



TECHNICAL MANUAL

Industrial Ni-Cd Batteries Standard Range

Made in Germany

*...the opportunity
to have the choice*





Preface

The GAZ® Ni-Cd battery consisting of pocket plate electrodes is one of the most reliable systems that can be found in the market, and often the only reasonable choice if a battery operating under extreme environmental conditions is requested. No other system is able to provide more favourable features than GAZ® Ni-Cd pocket plate batteries such as:

- very high power rating
- low internal resistance
- reduced loss of capacity at deep temperature
- no ice formation at temperatures below 0°C
- long lifetime at high temperatures
- insensitive against deep discharge
- long shelf life
- no electrolyte stratification
- insensitive against misuse and optimised for harsh operating conditions.

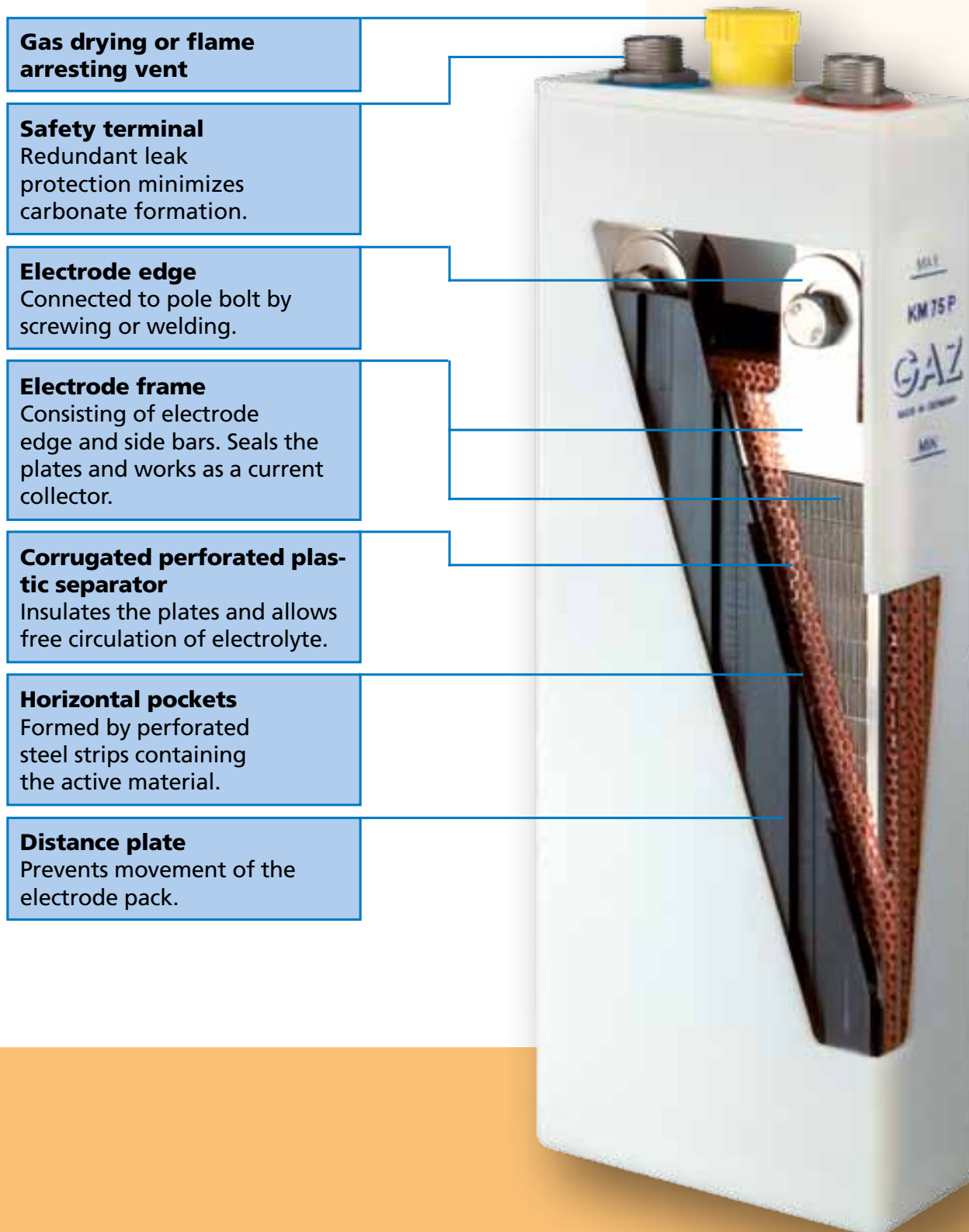
Based on more than 100 years of experience in the design, manufacturing and continuously improving and further developments in techniques GAZ® Ni-Cd batteries made in Germany will provide maximum performance and security independent of the main electrical supply. Our company prides itself on the high standards of quality for which it is known and is able to count well known companies all over the world as its customers.

This manual will answer most of the main technical questions regarding our standard pocket plate batteries.

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1. Design of a GAZ® Ni-Cd pocket plate cell



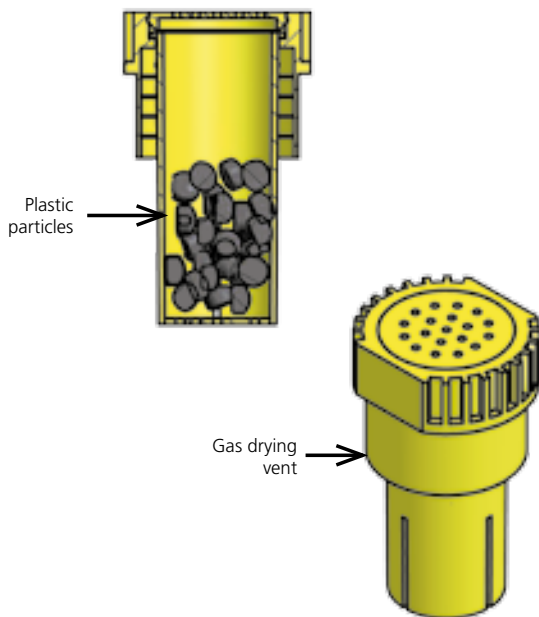
1.1 GAZ® Venting System

GAZ® batteries can be equipped with a normal flip-top vent or optionally with a special gas drying as well as a flame arresting vent.

