

FNC[®] Battery Systems for Rail Vehicles

Telecom/IT Battery Systems

AGV Battery Systems

Motive Power Systems

Railway Battery Systems

Power Supply

Standby



Unique worldwide: FNC® Technology

Over 1,000,000 FNC®-Cells - and more every day

The right battery for every application

UNIQUE WORLDWIDE: FNC® TECHNOLOGY

In 1983 a new type of nickel-cadmium battery, the so-called fibre-structured (FNC® for short) technology, was introduced.

FNC® technology is based on metallised polypropylene fibre-structured mat, originally developed for very demanding applications such as aerospace, also electric and hybrid vehicles.

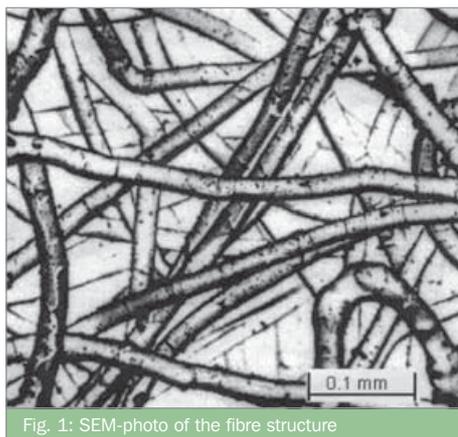


Fig. 1: SEM-photo of the fibre structure

This means that, in contrast to the two other technologies, the carrier material for the active material is not a heavy and rigid metal, but instead a very lightweight, flexible mat.

The highly dense, three-dimensional structure of the metallised fibre mat is so porous that 90% of the volume of the fibre electrodes remains free for filling with active material.

On account of its mode of construction, therefore, the FNC® technology has considerable advantages over other systems:

- High to very high currents possible during discharge and charging
- Low nominal capacity is sufficient for high currents
- Considerable savings in weight and volume

The fibre-structured electrodes have a conductive nickel matrix into which the active material is filled by a specially developed process, without the use of additives (e.g. graphite, iron, etc.).

For this reason, even over the entire working life of the battery, there is no ageing of the electrodes due to oxidation of graphite leading to the forming of carbonate in the electrolyte (aqueous solution of KOH with a density of 1.19 kg/l). Consequently, no change of electrolyte is necessary throughout the operating life of the battery, in contrast to conventional NiCd batteries.

A further benefit is that the fibre-structured electrodes retain their flexible character to a large extent, even after filling with the active material.

This property is very important since the charging and discharge cycles are accompanied by a change in volume of the active material which takes place in the three-dimensional hollow spaces of the fibre-structured electrodes.

The fibre-structured electrodes follow the volume change of the active material, and the contact between the active material and the electrode is maintained for the whole period of the charge/discharge cycle, right to the end of the life of the battery.

These changes in volume of the active material are something which the carrier materials of electrodes of other battery technologies are unable to follow.

The rated voltage of a FNC® cell is typically 1.2 V.

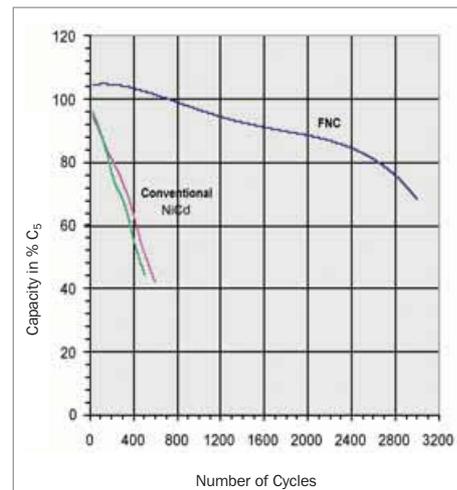


Fig. 2: Available capacity versus number of cycles

Further advantages of FNC® technology:

- Very low internal resistance
- High energy density
- Very high resistance to cycling
- Good resistance to shock and vibration

FNC® cells may be operated reliably in a temperature range from -20 to $+50^{\circ}\text{C}$ and, with special electrolyte, even from -50 to $+65^{\circ}\text{C}$.



FNC® is proven under the most extreme temperature conditions.



