an influence on the sizing of the battery. The performance of a battery decreases with decreasing temperature below +20°C (+68°F) and it results in a larger battery size. Temperature de-rating curves are provided to allow sizing adjustments.

9.4 State of charge or recharge time

Some applications may require that the battery shall give a full duty cycle after a certain time after the previous discharge. The factors used for this will depend on the depth of discharge, the rate of discharge, and the charge voltage and current. A requirement for a high state of charge does not justify a high charge voltage if the result is a high end of discharge voltage.

9.5 Ageing

Some customers require a value to be added to allow for the ageing of the battery over its lifetime. This may be a value required by the customer, for example 10 %, or it may be a requirement from the customer that a value is used which will ensure the service of the battery during its lifetime. The value to be used will depend on the discharge rate of the battery and the conditions under which the discharge is carried out.

9.6 Floating effect

When a nickel-cadmium cell is maintained at a fixed floating voltage over a period of time, there is a decrease in the voltage level of the discharge curve. This effect begins after one week and reaches its maximum in about 3 months. It can only be eliminated by a full discharge/charge cycle, and it cannot be eliminated by a boost charge. It is therefore necessary to take this into account in any calculations concerning batteries in float applications.

This is used in the IEEE sizing method and is included in the published data for Uptimax.

As the effect of reducing the voltage level is to reduce the autonomy of the battery, the effect can be considered as reducing the performance of the battery and so performance down-rating factors are used.

Note: for your battery sizing needs, please contact your local sales representative.

10. Installation and operating instructions

Type UP1 L and UP1 M

Important recommendations

- Never allow an exposed flame or spark near the batteries, particularly while charging.
- Never smoke while performing any operation on the battery.
- For protection, wear rubber gloves, long sleeves, and appropriate splash goggles or face shield.
- The electrolyte is harmful to skin and eyes. In the event of contact with skin or eyes, wash immediately with plenty of water. If eyes are affected, flush with water, and obtain immediate medical attention.
- Remove all rings, watches and other items with metal parts before working on the battery.
- Use insulated tools.
- Avoid static electricity and take measures for protection against electric shocks.
- Discharge any possible static electricity from clothing and/or tools by touching an earth-connected part "ground" before working on the battery.
- Ventilation, in accordance with the IEC 62485-2 standard, is mandatory during commissioning and operation.

10.1 Receiving the shipment

Upon receipt of the goods, any transportation damage, electrolyte spillage or irregularities must be reported to the carrier and to Saft.

The battery is shipped filled and charged, and is ready for immediate use. Storage of cells must not exceed the maximum storage time indicated on the packing case (first in, first out).

10.2 Storage

The battery must be stored in a dry indoor location, on open, well ventilated shelves away from direct sunlight between 0°C and + 30°C (+ 32°F and 86°F).

Uptimax batteries are supplied filled with electrolyte and charged. They can be stored in this condition for maximum 24 months from date of shipment in accordance with the recommendations set forth in this technical manual.

Storage of a filled battery at temperatures above + 30°C (+ 86°F) can result in permanent change and loss of product performance, depending on the duration of the storage above the maximum recommended temperature.

Never drain the electrolyte from the cells.

To ensure maximum protection of the cells always store the product in its original packaging.

10.3 Installation

10.3.1 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).

10.3.2. 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)

Protect connectors and terminals against the corrosion with a thin layer of NO-OX-ID "A" or neutral anti-corrosion oil, approved by Saft.

10.3.3 Ventilation

During operation the battery emits an amount of gas mixture (oxygen and hydrogen). Ventilation inside the battery room must be adequately managed, comply with IEC 62485-2 and local regulations.

10.3.4 Electrolyte

When checking electrolyte levels, a fluctuation in level between cells is normal. This is caused by a small difference in internal pressure in each cell. Normally there is no need to adjust the electrolyte level. If the level is 30 mm (1.2") below the minimum level mark, the affected product must be topped up using Saft's E22 electrolyte.

Do not top-up cells prior to an initial charge. After commissioning, when the level is stabilized, the electrolyte level should be between the maximum mark and 5 mm below.