Mode of action of GAZ® gas drying or flame arresting vent

The originated charging gases (hydrogen and oxygen), which occur during the charging process of Ni-Cd batteries, carry also small electrolyte drops of the electrolyte solution (aerosol). This leads to a quicker decline of the electrolyte level in comparison to the normal water decomposition during the overcharging and, thus, results in short maintenance intervals. Furthermore, a strong incrustation of the filling vents can be the result due to the creation of carbonate.

By using the GAZ® gas drying or flame arresting vents, this occurrence can be avoided. These vents containing small plastic particles on the large surface of which the electrolyte drops comprised are in the gas escaping from the cell are condensing to the greatest possible extent and, therefore, remain within the cells.

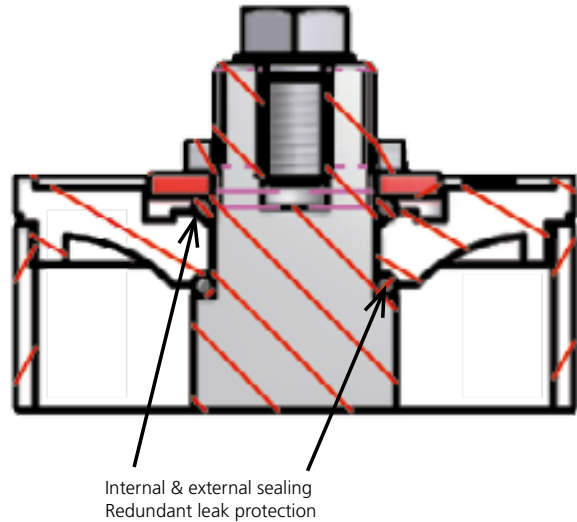


The additional feature of the GAZ® flame-arresting vent is the microporous disc on the top which results in a diffused leakage of the charging gases. Moreover, high local concentrations can be prevented which finally leads to a lower risk of flammability.

According to IEC 60623 the total amount of entrained potassium hydroxide shall be not more than 0.05 mg/ Ah during 2 hours overcharge. GAZ® batteries with the special venting system improve the required value many times over to 0.011 mg/ Ah during 2 hours overcharge.

1.2 GAZ® Safety Terminal

Use of the especially developed terminal design with redundant leak protection prevents any leakage of electrolyte. Depending on the cell range and type terminals are designed as female or male thread and polarity is colored marked.



1.3 Electrode frame

The electrode frame of GAZ® Ni-Cd batteries consists of a right and a left side bar as well as the electrode edge, which are connected by welding shaping the electrode frame.

The electrode frame operates as a current collector and also seals the electrode plates. This procedure leads to an electrode design with high mechanical robustness but also ensures a reliable service for the complete lifetime of the battery.

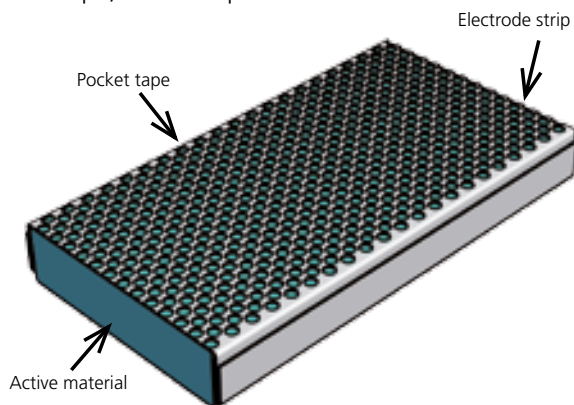
1.4 Separators

The separation of the electrodes is ensured by a corrugated perforated plastic (M- and L-types) or plastic grid separator (H-types). The plastic grid separator is used for high discharge types (H-types) in order to achieve a superior cell performance caused by a lower internal resistance, which is very typical and necessary for their high discharge currents.

The separator also ensures a large space between the electrodes, which allows free circulation of the electrolyte and a good dissipation of the gases generated during end of charging.

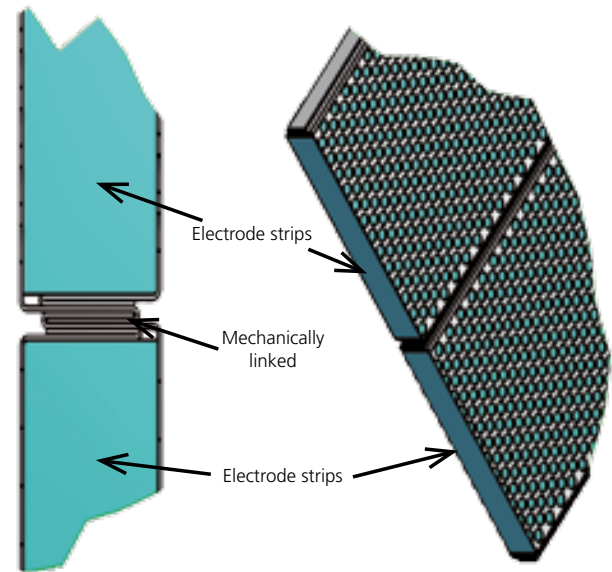
1.5 Positive and negative electrode plate

The nickel-cadmium cell is composed of the positive plates containing nickel hydroxide and the negative plates containing cadmium hydroxide. The pockets formed from a nickel plated and perforated steel tape, the so-called pocket tape, infold strips of the active material.



