FNC-T

Nickel-cadmium batteries in automated guided vehicles (AGVs) and other traction applications

Operating and assembly instructions

Version overview

Revision	date	Status	Name	Chapter	Reason for change
00	2025-05-16	Created	W. Pickart	-	New creation / transfer from old document
	2025-06-12	Checked	D. Baba		
	2025-06-16	Released	Dr D. Mahl		

Foreword

Dear customer,

Thank you for choosing a product from our company.

Read this documentation carefully before working on the battery system or its components. It contains important information on the safe and correct unpacking, storage, installation, commissioning, operation and maintenance of FNC-T batteries.

We reserve the right to make changes to the content of this documentation. Our products are constantly being further developed. Therefore, there may be differences between the illustrations in this documentation and the product you have purchased. These installation instructions are not subject to change.

Keep this documentation in such a way that it is immediately available to all persons who have to carry out activities in connection with the battery system or its components.

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Table of contents

1. About these instructions

These operating and installation instructions are intended to help you optimise the operation, installation and maintenance of the HOPPECKE nickel-cadmium batteries used. This is the only way to maximise their service life.

Contact your local contract partner:

- If you have any questions about this documentation
- If there are local rules and regulations that are not covered by this documentation or that contradict it.

1.1. Target group of this document

All work on the FNC-T cells may only be carried out by trained, fully qualified, authorised personnel (ideally by qualified electricians):

- Personnel authorised by the vehicle manufacturer's safety officer
- Personnel authorised by the vehicle operator's safety officer
- Personnel, authorised by HOPPECKE
- HOPPECKE specialists

Untrained personnel must not carry out any work on the FNC-T cells.

1.2. Symbols and signal words

The following symbols and signal words are used in these operating and maintenance instructions:

DANGER!

Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING!

Indicates a potential hazard with medium risk that can result in death or serious injury if not avoided.

CAUTION!

Indicates a low-risk hazard that could result in minor or moderate bodily injury if not avoided.

becomes.

Note

Indicates information that is important for optimum use of the product.

1.3. Notation of nominal data

In these operating and maintenance instructions, nominal battery data is used in accordance with the following notation:

Notation	Meaning	Value
U_n	Nominal voltage	1.2 V multiplied by the number of cells connected in series
C_n	Nominal capacity	C_5 (according to IEC EN 60623) Removable capacity when discharging with I_5 (see rating plate) up to 1.0 V per series-connected cell at nominal temperature
I_n	Rated current	I_5 (see rating plate) = Cn/5h
T_n	Nominal temperature	20 °C
D	Alkali density	1.19 kg/l or higher for project-specific requirements
D	Tightening torque of pole screws	M8: 20 Nm ± 3 % M10: 25 Nm ± 3 %
U_0	Open circuit voltage	1,3 V ... 1.35 V, fully charged
U_S	Nominal final discharge voltage	1.0 V per cell

1.4. Graphic symbols / pictograms on the battery system

The following graphic symbols are used in these operating and maintenance instructions and on the product:

EN ISO 7010 - W012
Warning of electrical voltage

EN ISO 7010 - W026
Warning of dangers from charging batteries

EN ISO 7010 - W023
Warning of corrosive substances

EN ISO 7010 - W002
Warning of explosive substances

EN ISO 7010 - P003
No naked flames; fire, naked sources of ignition and smoking prohibited

EN ISO 7010 - M002
Follow the instructions for use

EN ISO 7010 - M004
Use eye protection

EN ISO 7010 - M009
Use hand protection

EN ISO 7010 - M010
Use protective clothing

1.5. Nameplate information on the product

The type plate of a battery is attached to the container for the battery cells (container, trough, carrier). On the type plate you will find the serial number, date of manufacture, type, nominal voltage, number of battery cells and nominal capacity ($C_5 = C_n$) of the battery.

If battery kits (individual cells with accessories) are supplied, the type plate of the battery must be attached by the customer.

The date of manufacture of the FNC-T cells can be specified in 2 different ways:

- Production date until CW15/2024:

Note

The date of manufacture of the FNC rail cells is stamped on the top of each cell.

Each cell has a 9-digit cell code on the top of the cell cover. The last four digits provide information about the production week and the production year.

Example:

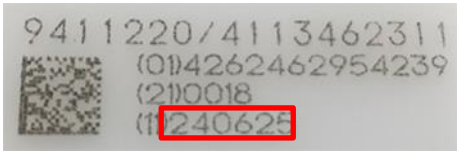
xxxxx2619 => Production week 26; production year 2019

- Production date from CW15/2024:

Note

The date of manufacture of the FNC-T cells is stamped on the top of each cell.

Each cell has a 6-digit cell code on the top of the cell cover. The 6 digits provide information about the production day, month and year, see the following graphic



Example:

240625 => Production year 24; production month 06, production day 25

1.6. Explanation of terms

The following table explains the terms used in these operating and installation instructions:

Abbreviation/term	Explanation
Reconditioning	Refers to the defined discharging and subsequent charging of the battery with a constant current. This can eliminate or minimise operational capacity losses in the battery system.
Trickle charge	Refers to the charging of a battery to equalise its self-discharge with the target of keeping the battery in a fully charged state.
Heavy load	Refers to the charging of a battery with increased voltage and a defined current in order to charge the battery as quickly as possible.
Electrolyte	FNC-T batteries are NiCd batteries and contain potassium hydroxide (KOH) as electrolyte with an addition of lithium hydroxide (LiOH). When handled properly, FNC-T batteries are safe. Contact with the electrolyte is excluded.
Formats	FNC-T cells are supplied in various formats: R2 (Format 2) R3 (Format 3)

1.7. Applicable documents

Document name	Explanation / Content
D00001-300-en<version number>-Water-Refilling.pdf	Instructions for topping up water with an automatic low-pressure water refill system
TD-Refilling-FNC-en-<version number>-.pdf	Instructions for topping up water with an automatic high-pressure water refill system
Electrolyte_Mixing.pdf	Instructions for mixing liquid electrolyte

2. Safety instructions

Observe the following safety instructions when handling the batteries and their components.

2.1. Sources of danger

2.1.1. Explosive gas mixture

Water is decomposed each time the batteries are charged. This can result in the formation of a hydrogen-oxygen gas mixture (oxyhydrogen gas), which ignites even with a low energy supply.

There is danger from:
- Explosions
- Fires
- Pressure waves
- Flying hot or molten substances

These hazards can be caused by the following ignition sources:
- Short circuits
- Electrostatic charges and discharges
- Smoking
- Open flames / fire, embers and sparks near the batteries
- Electrical sparks from switches or fuses
- Hot surfaces with temperatures above 300 °C

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Measures to avert the danger:
- Work with voltage-insulated, non-sparking tools.
- Ensure adequate ventilation of the battery compartment in accordance with DIN EN IEC 62485-3 so that any explosive gas mixture that may arise is removed.
- Avoid electrostatic charging:
  - Do not wipe batteries with plastic housings with a dry cloth or a cloth made of synthetic material!
  - Only clean batteries with a cotton cloth moistened with water. Wiping with a cotton cloth moistened with water does not generate an electrical charge.
  - Wipe batteries with a damp cloth (with water) before removing or tearing off a label.
  - Wear shoes and clothing that prevent the build-up of electrostatic charges due to their special surface resistance, see 2.2Personal protective equipment on page 17.
- Use hand lamps with mains cable without switch (protection class II) or hand lamps with battery (protection class IP54).

2.1.2. Electrical voltage

Metal parts of the batteries are always live. High currents flow in the event of a short circuit.

There is danger from:

- Tensions
- Electric shocks

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Measures to avert the danger:

- Be very careful when working on the batteries.
- Never place tools or other metal objects on a battery.
- Remove watches and jewellery before working on the batteries.
- Do not touch any bare battery parts, connectors, terminals or poles.

2.1.3. Electrolyte

FNC-T cells are NiCd cells and contain potassium hydroxide (KOH) with the addition of lithium hydroxide (LiOH) as the electrolyte.

The following dangers exist:

- When working on open FNC-T cells, contact with the electrolyte may occur.
- Electrolyte can leak out as a result of damage to the housing of a cell.
- Reverse polarity of the battery or individual cells can result in overheating and electrolyte leakage.
- The electrolyte can cause severe burns.

There is a possible medium-risk hazard that can result in death or serious injury if not avoided.

Measures to avert the danger:

- Always wear safety goggles and protective gloves when working on batteries.
- Wash clothing contaminated with electrolyte with water.
- Check correct polarity before making connections.

Take the following first aid measures if contact with electrolyte has occurred:

Electrolyte on the skin or hair

- Dab off electrolyte with a cotton or paper towel, do not rub off.
- Remove contaminated clothing, avoiding contact with unaffected body parts.
- Rinse affected areas under running water for a longer period of time.

Lye in the eye

- Gently rinse the eye for a few minutes with eye wash or under running water. Avoid excessive water pressure. If possible, remove any contact lenses and continue rinsing.
- See an ophthalmologist immediately.

Lye in the body

- Rinse out mouth. DO NOT induce vomiting.
- Consult a doctor or go to hospital immediately.

2.1.4. Toxic substances

Nickel-cadmium batteries contain toxic substances:

- Battery cells contain more than 0.1% cadmium (Cd)

There is a low-risk hazard that could result in minor or moderate bodily injury if not avoided.

Measures to avert the danger:

- Avoid contact with toxic substances.
- Wear personal protective equipment (see 2.2 Personal protective equipment on page 17).

2.1.5. Fire

In the event of a fire, there is a risk of:

- Hot or molten substances
- Short circuits
- Open flames / fire, embers and sparks
- Hot surfaces with temperatures above 300 °C

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Measures to avert the danger:

- Wear personal protective equipment against caustic solutions (see 2.2Personal protective equipment on page 17), also use respiratory protection with self-sufficient breathing air supply for large battery systems. Contact with water can lead to reactions with the electrolyte (caustic solution) and subsequently to violent splashing.
- Disconnect the battery electrically.
- Extinguish incipient fires with CO2.
- When extinguishing electrical fires with water in low-voltage systems (up to 1 kV), maintain a spray jet distance of 1 m and a full jet distance of 5 m.
- Delete at short intervals. Otherwise there is a risk of explosion due to possible static charge on the battery housing.

2.1.6. Improper transport

The batteries can be damaged if transported incorrectly. Falling batteries can result in personal injury.

If the batteries are transported incorrectly, there is a risk of:
- Suspended loads
- Falling batteries or parts of batteries
- Leaking electrolyte

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Measures to avert the danger:
- Use safety shoes and safety goggles.
- Do not tilt the batteries.
- Always lift batteries by the handles or lifting points provided for lifting equipment and never carry them by the poles of the battery or the cells.
- Only use authorised lifting and transport equipment, e.g. lifting slings. Lifting hooks must not cause any damage to cells, connectors or connection cables.
- Always set the batteries down carefully to avoid damaging them.
- Use suitable transport equipment.
- Carefully secure the charge during transport to prevent damage to the battery housing.

2.1.7. Notes on disassembly

If the connecting cables have not been disconnected before replacing the batteries, there is a risk of electric shock.

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Measures to avert the danger:
- Before starting to remove the batteries to be replaced, disconnect the supply lines (fuses).

Due to the cadmium and caustic potash content, FNC-T batteries must not be disposed of with the waste or deposited in a landfill at the end of their service life (see 13 Disposal on page 96).

2.2. Personal protective equipment

When working on the batteries and their components, always do so:

- Wear safety goggles
- Wear protective gloves
- Wear protective clothing, preferably made of cotton to avoid electrostatic charging of clothing and body
- Wear safety shoes

In the event of an accident, this can prevent injuries or at least mitigate the consequences of injuries.

The conductivity of textiles and shoes must have the following properties to prevent electrostatic charging:

- an insulation resistance ≥ 10^5 Ohm
- a surface resistance < 10^8 Ohm

2.3. Labelling on the product

The type plate of a battery is attached to the container for the battery cells (container, trough, carrier). The type, nominal voltage, number of battery cells and nominal capacity (C_5 = C_n) of the battery can be found on the type plate.

If battery kits (individual cells with accessories) are supplied, the type plate of the battery must be attached by the customer.

3. Use of the product

3.1. Intended use

The FNC-T cells of the battery are used to store and release electrical energy in driverless transport systems and similar traction applications. The AGV vehicles are controlled automatically and are used to transport materials. The battery is characterised by continuous cycling (charging and discharging) operation.

Use only in driverless transport systems and similar traction applications:
- Supply of the on-board electrical system and provision of traction energy
- Provision of energy in emergencies

The intended use includes the following requirements:
- Only operate the batteries when they are in perfect condition
- No deactivation or dismantling of safety devices
- Compliance with all instructions in these operating and maintenance instructions

3.2. Non-intended use

DANGER!

Improper use of the batteries can lead to personal injury and damage to property.

HOPPECKE Batterie Systeme GmbH accepts no responsibility or liability for personal injury or damage to property resulting directly or indirectly from handling the batteries if they are not used as intended. The risks associated with improper use are borne solely by the operator.

Any use other than that described under "Intended use" is not in accordance with the intended use and is therefore not permitted.

Non-intended use of the product includes in particular
- Operation in potentially explosive atmospheres
- Operation in safety-relevant applications, unless these applications are expressly specified or permitted in the product documentation
- Operation without permanent/insufficient fastening
- Operation outside the technical data
- Operation or storage outside the specified environmental conditions
- The electrical connection does not correspond to the documentation supplied with the battery.
- Operation with unauthorised changes or modifications to the product

4. Directives, laws and standards

Always observe the latest editions of the following regulations:

- Accident prevention regulations, in particular DGUV regulation 1: Accident prevention regulation; principles of prevention
- DIN EN ISO 20345 ("Personal protective equipment - Safety footwear")
- DIN VDE 0105 ("Operation of electrical installations"), regulates in particular the quality and qualification requirements for work on electrical installations (DIN VDE 0105-100)
- DIN VDE 100/IEC 60364 ("Erection of low-voltage installations")
- DIN EN 50110/VDE 0105 ("Operation of electrical installations")
- DIN EN 1175: 2024-01 (Safety of industrial trucks - Electrical/electronic requirements)
- DIN 41772 (power converters; semiconductor rectifiers, examples of characteristic curves for chargers)
- DIN 41776 (Power converters; semiconductor rectifier devices with I-characteristic for charging batteries; requirements**)**
- DIN EN IEC 62485-3 ("Safety requirements for secondary batteries and battery systems") Part 3: Traction batteries for electric vehicles
- DIN EN 60623/IEC 60623 ("Accumulators and batteries with alkaline or other non-acid electrolytes - Closed prismatic rechargeable nickel-cadmium single cells"), applicable primarily for testing the cells (type testing, series testing, field testing).
- DIN EN 60993/IEC 60993 ("Electrolyte for sealed rechargeable nickel-cadmium cells")
- DIN 43530-4 ("Water and refill water for lead accumulators and alkaline accumulators")
- VDI 3616: Lifting devices for industrial truck batteries 24 V, 48 V, 80 V
- ADR/RID: European Agreement concerning the International Carriage of Dangerous Goods by Road / Regulations concerning the International Carriage of Dangerous Goods by Rail
- IATA-DGR: Dangerous Goods Regulations - International Air Transport
- IMDG Code: International Maritime Code for Dangerous Goods, German: Dangerous goods labelling for dangerous goods in maritime transport
- Waste and Residual Substances Monitoring Ordinance (Federal Law Gazette 1996)

Observe any additional applicable territorial, operational and project-specific regulations.

5. Function and structure

5.1. Battery

The battery's FNC-T cells are used to store and release electrical energy in driverless transport systems and similar traction applications.

