## Contents

1. Safety and warranty statement ........................................... 3

2. Introduction ............................................................... 4

3. History ................................................................. 5

4. Electrochemistry of nickel-cadmium batteries .......................... 6

5. Types and construction ..................................................... 7
   5.1 Overview ............................................................ 7
   5.2 Pocket plate batteries .............................................. 7
   5.3 Sintered plate batteries ............................................ 9
   5.4 Plastic bonded electrodes ......................................... 9
   5.5 S/PBE batteries ................................................... 10
   5.6 Fiber plate batteries ............................................... 10

6. Nickel-cadmium telecom batteries ........................................ 11

7. Features and benefits .................................................... 13
   7.1 Long life ............................................................ 13
   7.2 Reliability .......................................................... 13
   7.3 Very low maintenance .............................................. 13
   7.4 Permanent mechanical integrity .................................. 13
   7.5 Resistant to electrical abuse .................................... 13
   7.6 Wide temperature range .......................................... 14
   7.7 Safe recycling ..................................................... 14
   7.8 Low life cycle cost ............................................... 14
   7.9 Special features ................................................... 15

8. Telecom network applications ............................................. 18
   8.1 Remote cabinets in access networks .............................. 18
   8.2 CEVs, huts and shelters ........................................... 20
   8.3 Customer premises ................................................ 20
   8.4 Central offices ..................................................... 20
   8.5 Cellular systems ................................................... 21
   8.6 Broadband transmission circuits ................................ 21
   8.7 Cable TV ............................................................ 22

9. Operating features ........................................................ 23
   9.1 Capacity ............................................................ 23
   9.2 Current rates ....................................................... 23
   9.3 Cell voltage ......................................................... 24
   9.4 Internal resistance ................................................ 25
   9.5 Effect of temperature on performance ........................... 25
   9.6 Effect of temperature on lifetime ................................ 26
   9.7 Short circuit values ............................................... 27
   9.8 Self discharge ..................................................... 27
   9.9 Cycling ............................................................. 28
   9.10 Water consumption ............................................... 29
   9.11 Gas evolution ...................................................... 29
Contents

10. Battery charging ................................................. 30
    10.1 Constant voltage charging ............................. 30
    10.2 Constant current charging ............................. 31
    10.3 Charge acceptance and efficiency ..................... 32
    10.4 Temperature effects .................................... 33
    10.5 Commissioning charge .................................. 33

11. Special operating features ................................. 34
    11.1 Electrical abuse ......................................... 34
    11.2 Mechanical abuse ....................................... 35
    11.3 Corrosion .................................................. 35

12. Battery sizing principles ................................. 36
    12.1 NCX and Ultima.plus sizing ........................... 36
    12.2 Sunica.plus sizing ..................................... 36
    12.3 Battery sizing for engine
        starting and cranking applications ..................... 36

13. Installation and operation ............................... 37
    13.1 Safety ..................................................... 37
    13.2 Transportation and storage ............................ 37
    13.3 Installation .............................................. 37
    13.4 Maintenance ............................................. 37

14. Disposal and recycling .................................... 38

15. Abbreviations and acronyms ............................ 39
1. Safety and warranty statement

Saft nickel-cadmium batteries are inherently safe to handle and operate. As long as Saft’s information and instructions are followed, they will last longer and function more reliably than other storage batteries. Furthermore, all chemicals and active materials will remain safely contained inside the batteries during their entire life, from production to reclamation. The physical integrity of Saft nickel-cadmium batteries will not deteriorate during the life of the batteries. All spent nickel-cadmium batteries will be recycled.

To obtain optimum performance and operating life, to ensure safe handling and operation and to ensure that Saft’s warranty will remain in force, Saft’s information and instructions must be followed. Any person responsible for handling, installing and operating Saft batteries must study and understand the following two documents:

- **MSDS** (Material Safety Data Sheet)
- **Installation and Operating Instructions** for the relevant type of Ni-Cd battery.

In addition, studying this **Technical manual** will give you a better understanding of Ni-Cd batteries used in the telecom industry and will help you to choose the right Ni-Cd battery for your application and make you more familiar with the behavior of Ni-Cd batteries and their operating characteristics. If you have questions about any of these documents or their content, contact your nearest Saft representative. Several contact points are detailed on the back cover of this document.

Non-compliance with information and instructions contained in the above mentioned documents, may lead to poor battery performance, reduced battery life, higher operating costs, risk of damage to the battery and in extreme cases, risk of damage to the battery’s environment and risk of personal injury. Saft will in such cases reserve the right to void any warranty or liability.

Spent batteries must be disposed of in accordance with national and local government regulations.

In most countries, it is the responsibility of the battery operator or owner to make sure such regulations are adhered to.

Saft has established approved facilities for battery collection and recycling. Consult the Installation and Operating Instruction or contact your nearest Saft representative for advice.

In conclusion: to get the most out of your Ni-Cd batteries at the lowest cost and without problems, follow the instructions closely.

Spending a little time learning more about Ni-Cd batteries and their behavior will help you to make the right battery selection and be a better operator and will also make the task more interesting. Do not be afraid to ask questions. Saft has a team of dedicated career battery professionals at your disposal.
2. Introduction

This document is meant as a guide to the selection and use of stationary Ni-Cd batteries in telecommunication applications. The batteries discussed here are all of a flooded construction but may employ different types of plates and maintenance reduction techniques. Small sealed Ni-Cd batteries as used in cellular telephones and other portable applications will not be covered in this document. Information provided here on battery features, charging requirements and performance must not be applied to portable sealed Ni-Cd batteries as their characteristics are quite different from the batteries discussed in this manual. In this manual “Ni-Cd batteries” will mean flooded, stationary nickel-cadmium batteries, also often referred to as industrial nickel-cadmium batteries.

Most operators of telecom facilities are familiar with lead-acid batteries. Specifications, designs and operating parameters of other telecom power equipment are, to a large extent, based on the operating requirements of lead-acid batteries. As Ni-Cd batteries represent a completely different electro-chemistry, this manual will therefore frequently draw attention to and discuss the difference between these two battery systems.

Stationary Ni-Cd batteries have over the years been used in various telecom applications. With higher purchase prices than for lead-acid batteries, there had to be good reasons for paying more up front for the Ni-Cd batteries. In general, the main reasons were a lower overall operating cost and significantly higher reliability.

**Ni-Cd batteries have over the years proven themselves to be exceptionally durable and reliable even with a minimum of maintenance and under severe operating conditions where other batteries fail prematurely. Hence, in such applications Ni-Cd batteries can clearly offer the lowest possible life cycle cost among comparable industrial batteries.**

This explains why most Ni-Cd telecom applications can be found in remote locations, where maintenance is irregular or rarely performed, where the temperature is often very high or very low and where reliability is critical. This is why Ni-Cd batteries are found safeguarding power to the oil and gas production process, navigational aids, solar powered repeater stations and on board jet aircraft where electric power failures cannot be tolerated.

Fig. 1 shows a picture of an older Subscriber Loop Carrier (SLC) system, using a 30 Ah nickel-cadmium battery. Extensive use of SLC and DLC systems mounted in remote outdoor cabinets, vaults and huts, have created a renewed interest in Ni-Cd batteries to improve power reliability in such installations. Manufacturers have responded by making new, application oriented batteries available at competitive prices. A more extensive use of Ni-Cd batteries in telecom applications is therefore expected.
The nickel-cadmium battery emerged from a family of alkaline batteries (nickel-iron, silver-zinc, silver-cadmium etc.) that were invented around the turn of the 20th century. Batteries that were remarkably similar were developed around the same time, but independently by Dr. Waldemar Jungner in Sweden and by Thomas Edison in the USA. See Figure 2.

As the intended electric vehicle market soon went to non-electric propulsion systems, the batteries found other applications in railroad, utilities and telecommunications. While the nickel-iron battery long remained popular among railroad customers in the US, European manufacturers soon turned to the nickel-cadmium battery, which was more suited to float charging applications due to higher charging efficiency and less maintenance.

Batteries that were commercially available during the first half of the century were mainly of the pocket plate construction. See section 5, “Types and Construction”. The pocket plate construction remains the most commonly used plate construction for industrial Ni-Cd batteries in stationary applications even today.

In the 70’s, the energy crunch promoted development of new plate technologies such as fiber and plastic bonded electrodes intended for electric vehicle applications. Some of these technologies have also proven themselves very suitable for standby applications and are now being employed in some of Saft’s new telecom batteries.

Saft has been involved in this development from the beginning and is today by far the world’s largest manufacturer of industrial Ni-Cd batteries.

Pocket plate batteries are today being manufactured at modern facilities in Sweden and in the Czech Republic while batteries with sintered and plastic bonded electrodes are manufactured in France and the USA. In response to recent developments in the telecom market, Saft can now supply optimized batteries based on proven technology for various telecom applications: the Ultima.plus telecom battery is based on a cost effective recombinant pocket plate technology, offering an almost maintenance free operation combined with long and reliable service. The NCX (Nickel Cadmium for eXtremes) telecom battery employs charge efficient plastic bonded negative electrodes and sintered positive electrodes in an energy dense couple that can replace VRLA (Valve Regulated Lead-Acid) batteries in compact telecom cabinets and in most cases without any modifications to battery compartment or charging systems.

Figure 2: Dr. Waldmar Jungner testing his EV in Stockholm, 1900
4. Electrochemistry of nickel-cadmium batteries

The Ni-Cd battery uses nickel hydroxide (Ni(OH)) as active material in the positive plates, and cadmium hydroxide (Cd(OH)) in the negative plates.