The so originated electrode strips are mechanically linked together forming the electrode plate and are consecutively cut to size of the appropriate plate width based on the cell type and range.

The plates then are welded or mechanically linked to the plate frame (see point 3) forming the electrodes – the heart of the battery – and assembled to the plate block.



The basis for the extremely long useful lifetime and the very good cycle life features of the GAZ® Ni-Cd pocket plate batteries are the special plate designs whose structural components are made of steel.

This prevents the possibility of gradual deterioration by corrosion and since the alkaline electrolyte does not react with steel the substructure of the battery remains intact for the total lifetime of the battery. Very important and unique is the enfolding of the electrochemical active masses in the perforated nickel plated steel pockets, so that the risk of shedding or penetration of material is very small and consequently also the risk of structural damages and of soft short circuits is well under control.

1.6 Distance plate

The distance plate operates as an additional stabilization to prevent any movement of the electrodes. It is an additional feature for applications where vibrations are possible.

1.7 Cell cases

The cell cases are made from a translucent polypropylene or polystyrene, which ensures a visual control of the electrolyte level. The exceptional sturdy GAZ® cell cases provide a satisfactory service for the total lifetime of the battery but also will have a superior finish at every stage. The lid and the container are welded or glued together forming an integrative compound.

All GAZ® Ni-Cd cells have a single cell design that prevents in the greatest possible extent any leakage of the cell cases since they are made by injection molding out of one piece. Therefore, the weld or glues seams of the cell cases and the lids lies over the electrolyte level. The GAZ® single cell design eliminates completely the risk of faulty welded seams on the sides and on the bottom of the cell cases. Caused by the single cell design an economical replacement of faulty cells is possible, where only the faulty cell can be replaced.

A special flame retardent material (acc. to standard UL 94 V0) is also available, which admittedly brings along some impaired properties. By using this material a visual check of the electrolyte is no longer possible.

1.8 Electrolyte

The electrolyte used in GAZ® Ni-Cd batteries is a solution of potassium hydroxide and lithium hydroxide that is optimized to give the best combination of performance, energy efficiency and a wide temperature range of use.

The concentration of the standard electrolyte allows operations between – 30°C and + 50°C. For special operations within very low temperatures a special high density electrolyte can be used.

It is an important property of the GAZ® battery, and indeed of all nickel-cadmium batteries, that the electrolyte does not change during charge and discharge. It retains its ability to transfer ions between the cell plates, irrespective of the charge level.

In most applications the electrolyte will retain its effectiveness for the life of the battery and will never need replacing. However, under certain conditions, such as extended use in high temperature situations, the electrolyte can become carbonated.

If this occurs the battery performance can be improved by replacing the electrolyte (see „Maintenance and Handling Instructions“).



400 KV INTERCONNECTION OF ABU DHABI ISLAND
400/132/11kV GRID STATIONS E48 AND E19

2. Battery range and applications

2.1 Battery ranges

In order to enable GAZ® batteries to offer an appropriate solution in accordance with the customer's requirements and to have a choice for any battery application existing on the market, GAZ® Ni-Cd batteries are designed in four different performance ranges.

KL ...P

This GAZ® cell type has been especially designed for low rates of discharge over long periods, where the current is relatively low in comparison with the total stored energy. The discharges can generally be infrequent and the recommended discharge time for the KL ...P range is 1 hour to 100 hours.

KM ...P

TP

The GAZ® M-type battery has been especially designed for "mixed loads" that include a mixture of high and

low rates of discharge. It is used for frequent and infrequent discharges and the recommended discharge time is 30 min to 120 min.

KM ...P/N NON-STOP

This GAZ® cell type is a further developed M-type, which because of a special perforation higher discharge currents for special applications up to 1 hour. It is especially used for UPS and similar applications and the recommended discharge time is 10 min to 60 min.

KH ...P

TSP

The GAZ® H-type battery was designed for high current discharging over short discharge periods. The recommended discharge time for this cell range is 1 s to 30 min.

Cell type	L Low rate of discharge	M Medium rate of discharge	M/N Medium rate of discharge	H High rate of discharge
	KL ...P KL ...	KM ...P KM ... TP ... T ...	KM ...P/N	KH ...P KH ... TSP ... TS ...
Intercity and urban transport	X	X	X	X
Substations & signalling	X	X	X	X
UPS	X	X	X	X
Offshore & onshore oil & petrochemical refineries	X	X	X	X
Emergency lighting	X			
Telecommunication	X	X		
Photovoltaic	X			
Diesel start				X
Ship equipment	X	X	X	X
Electricity, gas & water production & distribution	X	X	X	X
Emergency supply	X	X		X
Alarm equipment	X			

2.2 Applications and choice of cell type

GAZ® Ni-Cd batteries cover a wide range of applications and are used in almost every sector, no matter if it is a private, industrial, commercial, governmental or military one. The table on page 8 on which some examples can be found represents only a small overview in the extended field of applications. Therefore, it is to be understood as general information.

3. Electrochemistry of Ni-Cd batteries

Oxidation of cadmium at the negative electrode



Reduction of trivalent nickel ions to bivalent at the positive electrode



During charging the both reactions are reversed.

The complete reaction is:

negative electrode



positive electrode



cell reaction



4. Operating features

4.1 Capacity

The capacity of nickel-cadmium batteries is rated in ampere-hours (Ah) and is the quantity of electricity at +20°C (± 5°C) which can supply for a 5 hour discharge after being fully charged for 7.5 hours at 0.2 C₅. These figures and procedures are based on the IEC 60623 standard.

