Why Ni-Cd batteries are superior to VRLA batteries

Statements and facts

1. Maintenance

Maintenance for VLRA batteries leads to higher costs than for nickel-cadmium batteries.

2. Lifetime

In practice, the longevity of VRLA batteries is often very different from the figure given in the catalogues since it is sensitive to application conditions. The long lifetime of nickel-cadmium batteries is an attested fact.

3. Failure

VRLA batteries run a higher risk of failure than other industrial batteries, especially nickel-cadmium.

4. Environment

In extreme environmental conditions, nickel-cadmium batteries offer unrivalled performance. Electrical abuse and temperature variations make almost no impact on nickel-cadmium batteries, whereas they can lead to the total destruction of VRLA batteries.
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Statements and facts

1. Maintenance

VRLA batteries have been marketed as maintenance-free products, but a closer look at VRLA maintenance instructions clearly shows that they are not! Although VRLA batteries are indeed maintenance-free with respect to topping-up operations, the remaining operations needed to insure optimum performance carry a significant cost.

VRLA batteries are not maintenance-free products for at least two reasons:

① Terminal connections need to be checked from time to time.
② Battery and individual cell voltages need frequent checking.

“Every month, it is recommended to check that the total voltage at battery terminals is \((N \times 2.27V)\) for a temperature of 20°C, \(N\) being the number of cells in the battery.

Once a year, it is advisable to effect a reading of the voltages of cells constituting the battery.”

(Statement from OLDHAM FRANCE regarding the VRLA Espace range.)

The only "maintenance-free" feature is the fact that there is no need to top up with water.

But other restrictions appear, such as the need to check the temperature of each individual cell instead of just part of the complete battery, and to check the impedance or conductance of the cells and to carry out discharge tests. All these operations are costly and must be carried out several times a year so as to try to predict battery failure risks and hence the reliability of a mission-critical system equipped with such a battery.

Ni-Cd batteries are robust and have a very low failure rate.
They offer competitive solutions in terms of maintenance costs.
2. Battery life

The lifetime of VRLA batteries as quoted by manufacturers is only notional (something between 5 to 10 years). The real figure depends essentially on actual utilisation conditions.

"While the battery can float 8 years at room temperature, experience shows that due to variations in use, chargers and fluctuating ambient, the typical float life at room temperature is approximately 3-5 years."

(Statement from PANASONIC, extracted from the Panasonic Technical Handbook for VRLA batteries, published by Matsushita Battery Industrial Co., Ltd., Osaka, JAPAN.)

In fact VRLA batteries deteriorate quickly in applications for the following reasons:

a) VRLA battery life is highly sensitive to temperature conditions

If a 10-year life-time can be expected at 20°C, then for every 10°C temperature increase, battery life is halved. Therefore, the same VRLA battery would only perform 5 years at 30°C, and only 2.5 years at 40°C.

b) VRLA batteries require precise charging parameters

A float voltage higher than that stipulated by the constructor will result in excessive charging current, which in turn causes excessive gas production and water loss, leading to premature battery dry-out (very low electrolyte reserve). On the other hand, a too-low float voltage will lead to permanent capacity loss.

On the other hand, Ni-Cd batteries offer following advantages:
- A life time in excess of 20 years at 20°C in stand-by conditions.
- High temperatures do not have much impact on battery lifetime.

In contrast, for Ni-Cd batteries an excessive float voltage would only result in a higher water consumption, while a too low float voltage would result in an insufficient charge level.

In neither case are battery lifetime or electrical performance affected.
c) The charge voltage requires a temperature-compensating voltage adjustment battery charger

All installations require a high-quality and accurate temperature-compensating voltage adjustment battery charger. Frequent inspection and continuous supervision of the charging voltage are essential!

"It is recommended that the charge voltage be adjusted to compensate for the battery temperature... The reasons for temperature compensation of the charging voltage:
A) To prevent the thermal runaway of the batteries when they are used in high temperature atmosphere.
B) Insufficient charging when the batteries are used in low temperature atmosphere."

(Statement from PANASONIC, extracted from the Panasonic Technical Handbook for VRLA batteries, published by Matsushita Battery Industrial Co., Ltd., Osaka, JAPAN.)