10.4 Commissioning

Verify that ventilation, in accordance with the IEC 62485-2 standard, is provided during this operation.

Commissioning the battery is important: Charging at constant current is preferable. If the current limit is lower than indicated in the Installation & Operating Instruction (Table A), extend the charge time proportionally.

- Cells stored up to 6 months:
  A commissioning charge is normally not required and the cells are ready for immediate use. However, the product's full performance will only be achievable after 1-3 months of charging in service (see section 7.3 Charge acceptance).

  If the published performance is required immediately, please refer to the procedure dedicated to cells stored more than 6 months and up to 2 years.

- 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:
    10 h at 0.2 C_5 A recommended.

    Notice: At the end of charge the cell voltage will reach about 1.80 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 with current limited 0.2 C_5A.
    If these methods are not available, then charging may be carried out at lower voltages, 1.50 V/cell for 36 h minimum.
  - Commissioning at ambient temperature above +30°C (+86°F)
    - Only constant current charge:
    10 h at 0.2 C_5A 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).

When full battery performance is required for capacity test purposes, the cells shall be tested in accordance with IEC 62259.

10.5 Charging in service

The recommended charging voltages for continuous parallel operation, with occasional battery discharges, are:

- Two level charge:
  - float level: 1.39 ± 0.01 V/cell or 1.42 ± 0.01 V/cell
  - high rate (boost) level: 1.45 ± 0.01 V/cell
- Single level charge:
  1.39 ± 0.01 V/cell or 1.42 ± 0.01 V/cell

To achieve maintenance-free operation (in term of water topping-up), it is necessary to control the charge input to the battery to minimize water consumption during the entire life of the battery. Temperature Compensated Voltage (TCV) is generally mandatory. The conditions to apply TCV depend on charge voltage and ambient operating temperature.

1.39 V : TCV is mandatory from -20°C to +20°C (-4°F to +68°F), but shall not be used from +20°C to +40°C (+68°F to +104°F).

1.42 V : TCV is mandatory from -20°C to +40°C (-4°F to +104°F).

For more information, see section 7.2 Temperature compensation.

10.6 Periodic maintenance

Uptimax is maintenance-free battery under the recommended operating conditions, from -20°C (-4°F) to +40°C (+104°F) and requires only preventive maintenance.

Best practices include keeping the battery clean using only water. Do not use a wire brush or solvents of any kind.

Individual cell and total battery charge voltage must be checked and recorded once per year. Individual cells with voltages measured below 1.30 V during float charge must receive corrective action.

Please refer to Section 11.1.

- 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 Uptimax battery shall be carried out when battery is fully charged.

  Changing or measuring the electrolyte specific gravity is not required.
- Check all connections are tight every two years.
- Tightening torque for the terminals must be:
  - M 6 = 11 ± 1.1 N.m (97.4 ± 9.8 lbf.in)
  - M 8 = 20 ± 2.0 N.m (177.0 ± 17.7 lbf.in)
  - M10 = 30 ± 3.0 N.m (265.0 ± 26.6 lbf.in).
- Protect connectors and terminals against the corrosion with a thin layer of NO-OX-ID "A" or neutral anti-corrosion oil, approved by Saft.
- To maximise the topping-up interval check the charging voltage and adjust as required.