According to IEC 60623, 0.2 C₅A is also expressed as 0.2 I_t A. The reference test current I_t is expressed as:

$$I_t = \frac{C_n \text{ Ah}}{1 \text{ h}}$$

C_n is the rated capacity declared by the manufacturer in ampere-hours (Ah)

n is the time based in hours (h) for which the rated capacity is declared

4.2 Cell voltage

The cell voltage of a Ni-Cd cell is the result of the electrochemical potentials of the nickel and the cadmium active materials in cooperation of the potassium hydroxide electrolyte. Therefore, the nominal voltage for this electrochemical couple is 1.2 V. From the electrochemistry of the reaction given above (see point 3), the free voltage of 1.3 V is given for the Ni-Cd cell. This voltage is also observed directly after charging of the cell.

4.3 Internal resistance

The internal resistance of a Ni-Cd cell is very difficult to measure and to define since it varies with different temperature and state of discharge. The internal resistance also depends on the cell type and size as it increases for lower state of charge. Apart from this the internal resistance of a fully discharged cell carries no weight. Reducing the temperature also increases the internal resistance. The correct values regarding the special conditions can be provided by our technical staff.

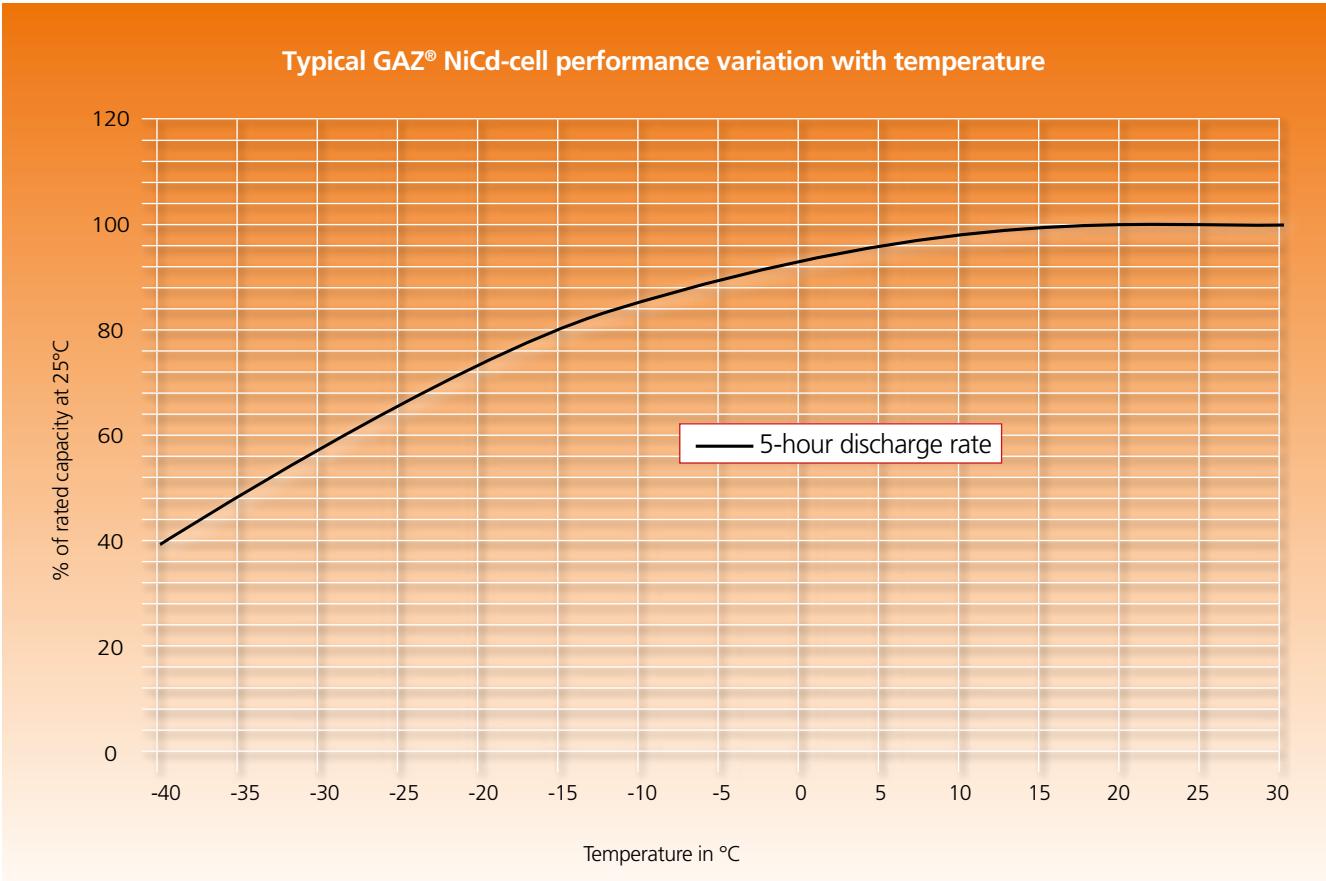
4.4 Impact of temperature on cell performance and available capacity

When sizing and choosing a battery the variations in ambient temperature and their influence on the cell performance have to be taken into consideration.

Low ambient temperature conditions reduce the cell performance, but on the other hand operations with

higher temperatures are similar to those at normal temperatures. The effect of low temperatures is increasing with higher rates of discharge.