The electrolyte is an alkaline aqueous solution of about 20% potassium hydroxide (KOH) as well as small quantities of lithium hydroxide (LiOH) to improve life and high temperature performance. The electrolyte is only used for ion transfer and is not chemically changed or degraded during the charge/discharge cycle. In the case of the lead-acid battery, the positive and negative active materials chemically react with the sulfuric acid electrolyte resulting in an unavoidable aging process and a diluted acid solution when the battery is discharged. In batteries with a limited amount of electrolyte such as AGM (Absorbed Glass Mat) type VRLAs, lack of acid at the end of the discharge may limit the battery’s capacity. In a nickel-cadmium battery the amount of electrolyte does not affect available capacity.

In a nickel-cadmium cell the support structure of both plate assemblies including the posts, is solid steel, which is relatively unaffected by the surrounding electrochemistry, and which therefore will retain its conductive and mechanical characteristics throughout the life of the cell. In the case of the lead acid battery, the basic support structure of both plates is lead, which is naturally corroded during the life of the battery resulting in positive plate growth, a mechanical weakening of the structure and a gradual loss of conductivity. In extreme cases corrosion can cause an open circuit in one cell and thus cause complete loss of battery support. This can not happen to a Ni-Cd battery.

The charge/discharge reaction of a nickel-cadmium battery is as follows:

\[
2 \text{NiOOH} + 2 \text{H}_2\text{O} + \text{Cd} \rightleftharpoons 2 \text{Ni(OH)}_2 + \text{Cd(OH)}_2
\]

During discharge the trivalent nickel hydroxide is reduced to divalent nickel hydroxide, and the cadmium, at the negative plate, forms cadmium hydroxide.

On charge, the reverse reaction takes place until the cell potential rises to a level where hydrogen is evolved at the negative plate and oxygen at the positive plate, which will result in water losses. By limiting the float charging voltage the overcharge current and the water losses can be kept at a minimum.

Note that the electrolyte (KOH) is not mentioned in the reaction formula. Water is produced in the plates during charging, but is not released into the electrolyte in sufficient quantities to affect its gravity to any significant degree. In contrast to the lead-acid battery, the electrolyte density therefore remains stable during charge and discharge. This allows flexibility with the electrolyte reserve without inconvenience to the electrochemistry of the Ni-Cd couple. With a permanent electrolyte concentration, low internal resistance can be maintained even at the end of discharge. The Ni-Cd battery may be fully discharged at low temperatures without increased risk of freezing and with only minimal derating of discharge performance.

Thus, through its electrochemistry, the nickel-cadmium battery has a much more stable behavior than the lead-acid battery, giving it a longer life, superior characteristics and much greater resistance to abusive conditions.
5. Battery types and construction

5.1. Overview
Nickel-cadmium batteries are generally classified with regards to their plate (electrode) construction. A battery’s plate construction will influence its features, characteristics and cost and will therefore determine its selection for certain applications. Further enhancements and application optimizations can be achieved by variations in plate thickness, separator selection, cell construction, venting system, control of oxygen recombination etc. The important point here is that all Ni-Cd batteries are not created equal: what you learn about one type can not automatically be applied to another.

The most common types that could be considered for telecom applications are:
- Pocket plate (PP)
- Sintered plate (SP)
- Fiber plate (FP)
- Plastic bonded electrode (PBE)

Most batteries use positive and negative electrodes of the same construction. Take for instance the pocket plate (PP) battery, which sometimes is also referred to as a P/P (pocket/pocket) type battery. However, it is not uncommon to find plate combinations of different constructions. In particular, batteries with SP positive plates and PBE negatives, referred to as S/PBE batteries, have become very popular for certain applications. Further details are given below.

5.2. Pocket plate batteries
PP batteries were developed at the beginning of the century and have since then been the most successful and most commonly used industrial Ni-Cd batteries for stationary applications. This time-tested technology has given Ni-Cd batteries their reputation for durability and reliability. It is not uncommon to find PP batteries over 30 years old still providing essential power protection. Over the years, PP batteries have often been used in extreme conditions for telecom applications.

The active materials in PP batteries are encased in 12-15 mm (about 1/2") wide perforated steel pockets with their length cut to fit the width of the battery plate. The pockets are mechanically interlocked side by side so the number of pockets will determine the height of the battery plate. See fig.3. The thickness of the plates will vary with the battery’s intended use: thin plates will be used for high rate applications such as engine starting, and thick plates will be used for long duration discharges such as telecom applications. Medium rate batteries are typically used for load requirements from 20 to 90 minutes.
The steel pockets give the plates high and permanent conductivity and also serve as mechanical barriers between positive and negative active materials. No additional separators are required apart from plastic pins or simple plastic grids that are used for optimum spacing between plates and to provide electrical insulation. The electrolyte will therefore circulate freely between the plates and maintain an even temperature in each cell. Active material shedding and separator problems are therefore not of any concern with PP batteries.

In order to answer the specific needs of telecom applications, Saft has optimized the pocket plate technology and developed the Ultima.plus battery. See figure 4. Special separators have been introduced between the plates, allowing for a higher degree of oxygen recombination on float charge. While regular pocket plate batteries already can go for 2-3 years without a top-up on float charge, the introduction of an oxygen recombination system with a 85-95% recombination efficiency will reduce the water consumption dramatically and make the batteries virtually maintenance free.

An additional benefit from the oxygen recombination process is the lower polarization of the negative plates of Ultima.plus and, consequently, a better charge acceptance by the positive electrode. The overall result is a faster recharge at the typical telecom voltage levels. With its generous volume of free electrolyte, the Ultima.plus is not at risk for thermal runaway even when operated at elevated temperatures.

Saft’s Sunica.plus battery is a PP battery that has been optimized for solar powered applications. This battery, depending on the application, may be used with or without charging regulators, as overcharging is not a concern with this type of battery. The Sunica.plus battery has very high charge efficiency at low charging currents and can operate safely for years without maintenance. Sunica.plus batteries are commonly found in remote locations with extreme temperature conditions and often power telecom repeater stations on arctic mountaintops or in isolated desert areas.

In addition to Ultima.plus and Sunica.plus batteries, an extensive range of high rate PP batteries (SBH series) are available for engine and turbine starting, from 8.3 to over 1000 Ah.

Unlike lead-acid batteries, PP batteries can be made with very thin plates to allow high discharge currents without jeopardizing mechanical integrity or life.

While PP batteries such as Ultima.plus and Sunica.plus generally need more space than S/PBE batteries, they cost less and Ultima.plus can operate with less maintenance.
5.3. Sintered plate batteries

Since WWII, the need for highly reliable batteries with low weight and high peak power arose from the emerging aircraft industry. Sintered plate (SP) Ni-Cd batteries optimized and manufactured by companies in several countries soon became the batteries of choice for this application. The SP technology also found an even more extensive use in sealed portable Ni-Cd batteries.

Sintered plates are made by pasting a slurry of nickel powder to both sides of a nickel-plated steel grid or perforated steel strip. By elevating the temperature to 800-1000°C (1500-1800°F) the powder will form highly porous layers firmly and permanently attached to the grid or strip. The porous structure is in the battery industry referred to as the plaque. It is highly conductive and forms an extremely large metallic surface with all its microscopic cavities.

The same plaque can be used for both positive and negative plates. The active materials are loaded into the plaques by various impregnation methods. Optimum battery performance is achieved by carefully balancing the loading: on the one hand the higher the loading, the higher the capacity, but, on the other hand, the plaque cavities should not be over-filled, as a large active surface is required for high current flow. After impregnation, the plates are cut to size, fitted with conductive tabs and assembled into plate stacks. The choice of separator technology is very important to battery life and performance and will vary with the battery's intended application.

SP batteries typically have very low internal resistance and hence are capable of very high discharge currents. Their energy to weight ratio is superior compared to pocket plate batteries, but as they are more expensive to produce, their usage has mostly been limited to portable batteries as well as aircraft applications and engine cranking. Flooded Ni-Cd batteries with both positive and negative sintered plates (S/S) will probably not be used in telecom applications.

5.4. Plastic bonded electrodes (PBE)

As this plate making method does not work well for positive plates, we will only discuss the production of the negative plates.

Cadmium hydroxide and a small amount of plastic bonding material are mixed with water to a slurry. The mixture is then pasted on both sides of a perforated nickel plated steel sheet and dried at an elevated temperature. The active material and the plastic will form a porous plastic looking laminate firmly attached to the steel sheet. The sheet is cut into plate sizes and prepared for plate stack assembly.

The plastic bonded plate making process is simple and can be highly automated in a continuous process and is therefore relatively inexpensive. Plastic bonded negative electrodes are mostly used together with positive sintered electrodes in a stack assembly very similar to the S/S (sinter/sinter) plate stack. This battery couple is referred to as a sintered/plastic bonded electrode (S/PBE) battery. Compared with S/S batteries, they cost less and have other considerable operating advantages.
5.5. Sintered/PBE batteries

Similar to the S/S batteries, the S/PBE batteries have high energy and power densities. Furthermore, on float charge their charging current is much lower and therefore the water consumption and the maintenance requirements have been greatly reduced. On float charge, the S/PBE battery can operate for more than 10 years without water replacement.

