HOPPECKE

Operation and Maintenance

of stationary Nickel-Cadmium Batteries with FNC cells

It is assumed that only qualified personnel are engaged in assembly and installation of the components provided. Qualified personnel are persons who, on the strength of their training, experience and instruction, together with their knowledge of the relevant standards, provisions, accident prevention regulations and operating conditions, have been authorised by those responsible for the safety of the components / installation, to carry out the relevant necessary work, with the ability to recognise and avoid possible hazards. Amongst other things, knowledge of First Aid and of local rescue equipment are also necessary.

Failure to observe the instructions on use, repair with non-original parts, unauthorised intervention, or use of additives to the electrolyte shall invalidate the warranty.

1. Safety instructions

The following safety measures relate to the handling of batteries and are to be observed in connection with all operating instructions contained in these instructions.

Observe assembly and installation instructions and display visibly at point of installation.
Work on batteries only after instruction by qualified staff. The operating instructions must always be accessible to personnel responsible for dealing with batteries.

Wear eye protection and protective clothing when working with batteries.
Observe accident prevention regulations.

No smoking. No open flame, embers or sparks in the vicinity of the battery, to avoid risk of explosion and fire.

Explosion and fire risk, avoid short-circuits. Warning! Metal parts of the battery cells are always live. Never place foreign objects or tools on the battery. Ensure adequate ventilation of the battery room, so that explosive gases produced during charging are drawn off (see DIN EN 50272-2).

Have eye rinsing bottle to hand. If electrolyte splashes into the eyes or onto the skin, rinse with plenty of clear water and seek immediate medical advice.
Clothing contaminated with electrolyte is to be washed thoroughly.

Electrolyte is highly corrosive. In normal operation there is no possibility of contact with the electrolyte. Electrolyte is released only if the cell housing is destroyed.

Do not tilt the battery!
Use only approved lifting and conveying equipment e.g. lifting gear. Lifting hooks must not cause damage to cells, connectors or connection cables.

Dangerous electrical voltage. Use only suitable tools and measuring instruments.

NiCd batteries or cells belong to flammability class E (see DIN EN 2). If electrical fires occur, it is possible that the equipment may be live! Extinguishing water or foam are ideal conductors and electric shocks may occur. Electrical fires must be fought with extinguishing powder or carbon dioxide CO_2.

2. First Aid measures

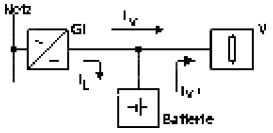
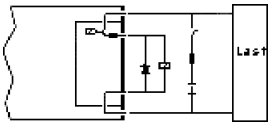
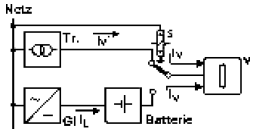
Electrolyte in contact with the eyes:
- Rinse immediately with plenty of water for at least 10 minutes.
- If available, rinse the eyes 1% boric acid solution
- Immediately visit the eye clinic/eye casualty department.

Electrolyte in contact with the skin:
- Immediately remove clothing contaminated by electrolyte, and wash affected areas of skin with plenty of water. Visit doctor if any problems occur.
- Skin which has been in contact with electrolyte has a soapy consistency. Continue rinsing with water until normal skin condition has been restored.

If electrolyte is swallowed:
- Rinse out mouth immediately with plenty of water, and repeatedly drink large amounts of water.

Do not induce vomiting. Call emergency medical service immediately. Any liquid spillage must be analysed for acidity and alkalinity using litmus papers. If the liquid is alkali neutralise with 1% Boric acid solution using half a cupful of Boric acid to 2 gallons of water. Any liquid collected should be kept in a plastic container and disposed of by an Authorised Contractor. Never put it into the sewage system!

3. Operating modes

Operating mode	Characterisation	Charging voltage	Characteristic
Standby parallel operation 	Load, direct current source and battery are constantly connected in parallel.	1.40 – 1.45 V/cell charge retention 1.55 – 1.65 V/cell boost charge after 7.5 h switch to charge retention	IU
Float operation 	Load, direct current source and battery are connected in parallel, with the direct current source supplying only the average load current and the battery covering the peak current demands.	1.45 – 1.50 V/cell	IU
Switching operation 	During charging, the battery is disconnected from the load.	1.40 – 1.45 V/cell charge retention 1.55 – 1.65 V/cell boost charge charge monitoring necessary safe cut-off criterion required up to 1.9 V/cell.	IU

All voltages shown are based on 20° Celsius. The charging voltages shown are temperature dependent and must be adjusted by the temperature correction factor of -2 mV/°K up to -3 mV/°K per cell for higher temperatures.