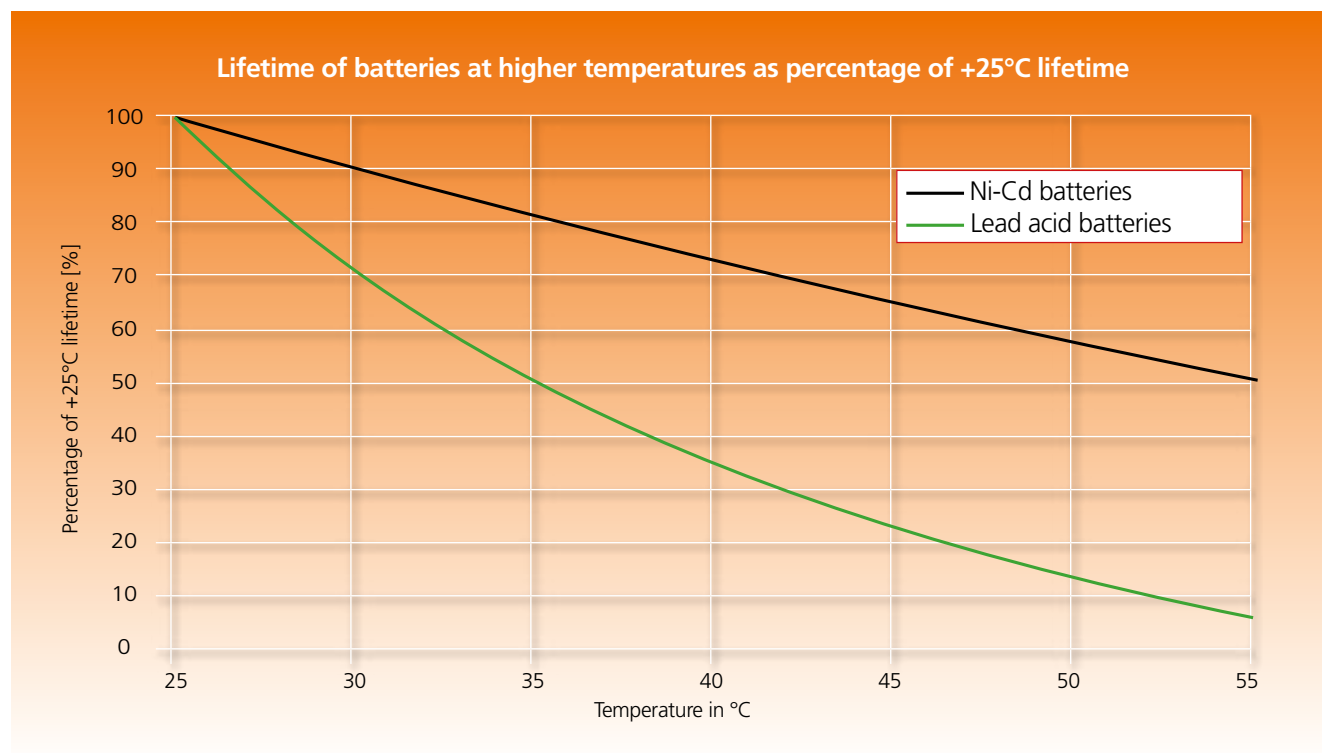
The values, which have to be taken into account, can be found in the following graph.



4.5 Impact of temperature on lifetime

As with every battery system an increased temperature always reduces the expected service lifetime and although the GAZ® Ni-Cd battery is designed to reach a lifetime of over 20 years this is also the case. The following graph is included to demonstrate that the reduction in lifetime of a GAZ® Ni-Cd battery

is many times lower than for a lead acid battery. For Ni-Cd batteries the normal operating temperature is based at + 20°C ($\pm 5^\circ\text{C}$) and, therefore, special considerations have to be taken into account when dimensioning a Ni-Cd battery for high temperature applications.



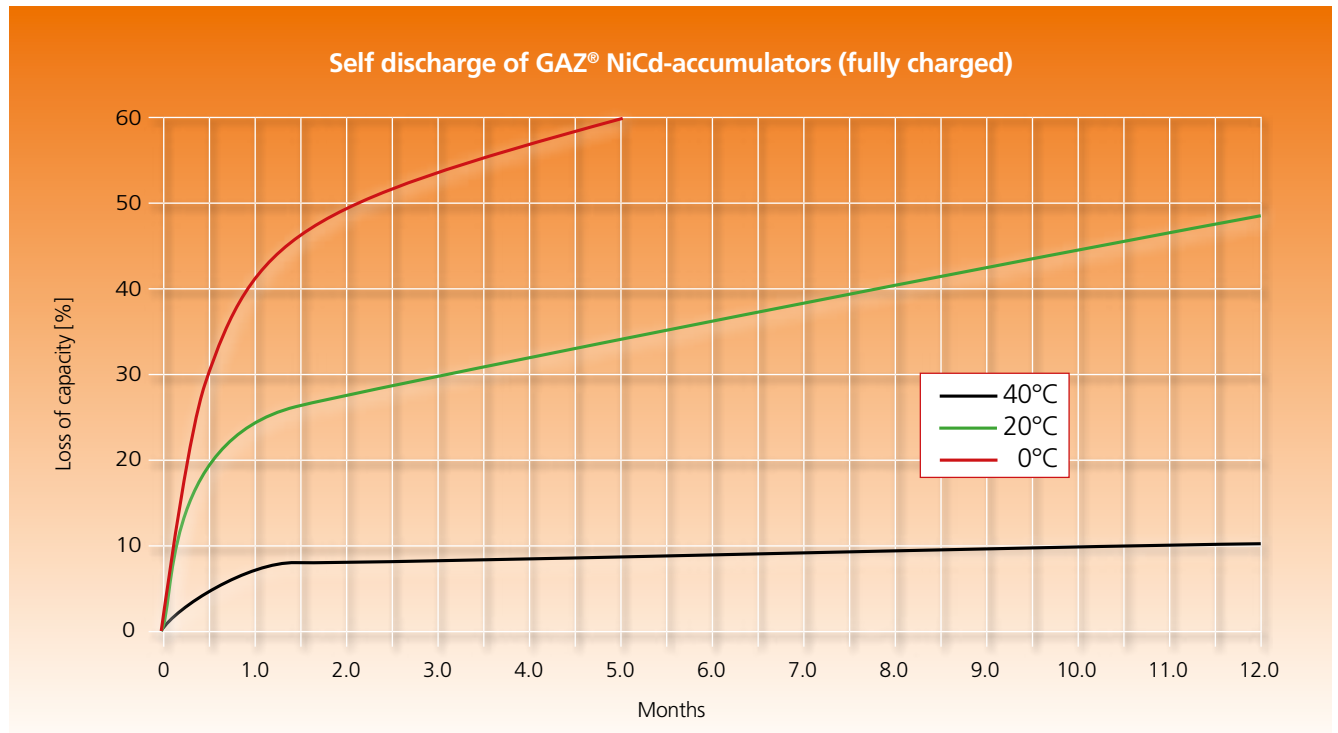
4.6 Short-circuit values

The short-circuit values of a GAZ® Ni-Cd pocket plate battery depend on and vary from cell range to cell range. The special values can be provided by our technical staff on request.