While S/PBE batteries were originally developed for electric vehicle applications, they are now commonly used and optimized for many other applications such as aviation, rail transit, engine starting, UPS and other critical standby installations. Fig.6 shows S/PBE modules made for telecom applications. S/PBE batteries for starting of emergency generators are made with thinner plates for low internal resistance and maximum cranking current.

For its reduced cost, high power density, low maintenance and good float charging characteristics, Saft chose the S/PBE construction as a direct replacement for VRLA in outdoor telecom applications.

The NCX (Nickel Cadmium for eXtremes) series of batteries were designed to fit existing VRLA battery compartments in outdoor telecom cabinets without modification to space or charging system.

Figure 6: NCX telecom battery

5.6. Fiber plate batteries

Fiber plates are manufactured by compressing tiny nickel-plated organic fibers into thin mats of high porosity and relatively good conductivity. The active material is generally loaded into the plates by a vibration process. The FP batteries were developed in Germany in the 70's mainly for electric vehicle applications, but have since been sold as industrial standby batteries for various applications. Saft has looked at fiber plates as an option, but has not been able to find any advantages over presently used technologies.
6. Nickel-cadmium telecom batteries

In many countries, major changes have taken place in the local access network. Equipment that previously only was found in the central office (CO), is now installed in remote terminals (RT) such as outdoor cabinets, telecom huts, controlled environmental vaults (CEVs) and customer premises. See Fig. 7 and 8. There are several reasons for this:

- Deregulation, causing increased competition and forcing the service providers to cut their cost.
- New technology, making it possible to reduce the size of the electronic circuits and offer new and exciting services such as high speed digital lines for data transmission.
- Rapid suburban growth, making it necessary to provide telephone service quickly in new areas to a large number of subscribers.

Installation of telecom equipment, including batteries, in remote terminals means locating this equipment in a more hostile environment. Large temperature variations are common, even in huts and CEVs that are normally equipped with heaters and air conditioners. Space is very limited and ventilation is often insufficient to extract the heat generated by compact equipment. With a rapid increase in the number of remote terminals and less maintenance staff available due to downsizing, the equipment is expected to operate for extended periods without attention.

As a result of these extensive changes, there has also been a marked change in the operating requirements of the battery. Several new requirements and demands has emerged such as:

- Long battery life at high temperatures
- High reliability under severe operating conditions
- Sudden and destructive failures not acceptable
- Compact battery construction
- Minimum maintenance and supervision
- Environmentally safe from cradle to grave
- Lowest life cycle cost under RT operating conditions

While the valve regulated lead acid (VRLA) battery initially appeared to answer these new battery demands; the network operators soon discovered many VRLA battery shortcomings:

- Short and unpredictable life
- Premature failures
- Destructive failures
- High operating costs

In response to a request from the telecom industry for a battery system that can better fulfil the new requirements, Saft has developed and optimised several batteries for various telecom applications.
An overview of these batteries is shown under Fig.9. Different Ni-Cd technologies were utilized to obtain the most economical and most suitable battery for the different telecom applications.

These technologies are described in section 5 above. In the following sections the applications and the specific battery features will be discussed. It is important to have a good understanding of the properties and the features of the different types of Ni-Cd batteries to be able to select the right battery for each application and to achieve superior performance, reliability, life and economy.

The batteries listed below in Fig.9 are presented in details under section 7.9 Special features. This section will explain the features that make each battery suitable for specific applications.

Figure 9: Nickel-cadmium batteries for telecom applications

<table>
<thead>
<tr>
<th>Battery type</th>
<th>Ultima.plus</th>
<th>NCX</th>
<th>Sunica.plus</th>
<th>SPH</th>
<th>SBH</th>
</tr>
</thead>
<tbody>
<tr>
<td>General use</td>
<td>Telecom standby</td>
<td>Photovoltaic systems</td>
<td>Generator starting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plate technology</td>
<td>PP</td>
<td>S/PBE</td>
<td>PP</td>
<td>S/PBE</td>
<td>PP</td>
</tr>
<tr>
<td>Cell range</td>
<td>STL 38 - 460 Ah</td>
<td>NCX 80 - NCX 160 Ah</td>
<td>SUN 45 - SUN 1110 Ah</td>
<td>SPH 11 - SPH 320 Ah</td>
<td>SBH 8.3 - SBH 920 Ah</td>
</tr>
<tr>
<td>Capacity range</td>
<td>38 - 460 Ah</td>
<td>80 - 160 Ah</td>
<td>45 - 1110 Ah</td>
<td>11 - 320 Ah</td>
<td>8.3 - 920 Ah</td>
</tr>
<tr>
<td>Typical Autonomy</td>
<td>3 - 24 hours</td>
<td>3 - 24 hours</td>
<td>1 - 100 days</td>
<td>10 - 180 sec.</td>
<td>10 - 180 sec.</td>
</tr>
<tr>
<td>Applications</td>
<td>Most suitable application indicated below</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor cabinets</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEVs and Huts</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer premise cabinet</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer premise Open rack</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote CO</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generator starting</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar power installations</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. Features and benefits

Understanding and appreciating the features and benefits of the different types of Ni-Cd batteries is important for the battery selection process. Some features are common to all Ni-Cd batteries, but as different batteries have been optimized for different applications, there are significant differences. The following features are common to all industrial Ni-Cd batteries:

1. Long life
2. Extremely reliable
3. Very low maintenance
4. Permanent mechanical integrity
5. Resistant to electrical abuse
6. Wide temperature operating range
7. Safe recycling
8. Low life cycle cost in suitable applications

7.1. Long life
Industrial nickel-cadmium batteries continue to demonstrate operating life in excess of 30 years on continuous float charge and in uncontrolled environments. They have for instance been used for nearly a century in outdoor rail signal applications where they have an excellent track record protecting life and valuable property.

There are many examples of 20 – 30 year old batteries testing close to 100% capacity.

7.2. Reliability
Nickel-cadmium batteries are the batteries of choice for the world’s airlines and rail transit systems, and are generally used when reliable power is required to protect people’s lives, valuable property or to avoid costly downtime.

Ni-Cd batteries are reliable because of their stable chemistry as described under section 4. They do not suddenly fail and the most common lead acid ailments such as corrosion, plate growth and sulfating are not present in this battery system.

7.3. Very low maintenance
On float charge, watering is recommended once a year for regular PP batteries, but Ultima.plus and NCX are ultra low maintenance batteries that can safely be left for over 5 years. Several test batteries have now been in field operation for several years at an average temperature of +40°C (+104°F). Water consumption has been closely monitored and indications are that the battery could be left for over 15 years without a top up. However, watering every 5 years is recommended for safety reasons.

Apart from watering, checking charging voltage and visual inspection, no other regular maintenance is required. See also section 13.

7.4. Permanent mechanical integrity
The electrolyte will not react with the structural parts of a nickel-cadmium cell. On the contrary, it will create a protective environment inside the cell. Without destructive corrosion and plate growth, the structural parts of the cells will remain unchanged during the entire life of the battery and will provide an absolute guarantee against open circuits inside the cell and sudden death failures.

7.5. Resistant to electrical abuse
Abusive conditions that will permanently damage lead-acid batteries, will have little to no effect on Ni-Cd batteries. Occasional overcharging may result in more water usage but will have no effect on life. Undercharging or lack of charging during extended storage may lead to a temporary loss of capacity due to self discharge. This loss is reversible and full battery capacity will be restored after proper charging. Reverse charging may even take place without any damage. This is why Ni-Cd batteries can be stored without having to be recharged periodically.
7.6. Wide temperature range

Ni-Cd batteries are frequently used in extreme temperature applications. Fig. 10 and 11 show examples of such applications.

The normal operating temperature range for Ni-Cd batteries is -20°C to +50°C (-4°F to +122°F), but they will survive temporary extremes without permanent damage from -50°C to +70°C (-58°F to +158°F).

As the electrolyte concentration does not change during charge or discharge, there is no risk of unexpected freezing which can be a problem with discharged lead-acid batteries.

Should lower operating temperatures be required, the electrolyte gravity can be increased from 1.20 to 1.25 g/ml.

7.7. Safe recycling

As nickel-cadmium batteries maintain their mechanical integrity throughout their life, spent batteries may be transported as easily and safely as new batteries. Established recycling facilities have been in operation for many years.

All parts and components of nickel-cadmium batteries are recycled and reused. Disposal certificates will be issued on request. See also section 14.

7.8. Low life cycle cost

The purchase price of Ni-Cd telecom batteries may be two to four times higher than commonly used VRLA telecom batteries of similar capacity. Note that, within the VRLA range, costs can vary with a factor two, mainly depending on construction and durability. Ni-Cd batteries will last several times longer than VRLA batteries and at elevated temperatures the life of a Ni-Cd battery may be 6-8 times as long. See also section 9.6 Effect of temperature on lifetime. Replacing batteries is expensive and inconvenient. Installation, transportation and procurement costs must be considered in addition to the battery price.

An estimated cost of ownership over a 10-year period is illustrated in Fig. 12, where about $500 has been added to the purchase price of each battery to cover installation and procurement costs. As indicated by the graph, the cost of using VRLA batteries may already exceed the cost of using Ni-Cd batteries after the first VRLA replacement. During a 10 year period, the accumulated cost of using VRLA batteries may be more than double the one of using Ni-Cd batteries. In addition, VRLA batteries often fail with the release of corrosive acid spray or mist that can cause extensive equipment damage.

Also, with a sudden loss of DC power, operators may face extensive downtime costs from loss of revenue, emergency repairs, penalties, legal action and loss of customers to competitors.