OVER 1,000,000 FNC® CELLS – AND MORE EVERY DAY



Since 1983, HOPPECKE Batterie Systeme has supplied more than 1,000,000 FNC® cells to its railway customers throughout the world. This success is based on the many advantages offered by FNC® technology as compared with other energy storage systems. These benefits are especially advantageous for long-life applications:

- No sudden failure because there is no internal corrosion
- Up to 15 years' life expectancy
- More than 3000 charge/discharge cycles
- No total failure of the battery in the event of deep discharge
- More than 85% of rated capacity available at -20°C (see Fig. 3)
- Rapid charging facility at currents of up to $7 \times C_5$
- No corrosive gases under float charging operation

All HOPPECKE FNC® cells for rail vehicles are manufactured at the Brilon site in Germany, which is certified to ISO 9001, ISO 14001 and DIN 6700 C5 standards.

THE RIGHT BATTERY FOR EVERY APPLICATION

HOPPECKE Batterie Systeme offer a large selection of FNC® cells, which find use in a very wide range of applications in rail vehicles in the versions XR, HR, MR and LR. Here:

X = extra high

H = high

M = medium

L = low each referring to the discharge current which may be withdrawn as specified in DIN EN 60623 and BS 6260.

FNC® cells for use in rail vehicles, identified by the code letter R, have electrode material which has been optimised for cyclic operation.

The HOPPECKE XR types are used for diesel starting and emergency braking, i.e. for high to very high currents, up to 20 times the rated capacity.

HR type batteries are suitable both for diesel starting and emergency braking. The MR and LR types are designed for auxiliaries and emergency systems for discharge periods of 45 to 60 minutes. If it is necessary to start a small diesel engine, while at the same time using the main load for the emergency systems, then in such exceptional cases MR types may also be used.

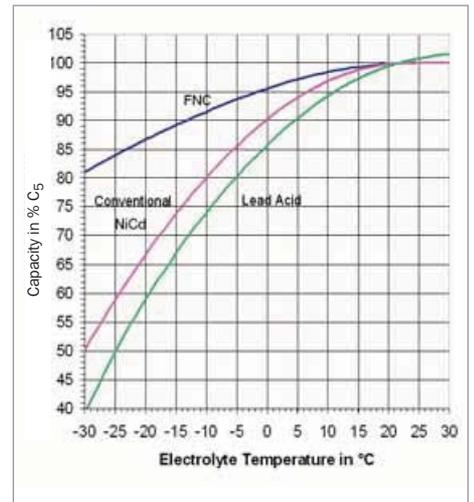


Fig. 3: Available capacity at $I_{Ea} = 0.2 \times C_5$

In terms of available capacity depending on temperature, there are clear differences between the various battery technologies (see Fig. 3).

When special electrolyte is used, up to 65% of rated capacity may be withdrawn at -40°C from FNC® batteries.

Proven and successful: HOPPECKE standard cells

Challenge us: HOPPECKE special types

Made of wood, HDPE or stainless steel: HOPPECKE battery crates

Individual cells are more economical than monobloc batteries

Reliable and load-bearing: HOPPECKE battery trays

PROVEN AND SUCCESSFUL: HOPPECKE STANDARD CELLS

Besides the polypropylene cell, HOPPECKE Batterie Systeme also offer as standard, cells from four other materials: stainless steel, polyether sulphone VO (PES), polypropylene VO and polyamide VO (Grilon) (see Fig. 4).

Plastic cells of polypropylene, polyamide and polyether sulphone with the suffix VO meet the enhanced fire prevention standards of UL 94 VO and NF F 16 101. They are used in particular on underground railways.



Fig. 5: HOPPECKE FNC® cut away cell in Grilon VO



Fig. 6: HOPPECKE special type cells (a selection)



Fig. 4: HOPPECKE FNC® standard cells

CHALLENGE US: HOPPECKE SPECIAL TYPES

No other technology is as suitable for the creation of special formats as the fibre-structured technology. Its enormous flexibility allows us to meet many individual requests from our customers (see Fig. 6):

- High cells which are also extremely flat
- Special cells in PES
- Standard format
- Low cells with a large base area
- Very compact low cells

The translucent polypropylene cells and the transparent PES cells allow visual inspection of the electrolyte level. With the polypropylene VO, Grilon VO and steel cells on the other hand, the electrolyte level is not visible and must be checked manually. Either with a glass tube or from an electrolyte level indicator incorporated in the cell lid (except in steel cells).

On request we can match the overall height of all cell types offered to the low floor design of the vehicle concerned. Modification of the cell base area is also possible, but will require the production of customised injection moulding tools.

The development and implementation of special solutions has been one of our special skills for many years now. We shall also be happy to cater for your special requirements.

Tell us what you need!