4.7 Open circuit loss

The state of charge of a cell on open circuit slowly decreases due to its self-discharge. This decrease is quite rapid during the first two weeks and then stabilizes at about 2% per month at + 20°C. In general the self-

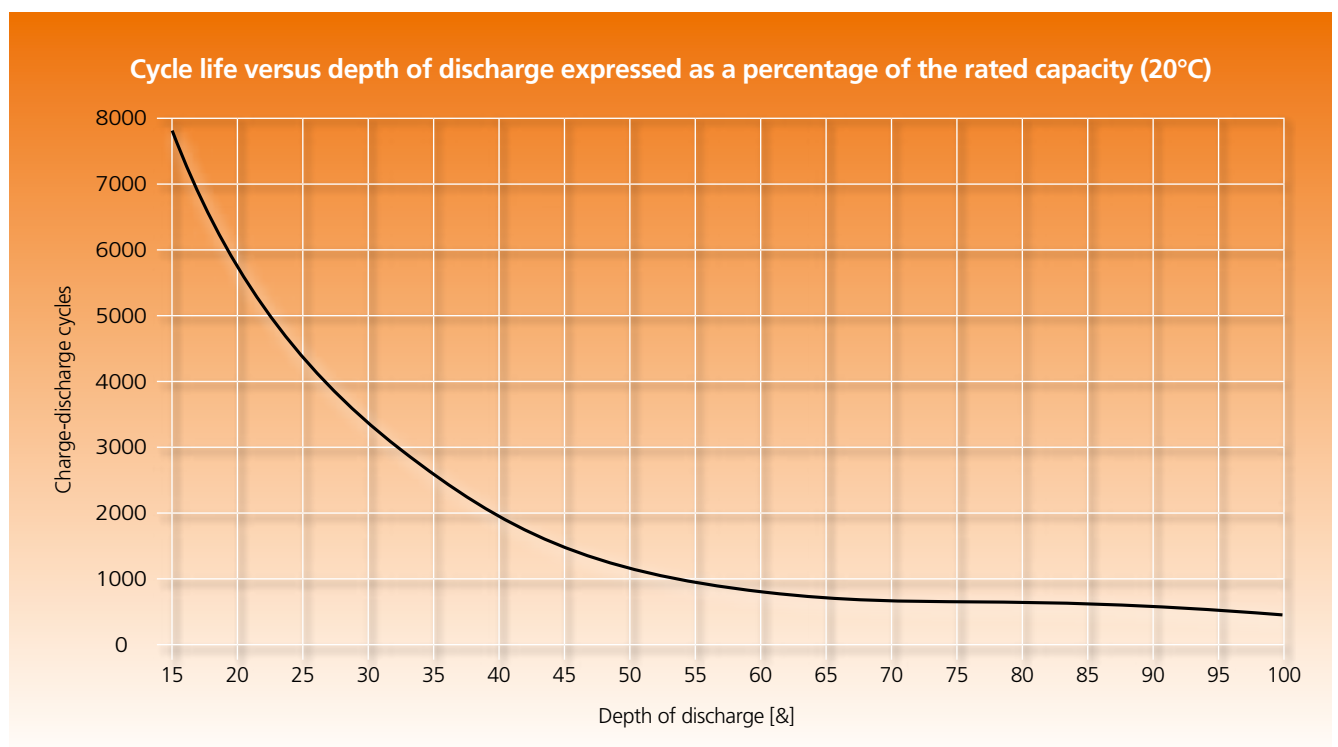
discharge of a GAZ® Ni-Cd battery is affected by various temperatures. The open circuit loss is reduced at low temperatures, while the self-discharge is significantly increased at higher temperatures.



4.8 Cycling

The GAZ® Ni-Cd battery is designed to obtain a huge number of cycles in stationary standby operations. The important fact and basis for the number of cycles the battery is able to provide is the depth of discharge. The less deeply a battery is discharged the

greater the number of cycles it is capable to provide before being unable to achieve the minimum design limit. On the graph below typical values for the effect of depth of discharge on the available cycle life can be found.



4.9 Water consumption and gas evolution

At the final stage of the charging procedure of a GAZ® Ni-Cd battery the provided electrical energy cannot be fully absorbed but is absolutely necessary to reach the fully charged state of the cells. The difference between absorbed and provided energy leads to a break down of the electrolyte's water content into oxygen and hydrogen (electrolysis). This loss has to be compensated by topping up the cells with pure distilled water.

The water loss depends on the current used for overcharging. A battery on stand by operation will consume less water than a battery that is cycled constantly, i.e. which is charged and discharged on a regular basis.

In theory, the quantity of water used can be found by Faraday's equation that each ampere hour of overcharge breaks down 0.336 cm³ of water.

However, in practice, the water usage will be less than this, as the overcharge current is also needed to counteract self-discharge of the electrodes.

The overcharge current is a function of both voltage and temperature, so both have an influence on the consumption of water. The table below gives typical water consumption values over a range of voltages.