Use only in driverless transport systems and similar traction applications:
- Supply of the on-board electrical system and provision of traction energy
- Provision of energy in emergencies

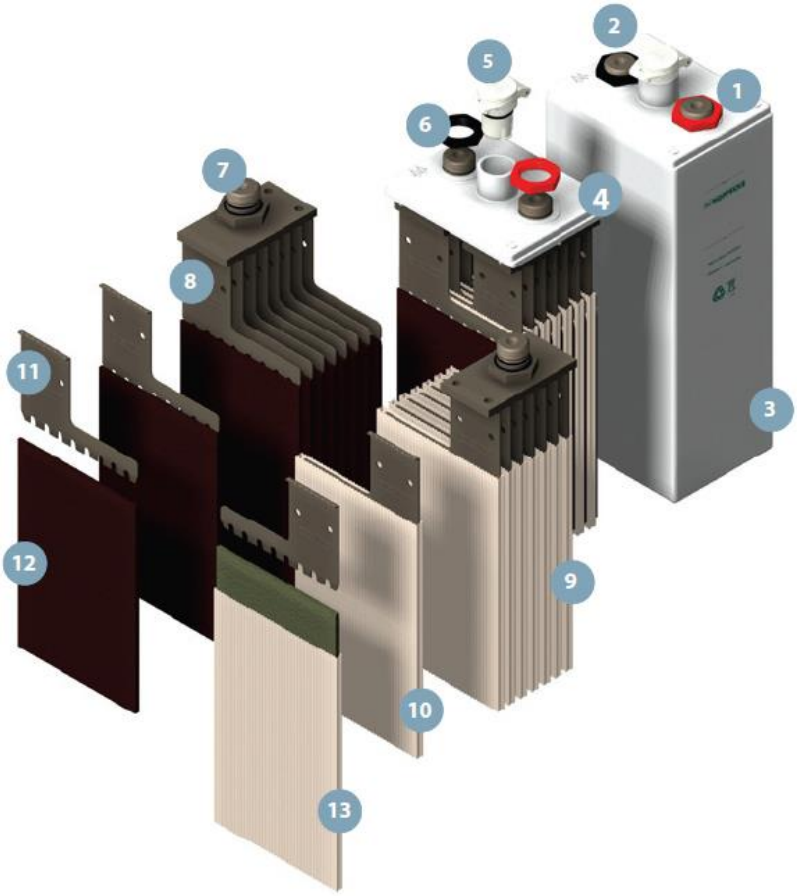
5.2. FNC-T cell

FNC-T cells are nickel-cadmium cells that are manufactured using fibre structure technology using an extremely porous, three-dimensional polypropylene fleece metallised with nickel.

Decisive features are:
- Best volume/weight ratio due to 90% volume filling of the fibre electrodes with active material
- High to very high currents are possible during discharging and charging
- No carbonates are formed in the electrolyte
- Long service life and many charging cycles even under extreme temperature conditions
- Withstands the highest shock and vibration requirements
- Cell containers optionally made of:
  - Polypropylene (PP)
  - Flame-retardant polypropylene (PP-V0)

- Wide variety of designs from high and extremely flat to low with a large footprint

The following drawing shows the internal structure of an FNC-T cell:



1 - Positive pole
2 - Negative pole
3 - Cell vessel
4 - Cell cover
5 - Vent plug
6 - Pole nut
7 - Cell pole
8 - Negative electrode package
9 - Positive electrode package
10 - Positive fibre structure electrode with separator
11 - Current vane
12 - Negative fibre structure electrode
13 - Separator

Note

The electrolyte used in the cells of the FNC-T batteries is caustic potash (KOH) with an addition of lithium hydroxide (LiOH). The standard lye density is 1.19± 0.02 kg/litre. Depending on the project and the ambient temperature, different lye densities may be necessary.

In contrast to lead-acid batteries, the alkaline density is not a measure of the state of charge.

5.3. Ambient conditions for FNC-T cells

Ambient conditions	Description of the
Cells with electrolyte density 1.19 kg/l	• Ambient temperatures -25°C ... +45°C • Internal temperatures -25°C ... +55°C
Cells with electrolyte density 1.236 kg/l	• Ambient temperatures -40°C ... +50°C • Internal temperatures -40°C ... +60°C

Note

- The optimum operating temperature is 0 to 30°C
- Higher temperatures result in reduced power acceptance and reduce the service life
- Lower temperatures reduce the removable capacity.

5.4. Low-pressure water refill system

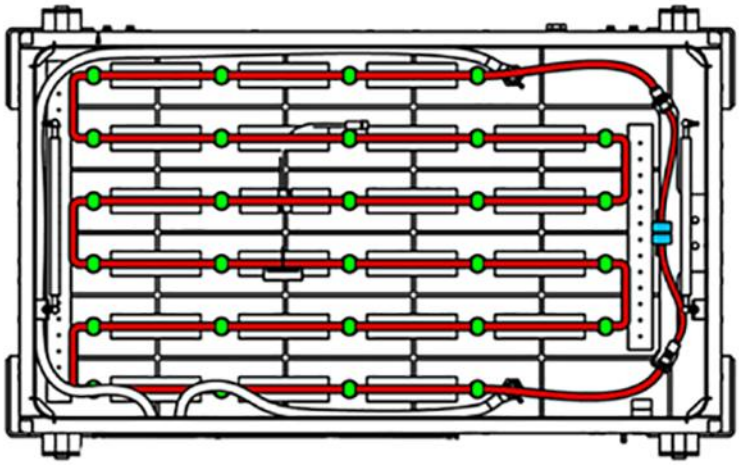
A water topping-up system can be an optional component of your battery. The low-pressure water topping-up system can be used to top up the electrolyte levels of the FNC-T cells with distilled water.

It consists of water refill plugs in the FNC-T cells, hoses and a backfire protection unit.

The following picture shows a water refill plug:

The following picture shows a backfire protection (example):

The following picture shows an example of a battery with a coloured water refill system (tubing = red; backfire protection = blue, water refill plug = green):



Note

To top up the water with a water refill system, refer to the separate document:

D00001-300-en<version number>-Water-Refilling.pdf

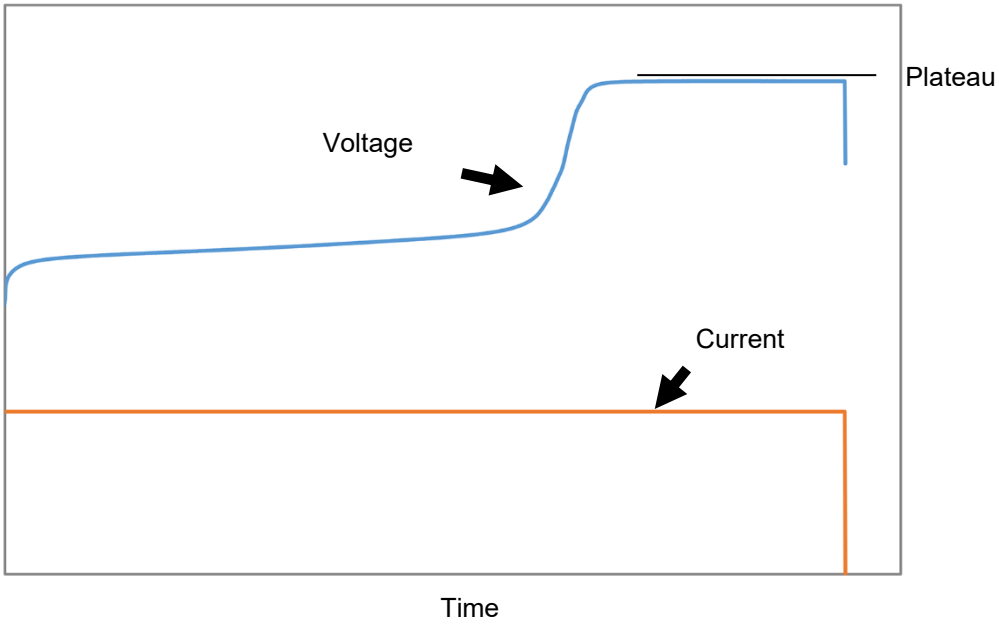
Note

The tubing of the water refill system must follow the potential of the electrical wiring of the battery in accordance with EN 62485-3 in order to minimise the occurrence of leakage currents. See also the project-specific technical drawings of the water refill system. This must be observed for all work on the water refill system.

5.5. Charging procedure for FNC-T cells

5.5.1. Charge with constant current (I)

With this charging method, the cell is charged with the constant current I5 = Cn/5h. The charging voltage is not limited. However, there is a time limit so that a defined capacity is charged into the cell.



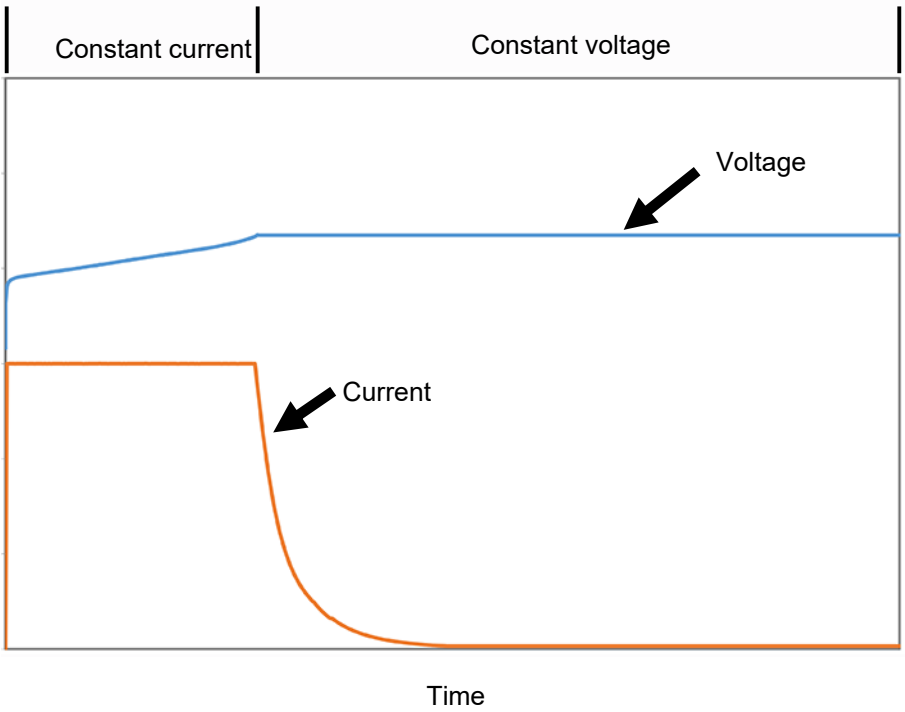
At the end of the charging process, relatively high cell voltages occur (up to 1.9V / cell). In this phase (also known as the "plateau" or gassing phase), most of the water is decomposed into hydrogen and oxygen by the charging current. This results in high water consumption.

The IEC60623 standard describes this charging procedure to prepare the cells for subsequent discharge tests. The current limit is at nominal current and the time is in the range of 7 to 8 hours. A fully charged state (100%) can be achieved with this charging process. At the same time, all cells of a battery connected in series are equalised. This method is therefore used for commissioning charging and for reconditioning FNC-T cells.

This charging method is not used for daily operation of the batteries due to the high gassing and high water consumption. Furthermore, the resulting high voltage is well above the permissible limit of the operating voltage of the on-board electrical system.

5.5.2. Single-stage charging with constant current, constant voltage (IU)

In this charging process, both the current (I) and the voltage (U) are limited. At the start of charging, the charging current is limited and the charging voltage rises slowly. When a defined voltage is reached, this is kept constant by the charger. The current then drops automatically to a low value.

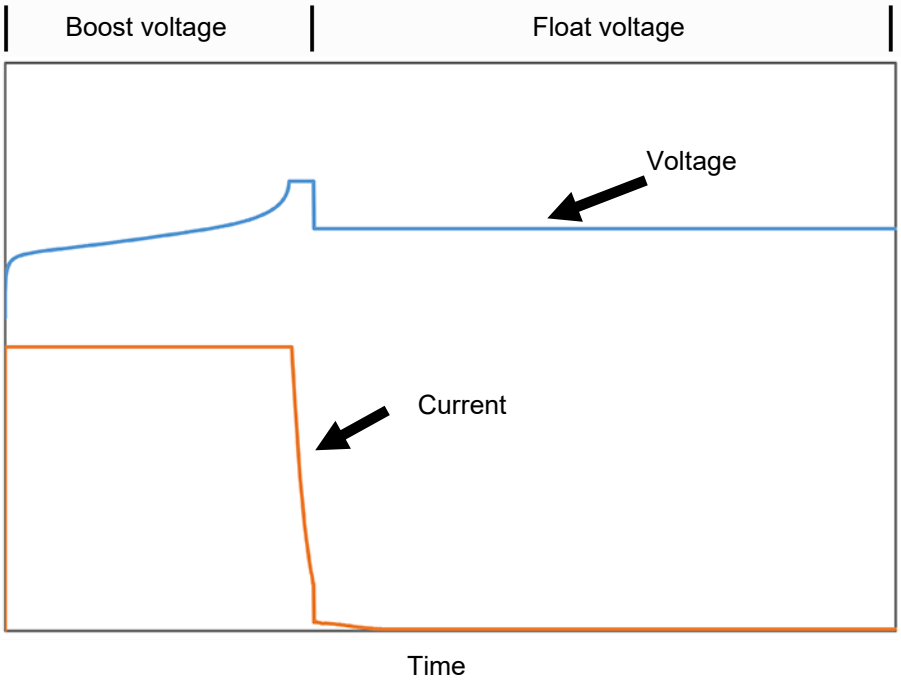


The charging voltage setting always represents a compromise between the achievable state of charge and water consumption. The higher the voltage, the higher the state of charge, but the remaining charging current also increases, resulting in higher water consumption.

In accordance with the limited charging voltage, a reduced state of charge must be assumed for the operation of the battery in the design. A value of 90% of the nominal capacity is usually assumed (EN 50547). In extreme applications (very high or very low temperatures, cyclical use), this value can also be lower.

5.5.3. Two-stage charging with constant current, constant voltage (IU0U)

The two-stage charging process (IU0U) initially works according to the same principle as single-stage charging. First the current is limited, then the voltage is kept constant once a certain value has been reached. This first voltage threshold is referred to as the "boost voltage" (also known as the strong charge voltage). Once the boost voltage has been reached, the charging current decreases. When a certain charging current is reached (usually I_{20} = Cn/20h), the voltage is reduced to a lower value. This voltage value is referred to as the "float voltage" (also known as the float charge voltage).



The advantage is that the boost voltage can be selected higher than with a single-stage charge. This extends the constant current phase, resulting in a better state of charge in a shorter time.

After reaching the current threshold (I_{20}), which indicates that the battery has been sufficiently charged, the voltage is switched to the float voltage. This is significantly lower than the voltage for single-stage charging. This minimises water consumption while maintaining the state of charge.

If the battery has been discharged, the charging current will increase again. When the switchover point (I_{20}) is reached, the charging voltage is set to the boost value again in order to recharge the battery quickly. The charging current then drops again and the charger switches back to float voltage.

As a result, this charging method eliminates the trade-off between water consumption and state of charge of single-stage charging.

Even with two-stage charging, a reduction must be taken into account for the state of charge when the battery is designed. The value is usually in the same range as for single-stage charging.

5.6. Alternating portion of the charging current

The superimposed effective alternating current component of the charging current Ieff (effective value) must be set to the values limited by the battery manufacturer during maintenance or heavy-duty charging. Higher values of the alternating current component have a detrimental effect on the service life of the batteries due to the generation of heat. The effective current Ieff can be measured with an ammeter (multimeter).

The upper limit for the proportion of alternating current flowing through the battery is for nickel-cadmium batteries:

- For trickle charging: 20 A per 100 Ah rated capacity of the battery
- For heavy charging: 20 A per 100 Ah rated capacity of the battery

6. Instructions for transport

Observe the regulations for the transport of batteries specified in the following sections.

Note

Observe the safety instructions, see 2 Safety instructions on page 12.

6.1. Land transport (road/rail) according to ADR/RID

Filled batteries with the UN number 2795 BATTERIES (ACCUMULATORS), WET, FILLED WITH ALCALCIATES are not classified as dangerous goods subject to declaration during transport. The following requirements must be met (in accordance with ADR Special Provision 598, Chapter 3.3):

New batteries, if:	they are secured against slipping, falling over and damage.
	they are equipped with carrying devices, unless they are stacked on pallets, for example.
	they have no dangerous traces of alkalis or acids on the outside; they are protected against short circuits
Used batteries, if:	their housings are not damaged.
	they are secured against leaking, slipping, falling over and damage, e.g. stacked on pallets.
	they have no dangerous traces of alkalis or acids on the outside.
	they are protected against short circuits.

"Used batteries" are those that are transported for recycling purposes after normal use.