MADE OF WOOD, HDPE OR STAINLESS STEEL: HOPPECKE BATTERY CRATES

HOPPECKE battery crates to hold 2 to 10 individual cells are obtainable in wood, HDPE or stainless steel.

Wooden crates are made up of several glued and impregnated laminated panels, ensuring good dimensional stability. The HDPE crates of highly compressed polyethylene are extremely durable. For highly demanding applications we recommend stainless steel crates, which last for up to 30 years in railway vehicles (see Fig. 7).

Recommended variants:

- *PP cells in HDPE, wooden or steel crates*
- *PP VO, Grilon VO, PES VO cells in steel crates*
- *Steel cells in wooden crates*

Battery crates may be provided with fixed, movable or recessed handles. We also offer the HDPE crates with front connection terminals.

All crates and trays made by HOPPECKE Batterie Systeme meet the requirements for shock and vibration as specified in IEC 77, DIN EN 61 373 and NF F 60 002.



Fig. 7: Crates of different materials

RELIABLE AND LOAD-BEARING: HOPPECKE BATTERY TRAYS

HOPPECKE battery trays can hold up to 84 cells (110 volt batteries). They are made of stainless steel and constructed for mounting on slide rails or rollers as requested. If the battery tray is to be lifted into the vehicle by fork-lift truck, we offer a special design for this purpose. Depending on battery voltage, two battery trays are generally used for especially large and heavy cells (see Fig. 8 and 9).

INDIVIDUAL CELLS ARE MORE ECONOMIC THAN MONOBLOC BATTERIES

In comparison with monobloc batteries, individual cells offer three critical advantages:

- They may be replaced individually, e.g. if damaged.
- They may be combined flexibly to form one battery.
- And they may be installed at intervals of 3 to 6 mm. This spacing improves the heat exchange between electrolyte and ambient air through convection or forced ventilation. As a result, water consumption is reduced and cell charging ability is improved.

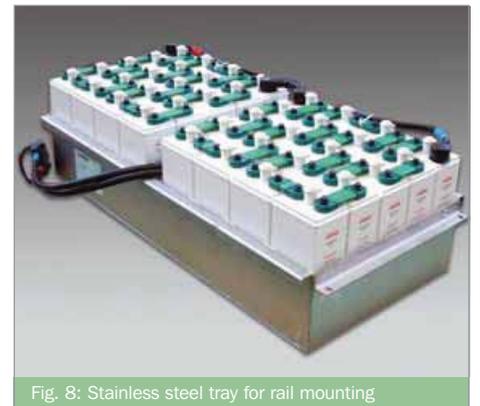


Fig. 8: Stainless steel tray for rail mounting

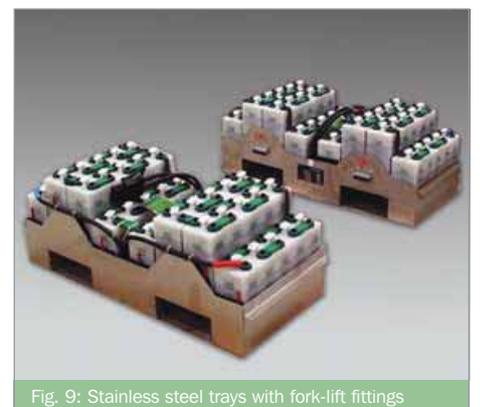


Fig. 9: Stainless steel trays with fork-lift fittings

Economical and reliable: The central water replenishment system

FNC® or lead-acid: You have the choice

For enhanced requirements: HOPPECKE charge/discharge rectifiers

Automatic shut-off: The HOPPECKE water refilling cart

Our service: A highly systematic approach

Our contribution to saving the environment: Our own recycling concept

Decide in favour of the most economical solution: FNC®

OUR COMPLETE SOLUTIONS:

POWER SUPPLY SYSTEMS

For a number of years, HOPPECKE Batterie Systeme has successfully sold complete power supply systems (see Fig. 10) comprising:

- FNC® cells
- Crates or trays
- Battery boxes

and the electrical components such as fuses, switches, diodes, etc.

In addition, for rail transport vehicles, we offer battery chargers which may be installed inside or outside the battery box as desired.