Example:

A cell KM 110 P is floated at 1.41 V/cell

The electrolyte reserve for this cell is approx. 400 cm³

From the table below a GAZ® cell at 1.41 V per cell

will use 0.25 cm³/month for 1 Ah of capacity

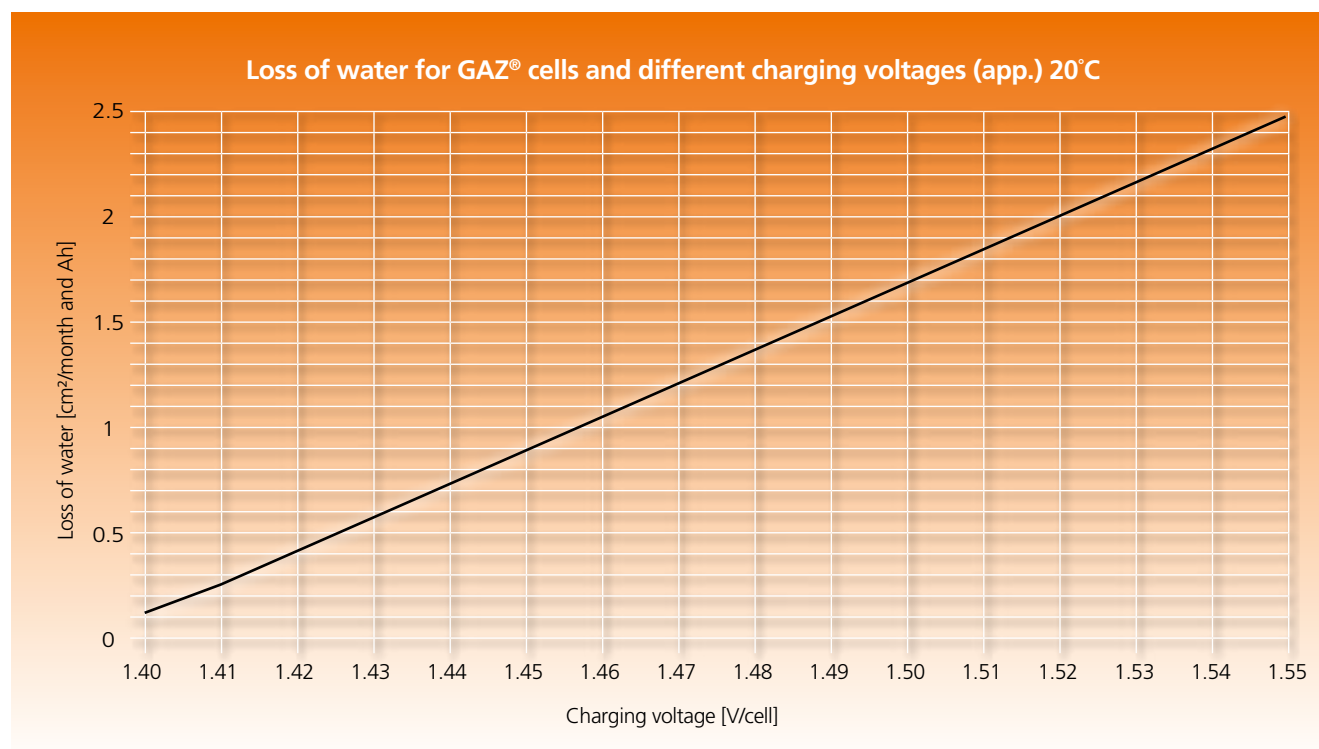
That means a KM 110 P will use

$0.25 \text{ cm}^3/\text{month} \times 110 \text{ Ah} = 27.5 \text{ cm}^3/\text{month}$

and the electrolyte reserve will be used in

$400 \text{ cm}^3 / 27.5 \text{ cm}^3/\text{month} = 14.5 \text{ months}$

The gas evolution is a function of the amount of water electrolyzed into hydrogen and oxygen and is predominantly given off at the end of the charging period. The battery does not give off any gas during a normal discharge. During electrolysis the amount of 1Ah produces 684 cm³ of gas mixture and this gas mixture is in the proportion of 2/3 hydrogen and 1/3 oxygen. Thus 1Ah produces about 456 cm³ of hydrogen.



5. Principles and methods of sizing of GAZ® Ni-Cd-batteries for standby applications.

All GAZ® Ni-Cd batteries used for standby floating applications are sized according to the international sizing method IEEE 1115. We have developed a special calculation program which is available over the Internet and allows us to update it regularly without bothering our customers. It provides the possibility to calculate with multiple discharges, and to include the temperature derating factor as well as the ageing factor of the battery. A significant feature and advantage of the GAZ® Ni-Cd battery in comparison to the lead acid battery is that it can be fully discharged without any inconvenience to the lifetime or recharge of the battery. Further, it is an advantage to discharge the battery to the lowest practical value to extract the maximum energy the battery is able to provide in order to find out the most beneficial solution. The most important sizing parameters are:

5.1 Voltage window

This is the minimum and maximum voltage acceptable for the system. The maximum voltage provides the voltage that is available to charge the battery, whereas, the minimum voltage gives the lowest voltage acceptable to the system to that the battery can be discharged.

5.2 Load profile

The load profile is the electrical performance required by the system from the battery for the particular application. It can be expressed in terms of amperes for certain duration or in watts for certain duration. The requirements might vary for example from just one discharge to multiple discharges of a complex nature. In order to calculate the appropriated battery size please take into consideration point 5.1 voltage window.

5.3 Ambient temperature

The ambient temperature will have in any case an influence on the sizing of the battery (see point 4.4 Impact of temperature on cell performance and 4.5 Impact of temperature on lifetime).

5.4 Recharge time and state of charge

Some applications might require a full discharge cycle of the battery after a certain time after the previous discharge. The factors to be taken into account depend on the depth of discharge, the rate of discharge as well as the charging conditions.