11. Troubleshooting

11.1 Troubleshooting procedures

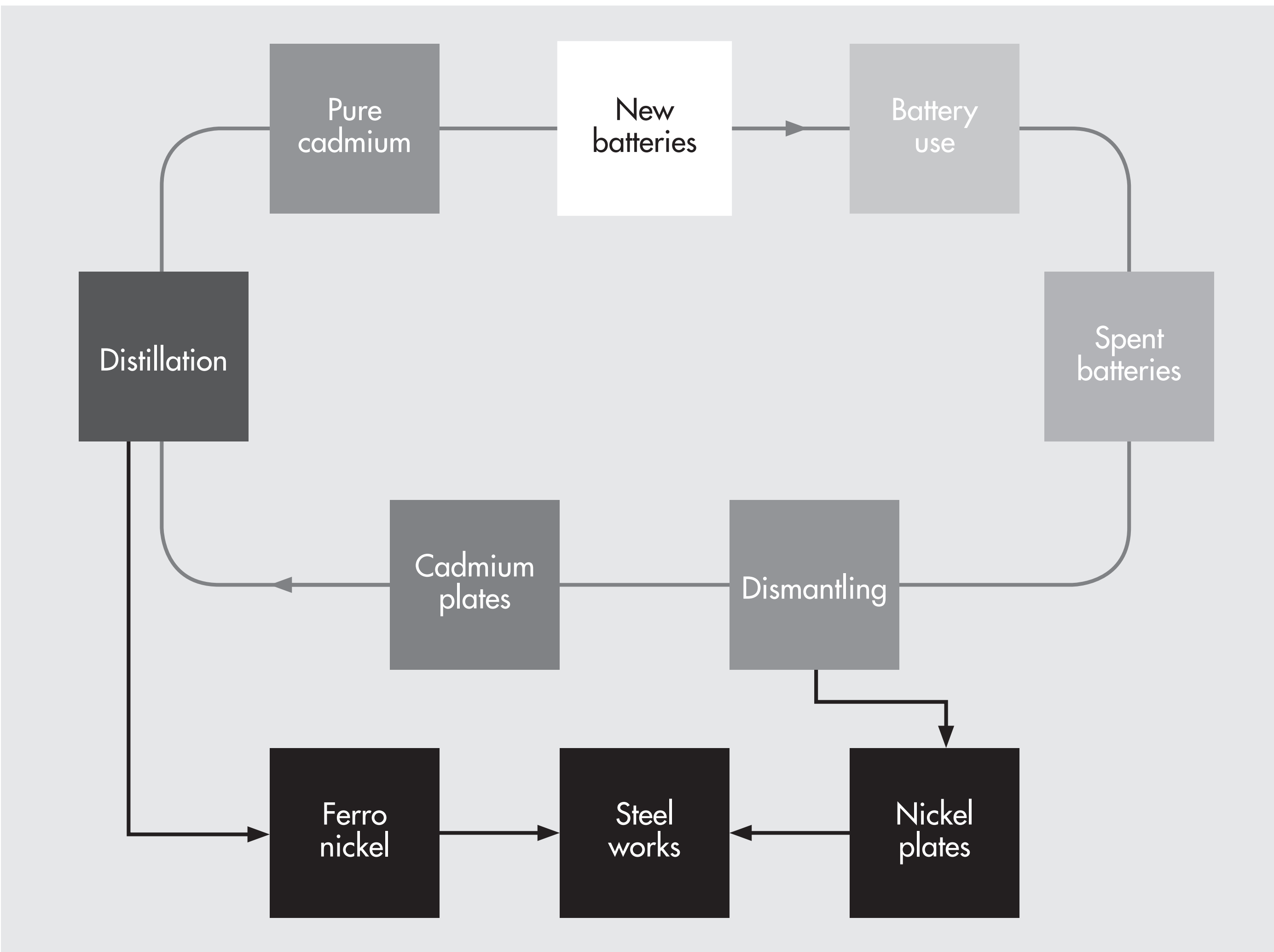
Symptom	Check	Possible cause	Action
The battery does not supply required energy or power	Identify the last operation performed by the battery	Battery has been discharged and not re-charged	Wait until the battery is recharged. Refer to Section 7.3 in this manual
	Check battery charge voltage	Charge voltage too low	Adjust the charging voltage according to Section 10.5
	Check individual cell voltage	Cell in partial or total shortcircuit	If a cell float voltage is found below 1.30 V, high rate charge is recommended to apply to the cell concerned. See Section 10.6
Excessive water consumption	Check battery charge voltage	Charge voltage too high	Adjust the charger voltage according to Section 10.5
	Check individual cell voltage	Cell in partial or total shortcircuit	If a cell float voltage is found below 1.30 V, high rate charge is recommended to apply to the cell concerned. See Section 10.6
	Check charger log	Frequent discharge/recharge	Check power supply to charger
Low or no water consumption	Check battery charge voltage	Charge voltage too low	Adjust the charger voltage according to Section 10.5
	Check connections to and on the battery	Loose connector	Retorque connector according to Section 10.3
Ground fault	Visual inspection of the battery	Wet and dirty battery	Clean the battery using only water and wipe it off with a soft and clean cloth