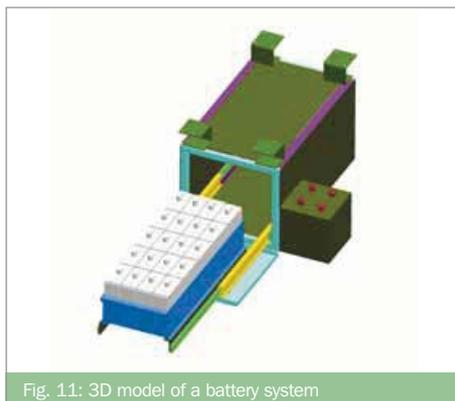


Fig. 11: 3D model of a battery system



Fig. 12: Results of an FEA

ECONOMICAL AND RELIABLE: THE CENTRAL WATER REPLENISHMENT SYSTEM

The central water replenishment system from HOPPECKE Batterie Systeme (see Fig. 13) offers the following benefits:

- Easy to use
- Individual replacement possible
- Saves cost and time
- May be retrofitted
- Safety

The replenishment of distilled or deionised water (DIN 43 530) is effected semi-automatically, i.e. after connection of the water pump to the inlet nozzle of the central water replenishment system, the system is switched on and the cells are quickly and reliably filled to the maximum level.

All batteries supplied by HOPPECKE Batterie Systeme to date may be retrofitted with the central water replenishment system.



Fig. 13: Safe against arc-back – central replenishment plug

FNC® OR LEAD-ACID: YOU HAVE THE CHOICE

In addition to FNC® cells, we also offer our complete battery system with vented or sealed lead-acid batteries. This makes HOPPECKE Batterie Systeme the only supplier in the world capable of equipping its battery systems with either lead-acid or NiCd batteries from its own production.

Our customers are also already receiving, in a very early stage of the project, 2D and 3D drawings of their battery system in AutoCad, Pro-Engineer or CATIA file format.

On request we will also carry out thermal analyses and finite element analyses to verify mechanical stability.



**FOR ENHANCED REQUIREMENTS:
HOPPECKE CHARGE/DISCHARGE
RECTIFIERS**

Our stationary charge/discharge rectifiers for railway maintenance depots are first class. They make possible not only the charging and controlled discharge of batteries but also equalising charging. This makes heavy demands on the setting of voltage and current, and on the charge/discharge characteristic.

Ia, IU, IUa, Wa and IUa charging characteristics may be programmed, together with I, P and W constant discharge characteristics. This is not possible with battery chargers installed on trains.

HOPPECKE Batterie Systeme also offer mobile charging units for on-train charging of batteries. This avoids the need for removal of the battery.



Fig. 14: Charge/discharge rectifier

**AUTOMATIC SHUT-OFF:
THE HOPPECKE WATER REFILLING CART**

It makes the manual topping-up of distilled water an easy, reliable and safe task.

The HOPPECKE water refilling cart has a filling nozzle with automatic shut-off facility. It measures the different light refraction indices of air and electrolyte.

As soon as the cell electrolyte level has reached the maximum, the filling process is terminated. A further advantage of this method of measurement: there are no electrical sparks and therefore no risk of explosion.

The HOPPECKE water refilling cart may be equipped with tanks of 30 or 60 litres capacity.

**OUR SERVICE:
A HIGHLY SYSTEMATIC APPROACH**



As an active worldwide supplier and manufacturer of system solutions for railway applications, we place quite special value on outstanding customer service. Not only in Germany, but also in all the countries in which our subsidiary companies operate: in the USA, China, Japan, Great Britain, Holland, Belgium, France, Spain, Italy, Poland and Russia. Whether lead-acid or NiCd batteries, whether our own systems or products of other manufacturers our experts undertake cleaning, repairs, reprocessing and capacity testing, including full documentation.

**OUR CONTRIBUTION TO SAVING THE
ENVIRONMENT:
OUR OWN RECYCLING CONCEPT**

In accordance with EU Directives, HOPPECKE Batterie Systeme contributes to responsible handling of industrial batteries by meeting our recycling quota. We guarantee to each of our customers that we will take back their used nickel-cadmium batteries – irrespective of technology, manufacturer or the age of the battery. We have developed and implemented our own recycling scheme for this very purpose.