While these cost factors can be significant, they are hard to predict and evaluate and have therefore not been included in the cost comparison under Figure 12.
7.9. Special features

7.9.1. The Ultima.plus battery

This battery has the lowest cost per Ah of all the Ni-Cd batteries. This is the result of an extensive cost reduction engineering program. Provided there is sufficient space available, the Ultima.plus will therefore cost less to operate than any other Ni-Cd battery. Ultima.plus is most cost effective in the larger capacities and can sometimes be close to the VRLA price. Larger Ultima.plus batteries have a higher energy density and may in some cases even fit into the same space as used by a VRLA battery. On float charge, Ultima.plus may operate for up to 20 years without a top-up thanks to gas recombination and an abundant electrolyte reserve. For safety reasons, more frequent water additions are recommended, depending on charging voltage and operating temperature.

But the key advantage of Ultima.plus is that, whatever the operating conditions, the period between two watering services will always exceed the life of a VRLA battery.

Ultima.plus can operate from the same charging circuit as used with VRLA batteries. No modifications or adjustments are generally required. However, temperature compensation should not be used. Figure 13 shows strings of 200 Ah Ultima.plus batteries installed in a telecom hut.
7.9.2. The NCX battery

This battery is engineered as a direct replacement for VRLA, with regards to space as well as to charging requirements.

*With its compact S/PBE construction, it can replace VRLA in most battery compartments and cabinets without any modifications.*

Figure 14 shows the lower part of an outdoor telecom cabinet where a battery drawer is equipped with a total of 250 Ah Ni-Cd battery capacity while the other drawer is equipped with the original 180 Ah VRLA battery capacity.

Each NCX battery is equipped with a central water filling system (CWS). This system serves several purposes. When it is time to water the battery, a water container is elevated at least two feet above the battery and may for instance be placed on top of a cabinet. A hose from the container is plugged into the CWS and each cell will automatically be filled to the correct level. This operation will normally take 10-20 minutes and will ensure filling of every cell to the correct level and will also save time and avoid spillage.

A side effect of the CWS is that a high relative humidity will be maintained inside the cells and tests have shown that water evaporation has almost been eliminated. Any condensation inside this system can only drip back into the cells. This is one of the reasons why the NCX can go for up to 10-15 years without a top-up.

The CWS may in addition serve as a hydrogen evacuation system, which will improve safety in cabinets and battery compartments with poor ventilation. Hydrogen accumulation will be prevented and the risk of explosions will be eliminated. The evacuation tube should be terminated in a flame arrestor vent mounted outside the cabinet.

The *NCX is like the Ultima.plus, an ultra low maintenance product with watering intervals that will exceed the entire life of a VRLA battery.*

NCX will accept most cable lugs fitted for VRLA batteries.
7.9.3. The Sunica.plus battery

Solar power is generally installed in remote areas where maintenance, repair and battery replacements are expensive and can not always be carried out on short notice. Battery replacement costs can run into several thousands of dollars in addition to the purchase cost of the new battery. The Sunica.plus battery was designed with such conditions in mind.

_Taking advantage of the inherent durability, reliability and wide temperature range of Ni-Cd batteries, The Sunica.plus is also engineered for deep discharges, low self discharge and high recharge efficiency at low charging currents._

_Extra electrolyte has been added to extend the periods between top-ups._

For further information, see the Sunica.plus Technical Manual.

Sunica.plus is mainly used by professional operators in the field of telecommunications as well as in other demanding applications such as lighthouse operation and navigational aids. Installations can be found all over the world from equatorial desert locations to far above the Arctic Circle where over 3 months of autonomy is often required.

7.9.4. The SPH and SBH generator starting batteries

The SPH and the SBH starting batteries use different plate technologies, but both have very thin plates to allow the energy to be discharged quickly and at a very high rate. Compared with lead-acid starting batteries, these Ni-Cd batteries can deliver two to three times more starting current per Ah. Ni-Cd batteries of less than half the Ah capacity can therefore be used to do the same starting job.

The SPH battery can go much longer without watering than the SBH, which on the other hand costs less and is available in a wider range of capacities.
8. Telecom network applications

Saft currently offers two ranges of standby batteries for regular telecom applications, the Ultima.plus and the NCX battery. In addition, Saft offers Sunica.plus batteries for PV (photovoltaic) applications and the SPH and SBH series of batteries for generator starting.

Various numbers of cells are connected in series, depending of the voltage of the telecom system:

- The voltage window may vary according to national standards. In the US, Telcordia has recommended that 38 Ni-Cd cells should be used in a 48 V string, but other markets may see 36-40 cells depending on specified voltage levels.
- Similarly, 24 V systems commonly used in cellular and microwave systems may consist of 18 to 20 cells.
- For starting applications, 10 cells are normally used for 12 V systems and 20 cells for 24 V systems.
- In PV applications, eight to ten cells may be used, depending on the specified voltage window and operating conditions.
- Cable TV networks generally use a 36 V battery that feeds the cable amplifiers through an on-line inverter.

The following is a brief discussion of various applications where Saft telecom batteries may offer substantial benefits over the traditional VRLA battery.

8.1. Remote cabinets in access networks

The use of outdoor cabinets in the access network started in the USA in the 70's. The early cabinets typically contained a few local subscriber circuits and a system that connected the subscribers to the central office (CO) over an extended distance by using only four copper wires. These systems are known as Subscriber Loop Carrier (SLC) systems. Fig. 1 shows a SLC 40 system equipped for 40 subscriber lines. Today remote cabinets may contain more than 1000 subscriber circuits generally connected by digital loop carrier (DLC) systems and fiber optic circuits. The power system is typically 48 V. High battery operating temperatures are usual in outdoor cabinets. Fig. 16 shows recordings of actual battery temperatures over a 12-month period in a telecom cabinet in Orlando, Florida.

Because of the critical requirements of small footprint and reduced maintenance, the VRLA battery seemed to be the obvious choice for this application, especially when advertised as a 20 year maintenance free product. In reality many operators have found that their VRLA batteries offered little more than a couple of years of reliable service in their remote cabinets. This is mostly due to temperature variations inside the cabinets, combined with little or no regular maintenance. In the USA, some operators have found it difficult to maintain lifeline level of service as mandated by the Federal government, mainly due to battery failures in remote locations. Furthermore, VRLA failures can be quite destructive, particularly when they go into thermal runaway. Extensive damage can occur to telecom equipment from heat and corrosive acid mist.

Using Ni-Cd batteries in outdoor cabinets can therefore provide major benefits to telecom operators:

- Lower overall costs due to longer life, less maintenance and no replacement costs.
- Lower risk of damage to telecom equipment.
- Lower risk of service interruptions and emergency repairs.
Most power systems in outdoor cabinets are of the “bulk power” type, while some of the earlier SLC systems such as SLC96, used “distributed power”.

Bulk power is simply a system where several rectifiers connected in parallel feed the load circuits and at the same time float charge one or several parallel strings of batteries. Typically, several parallel strings of 60 to 160 Ah batteries are utilized for bulk power installations in outdoor cabinets.

In distributed power systems, each battery string is charged separately off line by a current controlled charging system while the load is fed by a separate DC supply circuit. On AC failure the batteries are automatically connected to the load. The main problem with the distributed power systems is that thechargers can not be adjusted to fit the new charging requirements of replacement batteries. 25 to 30 Ah batteries are most commonly used in distributed power systems and several battery suppliers provide additional voltage regulators to protect their batteries.

The NCX telecom battery is designed primarily for remote cabinets and is the obvious choice as a Ni-Cd alternative to VRLA. The NCX battery can replace an equal amount of VRLA energy in most outdoor telecom cabinets without any modification to the battery compartment or the charging system. Figure 17 shows NCX batteries being installed in a telecom cabinet.

In cases where extra battery space is available, the Ultima.plus will offer better economy. For instance with SLC 96 systems, some operators have found it desirable to use the cabinet space normally occupied by the batteries for other equipment and to relocate the batteries to a new enclosure under the main cabinet. In such cases, there would be ample space available for the more economical Ultima.plus battery.

Some operators supply power to an increasing number of fiber optic curb nodes from existing cabinets by utilizing previously installed copper wires. The power requirement growing with the number of connected nodes, existing battery compartments become too small. External battery cabinets may have to be installed and Ultima.plus will offer the best economy in such cases.

Some cabinets, particularly earlier models, offer little or no ventilation of the battery compartment. The NCX battery is fitted with a central watering filling system (WFS) which also is designed as a gas evacuation system. (See also 7.9.2.) Where there is insufficient ventilation, the battery gasses must be evacuated through the WFS system to the outside of the cabinet.

 Ultima.plus or any other battery (including VRLA) without any gas evacuation system must not be installed in battery compartments without sufficient ventilation. Battery compartments in outdoor cabinets are generally fitted with heating pads in the lower part of the compartment. Although nickel-cadmium batteries are not as sensitive to low temperatures as lead-acid batteries, the use of these heating systems is encouraged as they ensure faster recharge and improved battery performance.

Figure 17: NCX battery being installed in outdoor cabinet
8.2. CEVs, huts and shelters

CEVs (Controlled Environmental Vaults), huts and shelters used in the local area network generally accommodate larger remote installations than those housed in cabinets. A typical hut is illustrated in Fig. 7. The equipment is mounted in open telecom racks as used in CO (Central Office) installations and may consist of switching systems, DLC, multiplexers, fiber optics, etc…

The batteries have traditionally been of the VRLA type and have been installed in battery racks or on trays mounted on telecom racks, adjacent to other telecom equipment. Any venting of VRLA battery gasses or any destructive failures could therefore damage the electronic equipment close by. Venting of Ni-Cd batteries does not carry any destructive amounts of corrosive fumes, and flooded Ni-Cd batteries can therefore be safely mounted next to electronic equipment.

