COSINE DEVELOPMENTS

LEADERS IN LIGHTING TECHNOLOGY

P.O. Box 74412,
Rochdale Park,
4034,
Durban,
South Africa.

Tel.: +27 (31) 5792172
Fax: +27 (31) 5792176
Email: sales@cosine.co.za
Website: www.cosine.co.za

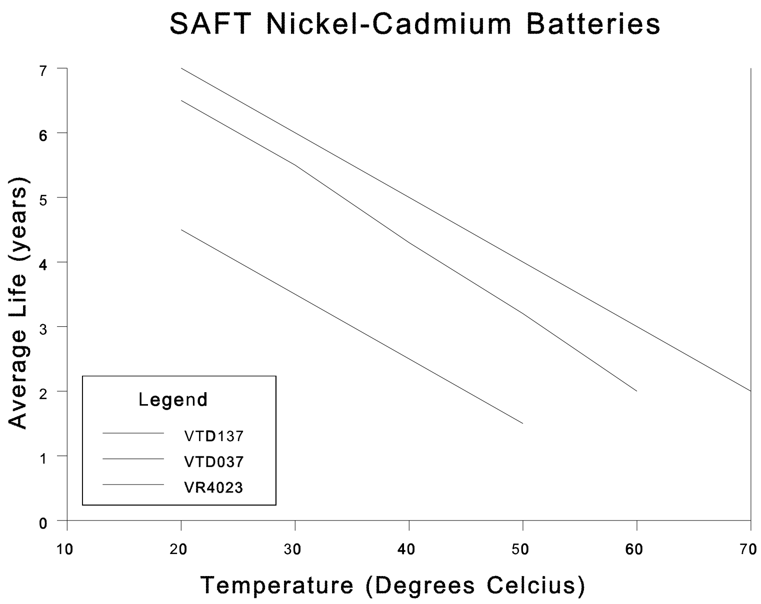
VAT No: 4710167067
Reg No: IT 1637/97

Version: 1.3

Effects of temperature and cycles on Battery Life

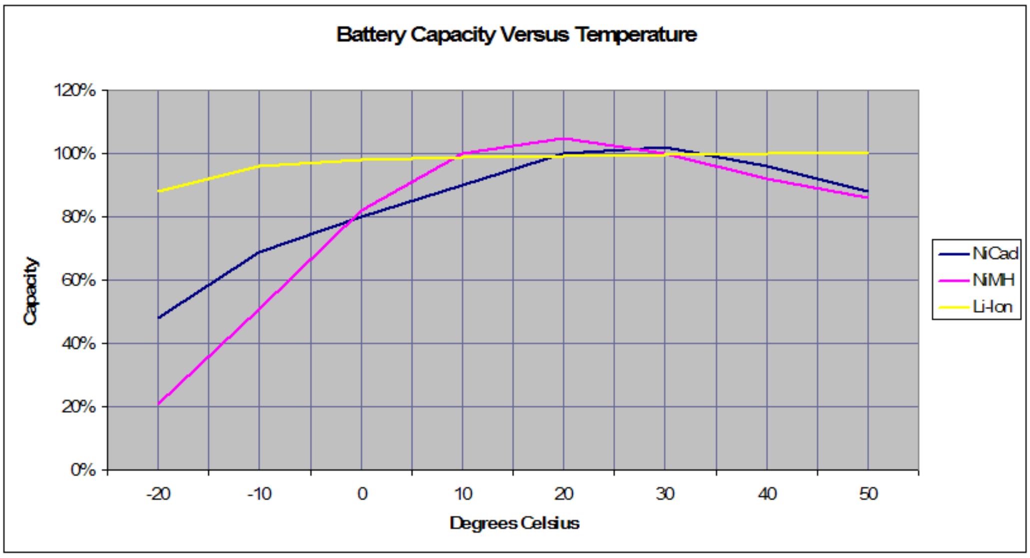
All batteries are adversely affected by high temperature. Both common batteries for emergency lighting, nickel-cadmium and lithium-ion, are discussed below. Also, All batteries have a finite number of discharge cycles which, when used up, render the battery useless. However, legal requirements dictate that emergency lighting systems must be tested every three months and so judicious use of the discharge cycles is necessary.