4. Maintenance

Correct maintenance of the battery system and its components is a basic requirement to ensure a satisfactory service life of the battery. This maintenance covers two aspects, on the one hand preventive maintenance and on the other hand corrective maintenance. If during preventive maintenance a deficiency is discovered, then this is rectified during corrective maintenance.

4.1 Preventive maintenance

To ensure that your battery remains in optimum condition, we recommend the following maintenance programme.
It is also recommended that maintenance records are kept, to include details of the temperature in the room in which the batteries are installed or they are stored.

Preventive Maintenance Table:

Activity	Frequency	Tool / Material (references)
Visual inspection of the battery	every 6 months	(see „Cleanliness / physical condition “)
Check electrolyte level	every 6 months	(see „Measurement of electrolyte levels“)
Measure overall battery voltage	every 6 months	Tool: G02 Voltmeter (see „Checking of individual and overall voltages“)
Clean battery	every 12 months	(see „Cleaning“)
Measure individual cell voltage of all cells	every 5 years	Tool: G02 Voltmeter, G07 Thermometer (see „ Checking of individual and overall voltages“)
Capacity test	every 5 years	Tool: G02 Voltmeter ,G04 External charging and discharge unit, G07 Thermometer (see „Capacity test“)

4.1.1 Cleanliness/physical condition

A clean battery is vitally important, not only for the sake of appearance but, more importantly, to avoid accidents and material damage, together with reduced life and availability of the battery. The cleaning of cells and battery racks is necessary to maintain the required insulation of the cells from earth or from external conductive components. Damage due to corrosion and leakage currents can also be avoided by cleaning. Regular cleaning of the battery is not only necessary to secure high availability but is also an important element in the observance of accident prevention regulations.

Dangerous contact voltages are possible.
The hazard warnings of these operating instructions must be observed.

During initial charging and in operation, the evaporation of entrained electrolyte droplets during water decomposition may lead to the deposition of white electrolyte residues on the cells. These residues should be removed without the use of cleaning agents. We recommend the use of a damp cloth.

- Plastic parts of the battery, in particular cell containers, may only be cleaned with water with added rinsing agent. With the transport plugs fitted, the battery may be cleaned using a high-pressure cleaner. The pressure must be set so that the plastic parts are not damaged

- Avoid electrostatic charging (do not use dry cloths for cleaning!).

The screws and nuts for the terminal posts must be tightened correctly. To prevent corrosion, a thin layer of neutral Vaseline or anti-corrosion oil should be applied to connection elements and cable eyes.

Screw size	Insulated screw	Non-Insulated screw
M8	16 Nm ± 1 Nm	20 Nm ± 1 Nm
M10	20 Nm ± 1 Nm	25 Nm ± 1 Nm

The enclosed washers insure the correct tightness.
Washers may be used only once. For a new connection a new washers must be used.

4.1.2 Measurement of electrolyte levels

During charging, electrolysis splits the water of the electrolyte into the gases $2H_2 + O_2$. This leads to a lowering of the electrolyte level. The volume of decomposed water depends on charging voltage, charging time per day and temperature. During the first phase of operation, electrolyte levels should be measured and recorded approximately every 3 months. After 12 months, the empirical values thus obtained give sufficient information to determine further monitoring intervals.

This maintenance interval may be doubled by the use of HOPPECKE AquaGen® vent plugs. The cells have polypropylene containers, through the sides of which the electrolyte levels may be read.

4.1.3 Checking of individual or overall voltages

In checking voltages, a distinction is made between individual cell voltages and the overall battery voltage, also between charging and open-circuit voltage. Measurement of the individual voltages is described below. Charging voltage is measured with a suitable voltmeter.

- Remove battery connections.

- Attach the measuring tips of a multi meter to the measuring contacts of the cell screw connector.

• Measure and record the voltage of the cells in turn.

• Mark cells where voltage varies by more than ± 20 mV from the average of all cell voltages.