Generally, it is 48 V bulk power systems that are installed in CEVs and huts, but some of the older installations may contain SLC systems with distributed power. The bulk power batteries generally consist of parallel strings, mostly of 100 Ah batteries but sometimes even a single string of a much larger capacity may be installed. Total installed battery capacity may vary from 400 to about 1600 Ah.

CEVs and huts are equipped with heating and cooling. Temperatures are not as tightly controlled as in CO locations, but the batteries will not face the very high temperatures they are exposed to in outdoor cabinets. Even so, many operators complain about short battery life and destructive failures of VRLA batteries and some have started to install Ni-Cd batteries to avoid such problems. Large capacity Ultima.plus is very price competitive in this application and sufficient space is often available.

Many CEVs and huts have limited ventilation to the outside in spite of the fact that industry safety standards and regulations clearly require a substantial rate of air change. Continuous ventilation is a requirement for all rooms and enclosures where batteries are being charged. This also applies to VRLA batteries.

8.3. Customer premises

Several types of equipment may be installed at the end-user, depending on the requirement. Smaller installations may fit in a single indoor cabinet, with a 30 Ah battery installed on the bottom shelf. Larger installations may require open telecom racks in a dedicated equipment room. Most of the operators offer standard equipment solutions. The battery requirements will vary accordingly and generally bulk power systems are used.

In cabinets with restricted battery space, the NCX is the only battery that will fit. For open rack installations, the Ultima.plus can often be accommodated.

8.4. Central offices (CO)

Traditionally, central office equipment is supported by parallel strings of flooded lead-acid batteries of the best industrial quality in capacities up to several thousands Ah. These batteries are installed in separate battery rooms to avoid equipment damage from corrosive acid fumes. Batteries in COs are generally well maintained.
and operated under ideal conditions and will therefore provide many years of reliable and economical service. There are relatively few complaints about these types of battery installation.

Many operators have equipped small, unmanned COs with VRLA batteries. They are often less satisfied with these batteries due to shorter life and higher operating costs than anticipated. Some operators have therefore installed Ni-Cd batteries to avoid problems and to reduce operating costs. Most CO locations are equipped with diesel generators as protection against long utility power outages. These generators are of little use if they do not start when they are needed. Therefore, the starting battery is a critical component that must absolutely work.

The cost of the battery is relatively minor compared to the total cost of the diesel generator and its associated equipment, and many operators have learnt that trying to save money by buying a cheap starting battery is false economy.

Starting problems, frequent battery replacements and high maintenance costs will quickly bridge the difference in battery price between a lead acid and a properly selected Ni-Cd battery. Saft’s SPH and SBH range of batteries are designed for stationary diesel starting applications. Some of the major telecom operators have standardized on such batteries for all diesel starting applications.

8.5. Cellular systems

Modern cellular networks are very diverse and complex. Their power backup needs range from remote, low powered base stations to switching centers requiring large banks of batteries of several thousands of Ah. Battery maintenance is always a problem in a geographically dispersed system and the cost of frequent battery replacements and poor reliability is a serious problem for many operators.

*Installations that are the best candidates for Ni-Cd batteries are in remote locations and in critical parts of cellular networks, such as switching centers and other locations that channel multiple circuits.*

Power backup of each base transceiver station (BTS) is not always as critical as most areas are covered by more than one BTS. Should one station lose power, another will automatically take over. Modern digital base stations use relatively low power and are often equipped with batteries sized for relatively short back-up time. However, failed batteries must be replaced, and frequent replacements in remote locations can build up to substantial costs that can be eliminated by Ni-Cd installations.

The demand for improved reliability in the cellular network is increasing and will continue to do so. If cellular operators want to compete with the reliability of the fixed telecom network, they will have to invest in more durable and reliable batteries.

8.6. Broadband transmission circuits

The growth in long distance transmission capacity has been phenomenal and is predicted to continue in the foreseeable future.
This is mainly due to increased Internet and data transmission traffic. There are several technologies involved in this growth, such as fiber optics in both land-based cables as well as in submarine cables, microwave systems and satellite links. All these technologies require reliable power, at their terminals and in amplifier and repeater stations. To a large extent, terminals are located in CO environments with large battery installations as described above.

**However, many of the amplifier and repeater stations are located in remote areas where service visits are expensive. As these circuits carry large volumes of traffic, reliability is of utmost importance and power failures cannot be tolerated. Such remote locations could benefit from the reliability and the durability of Ni-Cd batteries.**

Other utility companies such as railroads, electric utilities and pipeline companies have entered the telecom industry. They are using their right-of-way where they install telecom transmission lines, mainly fiber optic cables. Their transmission capacity is frequently sold to telecom service providers, with guaranteed quality of service. Reliable power is therefore an important requirement and as many of these installations are in remote areas, Ni-Cd batteries offer many advantages.

Furthermore, as many utility companies have already utilized Ni-Cd batteries in non-telecom applications for several decades, they are often familiar with the advantages and appreciate their cost saving features. Both NCX and Ultima.plus are being used by utilities for the protection of their telecom diversifications. Batteries are generally installed in remote huts in a bulk power configuration.

**8.7. Cable TV**

Most of us that live in rural or suburban areas and enjoy cable television, have experienced that in severe weather it is not uncommon to lose service. For those who are familiar with the distribution of cable service and the power backup system, this is not a surprise. With several amplifier stations along the cable route and with each station receiving power through an inverter backed up by a low cost VRLA battery, it is obvious that there are many weak links that can fail. And it will only take one failure to eliminate service to all those that are connected further down the line.

As cable companies are implementing telephone and data communications services in competition with the telephone companies, they have found it necessary to improve their power backup system significantly. Ni-Cd batteries offer outstanding benefits to operators in this environment, particularly in terms of reliability and durability as well as lower operating costs.
9. Operating features

9.1. Capacity

The Ni-Cd battery is rated in ampere-hours (Ah) which corresponds to the quantity of electricity that can be supplied under specified conditions. According to standards (International Electrotechnical Commission, IEC), Ni-Cd batteries are rated at room temperature at a 5 hour discharge rate to an end voltage of 1.0 V per cell and after constant current charging. This also applies to Saft’s batteries except the NCX and the Ultima.plus, which primarily are designed for telecom float charging conditions, and optimized for 8 hours standby. The rated capacity of NCX and Ultima.plus is therefore based on an 8 hour discharge at +25°C (+77°F) to an end voltage of 1.1 V per cell and after 24 hours on float charge. The actual available capacity or performance during operation will, for all batteries, vary with rate of discharge, temperature, charging history and end voltage.

9.2. Current rates

Charging and discharging may take place at different rates of current relative to the battery’s rated capacity. It is common in battery literature that the battery current is expressed as a fraction of the nominal battery capacity “C”. For instance, a current rate of 0.2 C means that the current is 0.2 or 20% of the battery capacity (expressed in Ampere). For a 100 Ah battery the 0.2 C rate is 20 A and the 0.1 C rate is 10 A. The 0.2 C rate may also be written as C/5. As this is close to the 5 hour rate of a battery, it is sometimes considered the same.

For most batteries the C/2 (or 0.5 C) current is considerably higher than a sustainable 2 hour current. Therefore, do not expect the C/2 rate to last for two hours or the C rate to last for one hour.

Most telecom batteries are optimized for discharges around the eight hour rate or the C/8 rate which is more or less the same. Figure 19 shows the discharge voltages of a telecom battery at different discharge rates. As the discharge rate is increased, the discharge voltage will be lower. At high rates such as the C rate, only a fraction of the battery capacity can be utilized before the minimum operating voltage of say, 1.10 V per cell is reached. Clearly, telecom batteries are not suitable for high rate applications. This is why Saft also manufactures medium rate and high rate batteries for such applications.
9.3. Cell voltage

The cell voltage of nickel-cadmium batteries is determined by the electrochemical potentials of the active materials in the presence of the electrolyte. The nominal voltage of a Ni-Cd cell is 1.20 V which is close to the average discharge voltage in most industrial applications. Most 48 V telecom installations use 38 Ni-Cd cells, which at 1.20 V per cell equates to a nominal battery voltage of 45.6 V. This may look too low a voltage. But at the eight-hour rate, the average discharge voltage is actually somewhat higher.

Figure 19 shows the 8 hour discharge voltage (follow C/8) during the entire discharge period. The discharge will start at just over 1.35 V per cell (51.3 V) and continue down to the minimum operating voltage between 1.0 to 1.15 V per cell. 43.74 V corresponds to 1.15 V per cell and 42 V corresponds to about 1.10 V per cell.

There is no need to protect the battery with a low voltage disconnect as the battery may safely be discharged to zero volts.

When a generator starting battery is used, the cell voltage will drop much lower than 1.0 V. Initially, the "breakaway voltage" may be as low as 0.65 V per cell. As soon as the engine starts to rotate, the "spinning voltage" will be much higher, but will at the end of the starting cycle typically drop towards 0.85 V per cell.

Figure 20 provides an overview of the typical cell voltages of Ni-Cd batteries.