If the conditions of special regulation 598 are not met, declare and transport new and used batteries as dangerous goods as follows:

UN dangerous goods class	8
UN No. (substance number)	2795
Naming and description	BATTERIES (ACCUMULATORS), WET, FILLED WITH ALKALIS
Packaging group	Not assigned to a packaging group
Hazard labelling	8
ADR Tunnel Restriction Code	E

6.2. Sea transport according to IMDG Code

Declare FNC-T batteries for sea transport as follows:

UN dangerous goods class	8
UN No. (substance number)	2795
Correct dispatch designation	BATTERIES (ACCUMULATORS), WET, FILLED WITH ALKALIS
Packaging group	Not assigned to a packaging group
Hazard labelling	8
EmS	F-A, S-B
Packaging instructions	P801

6.3. Air transport

Declare FNC-T batteries for air transport as follows:

UN dangerous goods class	8
UN No. (substance number)	2795
Correct dispatch designation	BATTERIES (ACCUMULATORS), WET, FILLED WITH ALKALIS
Packaging group	Not assigned to a packaging group
Hazard labelling	8
Packaging instructions	870

7. Notes on storage

The service life of the batteries begins with delivery ex works HOPPECKE. The storage times are to be fully counted towards the service life period.

Note

Observe the safety instructions, see 2Safety instructions on page 12.

7.1. General Notes

Unpack, install and commission the batteries as soon as possible after delivery, see 8 Commissioning /installation on page 34.

If this is not possible:

- Store batteries in a clean, dry, ideally frost-free room.
- Protect batteries against mechanical damage and soiling.
- Do not expose batteries to direct sunlight.
- Do not stack batteries on top of each other.
- Observe any project-specific regulations that may apply.

Note

The minimum storage temperature is -25 °C

The ideal storage temperature is +20 °C.

Higher storage temperatures lead to faster self-discharge and premature ageing of the battery.

The maximum storage temperature is +60 °C.

A maximum relative humidity of 90% is permissible during storage.

Note

Information on the storage period can be found under 7.2 Storage period on page 31.

7.2. Storage period

Note

The storage period of the battery must not exceed three months after manufacture.

If the foreseeable storage period will exceed three months, discharge the battery as described below.

The battery system prepared in this way can be stored for three years.

The date of manufacture of the FNC-T cells can be specified in 2 different ways:

- Production date until CW15/2024:

Note

The date of manufacture of the FNC rail cells is stamped on the top of each cell.

Each cell has a 9-digit cell code on the top of the cell cover. The last four digits provide information about the production week and the production year.

Example:

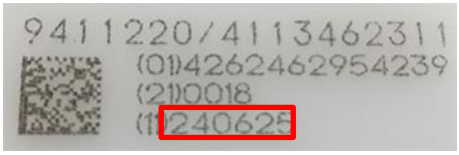
xxxxx2619 => Production week 26; production year 2019

- Production date from CW15/2024:

Note

The date of manufacture of the FNC-T cells is stamped on the top of each cell.

Each cell has a 6-digit cell code on the top of the cell cover. The 6 digits provide information about the production day, month and year, see the following graphic



Example:

240625 => Production year 24; production month 06, production day 25

Steps for preparing the battery for storage:

Goal: The battery is prepared for storage.

1. If the battery was supplied with yellow transport plugs, replace these with water refill plugs or vent plugs.
2. Discharge the battery using a charger/discharger with the nominal current I_5 (= $_{Cn}$ / 5h). Discharge until the battery voltage has reached an average of 1 V per series-connected cell.

Result: The battery is now ready for storage.

Note

Recommissioning:

Charge the battery system for recommissioning as described in 8.2.2 Charging for commissioning on page 41.

7.3. Storage with built-in battery

Note

Ideally, you should store the battery separately from the vehicle in a clean, dry and ideally frost-free room.

If it is not possible to disconnect the battery from the vehicle and the vehicle is parked, make sure that the battery is not deeply discharged.

Disconnect the battery electrically from the vehicle's electrical system to prevent permanent loads from discharging the battery.

Parking is to be regarded as normal operation with regard to maintenance. Carry out the regular maintenance intervals and work, see 10 Maintenance on page 52.

Note

If the duration of parking exceeds 2 months, carry out a commissioning before the vehicle goes into regular operation; see 8.2.2 Charging for commissioning on page 41.

8. Commissioning /installation

Note

Observe the safety instructions, see 2 Safety instructions on page 12.

Note

Batteries can be supplied in various ways:

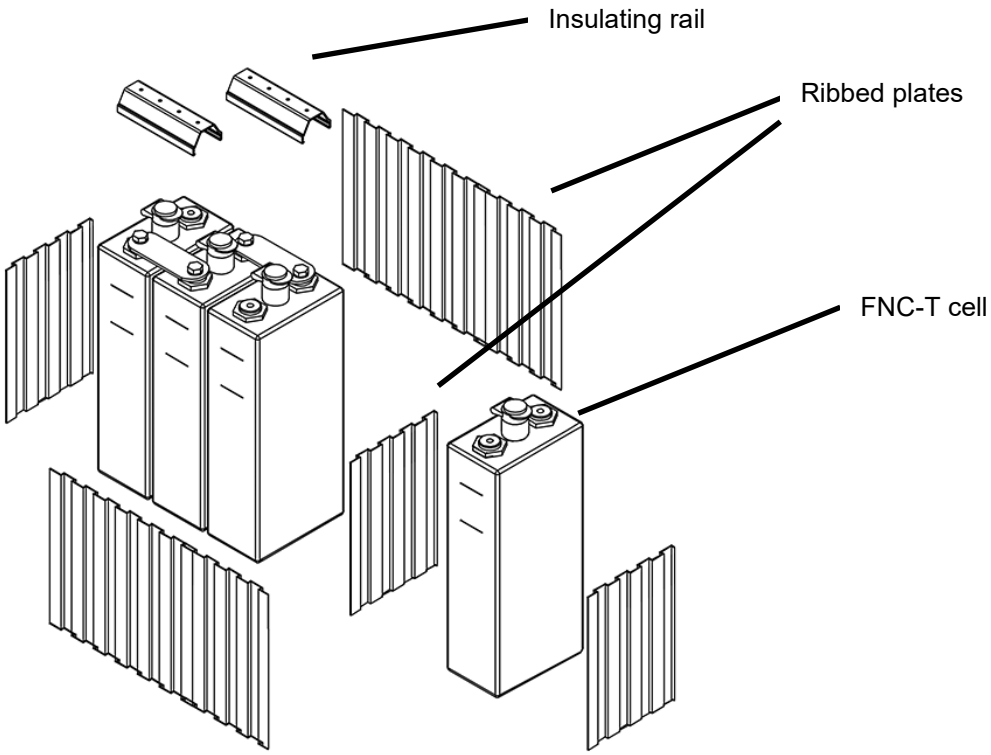
- Individual cells with connectors and other accessories for assembly by the customer. (so-called battery kits)
- Individual carriers that are installed by the customer in the battery compartment of the vehicle. The cells are already installed in the carriers.
- Complete battery containers that contain the battery and other electrical components fully assembled. The containers are installed on/in the vehicle by the customer.

Additional project-specific information may be included in separate documentation supplied.

CAUTION!

For the delivery of so-called battery kits with installation by the customer, observe the following points regarding the installation situation:

- The FNC-T cells must be installed in the carrier/container with a press fit before they are put into operation. This prevents bulging and therefore damage to the cell vessels.
- Additional ribbed plates between the cells.
- Ribbed plates also between the outside of the cell pack and the trough / container.



The batteries are usually supplied filled and charged. They can be connected and put into operation within three months of the date of manufacture without any special preparations.

The date of manufacture of the FNC-T cells can be specified in 2 different ways:

- Production date until CW 15/2024

Note

The date of manufacture of the FNC-T cells is stamped on the top of each cell.

Each cell has a 9-digit cell code on the top of the cell cover. The last four digits provide information about the production week and the production year.

Example:

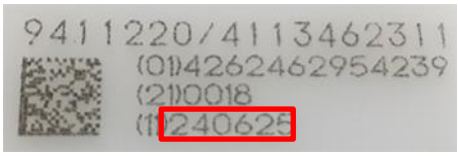
xxxxx2619 => Production week 26; production year 2019

- Production date from week 16/2024

Note

The date of manufacture of the FNC-T cells is stamped on the top of each cell.

Each cell has a 6-digit cell code on the top of the cell cover. The 6 digits provide information about the production day, month and year, see the following graphic



Example:

240625 => Production year 24; production month 06, production day 25

In the following cases, a commissioning charge must be carried out before installing and commissioning the batteries (see 8.2.2 Charging for commissioning on page 41):

- The date of manufacture is more than 3 months ago at the time of commissioning.
- Batteries supplied unfilled and uncharged should be put into operation. Carry out the commissioning charge after the batteries have been filled with alkaline solution (see 8.2.1.3 Preparation of batteries with unfilled cells on page 39).
- Filled and uncharged batteries should be put into operation.
- The vehicle in which the batteries are used should be put into regular operation after test operation, a longer standstill or transport time.

8.1. Checking the delivery

HOPPECKE Batterie Systeme GmbH packs your delivery with the greatest possible care to ensure that it arrives undamaged.
Check the delivery immediately:

- Completeness (comparison with the delivery note)
- Transport damage
- Document:
  - Damage to the outer packaging
  - Visible stains or moisture that would indicate electrolyte leakage.

If the delivery is incomplete or there is transport damage:

- Write a short defect report on the delivery note before you sign it.
- Ask the forwarding agent for an inspection and make a note of the name of the inspector.
- Draw up a defect report and send it to HOPPECKE Batterie Systeme GmbH and the carrier within 14 days.

Check goods for defects:

- Observe the instructions in the chapter 2 Safety instructions on page12.
- Unpack the batteries after delivery and check for defects by carrying out a visual and functional check.
- Document any defects and send them to Hoppecke Batterie Systeme GmbH in text form within 14 days.

Note

If you notify the freight forwarder of defects or incompleteness too late, this may result in the loss of your cltargets.

8.2. Measures before initial commissioning

8.2.1. Preparations

Note

HOPPECKE Batterie Systeme GmbH's range of accessories includes aids such as glass tubes for determining the fill level, devices for topping up water and chargers.

8.2.1.1. Replacing the battery cell transport plugs

When the batteries are delivered, the cells may be sealed with one of the following types of plugs:

Yellow transport plugs

White vent stoppers

Water refill plug (low-pressure system)

Note

The yellow transport plugs prevent the cells from being ventilated and can cause the destruction of individual cells when charging the battery.

If the cells are delivered with yellow transport plugs, replace these with the vent / water refill plugs supplied separately.

Note

The installation of a water refill system is described in the documentation supplied separately with the battery if required.

8.2.1.2. Recommendation of additional measures

It is recommended to carry out the following additional measures before installing and commissioning each battery:

- Check the cell connectors and their screw connections for tightness.
- Check the insulation resistance of the battery (see 10.1.5 Measuring the insulation resistance on page 61).
- Create a commissioning log for the battery (see 14.2 Commissioning protocol on page 99).

8.2.1.3. Preparation of batteries with unfilled cells

Target: The unfilled battery is prepared for use in the vehicle.

WARNING!

There is danger from:

- Work on open FNC-T cells. Contact with the electrolyte may occur.
- Damage to the housing. Electrolyte may leak from the affected cell.
- Reverse polarity of the battery or individual cells. This can result in overheating and electrolyte leakage.

There is a possible medium-risk hazard that can result in death or serious injury if not avoided.

The electrolyte can cause severe skin burns and serious eye damage.

Measures to avert the danger:

- Always wear safety goggles and protective gloves when working on batteries.
- Wash clothing contaminated with electrolyte with water.
- Check the correct polarity before making connections.

Observe the first aid measures, see 2.1.3Electrolyte on page 14.

Note

- Filling with acid destroys the cells of the FNC-T batteries. Improperly mixed caustic potash solution impairs battery performance.
- Only use electrolyte in accordance with IEC EN 60993 to fill the battery cells.

1. Remove the unfilled battery from storage and place it in a suitable battery workshop for wet chemistry.
2. Do not remove the yellow transport plugs and allow the battery to acclimatise for 6 hours if the temperature difference between the warehouse and the battery workshop is more than 10°C.

Note

Preparation and handling of the electrolyte are described in separate documentation from HOPPECKE Batterie Systeme GmbH. (see document: "Electrolyte_Mixing.pdf")

It is not necessary to change the electrolyte during the entire service life of the battery.

3. Only remove the yellow transport plugs immediately before filling the battery.
4. Fill each cell of the battery with the electrolyte to approx. 1 cm above the minimum mark.
5. Leave the battery to rest for 12 hours.
6. Fit degassing tubes (Hoppecke material number 4143180110) to each cell.
7. Charge the battery with the constant current I_5 for 7.5 hours.

Note

The battery must not exceed a temperature of 45 °C during charging.

If a temperature of 45 °C is reached, interrupt charging.

Make a note of the remaining loading time.

Do not continue charging until the cell temperature has dropped to 25 °C.

Complete the charging time of 7.5 hours after the battery has cooled down.

If the battery reaches a temperature of 45 °C again before the charging time of 7.5 hours is complete, interrupt charging again, etc.

8. Leave the battery to rest for at least 8 hours, preferably overnight.
9. Disconnect the charger/discharger from the battery.
10. Dismantle the degassing tubes.
11. Manually top up the electrolyte levels of the cells with electrolyte up to the maximum mark.

Battery cell format	Electrolyte level maximum according to measuring glass tube [mm]
R 2	36 ± 2 (3.5 rings)
R 3	

Note

The electrolyte levels of the cells can be checked using the Hoppecke measuring glass tube (Mat-No.: 4144140010), see 10.1.2 Check electrolyte level on page 54. The measuring glass tube contains a ring scale on which the electrolyte level can be read in rings.

12. Refit the vent plugs or the water refill system.

Result: The battery is now ready for use in the vehicle.

8.2.2. Charging for commissioning

Note

- Batteries with unfilled cells must always be given an initial charge after filling. Cells supplied uncharged must also receive a commissioning charge.
- Otherwise the following applies:
  If commissioning takes place up to 3 months after the date of manufacture, the measures described here are not necessary.
  - The date of manufacture (calendar week and year) of the battery is noted on the type plate.
- The date of manufacture of the FNC-T cells is stamped on the top of each cell.

Production date until CW15/2024:

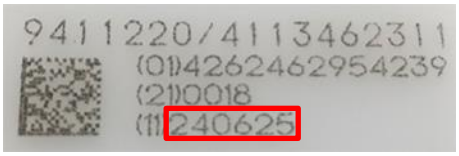
The date of manufacture of the FNC rail cells is stamped on the top of each cell.

Each cell has a 9-digit cell code on the top of the cell cover. The last four digits provide information about the production week and the production year.

Example:
xxxxx2619 => Production week 26; production year 2019

Production date from CW16/2024:

Each cell has a 6-digit cell code on the top of the cell cover. The 6 digits provide information about the production day, month and year, see the following graphic



Example:
240625 => Production year 24; production month 06, production day 25

DANGER!

Risk of explosion due to oxyhydrogen gas formation!

When the cells are charged, water is decomposed and a hydrogen-oxygen gas mixture (oxyhydrogen gas) is formed, which explodes even when only a small amount of energy is supplied.

Keep any source of ignition away from the battery:

- Open flames or fire
- Smoking
- smouldering sparks
- Flying sparks during grinding work
- Electrical sparks from switches or fuses
- Hot surfaces with temperatures above 300 °C
- Electrostatic discharges

Work with voltage-insulated, non-sparking tools.

Earth yourself when working directly on the battery.

Ensure sufficient ventilation of the container space in accordance with DIN EN IEC 62485-3 so that any explosive gas mixture that may arise is removed.

Note

The charge for commissioning is a constant current charge, see 5.5.1Charge with constant current (I) on page 24.

Tools required:

- Suitable charging/discharging device
- Measuring glass tube
- Digital multimeter
- Degassing tube
- Contact thermometer

Carry out the following activities in the order listed here:

Activity	Description of the
Prepare the load for commissioning	8.2.2.1 Preparation on page 43
Carry out charging for commissioning	8.2.2.2 Realisation on page 44
Preparing the load for commissioning	8.2.2.3 Follow-up on page 45

8.2.2.1. Preparation

Target: The cells are prepared for charging for commissioning.