• Reconnect the battery

In fully-charged condition, the open-circuit voltage should be 1.27 V per cell. These values relate to a temperature of 20°C; consult HOPPECKE if there are extreme variations. Temperatures deviating from 20°C affect these values. Charging voltage should be checked not later than every 6 months. If higher water consumption is detected, then charging voltage is the first factor to be checked.

4.1.4 Test of insulation resistance

DIN VDE 0510 Part 2 stipulates that the insulation resistance of a battery must not fall below the value of 100 Ω per volt of rated voltage. In new condition the insulation resistance is > 1MΩ. The insulation resistance falls over its service life due to aerosols escaping from the battery and because of dust.
An insulation tester with 1500 volts test voltage should be used. The positive terminal and the negative terminal of the battery should each be measured against the metal parts of the rollers.

• The actual setting value should be determined empirically. If insulation faults occur, first disconnect the battery and test the remainder of the electrical installation.

• If higher test voltages are prescribed for other electrical loads then in every case the battery should be disconnected from the onboard system during these tests.

4.1.5 Capacity testing of batteries in accordance with DIN IEC 623

The battery should be given a capacity test every 3-5 years. This is especially important after the commissioning of batteries after a long period of storage, so that the end of battery life may be forecasted accurately. In accordance with international standard DIN IEC 623, charging takes place at constant rated current I_5 (rated capacity C_5 / 5h) over a period of 7 to 8 hours. After charging the battery should be stored for a minimum of 1 h but for no more than 4 h at an ambient temperature of (20 ± 5)°C. Discharge is effected at rated current I_5 down to a voltage of 1.0 V per cell as an arithmetical average. To obtain a capacity of 100%, the minimum discharge time should be 5 h.

The capacity obtained during this test may be calculated as follows:

Capacity (%) = (discharge time (h) / 5 h) * 100

If after five charge/discharge cycles the capacity required for this test has not been reached, then the battery should be replaced.

To carry out a capacity test on the battery, proceed as follows:

1. Discharge at rated current I_5 down to a voltage of 1.0 V per cell on an arithmetical average.

2. Rest for at least 8 hours. During this waiting period, the cells must be sealed by standard or AquaGen® vent plugs.

3. Charge at constant rated current I_5 over a period of 7.5 h, with vent plugs removed.

4. 2-hour rest, during which the cells must be sealed by vent plugs (standard or AquaGen® vent plugs).

5. Discharge at rated current I_5 down to a voltage of 1.0 V per cell on an arithmetical average. This discharge completes the capacity test as specified in DIN IEC 623.

If insufficient capacity is determined in the capacity test under point 5 above, then points 2 to 5 should be repeated until capacity no longer rises.

After this capacity test, the following work is necessary for correct operation of the battery:

• Rest for at least 8 hours. During this waiting period, the cells must be sealed by vent plugs (standard or AquaGen® vent plugs).

• Charge at constant rated current I5 over a period of 7.5 h, with vent plugs removed.

• On completion of charging, the cells are sealed using standard or AquaGen® vent plugs.

• After a waiting period of at least 2 hours, top up the electrolyte with distilled or de-ionised water (no water containing acid!) to the maximum mark.

The capacity test forms part of reconditioning charging. If after several attempts at reconditioning the result of capacity testing is not satisfactory, then the battery has reached the end of its life.

4.1.6 Cleaning

A clean battery is absolutely essential to avoid accidents and material damage, also to maximise battery life and availability. It is necessary to clean cell holders, trays, racks and insulators in order to maintain the required insulation of the cells from one another, from earth, or from external conductive parts. Cleaning also prevents damage from corrosion and leakage current.
DIN VDE 0510 Part 2 specifies that the insulation resistance shall not fall below a value of 100 Ω per volt of cell voltage.
Depending on the location and duration of usage it is impossible to avoid deposits of dust on the battery. Small amounts of electrolyte particles which escape during battery charging above the gassing voltage form a more or less conductive layer on the cells or the block lids. So-called leakage currents then flow through this layer. This results in enhanced and varying self-discharge of the individual cells.
If higher leakage currents flow, then electrical sparks can not be ruled out. Such sparks may cause an explosion of the charging gas (detonating gas) escaping from the cell plugs.
Consequently the cleaning of batteries is necessary not only to ensure high availability, but also as an essential part of accident prevention.