![Figure 20: Typical voltage spectrum of Ni-Cd batteries](image)

Depending on operating conditions and cell types. In cyclic charging conditions, as typically found in rail car operation, the float voltage may be as high as 1.5 V per cell. In dual rate charging systems the high rate (equalize) voltage is normally set between 1.45 to 1.65 V per cell, mostly limited by the maximum operating voltage.

At the end of a constant current charging cycle, the cell voltage may go close to 1.9 V per cell depending on charging rate and temperature.

See also section 10.3.
9.4. Internal resistance

The internal resistance or impedance of a Ni-Cd cell will change only slightly with state of charge or battery age, thanks to the permanent concentration of the electrolyte. Therefore, repeated impedance testing does not provide a good indication of the condition of a cell or battery.

Thanks to the relatively limited variation of cell impedance with state of charge, a 50% charged starting battery will, for instance, deliver more than 80% of its fully charged starting current.

9.5. Effect of temperature on performance

Variations in battery temperature have a lesser effect on the performance of Ni-Cd batteries than on the one of lead-acid batteries. This effect may still have to be taken into account when sizing a battery. In telecom applications with heated battery compartments or enclosures, the temperature effect is minimal and may be ignored if other margins are included in the battery sizing calculations.

Battery capacity and performance will be reduced at lower temperatures. This is a result of higher internal resistance and hence a lower discharge voltage. The effect of low temperatures is therefore more severe at higher discharge rates. In high rate applications such as generator starting, temperature derating factors should always be considered in battery derating calculations.

Figure 21 shows typical temperature derating factors for various batteries down to −30°C (−22°F). These curves clearly show the difference between Ni-Cd and lead-acid batteries. They also show the differences between various types of Ni-Cd batteries. For accurate battery sizing in low temperature applications, please ask Saft for the derating factors of the precise type of battery you intend to use and for the discharge rate that will be applied.

Figure 21: Effect of temperature on capacity
9.6. Effect of temperature on lifetime

Ni-Cd batteries are designed to last 20 to 30 years at room temperature. At higher operating temperatures, the battery’s life will be reduced. However, the temperature effect on life is much lower for a Ni-Cd battery than it is for a lead-acid battery.

According to various independent organizations such as Eurobat, IEEE and Telcordia (Formerly Bellcore), for every 9°C (16°F) increase in battery temperature above room temperature, the reduction in life for a lead-acid battery is 50%. The corresponding life reduction for a Ni-Cd battery is only 20%.

This reduction in lifetime for a Ni-Cd battery and, for comparison, a lead-acid battery is illustrated graphically in Figure 22.

Figure 23 shows the lifetime of a 20-year Ni-Cd and of a 10-year VRLA battery at different temperatures, as typically used in remote telecom applications.
9.7. Short circuit values

The short circuit current depends on several factors such as battery capacity, state of charge, temperature and the internal impedance of the battery. A fully charged NCX or Ultima.plus battery can deliver a peak current of about 10 C (Ten times the Ah rating expressed in amperes), and an SPH or SBH cell can deliver around 30 C. This means that a 100 Ah string of Ultima.plus or NCX telecom battery can deliver up to 1000 A in a short circuit situation.

⚠️ This is more than enough to melt any metallic watchstraps or jewelry, and such objects must therefore be removed before handling batteries to avoid serious burns. All charged batteries must be handled with respect and care. Even a half-charged battery can deliver more than 80% of its fully charged short circuit current. At −20°C (+4°F) the short circuit current may be reduced to about half the room temperature current.

A lead-acid battery. At a reduced state of charge, lead acid batteries will soon begin to suffer from irreversible sulfating of the active material that will result in a permanent loss of capacity. Ni-Cd batteries do not suffer from any similar effects.

**S/PBE batteries can be stored completely discharged for years without any signs of damage.**

A Ni-Cd battery that has been allowed to self discharge for more than 6 months may need a reconditioning charge to recover full capacity.

Before storing Ni-Cd batteries for a longer period than 6 months, please follow the recommended operating procedures.

9.8. Self discharge

The state of charge of Ni-Cd batteries on open circuit will slowly decrease with time due to self-discharge. In practice, this decrease is relatively rapid during the first few days, but will later stabilize at about 2% per month at +25°C (+77°F) depending on the type of battery. Battery temperature affects the rate of self-discharge significantly. At low temperatures, the charge retention is much better than at room temperature and at higher temperatures the rate of self discharge will increase rapidly.

However, the effect of self discharge is much less significant for a Ni-Cd battery than it is for a
9.9. Cycling

Batteries in telecom applications are generally on float charge and will, during their life, see very few deep discharges. PP batteries can endure several hundred deep discharges before their life is affected and S/PBE batteries can sustain several thousand deep discharges. Figure 24 will give an indication of battery life in deep cycle applications.

The effect of cycling on the life of a Ni-Cd battery in a normal telecom application is therefore negligible, and all Ni-Cd telecom batteries apart from Sunica.plus, are optimized for continuous float charging conditions.

If a Ni-Cd battery is operated in a frequent cycling application, it will be necessary to apply a higher charging voltage to maintain the battery at a high state of charge (the same applies to lead acid batteries). The required charging voltage will depend on depth of discharge, charging rate, charging frequency and charging time and will often be higher than the normal voltage available in telecom applications. Offline charging or other charging arrangements may have to be introduced.

Frequent deep cycling of batteries on float charge at 1.43 V per cell (54.34 V for a 38 cell battery) will very gradually decrease their capacity. Full capacity can be restored at a higher charging voltage or after a very long period on float.

Repeated cycle testing (deep discharges) in the field of the same battery string with only float voltage recharge should be avoided.

Each recharge will gradually return less capacity to the battery, particularly at high temperatures. If more than one deep discharge has been performed in succession, a reconditioning charge may be needed to bring the battery back to full capacity. On float charge it will take several months to restore the last few percent of capacity after a deep discharge.

Repeated cycle testing does not represent normal telecom operating conditions and should only be conducted in a lab or a workshop with appropriate reconditioning chargers.

Ni-Cd batteries can easily be engineered for repeated cycle applications, but such batteries would cost more and would require much more maintenance.

Sonica.plus batteries are optimized for daily shallow cycles and will recharge efficiently at low charging currents. They can sustain several thousands of shallow discharges without any negative effect on life.
9.10. Water consumption

Battery water consumption is basically a result of overcharging (water electrolysis) and evaporation. Theoretically, after a battery is fully charged, it will use up to 1/3 ml of water per cell, per A and per hour. In addition, water losses from evaporation can be considerable and may in many situations exceed water losses from electrolysis. Water consumption will increase rapidly with the temperature, due to higher evaporation as well as to the effect of higher float currents.

Water replenishment has always been part of battery life. But with the increase of maintenance costs, efforts have been made to reduce the battery water consumption. Some battery systems, such as the VRLA batteries, are engineered to allow maximum gas recombination to reduce or eliminate water losses. To ensure proper battery operation and reduction of water evaporation, the VRLA cells are sealed from the atmosphere by a pressure release valve. A drawback is that the VRLA batteries will generate a certain amount of heat on charge depending on how much gas they have to recombine.

Different types of Ni-Cd batteries employ different techniques to reduce their water consumption and to increase time between top-ups.

The Ultima.plus battery has a generous electrolyte reserve combined with a 85-95% efficient gas recombination system which will allow the battery to stay on float charge for up to 20 years without water replenishment.

With its S/PBE plate construction, the NCX battery has a very low float current, about 0.4 mA per Ah. Furthermore, the NCX water filling system (WFS) more or less eliminates the problem of evaporation. Tests have confirmed that this battery can operate for well over 10 years without a top-up.

The SPH battery does not have any WFS, but a combination of very low float currents and a larger electrolyte reserve makes it possible to operate well over 10 years without watering.

Sunic.a.plus and the SBH batteries have large electrolyte reserves and can operate up to 3 years without maintenance.

9.11. Gas evolution

All Ni-Cd as well as lead acid batteries produce hydrogen and oxygen gas on charge. During continued floating of a fully charged cell, each Ah of overcharge will produces 0.23 liters (0.008 cubic feet) of oxygen and 0.46 liters (0.016 cubic feet) of hydrogen.

As mentioned above, some batteries employ recombination techniques to recombine hydrogen and oxygen to water, and as long as the recombination system works efficiently, the amount of gasses escaping from the batteries will be minimal.

However, recombination systems can only handle a limited amount of charging current and may fail to operate properly for various reasons.

Be aware that national safety regulations and standards do not only consider hydrogen evolution under normal operating conditions, but will require calculations for worst case and abnormal conditions such as loss of voltage control and full charging current being applied to the battery. Ventilation requirements depend therefore more on rated charger output than rated battery capacity. Most safety standards require the same ventilation for VRLA as for flooded batteries.
Ni-Cd batteries can be charged by any of the common charging methods such as constant voltage or constant current. In telecom applications, constant voltage is most common and several strings of batteries may be charged in parallel, while connected to the load. Constant current is not commonly used with standby systems, as it will lead to elevated voltages and off-line charging may be required.

Ni-Cd batteries may be optimized for different charging conditions. For optimum performance, operating instructions should be strictly followed. Remember that they are specific to each Ni-Cd battery type.

10.1. Constant voltage charging
Most telecom installations employ a single rate, constant voltage charging system. Several rectifiers connected in parallel may be wired or plugged in to the main DC bus. Similarly, several battery strings may be connected to the same DC bus. In some cases a breaker is installed for each battery string. In the USA, this system of parallel rectifiers and batteries is referred to as a “Bulk Power System”.