For Ni-Cd batteries, it is recommended to use temperature compensated charging voltage for applications covering a large temperature window. The aim is to insure a good charge level for the battery and to limit water consumption. Battery lifetime is not impacted by whether or not such a system is present.

3. Failure risks

Reliability is a key parameter for batteries: will the battery-based system perform as expected the day it is needed, i.e. 5, 10 or 20 years after the original date of installation? If the battery fails, the power system in which the battery has been integrated will fail as well.

Causes of failure are as follows:

a) Impact of the charging voltage and temperature parameters

Battery life and therefore failure risks are extremely dependent on charging voltage and temperature. Unacceptable charging and operating temperature conditions will significantly increase the risk of failure.

Ni-Cd batteries are tolerant to high temperatures, and inadequate charging conditions will usually not harm the battery.
b) **Corrosion**

Corrosion can affect the whole internal structure of VRLA cells. The risk of corrosion increases at high temperatures, and also under high electrolyte density. Corrosion is a permanent phenomenon in VRLA batteries once the battery has been filled with electrolyte.

It can reach such a level that it finally leads to the *"sudden death"* phenomenon (complete end of battery life) in an open-circuit situation where the whole current is cut.

But this "sudden death" is totally unpredictable.

*"Through gradual corrosion of the electrodes, the battery will eventually lose capacity and come to an end of life. It should be noted that the process will be eventually accelerated by higher ambient temperatures and/or higher charging voltages".*

(Statement from GLOBAL & YUASA Co., Ltd., Seoul, Korea.)

<table>
<thead>
<tr>
<th>The main components in a Ni-Cd battery are made of steel which are not affected by alkaline electrolyte. There is therefore no corrosion.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery ageing is a slow, linear process.</td>
<td></td>
</tr>
<tr>
<td>The end of battery life, or rather the moment when the battery is no longer able to supply the load during the requested back-up time, is easily predictable.</td>
<td></td>
</tr>
<tr>
<td>Ni-Cd batteries do not run a risk sudden death, and this ensures reliable back-up power.</td>
<td></td>
</tr>
</tbody>
</table>

c) **Battery dry-out**

The low quantity of electrolyte makes the battery highly vulnerable to any loss of water due to the gases generated from charging voltages which exceed constructor specifications at a given temperature. One part of the gas contributes to electrode corrosion, a second part is released via a re-sealable valve, and the third part is recombined. Water loss may be one of the causes of thermal runaway in VRLA batteries.

Since the cell water level cannot be monitored, this can lead to a further risk of battery failure.

| In most Ni-Cd batteries, it is easy to check the level of the ample electrolyte reserve which is visible through the translucent polypropylene container, and to add water if necessary to prevent any risk of battery dry-out. |  |
d) **Ripple currents**

High ripple currents can destroy a VRLA battery. In some UPS systems equipped with VRLA batteries, it has been reported that battery life was as short as 18 to 24 months. This represents yet another risk of battery failure.

"*To obtain maximum life, the ripple current at RMS should be regulated to less than 0.1C A.*"

(statement from GLOBAL & YUASA Battery Co., Ltd., Seoul, Korea).

"*The quality of the charging current affects the longevity of the batteries. The efficient intensity of the alternating component (fundamental and harmonic) must not exceed 0.1 C_{10} A in a steady state.*"

(statement from OLDHAM FRANCE)

- Ni-Cd batteries are unaffected by ripple currents.

e) **Discharging conditions**

VRLA batteries must always be charged immediately after any deep discharge. If not, plates may be irreparably sulfated, increasing cell internal resistance and making the battery more difficult or impossible to charge, which entails a further risk of failure.

"*It is a general phenomenon that, when lead acid batteries of any type are stored in a discharged condition for an extended period of time, lead sulfate is formed on the negative plates, which is referred to as sulfation. Since the lead sulfate acts as an insulator, it has a direct detrimental effect on charge acceptance.*"

(Statement of GLOBAL & YUASA Co., Ltd., Seoul, Korea.)

"*When the battery is completely discharged:*
- the consumption of sulfuric acid is total and the electrolyte consists only of water.
- the sulfation of the plates is maximum, increasing considerably the cell’s internal resistance.