It is essential that the following instructions are followed when cleaning batteries in installed condition:

• The cell plugs must not be removed or opened. Instead, the cells must remain closed.

• Plastic parts of the battery, in particular the cell containers, may be cleaned only with water or with cleaning cloths soaked in water without additives.

• After cleaning, dry the battery surface by suitable means, e.g. compressed air or cleaning cloths.

• Any fluid which has entered the battery tray must be siphoned off, and disposed of in accordance with the regulations governing waste and residues.

4.2 Corrective maintenance

Corrective maintenance table:

Activity	Frequency	Tools / Material (references)
Top up with distilled water	every 6-12 months	Tool: G06 Funnel Material: Distilled water (see „Topping-up the electrolyte“)
Reconditioning charge	every 5 years	Tool: G02 Voltmeter ,G04 External Charging and Discharge unit, G07 Thermometer (see „Capacity test“, „Reconditioning of the battery“)

4.2.1 Topping-up the electrolyte with distilled water

Nickel-cadmium batteries are filled with highly caustic potassium hydroxide solution (KOH) and an additive of lithium-hydroxide (LiOH) in accordance with DIN 43530. When working with the batteries, protective clothing such as rubber gloves and eye protection must be worn. If nevertheless electrolyte comes into contact with skin or eyes, then the latter should be rinsed immediately under running water, after which medical advice should be sought without delay.

If the electrolyte levels of the battery are below the mid-point between the min. and max. marks, the should be topped-up to the max. mark with distilled water.

Any splashes of electrolyte or water should be removed with a damp cloth. The fibre-structure technology allows the use of pure active materials. Additives such as graphite to increase the conductivity of the positive electrodes are no longer necessary. Any carbonisation of the potassium hydroxide solution due to the electrodes is therefore ruled out.

No change of electrolyte is necessary during the entire life of the battery.

4.2.2 Reconditioning the battery

The decline in the state of charge of a battery can be reversed only by charging at constant current. This is described as reconditioning of the battery. In order to carry out this reconditioning , the battery must be charged and discharged in a defined manner. Before this charging, the battery should be disconnected from the onboard system, since during reconditioning of the battery with constant current, cell voltages of up to 1.9 V may occur. Also during this charging, a larger amount of water is decomposed than during normal operation, so that provision for adequate ventilation must be ensured, in accordance with DIN VDE 0510.

The following discharge/charging procedure is recommended:

1. Discharge the battery at I5 down to 1.00 volt/cell on the arithmetic average.

2. Rest > 8 hours, if possible overnight

3. Charge at constant current I_5 over 7.5 hours

4. Rest for 2 hours

5. Discharge at I_5 down to 1.0 volt per cell on the arithmetic average (capacity test)

6. Rest > 8 hours, if possible overnight

7. Charge at constant current I_5 over 7.5 hours

If the capacity test reveals insufficient capacity then the tests covered by points 1 to 5 above are to be repeated until capacity no longer rises. The same criteria also apply to capacity tests.

5. Fault-finding

5.1 Excessive water consumption

Loss of water occurs on the one hand due to evaporation, but also due to the decomposing of the water into oxygen and hydrogen gas during charging. The first thing to check is the charging voltage in the system. If this is correct, then proceed as follows:

- Measure the individual cell voltages during charging
  If the individual cell voltages vary by more than ± 50 mV from the average, then the battery should be removed, and the following measurement undertaken after 2 days' rest:

- Measure the open-circuit voltage after 2 days' rest
  If individual cell voltages vary by more than ± 20 mV then a further rest of > 5 days is recommended. If the variation is even greater, then in any case a reconditioning of the battery should be implemented.

- Results of reconditioning
  If during the capacity test the discharge voltages after 3.5 hours discharge are uniform, but fairly large variations then start to occur, then steps 1 to 7 of the reconditioning should be repeated. If an improvement occurs, then repeat steps 1 to 4 until capacity no longer rises. If however capacity falls with each cycle, then HOPPECKE should be informed so that further action may be initiated.

5.2 Spread of cell voltages

Too wide a spread of individual cell voltages may be determined during preventive maintenance from the two pilot cells or by measuring all cell voltages. Possible causes of a wide spread of cell voltages are:

- Variations in cell temperature.