Single rate constant voltage charging of Ni-Cd batteries always represents a compromise: by maintaining the voltage as low as possible, minimum overcharge and minimum water consumption will occur. But after a discharge it will take longer to bring the batteries back to full capacity and the batteries may, for some period, operate below 100% state of charge. This will not reduce battery life, but full battery capacity may not always be available.

In other words, the lowest possible charging voltage is desirable from a maintenance point of view while a higher charging voltage is needed for faster recharge. The charging voltage should therefore be chosen carefully to obtain an acceptable level of recharge without increased maintenance costs.

Ni-Cd batteries may be charged continuously from 1.42 to 1.47 V per cell, and most Ni-Cd batteries will recharge to a high state of charge within 24 hours at those levels. Most 48 V telecom installations will charge at around 1.43 V per cell, which correspond to 54.35 V for 38 cells.

Temperature compensation is not recommended.

Charging at a higher voltage level will not be detrimental to the battery, but will cause increased maintenance as the batteries will use more water. Figure 25 shows voltage and current for an 48V NCX battery being recharged at a maximum current of 0.1 C and 1.43 V per cell.

A dual level constant voltage charging system is generally used for charging of generator starting batteries. This has certain advantages, as it will allow the batteries to be fully charged much faster at the “high rate” charging level, normally set at 1.45 to 1.65 V per cell. The float charging level can be set as low as 1.38 V per cell because the batteries are fully charged when they are switched to float. At 1.38 V per cell, the water consumption is very low and maintenance costs can be reduced. When dual level chargers are used, an automatic device can be utilized to switch between the charging levels.

It is particularly important that a timer or some kind of automatic device is employed to switch to float charge after dual level recharge because continuous high rate charging could deplete the battery of water within a few days.
10.2. Constant current charging

Constant current charging is the best way to get a Ni-Cd battery fully charged in the shortest possible time. Most Ni-Cd batteries can be charged at the 0.2 C rate. NCX and Ultima.plus can be charged at 0.05 C rate. Please read the relevant installation and operation instructions.

*Constant current is mainly used for reconditioning charging or rapid recharging before a test.*

Constant current is rarely used in telecom systems, as it is difficult to control charging current while loads are connected. In addition, the battery voltage will exceed the maximum operating voltage of the load. Some of the SLC systems commonly used in the USA are exceptions. Here the batteries are charged off line and are reconnected to the load by fast electronic switches if AC fails. New current controlled charging systems have been proposed to the telecom industry as a way to avoid thermal runaway in VRLA batteries.

Figure 26 shows the charging voltages at various charging rates for a SPH battery. These curves clearly show that, in order to recharge a Ni-Cd battery at a constant current rate, a relatively high voltage would be required. As illustrated by the curves, the battery will charge at a modest voltage until it is about 80% charged. At that stage, the voltage will start to increase rapidly and the battery will start to produce gas. As the battery approaches full charge, the voltage will reach a plateau and the gassing will reach its maximum as practically all charging current will be used for electrolysis.

Figure 26: Battery voltage at different temperatures during constant current charging

To restore full capacity by constant current charging, PP batteries must receive 140% of their nominal capacity while the S/PBE batteries will need at least 120%.

For a reconditioning charge, that might be required after frequent cycling or long storage, additional overcharging will be required. See 10.6.
10.3. Charge acceptance and efficiency

During a constant current charge, a Ni-Cd battery will be able to store close to 100% of the received capacity until 70 - 80% of its rated capacity has been restored. After that stage, gassing will start and gradually more and more of the charging current will be used for water electrolysis. This means that the batteries are almost 100% charge efficient until the gassing starts and become less efficient as more and more current is used to produce gas. The overall charge efficiency of a Ni-Cd battery depends on plate type, charging rate and temperature, and is about 82% for a S/PBE battery and 71% for a PP battery when charged at the 0.1 – 0.2 C rate and at room temperature. The charging efficiency is at its maximum at room temperature and will drop slightly with decreasing temperatures. The charging efficiency is poor at extremely high temperatures.

During a constant voltage recharge, the battery will generally accept maximum current from the charger until the constant voltage level has been reached. The charging current will then start to drop and will after some time stabilize at a rate determined by the charging voltage and temperature. See Fig. 25 above.

At a charging voltage of 1.43 volts per cell and at room temperature, the float current will be about 40 mA for a 100 Ah NCX battery. Because of the drop in charging current before full charge has been reached, gassing will be kept at a minimum and the total recharge will be very efficient. Figure 27 shows state of charge after charging an NCX battery during 24 hours at different voltage levels.
10.4. Temperature effects
With increased temperatures, most electrochemical reactions become more active. During constant voltage charging, an increase in temperature will cause an increase in charging current and an increase in water consumption.

Utilizing a temperature compensation circuit in the charging system could counteract these effects.

*While temperature compensation circuits are widely recommended for VRLA batteries, they are not recommended for nickel cadmium batteries in telecom applications where a single level constant voltage charging system is employed.*

The reason for this is as follows:

With an increase in temperature, charge efficiency will decrease and therefore an increase in charging current is needed to compensate for that effect. Further, the battery's rate of self-discharge will increase and again more charging current is needed as compensation. It is therefore clear that the battery needs an increase in float current with elevated temperatures to maintain the batteries at a healthy state of charge. A temperature compensation circuit that is designed to keep the current constant is therefore not desirable.

With a decrease in temperature, the charging current will drop. As the battery's self-discharge is also reduced, this would seem acceptable. However, at very low temperatures, a higher charging voltage is needed to bring the battery back to full capacity. This voltage in most cases would exceed the maximum equipment voltage. In general, battery compartments in areas with sub zero temperatures are equipped with heaters. This is a good solution as it eliminates the need for high charging voltages and it also ensures better battery performance on discharge.

10.5. Commissioning charge
A commissioning charge or reconditioning charge may be necessary for batteries that have been subjected to various forms of electrical abuse or irregular operating conditions such as:

- long storage periods (more than 6 months)
- frequent deep discharges with limited constant voltage recharge
- cycling at high temperatures with insufficient recharge.

Steps of a commissioning charge are as follows:

Before charging, the battery should be discharged to 1.0 V per cell. Then, charge at least 200% of the battery's nominal capacity at the 0.05 – 0.2 C rate, depending on battery type. To check the result, a capacity test must be performed followed by a 150% capacity constant current recharge.

⚠️ Top up with water before the battery goes back into service.

*As Ni-Cd batteries represent a relatively high initial investment, batteries that appear to have low capacity should not be discarded. A commissioning charge may completely restore the battery to full capacity.*

If facilities for such work are not available within your company, there are battery service companies nearby that will be able to assist you. Call your Saft representative for advice or consult Saft's operation and maintenance instructions, which will provide details about commissioning charge.
11. Special operating factors

11.1. Electrical abuse

Nickel-cadmium batteries are able to sustain electrical abuse much better than VRLA. Occasional complete discharges, charging in reverse, overcharging, short-circuits, lack of charging, etc., have little effect on the life of a Ni-Cd battery.

However, continuous excessive abuse may cause some maintenance problems and should be avoided.

11.1.1. Ripple effects

Ripple current is generally not a concern in telecom installations as the rectifiers’ outputs are well filtered. However, nickel-cadmium batteries are also used for other applications such as UPS back up or engine cranking where relatively simple unfiltered chargers may be used. Large inverter loads may also cause high ripple currents.

While even a modest level of ripple current may be of concern for VRLA batteries, high ripple currents have very little detrimental effect on nickel-cadmium batteries unless the current is so high that the thermal effect will elevate the battery temperature to unacceptable levels.

Nickel-cadmium batteries can easily tolerate ripple currents up to 0.2 C without any significant increase in temperature.

However, if the batteries already operate in extremely high ambient temperatures, additional temperature increases should naturally be avoided.

11.1.2. Over-discharge

Ni-Cd batteries can tolerate complete discharges and even limited reverse charging without any damages.

If a string of cells is allowed to discharge to zero volts, cells with the least capacities will always receive some reverse charging. Continuous charging in reverse at high current should be avoided as it will cause heavy gassing (and possibly electrolyte spillage) and a high water consumption. This situation can occur if a battery block is installed with reversed polarity. Generally no permanent damage will occur with a Ni-Cd battery as long as the situation is rectified before the electrolyte reaches its minimum level. Such treatment would ruin a lead-acid battery.

11.1.3. Overcharge

Occasional overcharging will not harm a Ni-Cd battery, as long as the electrolyte levels are maintained. Continuous overcharging will cause high water consumption and additional maintenance (see 9.9 above). Overcharging at very high currents will cause heavy gassing that could force some electrolyte out of the cells. Continuous overcharging at elevated temperatures will lead to shorter battery life and must be avoided.

In telecom applications, overcharging rarely occurs unless something goes wrong or mistakes are made. It could occur as a result of high charging voltage from a faulty rectifier or by installation mistakes, for instance, if cells or battery blocks are installed in reverse. If correct cell voltage is maintained, overcharging will not occur.
11.2. Mechanical abuse
With their solidly welded internal steel structure, Ni-Cd batteries can handle continuous abuse from shock and vibrations. This is one of the reasons why they are the batteries of choice onboard passenger rail cars all over the world. Ni-Cd batteries have been shock and vibration tested and certified by independent laboratories for a variety of installations and applications.

As the steel structure is virtually immune from destructive corrosion during the life of the battery, the mechanical integrity will not deteriorate as the batteries age.