Note

Carry out measures on the dismantled battery - i.e. mechanically separated from the vehicle - before initial start-up.

Note

It is strongly recommended that charging for commissioning is carried out in an air-conditioned working area at 20 °C (±5 °C).

1. Remove the vent plugs from each FNC-T cell or, if present, remove the tubing and the water refill plugs.
2. Remove the insulating rails.

3. Measure the individual cell voltages with a digital multimeter and note the values in a test report.

Note

If the open-circuit voltage of a cell is < 1.2 V, contact HOPPECKE Service.

4. Place a degassing tube (HOPPECKE material number: 4143180110) on each FNC-T cell.

Result: The cells are now ready to be charged for commissioning. Continue with the procedure.

8.2.2.2. Realisation

Target: The cells are put into the charged state.

Note

Steps 1 and 2 do not apply if the battery was purchased in an uncharged state or if it was discharged in advance in accordance with 7.2 Storage period on page 31.

1. Discharge the battery using a charger/discharger with the rated current I_5 until the battery voltage has dropped to 1 V per cell.
2. Allow the load-free battery to rest for at least 4 hours.
3. Measure the temperature of the battery, e.g. with a contact thermometer.
   The cell to be measured should be installed in the centre of the battery in order to detect the warmest point of the system.
4. Charge the battery with the constant current I_5 for 7.5 hours.

Note

If the charger used requires a voltage limit to be entered, set this to 2 V per cell.

Note

The battery must not exceed a temperature of 45 °C during charging.

If a temperature of 45 °C is reached, interrupt charging.

Make a note of the remaining loading time.

Do not continue charging until the cell temperature has dropped to 25 °C.

Complete the charging time of 7.5 hours after the battery has cooled down.

If the battery reaches a temperature of 45 °C again before the charging time of 7.5 hours is completed, interrupt the charging process again, etc.

Note

During commissioning charging, the battery is supplied with an electrical charge of 1.5 C_n, whereby relatively high cell voltages (up to 1.9 V/cell) can occur during charging. The loads must therefore be disconnected from the battery. During commissioning charging, a larger quantity of water is decomposed than during normal operation of the battery. Sufficient ventilation must therefore be provided in accordance with DIN EN IEC 62485-3.

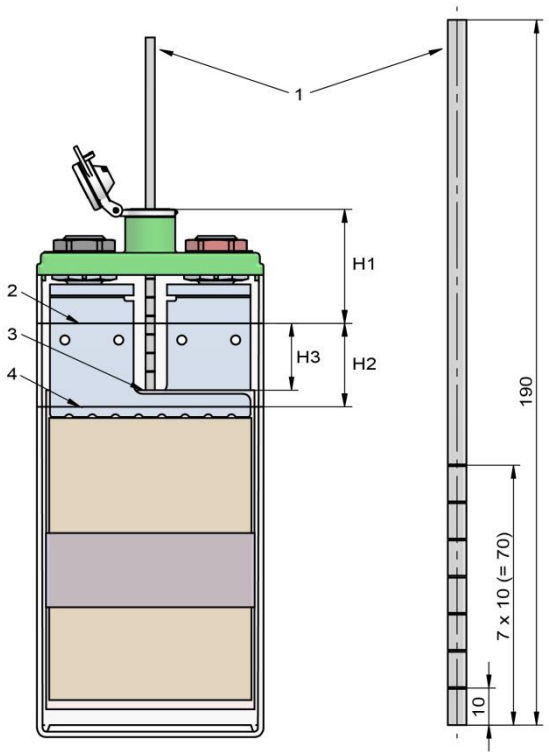
5. Leave the battery to rest for at least 8 hours, preferably overnight.
6. Disconnect the charger/discharger from the battery.

Result: The cells are now in a charged state. Continue with the follow-up.

8.2.2.3. Follow-up

Target: The cells are made ready for operation again after charging.

1. Remove the degassing tube.
2. Measure the electrolyte level in each cell using the measuring glass tube (HOPPECKE material number: 4144140010).
   - Keep the upper opening of the measuring glass tube free and insert it into the cell until it encounters resistance.
   - Close the upper opening of the measuring glass tube with your index finger.
   - Remove the measuring glass tube from the cell until the scale becomes visible.
3. Read the electrolyte level in the cell from the electrolyte remaining in the measuring glass tube and allow the electrolyte in the measuring glass tube to flow back into the cell
4. Fill the cells with distilled water to the maximum level.



1 = HOPPECKE measuring glass tube

2 = MAX electrolyte level

3 = Top edge of separator

4 = MIN electrolyte level

H1 = Height from the open vent plug to the MAX electrolyte level

H2 = Total electrolyte lift between MIN and MAX

H3 = Measurable electrolyte lift

Battery cell format	Electrolyte level maximum according to measuring glass tube [mm]
R 2	36 ± 2 (3.5 rings)
R 3	

5. Reinsert the vent plugs or reinsert the water refill plugs and restore the tubing.
6. Thoroughly remove any dirt from the battery with a clean, damp cloth.
7. Measure the individual cell voltages with a digital multimeter and note the values in a test report. If the individual cell voltages deviate more than± 50 mV from the average of all cell voltages, contact HOPPECKE Service.

8. Replace the insulating rails.

Result: The cells are now ready for operation again.

8.3. Installation and connection

Target: The battery is connected for use in the vehicle.

DANGER!

Danger due to a short circuit between the positive and negative terminals of a battery.

If the positive and negative terminals of a battery are short-circuited, there is a risk of overheating and explosion.

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Never short-circuit the positive and negative terminals of a battery.

DANGER!

Danger when connecting a battery to the load.

Reverse polarity of batteries can cause overheating and leakage of alkaline solution.

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Always check the correct polarity before making connections.

Ensure that all consumers in the vehicle and the charger are disconnected or switched off.

Note

If the terminals of a battery are damaged, the battery can no longer be used.

Do not damage the battery terminals.

Note

- Provide stable, secure surfaces for carriers/troughs/battery cells.
- Ensure that all consumers in the vehicle and the charger are switched off.

Note

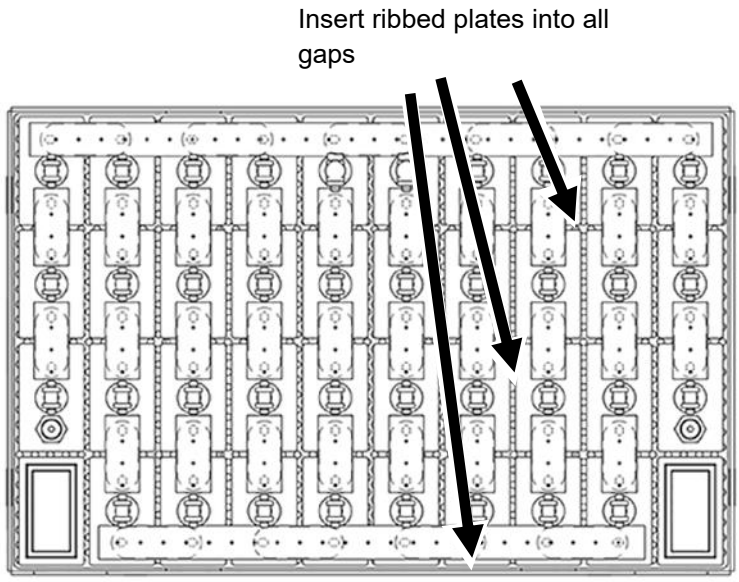
Observe the project-specific electrical circuit diagram.

For delivery of so-called battery kits (cells, connectors, terminal screws):

- Install the cells in the battery compartment of the vehicle according to your customer's installation drawing.
- Install the connector.
- Connect end poles.

Note

Cells and ribbed plates are always installed from the outside inwards (and as specified in the construction drawing). Any gap corrections and unevenness on the outer walls are levelled out with ribbed plates depending on the gap. This ensures a form-fit installation of the cells in the battery trays.



Note

The cells must be installed on a flat surface (trough floor). The maximum flatness tolerance is 3 mm in relation to the total area of the trough.

Note

When installing cells in containers or carriers, the cells must not be "driven in". They must be inserted without applying excessive force, as otherwise the box/lid weld seam will be overloaded and leaks will occur.

Note

Observe the tightening torque when making the screw connections.

- M8 Torque: 20 Nm ± 3%
- M10 Torque: 25 Nm ± 3%
- Use new spring washers.

1. Connect the positive terminal of the battery to the positive terminal of the vehicle electrical system or charger.
2. Connect the negative terminal of the battery to the negative terminal of the vehicle electrical system or charger.
3. If available, connect control lines (e.g. medium voltage taps etc.).
4. Check the battery connection, for example by checking the charging voltage and the control signals.

Result: The battery is now connected for use in the vehicle.

9. Operation

Note

- Only direct current may be used for charging. All charging methods with their limit values in accordance with DIN 41 772 and DIN 41 776 are applicable.
- Only connect to the assigned charger approved for the battery size in order to avoid overloading the electrical cables and contacts, impermissible gas formation and electrolyte leakage from the cells.
- If the charger was not purchased together with the battery, it is advisable to have it checked for suitability by the battery manufacturer's customer service.
- In AGV operation, gassing of the battery is largely avoided so that the battery can be charged in the vehicle. It must be ensured that no dangerous accumulation of charging gases can occur in the vehicle. When charging, it must be ensured that the charging gases are properly extracted. Trough lids or covers of battery installation compartments must be opened or removed. Ensure adequate ventilation of the container space in accordance with DIN EN IEC 62485-3 so that any explosive gas mixture that may arise is removed.
- The vent plugs and water refill plugs remain on the cells when charging. Do not open the vent plugs.
- The battery must be connected to the switched-off charger with the correct polarity. Then switch on the charger.

9.1. Operation in automated guided vehicle systems (AGV)

In this operating mode, the battery is used to drive an automated guided vehicle (AGV). The AGV vehicles are controlled automatically and are used to transport materials. The battery is characterised by continuous cycling (charging and discharging) operation.

9.1.1. Discharging in AGV operation

The following operating parameters apply for discharging the battery:

- The maximum discharge depth for each cycle is 30% CN.
- The capacity that can be removed per day (in Ah per day) can be up to 3 x CN without the need for additional cooling at an ambient temperature of up to 30°C.
- If the capacity converted per day exceeds the value specified above, options for air exchange (convection) should be provided in the battery tray. If this is not possible or if the capacity converted per day exceeds a value of 6 x CN, forced ventilation must be provided for the battery.
- The battery may only be loaded with the maximum parameters specified in the battery design.

Note

Unless otherwise specified the manufacturer, the discharge voltage must not fall below the nominal discharge voltage of 1V per cell.

9.1.2. Charging in AGV operation

The battery is charged according to an IUOU characteristic curve or IUIa characteristic curve in accordance with DIN 41 772.

The following parameters are observed:

- Charging current X types: 5 to 20 x I5.
- Charging current H-types: 5 to 12.5 x I5
- Charging current M types: 5 to 7.5 x I5.

- Charging voltage limits:
  - 1.55 V per cell to 1.60 V per cell with heavy charging
  - 1.4 V per cell to 1.45 V per cell with float charge

9.2. Operation in hand-guided industrial trucks

FNC-T batteries are also used in hand-operated industrial trucks or forklift trucks. Depending on the design of the battery, the depth of discharge can be up to 40% of the nominal capacity.

Note

Ensure that the electrolyte temperature does not exceed 35°C by ventilating the battery. In the short term, 45°C is also tolerable.

The load on the battery in this operating case is generally in the following order of magnitude:

- For FNC-T X and H types:
  - Constant drive current: 1 to 2.5 x I5.
  - Peak current: 10 to 20 x I5
- For FNC-T M types:
  - Constant drive current: up to 1.5 x I5
  - Peak current: up to 10 x I5
- Voltage range: 1 to≥ 1.2V per FNC-T cell

The battery is charged according to an IU0U characteristic curve or preferably according to an IUIa characteristic curve with the following parameters:

- Main charge:
  - Charging current X types: 5 to 20 x I5.
  - Charging current H-types: 5 to 12.5 x I5
  - Charging current M types: up to 7.5 x I5.
- Charging voltages
  - 1.55 V per cell to 1.60 V per cell with heavy charging
  - 1.4 V per cell to 1.45 V per cell with float charge
- Recharging (IUIa characteristic curve):
  - for all types: 0.5 x I5
  - Charge factor: 1.2
  - Charging voltage 1.55 V to 1.60 V per cell

Note

Voltages≥ 1.9 V per cell can occur in the Ia branch of the characteristic curve. Therefore, disconnect the batteries from the load.

10. Maintenance

10.1. Preventive maintenance

Note

Observe the safety instructions, see 2 Safety instructions on page 12.

If you are unable to carry out maintenance yourself, have the batteries serviced regularly and properly by HOPPECKE specialist personnel or by personnel authorised by HOPPECKE Batterie Systeme GmbH.

To ensure that the battery is in optimum condition, follow the maintenance schedule:

Activity	Interval	Description of the
Carry out a visual inspection	6 months	10.1.1 Visual Inspection on page 53
Check electrolyte level	6 months or after each equalisation charge (whichever applies first)	10.1.2 Check electrolyte level on page 54
Top up with distilled water	6 months or after each equalisation charge (whichever applies first)	10.1.3 Top up with distilled water on page 57
Clean battery	6 months or after each equalisation charge (whichever applies first)	10.1.4 Battery cleaning en on page 60
Measuring the insulation resistance	6 months or after each equalisation charge (whichever applies first)	10.1.5 Measuring the insulation resistance on page 61
Perform equalising charge	project-dependent	10.1.6 Perform equalising charge on page 63
Carry out reconditioning	project-dependent	The instructions for reconditioning include • Measuring the electrolyte level • Measuring the individual cell voltages 10.1.7 Carry out reconditioning on page 67
Replacing the FNC-T cells and attachments	project-dependent (1-10 years) If the remaining battery capacity is below 70%	12 Disassembly / assembly of FNC-T cells and accessories on page 87

*) Intervals may vary depending on the project and/or the ambient temperature.

Note

To provide evidence in the event of a warranty cltarget, enter the activities and the measured values in a maintenance report, see 14.3 Maintenance log on page 101.

10.1.1. Visual Inspection

Target: The visual inspection of the battery is carried out.

1. Check the battery with regard to the following criteria:

Test object	Test criterion	Remedy
Pollution	Check battery cells, screws, connectors and cable lugs for dirt.	Thoroughly remove any dirt from battery cells, screws, connectors and cable lugs with a clean, damp cloth, as dust and moisture can lead to leakage currents.
Ventilation	Check ventilation openings for free passage	Clear the ventilation openings.
Mechanical damage	Check battery and container for mechanical damage	Please contact the depot manager or HOPPECKE Service.
Tight fit of connectors, screws and cables	Connectors, screws and cables must not be loose	Tighten connectors, screws, cables.
Electrolyte level of the battery cells	Electrolyte level must be between min and max mark	If necessary, top up with distilled water, see 10.1.3 Top up with distilled water on page 57.
Impurities due to electrolyte	Plugs must be tight (no stains from electrolyte on the plugs or on the cells)	Check plug for tight fit, correct if necessary.
Tight fit of the water refill system	Water refill systems, if present, must be correctly installed (no loose hoses or plugs)	Check hoses and plugs for tight fit, correct if necessary.
Seals	The container seals, if present, must not show any signs of mechanical damage.	Replace damaged seals.

2. Enter activities in a maintenance report, see 14.3 Maintenance log on page 101.

Result: The visual inspection was carried out.

10.1.2. Check electrolyte level

Target: The electrolyte level of the battery cells was checked.

When a battery is overcharged, the water in the electrolyte is broken down into gases (H_2 and O_2) by electrolysis. This causes the electrolyte level to drop. The amount of decomposed water depends on the charging voltage, the charging time per day and the temperature.

WARNING!

Contact with the electrolyte may occur when checking the electrolyte level.

There is a possible medium-risk hazard that can result in death or serious injury if not avoided.

The electrolyte can cause severe skin burns and serious eye damage.

Wear safety goggles and protective gloves when working on the batteries. (Five-fingered gloves made of latex or PVC).