For further information contact Saft

12. 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. Uptimax 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

§ IEC 60050-482 - International electro technical vocabulary - Part 482: Primary and secondary cells and batteries

§ 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.

§ IEEE 1115-2000 - IEEE Recommended practice for sizing Nickel-Cadmium batteries for stationary applications

Saft is committed to the highest standards of environmental stewardship

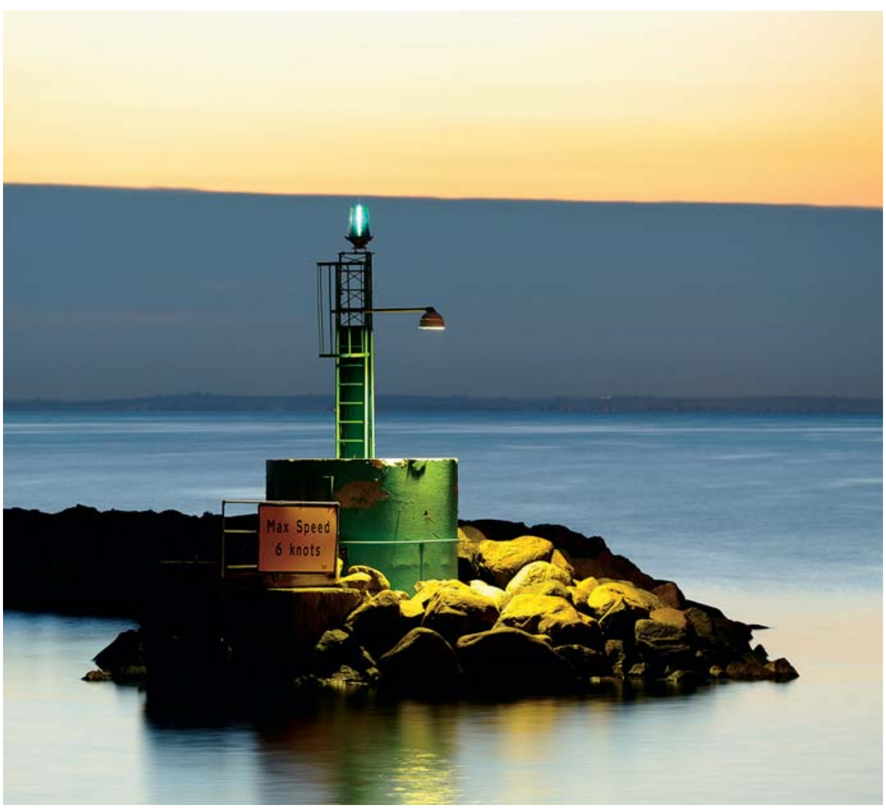
Saft is committed to protecting and preserving the environment. We are engaged in a sustained effort to use resources responsibly and to act in a way that clearly demonstrates our great respect for the planet.

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 batteries, Saft has set up a network of Bring Back Points (BBPs) which receive end-of-life nickel-based batteries from end users free of charge. These batteries are then shipped by these BBPs to our recycling facility in Sweden or to fully permitted recycling companies, in compliance with the laws governing trans-boundary waste shipments.

The recycling efficiency of these recyclers exceeds 75% of the nickel-based battery weight (a level which exceeds the mandated recycling efficiency of 65% applicable to lead-acid batteries), and recycled materials are reused as secondary raw material for industry.

This network of Bring Back Points comprises over 30 entities and provides services in all of our major markets in Europe, North America, Asia and Africa. The list of BBPs and their contact details are available on the Saft website.



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