1. Nickel-Cadmium Cells



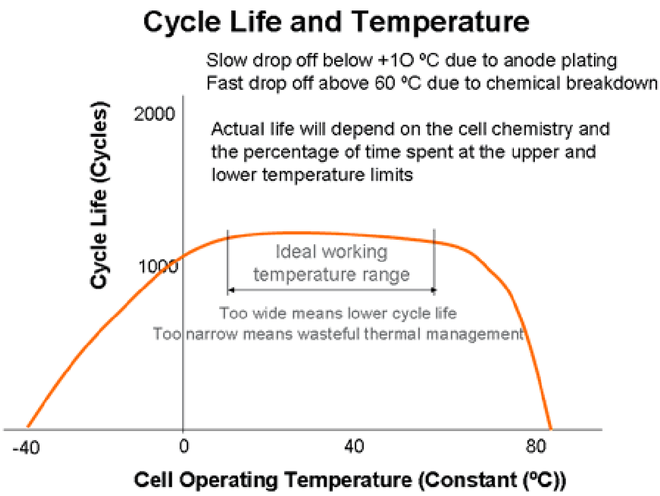
This graph shows the averaged expected service life of various SAFTTM nickel cadmium cells. Note the large difference in expected life between the various cell types. There is roughly a one year gain in cell life for every 10^0C reduction in cell temperature. High temperature types are more expensive and are therefore seldom used in the fiercely competitive emergency lighting market in South Africa. As the effect of temperature on cell life is fairly linear it follows that averaged room temperature can be used to predict cell life in a given emergency luminaire. The 20 year averaged ambient temperature for Durban is 20.8^{0}C. The average cell temperature of the sample maintained bulkhead using two PL9W lamps would therefore be approximately 54^{0}C (in Durban). Using the manufacturer's data the predicted service life of the VR4 type cell would be about one year, the VTD037 would last 2.5 years and the VTD137 cell would last 3.5 years.

2. Nickel-Metal-Hydride Cells



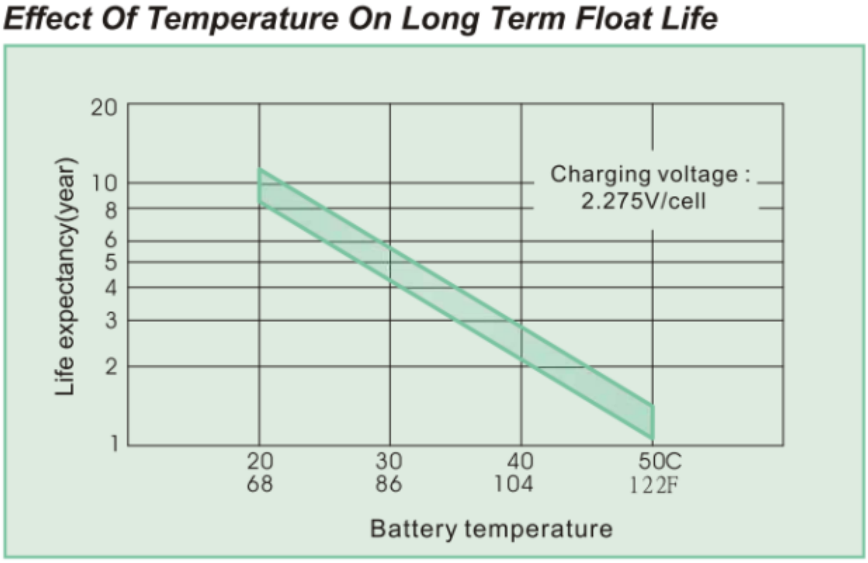
This figure shows that NiMH cells have similar performance characteristics as Ni-Cad and also suffer at high temperatures.

3. Lithium-Ion Cells



This graph shows that battery life reduces dramatically above 60^{0}C. The battery will be destroyed if exposed to temperatures above 80^{0}C.