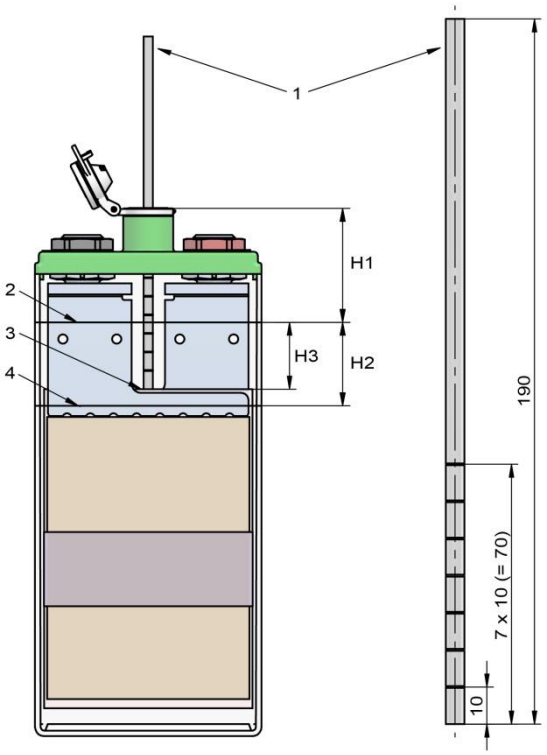
Tools required:

- Measuring glass tube

Cells can also have polypropylene containers (PP-V0), through the walls of which the electrolyte levels are not visible. With translucent standard polypropylene (PP) containers, individual electrolyte levels may not be visible due to the installation situation. In these cases, the measuring glass tube available from HOPPECKE (material number: 4144140010) must be used as an aid for checking the electrolyte level.

1. Open the vent plugs or remove the water refill plug from 10% of the battery cells. For example, 2 cells in a 20-cell battery.

2. Keep the upper opening of the measuring glass tube free and insert it into the respective cell until it encounters resistance.
   - Close the upper opening of the measuring glass tube with your index finger.
   - Remove the measuring glass tube from the cell until the scale is visible.



1 = HOPPECKE measuring glass tube

2 = MAX electrolyte level

3 = Top edge of separator

4 = MIN electrolyte level

H1 = Height from the open vent plug to the MAX electrolyte level

H2 = Total electrolyte lift between MIN and MAX

H3 = Measurable electrolyte lift

3. Read the electrolyte level in the cell from the electrolyte remaining in the measuring glass tube and allow the electrolyte in the measuring glass tube to flow back into the cell.

Note

The rings count upwards from the bottom edge of the measuring glass tube.

- If the electrolyte level is greater than 2 rings (R2 and R3), do not top up with distilled water. Continue with step 4.
- If the electrolyte level in one of the FNC cells is less than or equal to 2 rings (R 2 and R3), top up with distilled water to the maximum level. (see 10.1.3 Top up with distilled water on page 57)
- If the electrolyte levels of the FNC cells differ by more than 2 rings, contact HOPPECKE Service.
- If the electrolyte level in one or more cells is above 5 rings (R2 and R3), contact HOPPECKE Service.

4. Measure the electrolyte density with a caustic density meter. If the deviation from the target value is greater than± 0.02 kg/l, contact Hoppecke Service.

Note

The electrolyte density must not be measured immediately after topping up with distilled water. This can result in incorrect readings as the water has not mixed with the electrolyte.

5. Close the vent plug again or reinsert the water refill plug.
6. Enter activities in a maintenance report, see 14.3 Maintenance log on page 101.

Result: The electrolyte level of the battery cells has now been checked.

10.1.3. Top up with distilled water

Target: The battery is topped up with distilled water.

WARNING!

Contact with the electrolyte may occur when checking the electrolyte level.

There is a possible medium-risk hazard that could result in death or serious injury if not avoided.

The electrolyte can cause severe skin burns and serious eye damage.

Wear safety goggles and protective gloves (five-finger gloves made of latex or PVC) when working on the batteries.

Note

Always check the electrolyte level before this maintenance step, see 10.1.2 Check electrolyte level on page 54.

Note

- Filling with acid destroys the FNC-T cells.
- Tap water is not permitted and will impair your battery performance.
- Only use distilled / deionised water in accordance with EN 60993 or DIN 43530-4 to refill the FNC-T cells.

Distilled water can be topped up using 3 different methods:

Method	Description of the
Manual water refill	See 10.1.3.1 Top up distilled water manually on page 58
Top up water with the central water refill system	See 10.1.3.2 Refill distilled water with the central water refill system on page 58
Refilling water with the water refill trolley for single cells	See 10.1.3.3 Refill distilled water with the water refill trolley for single cells on page 59

Result: The electrolyte levels of the battery are topped up with distilled water.

10.1.3.1. Top up distilled water manually

Tools required:

- Measuring glass tube
- Funnel or pipette for filling the distilled water into the cells

1. Open all vent plugs.
2. Fill each FNC-T cell with distilled water to the maximum level.

For cell types R2 and R3 (the type information is part of the cell designation, see label on each cell), observe the following table when refilling with distilled water:

Battery cell format	Electrolyte level maximum according to measuring glass tube [mm]
R 2	36 ± 2 (3.5 rings)
R 3	

3. Close the vent plug.
4. Clean the battery system if necessary, see 10.1.4 Battery cleaning en on page 60.
5. Enter activities in a maintenance report, see 14.3 Maintenance log on page 101.

10.1.3.2. Refill distilled water with the central water refill system

Note

If a water refill system is installed on the battery, the following applies:

Top up with distilled water using the central water refill system. Instructions are described in the following document:
D00001-300-en<version number>-Water-Refilling.pdf

Enter activities in a maintenance report, see 14.3 Maintenance log on page 101.

10.1.3.3. Refill distilled water with the water refill trolley for single cells

Note

If a water refill trolley is available for individual cells, the following applies:

Top up with distilled water using the water refill trolley for single cells. Instructions are described in the following document:
D00003-300-en<version number>_Manual_SemiAutomaticWaterfilling.pdf

Enter activities in a maintenance report, see 14.3 Maintenance log on page 101.

10.1.4. Battery cleaning en

Target: The battery is cleaned.

A clean battery is essential to prevent accidents and material damage as well as a reduced service life and availability.

Cleaning the FNC-T cells and the trough or container is necessary to maintain the required insulation of the cells against each other, against earth or other conductive parts. Damage caused by corrosion and leakage currents is also avoided.

Cleaning the battery is not only necessary to ensure high availability, but is also an essential part of the accident prevention regulations.

Note

Improper cleaning can damage the batteries.

Avoid damaging the battery:

- Do not use solvents or wire brushes for cleaning.
- Prevent cleaning water and dirt particles from entering the cells. The vent plugs must be closed.

1. Clean the batteries with clean cotton cleaning cloths and water without adding any cleaning agents.

2. Allow the surfaces of the batteries to dry after cleaning.

Note

Remove any liquid that has got into the battery compartment. Dispose of in accordance with the Waste / Residual Substances Monitoring Ordinance.

3. Enter activities in a maintenance report, see 14.3 Maintenance log on page 101.

Result: The battery is now cleaned.

10.1.5. Measuring the insulation resistance

Target: The insulation resistance of the battery is measured.

The insulation resistance of a battery in a rail vehicle is a measure of its conductivity. This results from moisture and soiling of the battery between the battery terminals of each individual cell and the vehicle chassis. Ideally, there is no electrical conduction here if the insulation resistance of the battery is infinitely high.

When commissioning a new battery, the insulation resistance must be > 1 MΩ. It decreases with the operating time (due to aerosols from the batteries, condensation, dust) and must not fall below the following values depending on the nominal battery voltage:

Nominal battery voltage	Standard	Insulation resistance (minimum value)
Under 120 V	IEC 62485-3	50 Ω per volt of nominal voltage or not less than 1 kΩ per battery
Above 120 V, i.e. from 100 cells	IEC 62485-3	Number of cells x 1.2 V nominal voltage x 500 Ohm/V

If these minimum values are not reached, this can result in the activation of any existing insulation monitor, an undesirable increased discharge and loss of battery performance.

Note

Use an insulation tester with a test voltage of 500 V for FNC-T batteries.

Use a suitable measuring device, e.g. Fluke 1507 (HOPPECKE material number: 4141201237), with the settings 500 V/DC.

CAUTION!

Risk of damage to the vehicle's electrical system.

An insulation test voltage of 500 V can damage other components connected to the battery.

Disconnect all poles of the battery from the vehicle's electrical system when measuring the insulation resistance.

WARNING!

There is a risk of electric shock when carrying out measurements with an insulation measuring device.

There is a possible medium-risk hazard that can result in death or serious injury if not avoided.

Observe the safety precautions described in the documentation for the insulation measuring device.

Tools required:

- Insulation tester (e.g. Fluke 1507)

1. Check the function of the insulation measuring device by measuring any metal part of the battery tray / battery container against any metal part of the vehicle chassis. The measured resistance must be 0 Ohm.
2. Measure the insulation resistance between the positive terminal of the battery and a metal part of the vehicle chassis (battery compartment or central earthing point).
3. Measure the insulation resistance between the negative terminal of the battery and a metal part of the vehicle chassis.
4. Check the function of the insulation measuring device by measuring any metal part of the battery tray / battery container against any metal part of the vehicle chassis. The measured resistance must be 0 Ohm.
5. Clean the battery if the measurements fall below the minimum value (see 10.1.4 Battery cleaning en on page 60).
6. Measure the insulation resistances again according to steps 2 and 3.

Note

If the insulation test fails again, contact HOPPECKE Service.

7. Enter activities in a maintenance report, see 14.3 Maintenance log on page 101.

Result: The insulation resistance of the battery has now been measured.

10.1.6. Perform equalising charge

Equalising charges are used to ensure the service life and maintain the capacity. They are required as part of maintenance work and after deep discharges and repeated insufficient charging. The equalisation charge is a constant current charge with the nominal current I5 of the battery.

Note

After a certain operating time, which depends on the load on the battery, an equalising charge is required. The operating time is usually between 3 and 12 months.

10.1.6.1. Preparation

Target: The cells are prepared for equalisation charging.

Note

It is strongly recommended that the equalisation charge is carried out in an air-conditioned working area at 20 °C (±5 °C).

1. Remove the vent plugs from each FNC-T cell or, if present, remove the tubing and the water refill plugs.
2. Remove the insulating rails.

3. Measure the individual cell voltages with a digital multimeter and note the values in a test report.

Note

If the open-circuit voltage of a cell is < 1.2 V, contact HOPPECKE Service.

4. Place a degassing tube (HOPPECKE material number: 4143180110) on each FNC-T cell.

Result: The cells are now prepared for equalisation charging. Continue with the procedure.

10.1.6.2. Realisation

Target: The cells are put into the charged state.

1. Measure the temperature of the battery, e.g. with a contact thermometer.
   The cell to be measured should be installed in the centre of the battery in order to detect the warmest point of the system.
2. Charge the battery with the constant current I_5 until a voltage of at least 1.75 V per cell is reached.
3. After reaching a voltage of more than 1.75 V per cell, continue charging the battery for another 4 hours at the rated current I_5.

Note

If the charger used requires a voltage limit to be entered, set this to 2 V per cell.

Note

The battery must not exceed a temperature of 45 °C during charging.

If a temperature of 45 °C is reached, interrupt charging.

Make a note of the remaining loading time.

Do not continue charging until the cell temperature has dropped to 25 °C.

Note

Relatively high cell voltages (up to 1.9 V/cell) can occur during equalisation charging. The loads must therefore be disconnected from the battery. During commissioning charging, a larger quantity of water is decomposed than during normal operation of the battery. Sufficient ventilation must therefore be provided in accordance with DIN EN IEC 62485-3.

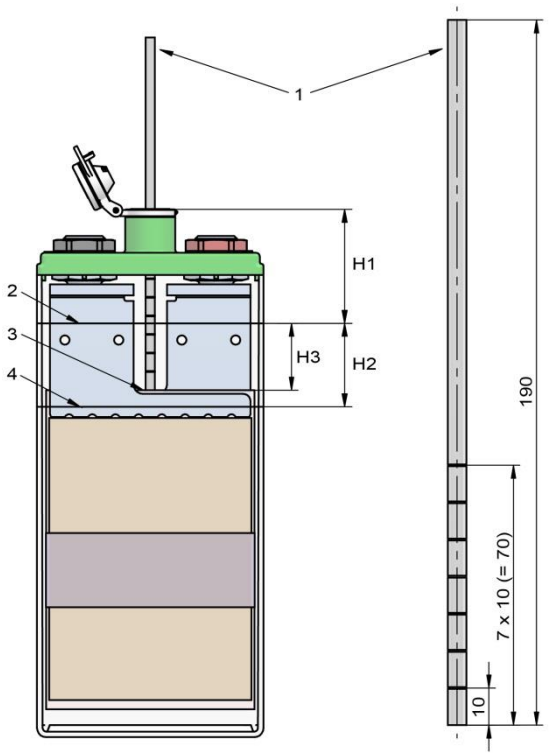
4. Leave the battery to rest for at least 8 hours, preferably overnight.
5. Disconnect the charger/discharger from the battery.

Result: The cells are now in a charged state. Continue with the follow-up.

10.1.6.3. Follow-up

Target: The cells are made ready for operation again after equalisation charging.

1. Remove the degassing tube.
2. Measure the electrolyte level in each cell using the measuring glass tube (HOPPECKE material number: 4144140010).
   - Keep the upper opening of the measuring glass tube free and insert it into the cell until it encounters resistance.
   - Close the upper opening of the measuring glass tube with your index finger.
   - Remove the measuring glass tube from the cell until the scale becomes visible.
3. Read the electrolyte level in the cell from the electrolyte remaining in the measuring glass tube and allow the electrolyte in the measuring glass tube to flow back into the cell
4. Fill the cells with distilled water to the maximum level.



1 = HOPPECKE measuring glass tube

2 = MAX electrolyte level

3 = Top edge of separator

4 = MIN electrolyte level

H1 = Height from the open vent plug to the MAX electrolyte level

H2 = Total electrolyte lift between MIN and MAX

H3 = Measurable electrolyte lift

Battery cell format	Electrolyte level maximum according to measuring glass tube [mm]
R 2	36 ± 2 (3.5 rings)
R 3	

5. Reinsert the vent plugs or reinsert the water refill plugs and restore the tubing.
6. Thoroughly remove any dirt from the battery with a clean, damp cloth.
7. Measure the individual cell voltages with a digital multimeter and note the values in a test report. If the individual cell voltages deviate more than± 50 mV from the average of all cell voltages, contact HOPPECKE Service.

8. Replace the insulating rails.

Result: The cells are now ready for operation again.

10.1.7. Carry out reconditioning

Reconditioning can eliminate or minimise battery capacity losses. It is carried out by discharging/charging the battery several times with a constant current.

DANGER!

Risk of explosion due to oxyhydrogen gas formation!

When the cells are charged, water is decomposed and a hydrogen-oxygen gas mixture (oxyhydrogen gas) is formed, which explodes even when only a small amount of energy is supplied.

Keep any source of ignition away from the battery:

- Open flames or fire
- Smoking
- smouldering sparks
- Flying sparks during grinding work
- Electrical sparks from switches or fuses
- Hot surfaces with temperatures above 300 °C
- Electrostatic discharges

Work with voltage-insulated, non-sparking tools.

Earth yourself when working directly on the battery.

Ensure sufficient ventilation of the battery compartment in accordance with DIN EN IEC 62485-3 so that any explosive gas mixture that may arise is removed.

WARNING!

Contact with the electrolyte may occur when checking the electrolyte level.

There is a possible medium-risk hazard that can result in death or serious injury if not avoided.

The electrolyte can cause severe skin burns and serious eye damage.

Wear safety goggles and protective gloves (five-finger gloves made of latex or PVC) when working on the batteries.

Note

- Reconditioning must be carried out on the dismantled battery, i.e. mechanically separated from the vehicle.
- Carry out reconditioning in an air-conditioned work area at 20 °C (±5 °C).

Note

Reconditioning charging is constant current charging, see 5.5.1 Charge with constant current (I) on page 24.

Tools required:

- Suitable charging/discharging device
- Measuring glass tube
- Digital multimeter
- Degassing tube
- Torque spanner with suitable spanner sizes for M8/M10 screws
- Contact thermometer

During reconditioning, the battery is supplied with an electrical charge of 1.5 C_n, whereby relatively high cell voltages (up to 1.9 V/cell) can occur during charging, e.g. up to 72.2 V for a 38-cell battery.