11.3. Corrosion
The electrolyte protects the internal structural steel from destructive corrosion. Nickel-cadmium batteries are, therefore, completely free from one of the main ailments of lead acid batteries: grid corrosion with subsequent grid growth and weakening of the plate structure. See Fig. 28.

All external metal parts made from copper and steel have been heavily nickel plated. In addition, a special protective coating has been applied. Connectors and terminals are further protected from electrical and mechanical damage by the plastic connector covers. Once correctly installed and the right torque has been applied to the terminal bolts, there is no need to reapply torque on a regular basis.

Experience has shown that repeated use of a wrench may do more harm than good as it may disturb the protective coating and ruin the nickel plating.

A properly installed nickel-cadmium battery should not suffer from external corrosion during its lifetime even when operated in relatively high humidity.

Figure 28: Positive (Ni) sintered plate after 10 year operation (above). Grid corrosion on lead-acid plate (below)
12. Battery sizing principles

Most telecom battery sizing calculations are simply based on an estimated Ah requirement.

Very detailed calculations with all the appropriate sizing factors are usually not necessary, because:
• loads depend on the amount and type of equipment installed as well as on traffic
• equipment modifications and additions are somewhat unpredictable
• in most installations additional battery strings can be installed if required.

Should your company require any assistance in battery sizing, please contact your nearest Saft representative who will put you in contact with a Telecom Application Engineer.

12.1. NCX and Ultima.plus sizing

For new installations, past experience and recommendations from the equipment manufacturer usually dictate the battery capacity. If calculations have to be made, the load current is estimated or obtained from the electronic equipment manufacturers. Most manufacturers will give conservative load estimates, corresponding to high traffic conditions. Allowances may be made for near future expansions.

The load current is multiplied by the required standby time, normally 8 hours. A 25% aging factor is often added and the required capacity can be determined.

Most installations utilize parallel strings of standard battery sizes. A sufficient number of strings must be installed to cover the calculated battery capacity.

Some telecom operators will add an extra string for redundancy. For future equipment additions, the load current is usually monitored and battery strings are added if required based on the same simple formula:

\[ N = 1.25 \times I \times \frac{T}{C_s} \]

\[ N = \text{Number of strings required} \]
\[ 1.25 = \text{Aging factor or margin factor} \]
\[ I = \text{Average load current in amperes} \]
\[ T = \text{Standby time in hours} \]
\[ C_s = \text{Ah capacity per string} \]

The calculated number is always rounded up to the next integer and an additional string may be added for redundancy.

This relatively simple battery calculation method will also work well with Ni-Cd batteries. We encourage the practice of adding 25% to the basic capacity as Ni-Cd batteries will also lose some performance with time and may not always be able to provide 100% capacity in some severe telecom environments.

We do not encourage that a redundant string is installed, as Ni-Cd batteries are highly reliable.

12.2. Sunica.plus sizing

Calculating the required battery capacity for Sunica.plus batteries in PV applications is more complex. Please refer to the Sunica.plus technical manual.

12.3. Battery sizing for engine starting and cranking applications

In order to select and size the right battery for engine cranking applications, please ask your local Saft contact.
13. Installation and operation

Ni-Cd batteries are designed for easy installation, minimum maintenance and safe operation.

All batteries contain hazardous materials and energy that can cause damage and bodily harm if not handled properly and correctly.

Therefore, before handling any type of battery, make sure you have a copy of an Installation and Operating Instruction Sheet for your particular battery. There should be an instruction sheet packed with each battery. If it is missing, contact your nearest Saft representative and request a new instruction sheet.

Familiarize yourself with the content of the ISO Instruction Sheet before you handle the battery and follow the instructions step by step. The instructions will help you to install the battery efficiently and safely and will allow you to obtain maximum battery life and performance at the lowest possible cost.

13.1. Safety

The most important part of the instructions is the section that deals with safety. Be aware of the potential sources of hazards and learn how to deal with them and understand what precautions are required. Here are a few basic points:

Corrosive electrolyte

Eye protection is a must as a small splash of electrolyte may cause permanent eye damage. Electrolyte may also cause skin irritation and ruin clothing unless washed off immediately. Wear protection.

Explosive gasses

Hydrogen and oxygen are developed during charging. The gas mixture inside the cells should always be considered highly explosive. Explosive mixtures of hydrogen and air or oxygen may also accumulate inside battery enclosures and rooms unless generously ventilated.

Never smoke, use open flame or generate sparks near a battery. Do not wear clothing that generate static electricity and discharge your body and your tools to a grounded (earthed) metal object before you work on a battery that has been charged.

Electrical shocks and burns

Care must be exercised to avoid electric shocks, particularly from high voltage batteries. Care and precautions must be taken to avoid short circuits from tools and other metal objects such as jewelry.

Metal watchstraps and jewelry must not be worn when working on batteries. Read more about safety in the Installation and Operating Instructions.

13.2. Transportation and storage

The different types of Ni-Cd batteries are transported and stored differently.

All S/PBE batteries such as NCX and SPH are shipped and stored filled with electrolyte and discharged. These batteries are most stable and durable in this condition. They can be left in storage in this condition for several years. No commissioning charge is necessary before installation.

PP batteries such as Ultima.plus, Sunica.plus and SBH types are generally shipped filled and charged. They can be stored in this condition for up to one year. If stored for more than 6 months before installation, it is recommended that a commissioning charge should be made first.

Batteries are shipped and classified as hazardous material. Some communities have regulations regarding reportable quantities of hazardous materials stored and installed. If you plan a large battery installation, you should check with your local environmental authorities or fire protection department.

The storage area must be dry, clean and located indoors. The plastic casing of the batteries must be protected from direct sunlight.

13.3. Installation

Ni-Cd batteries should be installed in a dry and clean location, free from direct sunlight and heat. The battery compartment or room must be well ventilated. Follow applicable safety standards for ventilation. Batteries work best in temperatures between +10°C to +30°C (+50°F to +86°F). Follow Saft’s installation instructions.

13.4. Maintenance

Saft batteries are designed for minimum maintenance.

Simply follow the Installation and Operation Instructions that are written for your type of battery, as different batteries and different applications have different requirements.

If you find the maintenance procedures impractical or difficult to follow, consult a Saft Telecom Application Engineer.
After a long life, spent nickel-cadmium batteries should be returned for proper recycling. Saft operates a network of collection points around the world that forward batteries to recycling plants for proper treatment.

Ni-Cd batteries must not be discarded as harmless waste. The batteries contain heavy metals and a corrosive liquid. They must be disposed of in accordance with national and local government regulations.

In most countries, users of industrial Ni-Cd batteries are responsible for their safe disposal. Saft operates a network of collection points around the world, and if you use only a small number of cells or batteries, you can transport them to one of these collection points. They will be forwarded to Saft’s Oskarshamn plant or to another recycling plant approved by Saft.

If you intend to handle spent batteries, you need to be familiar with regulations with regards to reportable storage quantities and allowable storage time. Your local Saft representative can assist you with this information.

Saft strongly supports full recycling of spent batteries. The simple and unique nature of the parts of a Ni-Cd battery make them all readily recyclable.

The recycling techniques are simple and direct. See figure 29. Contact your Saft representative for information on how to dispose your spent batteries.

To locate the nearest collection site, please visit www.saftbatteries.com.
## 15. Abbreviations and acronyms

The following abbreviations and acronyms are used in this manual:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Ampere</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>AGM</td>
<td>Absorbed Glass Mat</td>
</tr>
<tr>
<td>Ah</td>
<td>Ampere hour [battery capacity]</td>
</tr>
<tr>
<td>CEV</td>
<td>Controlled Environmental Vault</td>
</tr>
<tr>
<td>CO</td>
<td>Central Office</td>
</tr>
<tr>
<td>CWS</td>
<td>Central Watering System</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DLC</td>
<td>Digital Loop Carrier</td>
</tr>
<tr>
<td>FP</td>
<td>Fiber Plate</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>LCC</td>
<td>Life Cycle Cost</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material Safety Data Sheet</td>
</tr>
<tr>
<td>Nicad</td>
<td>Nickel-cadmium</td>
</tr>
<tr>
<td>P/P</td>
<td>Pocket/Pocket Plate Couple</td>
</tr>
<tr>
<td>PBE</td>
<td>Plastic Bonded Electrode</td>
</tr>
<tr>
<td>PP</td>
<td>Pocket Plate</td>
</tr>
<tr>
<td>S/PBE</td>
<td>Sinter/Plastic Bonded Electrode couple</td>
</tr>
<tr>
<td>S/S</td>
<td>Sinter/Sinter Plate Couple</td>
</tr>
<tr>
<td>SLC</td>
<td>Subscriber Loop Carrier</td>
</tr>
<tr>
<td>SP</td>
<td>Sintered Plate</td>
</tr>
<tr>
<td>UL</td>
<td>Underwriters Laboratory</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterruptible Power Supply</td>
</tr>
<tr>
<td>V</td>
<td>Volt</td>
</tr>
<tr>
<td>VRLA</td>
<td>Valve Regulated Lead Acid</td>
</tr>
<tr>
<td>WFS</td>
<td>Water Filling System</td>
</tr>
<tr>
<td>Wh</td>
<td>Watt hour</td>
</tr>
</tbody>
</table>
Committed to a clean environment
Saft takes seriously its responsibility to safeguard the environment.
At several sites worldwide, more than 99% of metals contained in the battery are recycled. This process safeguards valuable natural resources and is a service to customers that Saft will continue to offer for future generations.
To locate the nearest collection site, visit www.saftbatteries.com.