The water surroundings in which the battery is placed as a consequence of the state of deep discharge, may provoke metallic dendrites during recharge in the separator, which can short-circuit the cell."

(Statement from OLDHAM FRANCE.)

- Ni-Cd batteries can be deep discharged, and left in a discharged state for long periods of time. The discharged state of a Ni-Cd battery has no impact on its performances or life time.
4. Environment

In general, lead acid batteries are more sensitive to environmental conditions than Ni-Cd batteries, in particular with respect to:

- Extreme temperatures
- Electrical abuse
- Storage
- Mechanical abuse

a) Extreme temperatures

High temperatures have a disastrous impact on VRLA battery longevity.

At low temperatures, electrical performances are significantly affected and the gas recombination level is reduced. In cases of deep discharge at temperatures below 0°C, the electrolyte can freeze, causing irreversible damage in the cells (the electrolyte consists mainly of water).

An example of the low temperature influence on VRLA performances is shown below:

*Capacity affected by temperature (discharge rate 1°C):*

If at 25°C the battery performance is : 100%.
The battery performance at 0°C is : 80%.
and at -20°C is : 45%.

(*Statement from PANASONIC, extracted from the Panasonic Technical Handbook for VRLA batteries, published by Matsushita Battery Industrial Co., Ltd., Osaka, JAPAN.*)

Ni-Cd batteries are typically used between -20°C and +60°C, with excursions possible outside this range for short periods of time.

The alkaline electrolyte density is constant at any state of charge of a Ni-Cd battery and does not freeze at low temperatures.

Ni-Cd batteries can still offer 85% of their ambient temperature performances at -20°C.
b) **Electrical abuse**

- VRLA batteries must be protected from deep discharge.

- VRLA batteries cannot withstand prolonged overcharge conditions.

"Any extra charge after the battery is fully charged is called overcharge. Continued overcharge shortens the battery life."

*(Statement from PANASONIC, extracted from the Panasonic Technical Handbook for VRLA batteries, published by Matsushita Battery Industrial Co., Ltd., Osaka, JAPAN.)*

- The end voltage per cell should not fall below 1.60V/cell and this value must not be a deep discharge state.

- The charging current must be limited to 0.1$C_{10}$ A.

- Ripple currents must be as low as possible.

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| Ni-Cd batteries can even be fully discharged without damage. |
| Ni-Cd batteries can be charged with currents of up to 3$C_s$ A. |
| Ni-Cd batteries can be left in discharge condition for years. |
| Ni-Cd batteries are unaffected by ripple currents. |

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c) **Storage**

VRLA batteries need periodic refresh charges, in order to keep the battery in good shape.

"When batteries are placed in extended storage, it is recommended that they receive a refresh charge at recommended intervals:

<table>
<thead>
<tr>
<th>Storage ambient</th>
<th>Recommended interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>below 20°C</td>
<td>12 months</td>
</tr>
<tr>
<td>20°C to 30°C</td>
<td>6 months</td>
</tr>
<tr>
<td>30°C to 40°C</td>
<td>3 months&quot;</td>
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</tbody>
</table>

*(Statement from PANASONIC, extracted from the Panasonic Technical Handbook for VRLA batteries, published by Matsushita Battery Industrial Co., Ltd., Osaka, JAPAN.)*

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| Ni-Cd batteries can be stored for years, even if fully discharged. |
| They do not need periodic refresh charges. |
d) **Mechanical abuse**

The mechanical structure of a VRLA battery is based on lead alloys. Lead alloys are used to obtain higher mechanical resistance than the pure lead which is the base component in the electrochemistry of lead acid batteries. Each type of lead alloy gives more or less satisfying mechanical performances and results in different kinds of specific electrical behaviour and lifetime (corrosion) depending on the application in question. The mechanical benefit of each lead alloy must always assessed in terms of its effects on electrical characteristics over time.

NiCd batteries feature a steel internal structure and are therefore very resistant to mechanical abuse. They are also corrosion-proof and do not run any risk "electrical" breakdown. The polypropylene or steel containers are therefore extremely resistant.