Carry out the following activities in the order listed here:

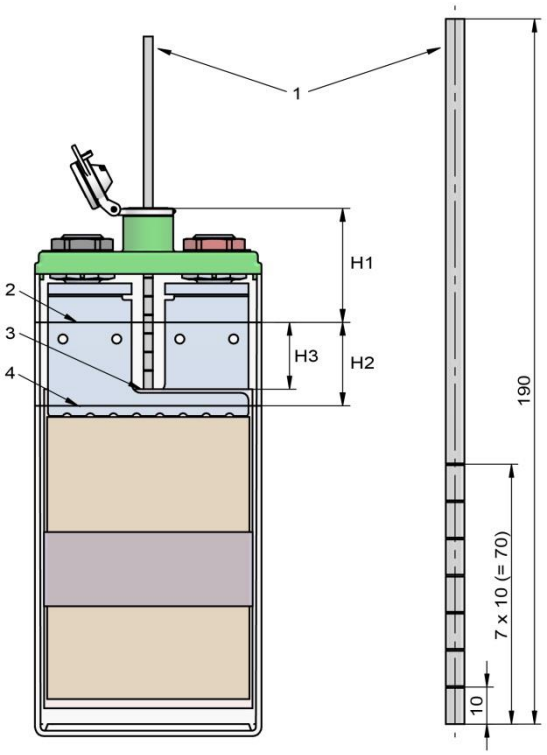
Activity	Description of the
Prepare reconditioning	10.1.7.1 Preparation on page 69
Carry out reconditioning	10.1.7.2 Realisation on page 71
Follow up reconditioning	10.1.7.3 Follow-up on page 74

10.1.7.1. Preparation

Target: The cells are prepared for reconditioning.

1. Remove the vent plugs or the water refill plugs and their tubing from each FNC-T cell.
2. Clean the vent plug or the water refill system in warm water, i.e. place in warm water and leave to soak during the reconditioning period. Then rinse with fresh water.
3. Remove the insulating bars on the connectors.

4. Clean the insulating rails with warm water.
5. Measure the electrolyte level in each cell using the measuring glass tube (HOPPECKE material number: 4144140010).
   - Keep the upper opening of the measuring glass tube free and insert it into the cell until it encounters resistance.
   - Close the upper opening of the measuring glass tube with your index finger.
   - Remove the measuring glass tube from the cell until the scale becomes visible.



1 = HOPPECKE measuring glass tube

2 = MAX electrolyte level

3 = Top edge of separator

4 = MIN electrolyte level

H1 = Height from the open vent plug to the MAX electrolyte level

H2 = electrolyte reserve between MIN and MAX mark

H3 = Measurable electrolyte lift

6. Read the electrolyte level in the cell from the electrolyte remaining in the measuring glass tube and allow the electrolyte in the measuring glass tube to flow back into the cell.

Note for FNC cells format 2 and 3:

- If the electrolyte level in one or more cells is above 4 rings (counting from bottom to top):
  - take the battery out of service
  - Contact HOPPECKE Service.
- The electrolyte level must be at least 1.5 rings. If necessary, top up the cell to this level with distilled water.
  - Proceed with reconditioning, see step 7
- If the electrolyte levels in the FNC cells are above 3.5 but below 4 rings:
  - Proceed with reconditioning, see action step 7
  - Greater contamination (ejection of electrolyte) must be expected
  - Prevent soiling by covering with a highly absorbent paper towel.
- If the electrolyte levels of the selected FNC cells are equal to or below 3.5 rings:
  - Proceed with reconditioning, see action step 7

7. Measure the individual cell voltages with a digital multimeter and record the values in a maintenance report .

Note

If the open-circuit voltage of a cell is < 1.2 V, contact HOPPECKE Service.

8. Place a degassing tube (HOPPECKE material number: 4143180110) on each FNC-T cell.

9. Connect the charger/discharger to the main terminals of the battery.

Note

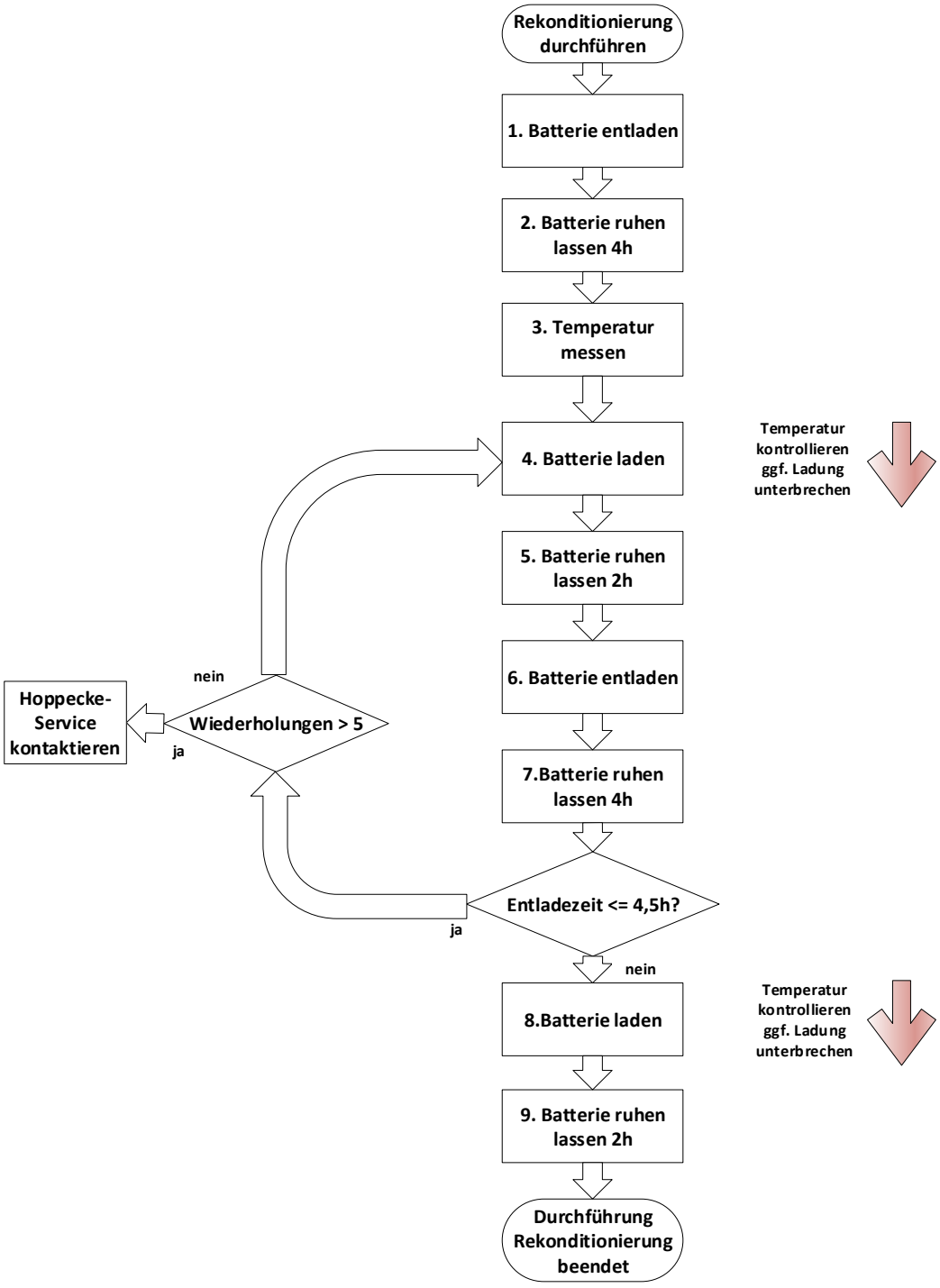
- M8 Torque: 20 Nm ± 3%
- M10 Torque: 25 Nm ± 3%
- Use new spring washers.

Result: The cells are now prepared for reconditioning. Continue with the procedure.

10.1.7.2. Realisation

Target: The cells are put into a reconditioned state.

The following diagram illustrates the steps required for reconditioning:



The individual steps are described in detail in the following instructions:

8. Discharge the battery with the nominal current I_5 until the voltage of the battery has fallen to 1.0 V per cell, e.g. 38 V for a 38-cell battery.

1. Allow the load-free battery to rest for at least 4 hours, preferably overnight.

2. Measure the temperature of the battery, e.g. with a contact thermometer.
   The cell to be measured should be installed in the centre of the system in order to record the warmest possible point of the system
   Record the measured value.

9. Charge the battery with the constant current I_5 for 7.5 hours.

Note

The battery must not exceed a temperature of 45 °C during charging.

If a temperature of 45 °C is reached, interrupt charging.

Make a note of the remaining loading time.

Do not continue charging until the cell temperature has dropped to 25 °C.

Complete the charging time of 7.5 hours after the battery has cooled down.

If the battery reaches a temperature of 45 °C again before the charging time of 7.5 hours has elapsed, interrupt the charging process again, etc.

3. Leave the battery to rest for 2 hours.

10. Discharge the battery with the nominal current I_5 until the battery voltage has dropped to 1.0 V per cell and measure the time. This is the capacity test.

Note

If the battery takes 5 hours to drop to a voltage of 1.0 V per FNC-T cell, it has a capacity of 100 %. The following applies:

- 5 hours -> 100 %
- 4.5 hours -> 90 %
- 4 hours -> 80 %
- 3.5 hours -> 70 %

...

4. Allow the battery to rest for at least 4 hours, preferably overnight.
   If the discharge time is ≤ 4.5 hours, repeat the process from point 4.

Note

If the discharge time is still ≤ 4.5 hours after 5 repetitions, contact HOPPECKE Service.

11.Charge the battery with the constant current I_5 for 7.5 hours.

Note

The battery must not exceed a temperature of 45 °C during charging.

If a temperature of 45 °C is reached, interrupt charging.

Note the remaining loading time.

Do not continue charging until the cell temperature has dropped to 25 °C.

Complete the charging time of 7.5 hours after the battery has cooled down.

If the battery reaches a temperature of 45 °C again before the charging time of 7.5 hours is complete, interrupt charging again, etc.

5. Leave the battery to rest for 2 hours.

Result: The cells are now reconditioned. Continue with the post-processing.

10.1.7.3. Follow-up

Target: The cells are made ready for operation again after reconditioning.

1. Disconnect the charger/discharger from the battery.
2. Remove the degassing tube.
3. Check the electrolyte level on each cell and fill the electrolyte level manually with distilled water up to the maximum level, see 10.1.3.1 Top up distilled water manually on page 58.
4. Thoroughly remove any dirt from the battery with a clean, damp cloth.
5. Use a digital multimeter to measure and record the individual cell voltages.

Note

If the individual cell voltages deviate by more than ± 50 mV from the average of all cell voltages, contact HOPPECKE Service.

6. Replace the insulating bars on the cell connectors.
7. Re-insert the vent plugs or the water refill plugs for each FNC-T cell.
8. If present, restore the hoses of the water refill system.
9. Measure the insulation resistance of the battery, see 10.1.5 Measuring the insulation resistance on page 61.

12. Enter activities in a maintenance report, see 14.3 Maintenance log on page 101.

10. Result: The cells are now ready for operation again and can be installed in the vehicle.

10.2. Corrective maintenance

Note

Observe the safety instructions, see 2 Safety instructions on page 12.

10.2.1. Replace FNC-T cell n

DANGER!

When establishing access to the battery system, contact with sharp edges and/or live components may occur due to the design.

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Measures to avert the danger:

- Be very careful when working on the batteries.
- Wear personal protective equipment, see 2.2 Personal protective equipment on page 17.

DANGER!

Loose connections on the pole screws can become very hot and cause ignition or explosions.

Only use each spring washer once.

- Initially tighten the pole screws by hand only.
- Align the batteries and connectors again if necessary.
- Then tighten the pole screws to the specified torque.

Note

- Switch off all consumers and chargers from the battery system before starting maintenance work
- A battery always has a voltage at the terminals.
- A battery must not be earthed or short-circuited.
- Batteries/troughs are very heavy. Carry battery trays with a sufficient number of people or use suitable lifting gear and means of transport.

If FNC-T cells are defective, you can replace a maximum of 10% of the total number of cells in the entire battery system with new, unused cells of the same type. If more cells are defective, all cells must be replaced.

Note

The mixing of cells from different used batteries to form a single
Total battery is not permitted.

The replacement cells must be charged cells. The cover code of the cells must be observed:

- If the cells were manufactured within the last 3 months, no commissioning charge is required. Replace the cells to be replaced as described at 10.2.1.2 Replace one or more FNC-T cell (n) on page 78.
- If stored cells older than 3 months are used, a commissioning charge must first be carried out for these cells, see 10.2.1.1 Prepare the FNC-T cell(s) to be replaced on page 77.

The date of manufacture of the FNC-T cells can be specified in 2 different ways:

- Production date until CW15/2024:

Note

The date of manufacture of the FNC rail cells is stamped on the top of each cell.

Each cell has a 9-digit cell code on the top of the cell cover. The last four digits provide information about the production week and the production year.

Example:

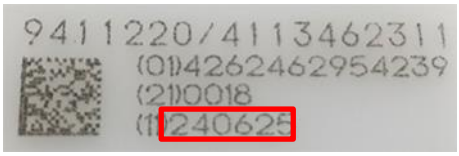
xxxxx2619 => Production week 26; production year 2019

- Production date from CW15/2024:

Note

The date of manufacture of the FNC-T cells is stamped on the top of each cell.

Each cell has a 6-digit cell code on the top of the cell cover. The 6 digits provide information about the production day, month and year, see the following graphic



Example:

240625 => Production year 24; production month 06, production day 25

10.2.1.1. Prepare the FNC-T cell(s) to be replaced

Target: The new replacement cells are prepared for operation in the vehicle.

Tools required:

- Suitable charging/discharging device
- Measuring glass tube
- Digital multimeter
- Degassing tube
- Torque spanner with suitable spanner sizes for M8/M10 screws
- Contact thermometer

1. Use a digital multimeter to measure the individual cell voltages of the replacement cells and note the values in a test report.

Note

If the open-circuit voltage of a cell is < 1.2 V, contact HOPPECKE Service.

2. Connect replacement cells in series with suitable connecting cables or cell connectors.

Note

Use a suitable cable to connect the cells:

- M8 or M10 cable lug
- M8: 20 Nm tightening torque / M10: 25 Nm tightening torque
- Use new spring washers.

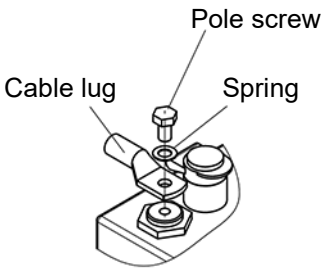
3. Place a degassing tube on each replacement cell (HOPPECKE material number: 4143180110).

4. Connect the series-connected replacement cells to a suitable charger/discharger.

Note

Use a suitable cable to connect the charger/discharger:

- M8 or M10 cable lug
- M8: 20 Nm tightening torque / M10: 25 Nm tightening torque
- Use new spring washers



5. Discharge replacement cells using the discharger with the nominal current I_5 until the voltage has dropped to 1.0 V per cell.

6. Allow load-free replacement cells to rest for at least 4 hours.
7. Measure the temperature of at least one of the replacement cells.
8. Charge replacement cells with the constant current I_5 for 7.5 hours.

Note

The battery must not exceed a temperature of 45 °C during charging.

If a temperature of 45 °C is reached, interrupt charging.

Make a note of the remaining loading time.

Do not continue charging until the cell temperature has dropped to 25 °C.

Complete the charging time of 7.5 hours after the battery has cooled down.

If the battery reaches a temperature of 45 °C again before the charging time of 7.5 hours is complete, interrupt charging again, etc.

9. Leave the replacement cells to rest for at least 4 hours, preferably overnight.
10. Disconnect the charger/discharger from the replacement cells
11. Remove the degassing tube.
12. Manually top up the distilled water in the replacement cells to the maximum level, see 10.1.3.1 Top up distilled water manually on page 58.
13. Replace the vent plug or water refill plug.
14. Thoroughly remove any dirt from the battery with a clean, damp cloth.
15. Measure the individual cell voltages with a digital multimeter and note the values in a test report.