**DECIDE IN FAVOUR OF THE MOST
ECONOMICAL SOLUTION: FNC®**

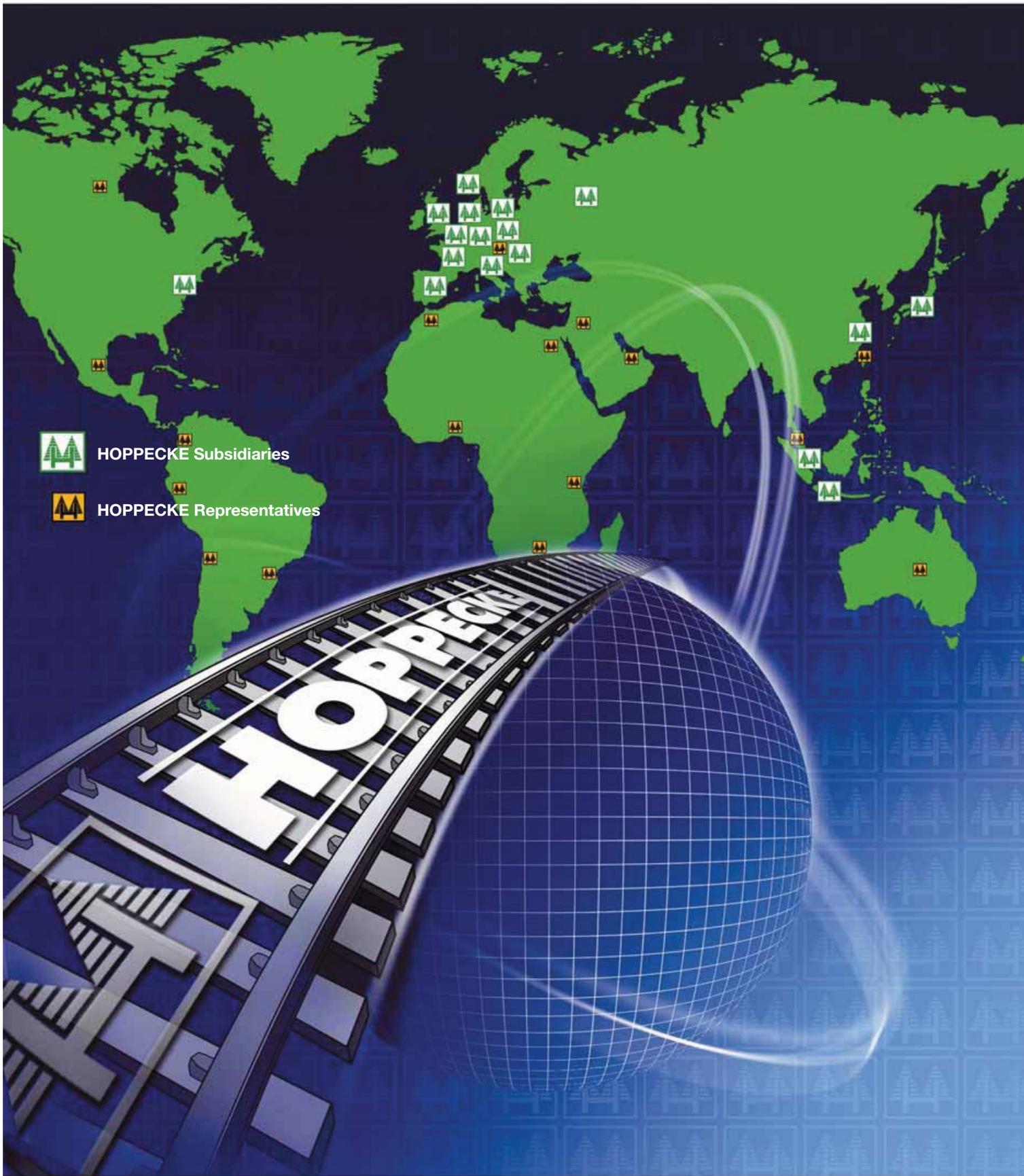
- *Good resistance to cycling*
- *No change of electrolyte*
- *Low water consumption*

FNC® batteries may be cycled over 3000 times. At the same time they are more powerful than any other NiCd system, exceeding even UIC standard 854 R*) many times. Since FNC® electrodes manage without graphite as an additive, there is never any need to change the electrolyte – this applies over the whole life of the battery!

FNC® cells recombine to water a high proportion of the gases H₂ and O₂ which evolve during operation. Consequently FNC® cells need less maintenance than NiCd cells which recombine to a lesser extent or even not at all. Maintenance intervals may be up to 2 years, depending on the set charging voltage, ambient temperature and frequency of cycling.

In short, it may be said that, viewed over their whole life cycle, FNC® cells generate lower follow-on costs than other batteries, and so represent the most economic option.

*) 500 cycles with a residual capacity of 70% of rated capacity, 40% depth of discharge at 40°C.



HOPPECKE Subsidiaries



HOPPECKE Representatives