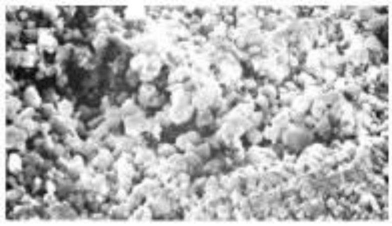
4. Lead-Acid Batteries



Lead-acid batteries are very sensitive to temperature. This graph shows that temperatures reduce the battery’s life dramatically.

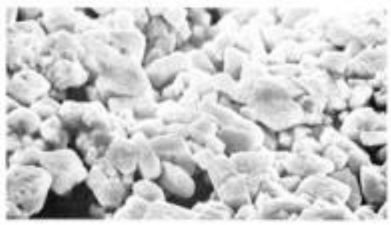
5. Memory Effect in Nickel-Cadmium

During the nickel-cadmium years in the 1970s and 1980s, most battery ills were blamed on “memory.” Memory is derived from “cyclic memory,” meaning that a nickel-cadmium battery could remember how much energy was drawn on previous discharges and would not deliver more than was demanded before. On a discharge beyond regular duty, the voltage would abruptly drop as if to rebel against pending overtime. Improvements in battery technology have virtually eliminated the phenomenon of cycling memory. These figures illustrate the stages of crystalline formation that occur on a nickel-cadmium cell if overcharged and not maintained with periodic deep discharges. The first enlargement shows the cadmium plate in a normal crystal structure; the middle image demonstrates full-blown crystalline formation; and the third reveals some form of restoration.



The top image shows a new nickel-cadmium cell. The anode (negative electrode) is in fresh condition. Hexagonal cadmium-hydroxide crystals are about 1 micron in cross section, exposing large surface area to the electrolyte for maximum performance.

The middle image shows a cell with crystalline formation. Crystals have grown to 50 to 100 microns in cross section, concealing large portions of the active material from the electrolyte. Jagged edges and sharp corners can pierce the separator, leading to increased self-discharge or electrical short.



The bottom image shows a restored cell. After a pulsed charge, the crystals are reduced to 3–5 microns, an almost 100% restoration. Exercise or recondition is needed if the pulse charge alone is not effective.

The modern nickel-cadmium battery is no longer affected by cyclic memory but suffers from crystalline formation. The active cadmium material is applied on the negative electrode plate, and with incorrect use a crystalline formation occurs that reduces the surface area of the active material. This lowers battery performance. In advanced stages, the sharp edges of the forming crystals can penetrate the separator, causing high self-discharge that can lead to an electrical short. The term “memory” on the modern Ni-Cd refers to crystalline formation rather than the cycling memory of old.

When nickel-metal-hydride was introduced in the early 1990s, this chemistry was promoted as being memory-free but this claim is only partially true. NiMH is also subject to memory but to a lesser degree than Ni-Cd. While NiMH has only the nickel plate to worry about, Ni-Cd also includes the memory-prone cadmium negative electrode. This is a non-scientific explanation of why nickel-cadmium is more susceptible to memory than nickel-metal-hydride.

Crystalline formation occurs if a nickel-based battery is left in the charger for days or repeatedly recharged without a periodic full discharge. Since most applications fall into this user pattern, NiCd requires a periodic discharge to one volt per cell to prolong service life. A

discharge/charge cycle as part of maintenance, known as exercise, should be done every one to three months. Avoid over-exercising as this wears down the battery unnecessarily.
If regular exercise is omitted for six months and longer, the crystals ingrain themselves and a full restoration with a discharge to one volt per cell may no longer be sufficient. However, a restoration is often still possible by applying a secondary discharge called “recondition.”
Recondition is a slow discharge that drains the battery to a voltage cut-off point of about 0.4V/cell and lower. Tests done by the US Army indicate that a Ni-Cd cell needs to be discharged to at least 0.6V to effectively break up the more resistant crystalline formations. During this corrective discharge, the current must be kept low to minimize cell reversal and, as discussed earlier, Ni-Cd can tolerate a small amount of cell reversal. Figure 2 illustrates the battery voltage during a discharge to 1V/cell, followed by the secondary discharge to 0.4V/cell.