Result: The replacement cells are now ready for operation in the vehicle.

10.2.1.2. Replace one or more FNC-T cell (n)

Target: The defective cells are replaced with new replacement cells.

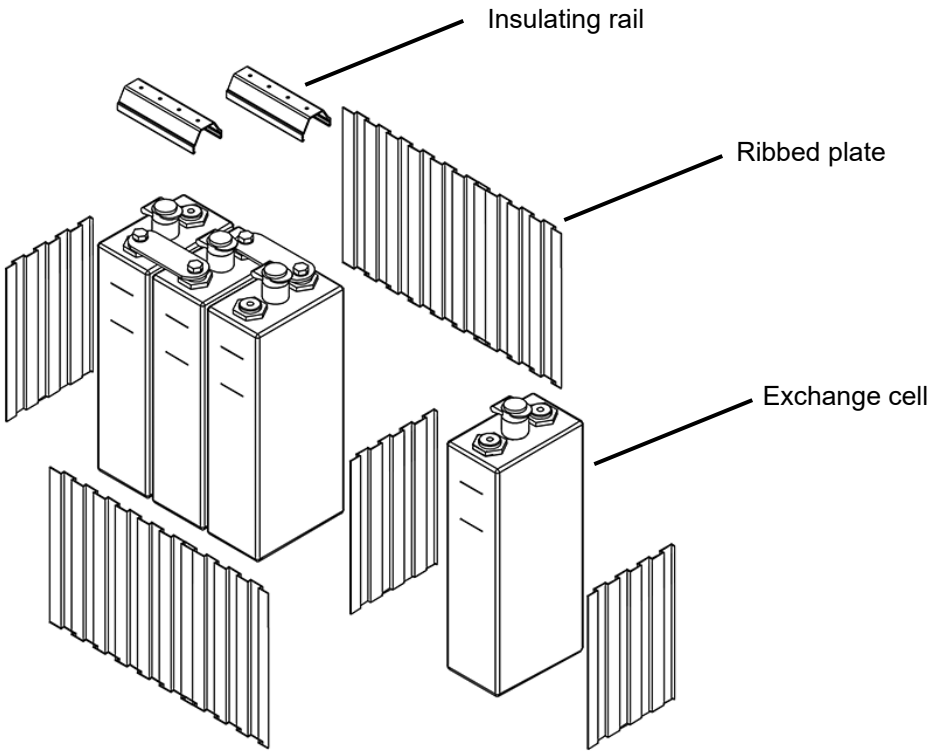
Tools required:
- Digital multimeter
- Cell lifter
- Torque spanner with suitable spanner sizes for M8/M10 screws

1. Disconnect chargers and loads from the battery system.
2. Open the battery container if available.
3. Remove the insulating rails.
4. If present, remove the tubing from the water refill system.
5. Remove the cell connector. (M8 or M10 screws)

Note

Use the Hoppecke cell lifter to lift the cell. (M8: HOPPECKE material number: 4141900002 / M10: HOPPECKE material number: 4141900003).

6. Remove the cell from the container / trough.
7. Remove the vent plugs or water refill plug from the cell to be replaced and fit it to the replacement cell.
8. Install replacement cell in container / trough.



Note

If the replacement cells are older than 3 months, carry out a preparation beforehand in accordance with 10.2.1.1 Prepare the FNC-T cell(s) to be replaced on page 77.

The date of manufacture of the FNC-T cells can be specified in 2 different ways:

- Production date until CW15/2024:

Note

The date of manufacture of the FNC rail cells is stamped on the top of each cell.

Each cell has a 9-digit cell code on the top of the cell cover. The last four digits provide information about the production week and the production year.

Example:

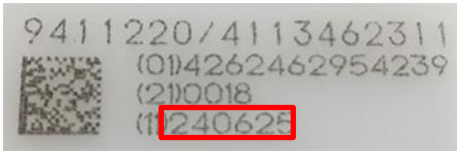
xxxxx2619 => Production week 26; production year 2019

- Production date from CW15/2024:

Note

The date of manufacture of the FNC-T cells is stamped on the top of each cell.

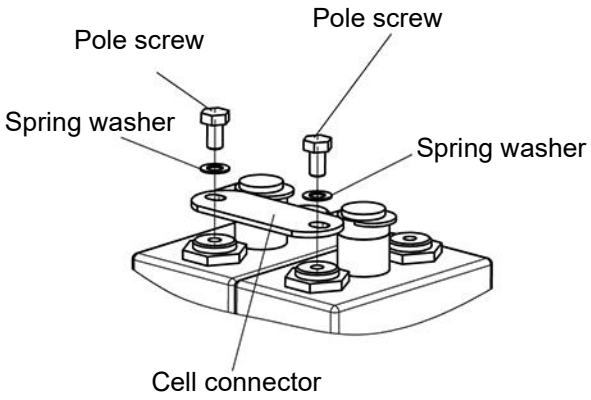
Each cell has a 6-digit cell code on the top of the cell cover. The 6 digits provide information about the production day, month and year, see the following graphic



Example:

240625 => Production year 24; production month 06, production day 25

9. Install cell connector.



Note

- M8 Torque: 20 Nm ± 3%
- M10 Torque: 25 Nm ± 3%
- Use new spring washers.

10. Attach the insulating rails.

11. Reinsert the vent plugs or water refill plug and install the pipework.

12. Check the total voltage of the battery.

Note

If the total voltage is below the number of cells x 1.2 V, contact HOPPECKE Service.

13. Document the exchange and number of cells.

Result: The defective cells have now been replaced with new replacement cells.

10.2.2. Replace cell connector

Target: A defective cell connector is replaced with a new cell connector.

DANGER!

When establishing access to the battery system, contact with sharp edges and/or live components may occur due to the design.

There is an imminent danger with a high risk that will result in death or serious injury if it is not avoided.

Measures to avert the danger:

- Be very careful when working on the batteries.
- Wear personal protective equipment, see 2.2 Personal protective equipment on page 17.

DANGER!

Loose connections on the pole screws can become very hot and cause ignition or explosions.

Only use each spring washer once.

- Initially tighten the pole screws by hand only.
- Align the batteries and connectors again if necessary.
- Then tighten the pole screws to the specified torque.

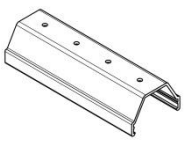
Prerequisite

- Switch off all consumers and chargers from the battery system before starting maintenance work.
- A battery always has a voltage at the terminals.
- A battery must not be earthed or short-circuited.
- Batteries/troughs are very heavy. Carry battery trays with a sufficient number of people or use suitable lifting gear and means of transport.

Tools required:

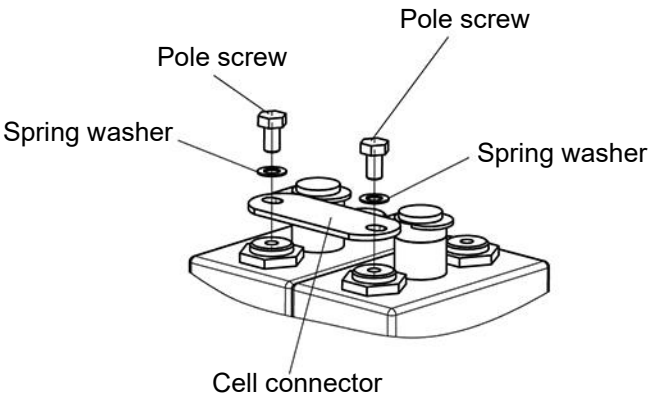
- Torque spanner with suitable spanner sizes for M8/M10 screws

1. If present, remove the water refill hose above the affected cell connector.
2. Remove the insulating bar of the affected cell connector.



3. Remove the pole screws.
4. Remove the defective cell connector.

5. Install new cell connectors.



Note

- M8 Torque: 20 Nm ± 3%
- M10 Torque: 25 Nm ± 3%
- Use new spring washers.

6. Install the insulating rail.

7. If available, fit the water refill hose .

Result: The defective cell connector has now been replaced with a new cell connector.

11. Error sources

Note

Observe the safety instructions, see 2 Safety instructions on page 12.

11.1. Capacity too low

If the battery capacity is too low, proceed as follows:

Possible cause	Remedy
Charging process too short	Check the charger in the vehicle, carry out reconditioning
Loosened or oxidised poles	Check all connections, replace connectors if necessary (the spring washers must be replaced)
Excessive cyclisation	Carry out reconditioning

11.2. Insulation resistance too low

When commissioning a new battery, the insulation resistance must be > 1 MΩ. It decreases with the operating time (due to aerosols from the batteries, condensation, dust) and must not fall below the following values depending on the nominal battery voltage:

Nominal battery voltage	Standard	Insulation resistance (minimum value)
Under 120 V	IEC 62485-3	50 Ω per volt of nominal voltage or not less than 1 kΩ per battery
Above 120 V, i.e. from 100 cells	IEC 62485-3	Number of cells x 1.2 V nominal voltage x 500 Ohm/V

If the value falls below this minimum value, any insulation monitor in the vehicle may respond, resulting in an undesirable increased discharge and loss of battery performance.

If the insulation resistance is too low, leakage currents can reduce the available capacity. This can also lead to different voltages between the cells. Regular cleaning prevents these leakage currents.

Possible cause	Remedy
Pollution	Cleaning
Leaking cells	Eliminate the cause of the leak, replace the cell if necessary
Leaking water refill system	Eliminate the cause of the leak, replace water refill plugs/hoses if necessary

11.3. No battery voltage

If you cannot measure any voltage at the battery, proceed as follows:

Possible cause	Remedy
Battery plug not plugged in	Insert battery plug
Battery plug defective	Replace battery plug
Cable break	Replace cable
Cell connector defective	Replace the cell connector (the spring washers must be replaced)

11.4. Malfunction of the water refill system

If malfunctions occur when topping up water, proceed as follows:

Impact	Cause	Remedy
Individual cells are not refilled	Dirt in the water refill plug	Clean the water refill plug with warm water or replace if necessary. Then check all cells manually and top up with deionised/distilled water manually to ensure an even level in all cells. Use the water topping-up system again at the next maintenance interval.
Water leaks during refilling	Connection between hose and water refill plug is defective	Check connection and replace water refill plug and/or hose if necessary
	O-rings on the water refilling plug are damaged or displaced	Replace O-rings
Cells are filled above the maximum level	Incorrect operation during the maintenance interval Note: Only carry out the water refill process once per maintenance interval. You will overfill the cells if you start the process many times in succession (comparable to the possible overfilling of a car tank)	-
	Hose kinked	Eliminate cause, replace hose if necessary
	The return line of the water refill trolley is not connected to the battery system	Connect the water refill trolley correctly.
	Cell(s) is (are) leaking	Eliminate cause, replace cell(s) if necessary
	O-rings on the water refilling plug are damaged or displaced	Replace O-rings

Note

If cells are filled above the maximum level, contact HOPPECKE Service.

12. Disassembly / assembly of FNC-T cells and accessories

12.1. Disassembly of FNC-T cells and accessories

DANGER!

Depending on the installation conditions, access or access to the battery system may result in death or serious injury caused by the vehicles or parts thereof or the battery system.

Carry out the prescribed safety measures that apply to the required installation work on the vehicles, see 2 Safety instructions on page 12.

DANGER!

- A battery always has a voltage at the terminals.
- Battery trays/troughs are very heavy.
- A battery must not be earthed or short-circuited. Carry the battery trays/troughs with a sufficient number of people or use suitable lifting equipment and transport devices.

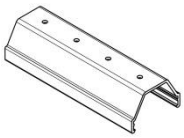
DANGER!

Only use fully insulated tools when working on batteries.

Note

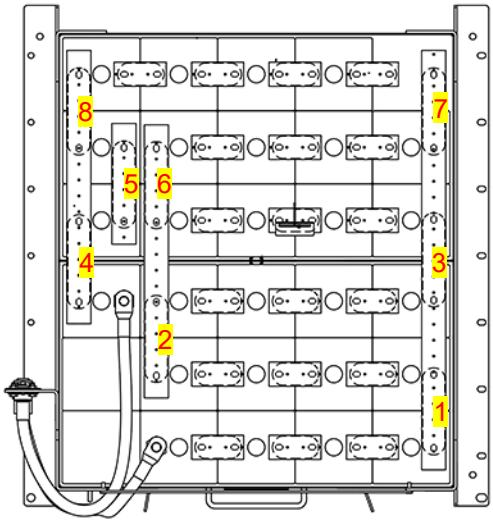
- The battery system must be made accessible and removed from the vehicle for the work. The deinstallation must be carried out specifically in the vehicle.
- The battery system must be removed from the vehicle by the vehicle manufacturer or operator.
- After dismantling, the battery system must be taken to a battery workshop for the work.

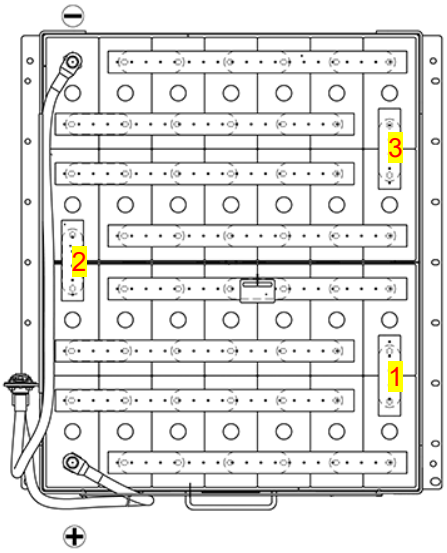
1. Disconnect all consumers from the battery system.
2. Switch off the main battery switch
3. Disconnect the electrical connection of the battery from the surrounding parts of the battery system (electrical parts in the E-Box or similar) and the vehicle at all poles. This must be carried out depending on the installation situation.
4. Disconnect the mechanical connection between the battery system and the vehicle and remove the battery system. Use a suitable lifting device (forklift, hoist) to lift the battery.
5. Place the battery on a secure surface in a battery workshop.
6. Remove the water refill system (plugs and hoses), if the battery is equipped with one, and clean it in warm water without adding cleaning agents.
7. Dismantle the insulating rails.



8. Loosen the pole screws of the main poles and lay the cables to one side.

9. First remove the connectors between the cell rows in the order shown in the following example illustrations.





Note

The illustration above is an example. The project-specific drawings must be used when working on the battery.

10. Then remove the connectors between the cells in the rows.

Note

Observe the following sequence when removing the connectors:

- Loosen the terminal screws on the cell, but leave the last few turns in. Do not remove the terminal screws in this first step.
- Unscrew the terminal screws by hand the last few turns and set them aside for reuse.
- Lift out the connectors by hand and set them aside for reuse.

DANGER!

- A battery always has a voltage at the terminals.
- Battery trays/troughs are very heavy.
- A battery must not be earthed or short-circuited. Carry the battery trays/troughs with a sufficient number of people or use suitable lifting equipment and transport devices.

11. Lift out the cells one by one.

Note

Use the Hoppecke cell lifter to lift the cell. (M8: HOPPECKE material number: 4141900002 / M10: HOPPECKE material number: 4141900003).

12. If present, lift out the spacer material (ribbed plates) and clean it in warm water without the addition of cleaning agents.

13. Prepare the trough or container for reuse by cleaning it in a suitable washing area as follows:

For low electrolyte contamination:

- Protect additional electrical components from liquids with a plastic bag.
- Clean the trough under running water.
- Wash out any soiling with a clean, damp cloth without the addition of cleaning agents.
- Dry the trough with compressed air.

For heavy soiling due to electrolyte:

- Protect additional electrical components from liquids with a plastic bag.
- Clean the trough with diluted citric acid (5%).
- Clean the trough under running water.
- Wash out any soiling with a clean, damp cloth without the addition of cleaning agents.
- Dry the trough with compressed air.

12.2. Installation of new FNC-T cells and accessories

DANGER!

Depending on the installation conditions, access or access to the battery system may result in death or serious injury caused by the vehicles or parts thereof or the battery system.