- Differences in the electrolyte density of the cells.

- Varying electrolyte levels.

- Plate short-circuits in various cells.

- Varying states of charge

5.3 Insufficient capacity

Even when all cells have an adequate level of electrolyte, the density of the electrolyte may vary. This may lead to individual cells having different capacities. Insufficient capacity may be due to the following causes:

- Charging for too short a time.
- Electrolyte levels too low.
- Loose or oxidised terminals.

5.4 Insulation fault

If there is an insulation fault, leakage currents may reduce the available capacity, also leading to variations in cell voltage. Regular cleaning can prevent these leakage currents.

5.5 No battery voltage

If it is found that the system is no longer backed up by the battery, i.e. the complete battery voltage has failed, this may be due to the following causes:

- Fuses tripped
- Cable breakage
- Loose terminal

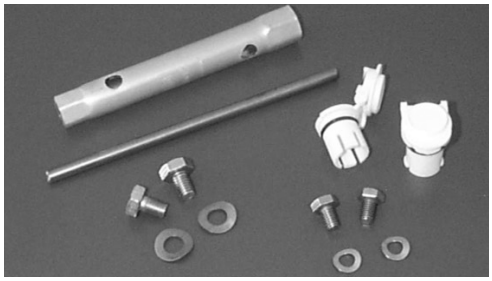
If a fuse has tripped, it should be ensured that none of the cables from the fuse box to the positive or negative terminals of the battery is damaged.

6. Test and measuring instruments, tools

All tools needed for maintenance and repair work may be ordered from the comprehensive range of HOPPECKE accessories. Under order number 7140200020 HOPPECKE offer a complete toolkit for the maintenance of nickel-cadmium batteries.

Measuring instruments and other equipment:

G01: Electrolyte density meter
G02: Voltmeter
G03: Insulation tester
G04: External charging and discharge unit
G05: Cell lifter
G06: Funnel
G07: Thermometer



Shown adjacent is the type HO27-02-1012 water replenishment cart for topping-up with distilled water in HOPPECKE NiCd FNC batteries.

This water replenishment cart is battery-powered and comes optionally with a 25 or 60 litre tank.

After the water replenishment cart has been in use it is connected to the power supply.
Leave the water replenishment cart connected to the mains until it is next required, so that the battery is fully charged.

7. Taking the battery out of service

- Discharge at rated current I5 down to a voltage of 1.0 V per cell.
- Replace the standard vent plugs (hinged lid vent plugs) or AquaGen® vent plugs by the yellow transport plugs. This is important to avoid atmospheric oxygen coming into contact with the electrodes.
- Clean the battery including all cells
- Store on pallets in a dry, frost-free room. The complete battery or the individual cells should be provided with a cover.

In principle, when taking the battery out of service, the standard vent plugs (hinged lid vent plugs) or AquaGen® vent plugs on the individual cells should be replaced by the yellow transport plugs. The standard vent plugs (hinged lid vent plugs) or AquaGen® vent plugs should be kept for subsequent use.

Depending on the length of storage after being taken out of service, the battery should be brought back into service again in accordance with these instructions.

7.1 Disposal

Disassembly and disposal of the battery should be carried out only by trained personnel. EC Directives 91156 (EEC) and 9386 (EEC) must be observed. Your local HOPPECKE representative will be pleased to give you a quotation for proper disassembly and disposal of your battery. The long-term objective of the Hoppecke recycling concept is that all NiCd cells brought into use are returned for proper recycling. HOPPECKE have a European-wide network of collection points for spent NiCd batteries. The benefit of the Hoppecke recycling concept is that the cadmium content of the batteries is recycled for use in the production of new NiCd batteries. The recycled cadmium is thus continually reused in a “closed loop”.

Further action, in particular the operation and maintenance of the battery, is described in the instructions “Operation and maintenance of stationary nickel-cadmium batteries with FNC cells”. It is essential that these instructions, which are supplied with the battery, are followed.

Used batteries with this symbol are recyclable goods and must be sent for recycling.
Used batteries which are not sent for recycling are to be disposed of as special waste under the appropriate regulations. HOPPECKE have a “closed loop” recycling system for NiCd batteries. Your local HOPPECKE representative will be pleased to give you a quotation for disposal of your battery.

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