Carry out the prescribed safety measures that apply to the required installation work on the vehicles, see 2 Safety instructions on page .12

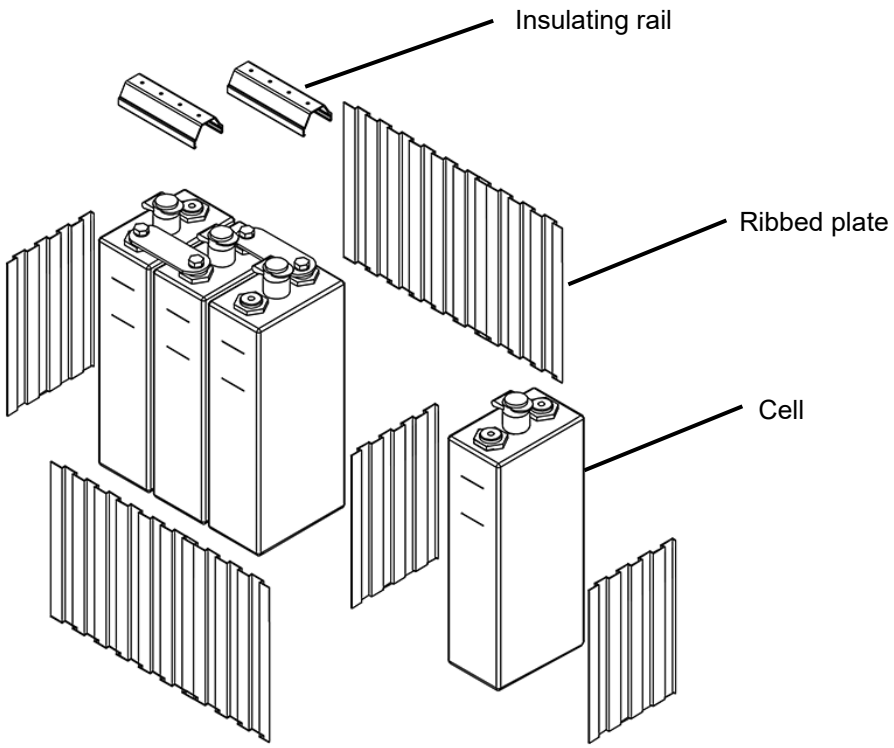
DANGER!

- A battery always has a voltage at the terminals.
- Battery trays/troughs are very heavy.
- A battery must not be earthed or short-circuited. Carry the battery trays/troughs with a sufficient number of people or use suitable lifting equipment and transport devices.

Note

The cells are supplied sealed with yellow transport plugs. Leave the yellow transport plugs on the cells during the installation process until the vent plugs or water refill plugs have been installed.

1. Install the new cells according to the technical drawing. Use the ribbed plates, if present, to separate the cells from each other and from the trough, see the following illustration. Information on the thickness of the ribbed plates can be found in the drawings and parts lists.



Note

The illustration above shows an installation example with ribbed panels.

Note

Use the Hoppecke cell lifter to lift the cell. (M8: HOPPECKE material number: 4141900002 / M10: HOPPECKE material number: 4141900003).

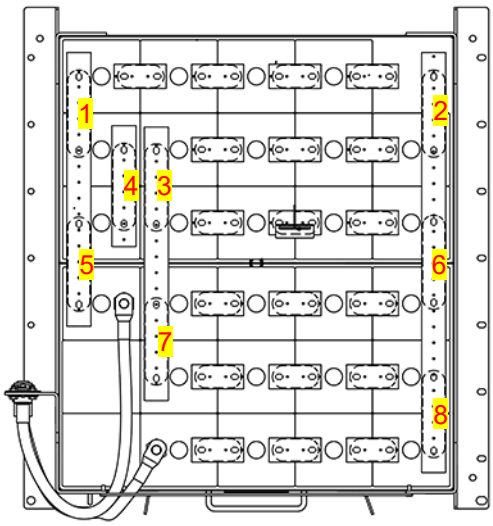
Note

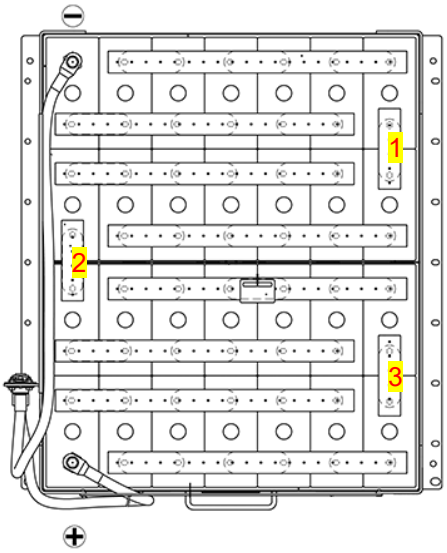
To achieve a "press fit" installation of the cells in the trough, follow the installation sequence as described in the following photos (example from a project):

Start at the main positive terminal and align the cells on the outer wall of the tray according to the technical drawing. For single-row battery trays, the centre cells should also be installed in the last position.

Continue with the next row towards the centre of the trough and so on until all the cells have been placed:

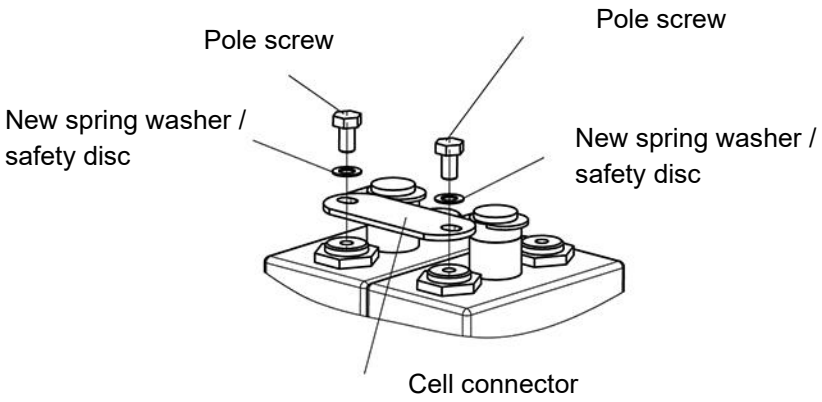
2. Fit the cell connectors according to the technical drawing. Use new spring washers. First fit the connectors in the cell rows, then the connectors between the cell rows in reverse order to uninstall, see the following example illustrations:





Note

The illustration above is an example. The project-specific drawings must be used when working on the battery.



Note

Observe the following sequence when reinstalling the cell connectors:

- Place the cell connector in the desired position.
- Screw in the pole screws the first few turns by hand on both sides of the cell connector.
- Align the cells again.
- Tighten the pole screws with a torque spanner.

DANGER!

- A battery always has a voltage at the terminals.
- Always install the connectors very carefully so that they do not short-circuit the cell or neighbouring cells.
- When attaching the first screw of a connector, always hold the connector in the intended direction. This prevents short circuits caused by twisting the connector.

Note

- M8 Torque: 20 Nm ± 3%
- M10 Torque: 25 Nm ± 3%
- Use new spring washers

3. Reinstall the insulating rails.

4. If present, dry the water refill system (plugs and hoses) with compressed air.
5. Install the water refill system, if present (plugs and hoses), or the vent plugs according to the technical drawing.
6. Reconnect the main cables by refitting the pole screws of the main poles
7. Check the function of the battery according to the test specification in the separate document: PVE 10-20-General-00_Battery_Tray_rev000.pdf

8. Re-install the battery in the vehicle and re-establish the mechanical connection. Use a suitable lifting device (forklift, hoist) to lift the battery.
9. Reconnect the electrical connection of the battery to the surrounding parts of the battery system (electrical parts in the E-Box or similar) and to the vehicle at all poles. This must be carried out depending on the specific installation situation.

Note

The reinstallation of the battery system in the vehicle must be carried out by the vehicle manufacturer or operator.

10. Switch on the main battery switch.
11. Connect the loads to the battery system.

13. Disposal

Note

Observe the safety instructions, see 2 Safety instructions on page 12.

Note

Used batteries with this symbol are recyclable economic goods and must be returned to the recycling process.

Use the HOPPECKE recycling system. Used batteries are collected and recycled. Contact HOPPECKE Service for further information.

Note

Dispose of nickel-cadmium batteries that are not recycled as hazardous waste in compliance with all regulations.

Due to the cadmium and potassium hydroxide content, FNC-T cells must never be disposed of with household waste or deposited in a landfill at the end of their service life.

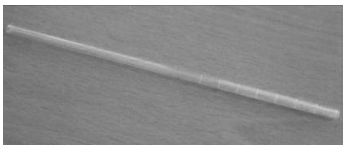
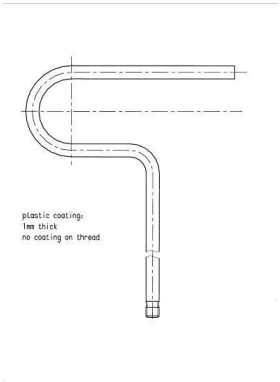
Observe the country-specific rules and regulations for disposal separately.

14. Appendix

14.1. Additional tools

Additional tools for maintenance and service are listed below:

Tool	Description of the
	Voltmeter/multimeter (Picture shows an example)
	Current clamp DC (Picture shows an example)
	Contact thermometer (Picture shows an example)
	Insulation tester: Fluke 1507 HOPPECKE material number: 4141201237
	Charger/discharger (Picture shows an example)

 	Water refill trolley for centralised low-pressure water refill systems: HOPPECKE material number: 4147000230 230 V HOPPECKE material number: 4147000235 115 V
	Water refill trolley for single cells for formats 1-5: HOPPECKE material number: 4147000210 230 V HOPPECKE material number: 4147000215 115 V
	Water refill trolley for special cells with adjustable gun HOPPECKE material number: 4147000220 230V HOPPECKE material number: 4147000225 115V
	Measuring glass tube HOPPECKE material number: 4144140010
	Degassing tube HOPPECKE material number: 4143180110
	Cell lifter Format 3, 4, 5 M10: HOPPECKE material number: 4141900003 Format 1, 2 M8: HOPPECKE material number: 4141900002
	Fully insulated torque spanner HOPPECKE material number: 4142500121
	Caustic density meter (Picture shows an example)

14.2. Commissioning protocol

Serial number of the battery system: _____

Vehicle number: _____

Date of commissioning: _____

Auditor (signature): _____

Note

Measure the temperature of the battery, e.g. with a contact thermometer.

The cell to be measured should be installed in the centre of the battery in order to detect the warmest point of the system.

The battery must not exceed a temperature of 45 °C during charging.

If a temperature of 45 °C is reached, interrupt charging.

Make a note of the remaining loading time.

Do not continue charging until the cell temperature has dropped to 25 °C.

Complete the charging time of 7.5 hours after the battery has cooled down.

If the battery reaches a temperature of 45 °C again before the charging time of 7.5 hours is complete, interrupt charging again, etc.

The following applies to the table headings:

- 1*: Open-circuit voltage before charging
  Note: If the open-circuit voltage of a cell is < 1.2 V, contact HOPPECKE Service.
- 2*: Open circuit voltage after charging
- 3*: Deviation of the individual cell voltage from the average individual cell voltage (sum of all cell voltages divided by the number of cells)
  Note: If the voltages of the individual cells deviate more than ± 50 mV from the average value of all cell voltages, please contact HOPPECKE Service.

Cell no.	1* [V]	2* [V]	3* [mV]	Cell no.	1* [V]	2* [V]	3* [mV]	Cell no.	1* [V]	2* [V]	3* [mV]
1				28				55			
2				29				56			
3				30				57			
4				31				58			
5				32				59			
6				33				60			
7				34				61			
8				35				62			
9				36				63			
10				37				64			
11				38				65			
12				39				66			
13				40				67			
14				41				68			
15				42				69			
16				43				70			
17				44				71			
18				45				72			
19				46				73			
20				47				74			
21				48				75			
22				49				76			
23				50				77			
24				51				78			
25				52				79			
26				53				80			
27				54				*1)			

*1) Expand this table if the battery system consists of more than 80 cells.

14.3. Maintenance log

Note

Enter the activities and the measured values in the maintenance log as proof in the event of a warranty cltarget.

Serial number of the battery system: _____

Vehicle number: _____

Date of commissioning: _____

14.3.1. Half-yearly maintenance interval

14.3.1.1. Maintenance - visual inspection of the entire battery system

Interval	Visual inspection - Done (tick the appropriate box)	date	Auditor (name)
0,5			
1			
1,5			
2			
2,5			
3			
3,5			
4			
4,5			
5			
5,5			
6			
6,5			
7			
7,5			
8			
8,5			
9			
9,5			
10			
10,5			
11			
11,5			
12			
12,5			
13			
13,5			
14			
14,5			

14.3.2. Half yearly or after each equalising charge

14.3.2.1. Maintenance - Check electrolyte level

Interval	Electrolyte level checked - Done (tick)	date	Auditor (name)
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			

14.3.2.2. Maintenance - Measuring the charging voltage

Interval	Voltage [V]	Current [A]	Temperature [°C]	date	Auditor (name)
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					
Half yearly or after each equalising charge					

14.3.2.3. Maintenance - topping up the electrolyte level

Interval	Refill electrolyte level - Done (tick the appropriate box)	date	Auditor (name)
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			

14.3.2.4. Maintenance - Cleaning

Interval	Cleaning - Done (tick the appropriate box)	date	Auditor (name)
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			

14.3.2.5. Maintenance - Measuring the insulation resistance

Interval	Insulation resistance [Ω]	date	Auditor (name)
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			
Half yearly or after each equalising charge			

14.3.3. Project-dependent

14.3.3.1. Maintenance - Equalising charge

Interval	Done (tick the appropriate box)	date	Auditor (name)
project-dependent			
project-dependent			
project-dependent			
project-dependent			
project-dependent			
project-dependent			
project-dependent			
project-dependent			

14.3.3.2. Maintenance - Reconditioning

Interval	Done (tick the appropriate box)	date	Auditor (name)
project-dependent			
project-dependent			
project-dependent			
project-dependent			
project-dependent			
project-dependent			
project-dependent			
project-dependent			

14.3.3.3. Maintenance - Measuring the voltage of individual FNC-T cells

Interval: project-dependent

The following applies to the table headings:

- 1*: Open-circuit voltage before charging
  Note: If the open-circuit voltage of a cell is < 1.2 V, contact HOPPECKE Service.
- 2*: Open circuit voltage after charging
- 3*: Deviation of the individual cell voltage from the average individual cell voltage (sum of all cell voltages divided by the number of cells)
  Note: If the voltages of the individual cells deviate more than ± 50 mV from the average value of all cell voltages, please contact HOPPECKE Service.

Cell no.	1* [V]	2* [V]	3* [mV]	Cell no.	1* [V]	2* [V]	3* [mV]	Cell no.	1* [V]	2* [V]	3* [mV]
1				28				55			
2				29				56			
3				30				57			
4				31				58			
5				32				59			
6				33				60			
7				34				61			
8				35				62			
9				36				63			
10				37				64			
11				38				65			
12				39				66			
13				40				67			
14				41				68			
15				42				69			
16				43				70			
17				44				71			
18				45				72			
19				46				73			
20				47				74			
21				48				75			
22				49				76			
23				50				77			
24				51				78			
25				52				79			
26				53				80			
27				54				*1)			

*1) Expand this table if the battery system consists of more than 80 cells.

Date: _____ Reviewer: _____

Interval: project-dependent

The following applies to the table headings:

- 1*: Open-circuit voltage before charging
  Note: If the open-circuit voltage of a cell is < 1.2 V, contact HOPPECKE Service.
- 2*: Open circuit voltage after charging
- 3*: Deviation of the individual cell voltage from the average individual cell voltage (sum of all cell voltages divided by the number of cells)
  Note: If the voltages of the individual cells deviate more than ± 50 mV from the average value of all cell voltages, please contact HOPPECKE Service.

Cell no.	1* [V]	2* [V]	3* [mV]	Cell no.	1* [V]	2* [V]	3* [mV]	Cell no.	1* [V]	2* [V]	3* [mV]
1				28				55			
2				29				56			
3				30				57			
4				31				58			
5				32				59			
6				33				60			
7				34				61			
8				35				62			
9				36				63			
10				37				64			
11				38				65			
12				39				66			
13				40				67			
14				41				68			
15				42				69			
16				43				70			
17				44				71			
18				45				72			
19				46				73			
20				47				74			
21				48				75			
22				49				76			
23				50				77			
24				51				78			
25				52				79			
26				53				80			
27				54				*1)			

*1) Expand this table if the battery system consists of more than 80 cells.

Date: _____ Reviewer: _____