5.5 Ageing

It might be required that a value has to be added to ensure the correct service of the battery during the lifetime. The value to be used depends on the discharge rate of the battery and on the conditions under which is carried out. Our experts or partners are able to help you choose the right battery for your special requirements.

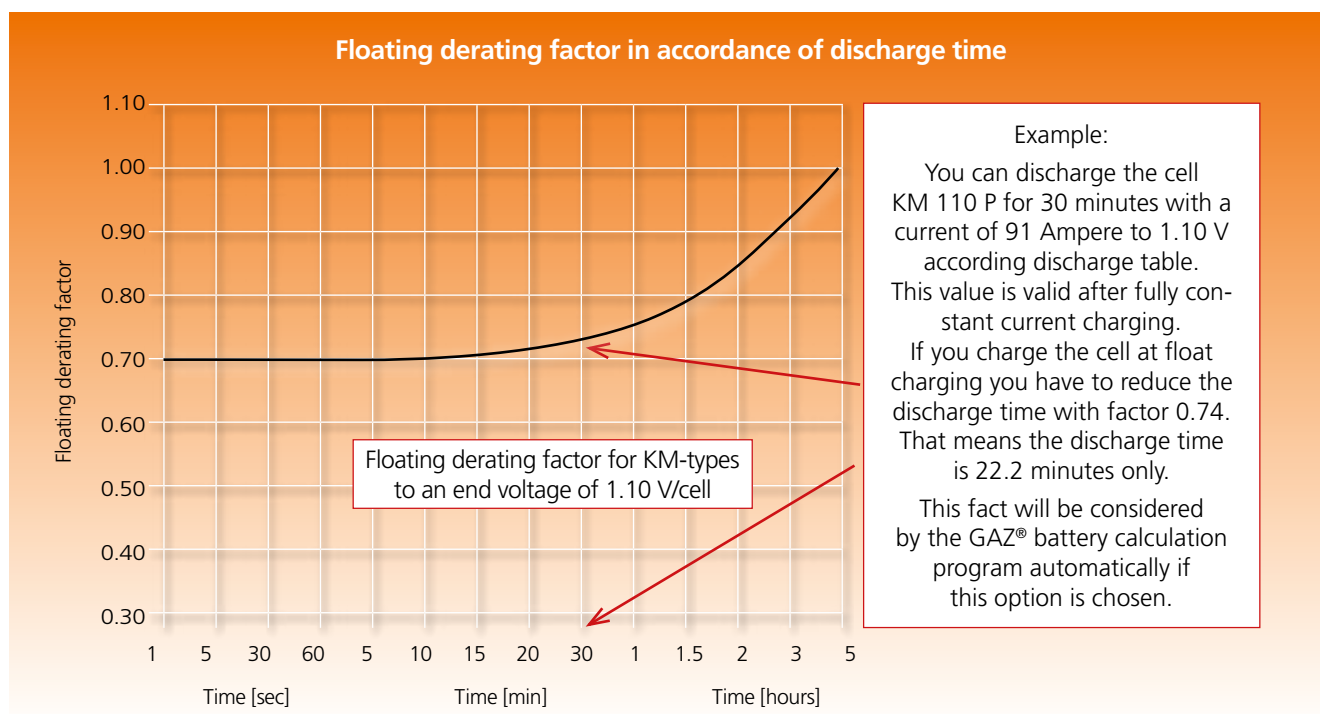
computed values according to IEEE Std 1115-2000							
period	load (amperes)	change in load (amperes)	duration of period (minutes)	time to end of section (minutes)	capacity rating factor at t Min Rate (Kt)	temperature derating factor for t Min (Tt)	required section (rated amp hrs)
section 1							
1	100.00	100.00	600	600	9.8590	1.1351	1119.0692
section 1 total:							1119.0692
range: KL 150-1700 P				design margin factor:		1.10	
endvoltage per cell:		1.05 Vpc		aging factor:		1.25	
temperature:		5°C to 50°C		use floating derating factor:		1.00 (use: Yes)	
max section size:		1119.07 Ah					
computed cellsize:				1538.72 Ah			
use the cell:				KL 1620 P			
user:				Peko			
order number:				002062			
date:				2008-09-30 15:36:02			
Your data was saved successfully. Please contact GAZ with order number 002062.							

5.6 Floating effect - Voltage depression

When a GAZ® Ni-Cd battery operates at a fixed floating voltage over a certain period of time, a decrease in the voltage level of the discharge curve occurs. It begins after one week and reaches its peak in approximately 3 months. Since this effect reduces the voltage level of the battery it can be considered as reducing the performance and autonomy of the battery too. Therefore, it is necessary to take this effect into consideration when sizing a GAZ® Ni-Cd battery. The GAZ® calculation program gives the possibility to

include this factor into the customers' calculation.

The floating effect is a reversible effect and can only be eliminated by a full discharge/ charge cycle. Please note that it cannot be prevented by just a boost charge. The GAZ® battery sizing program provides the option to calculate with and without this floating effect so that the customer is able to see the added values. Our recommendation is always to include this factor when sizing a battery.



6. Charging

The GAZ® Ni-Cd battery can generally be charged by all normal methods. Usually, batteries in parallel operation with charger and load are charged with constant voltage. For operations where the battery is charged separately from the load, charging with constant current is possible. Overcharging will not damage the battery but will lead to an increase of water consumption.

by a lower voltage float level charge. This results in a quick charge of the battery and in relatively low water consumption due to the low level float charge.

Two level charge

Boost charge: 1.55 – 1.70 V/cell

Floating 1.40 – 1.42 V/cell

A high voltage will increase the speed and efficiency of recharging the battery.

In reality often single level charger can be found. This is surely a compromise between a voltage high enough to charge the battery and low enough to have adequate water consumption.

Single level charge

1.45 – 1.50 V/cell

For commissioning the batteries please see point 7.3.5.

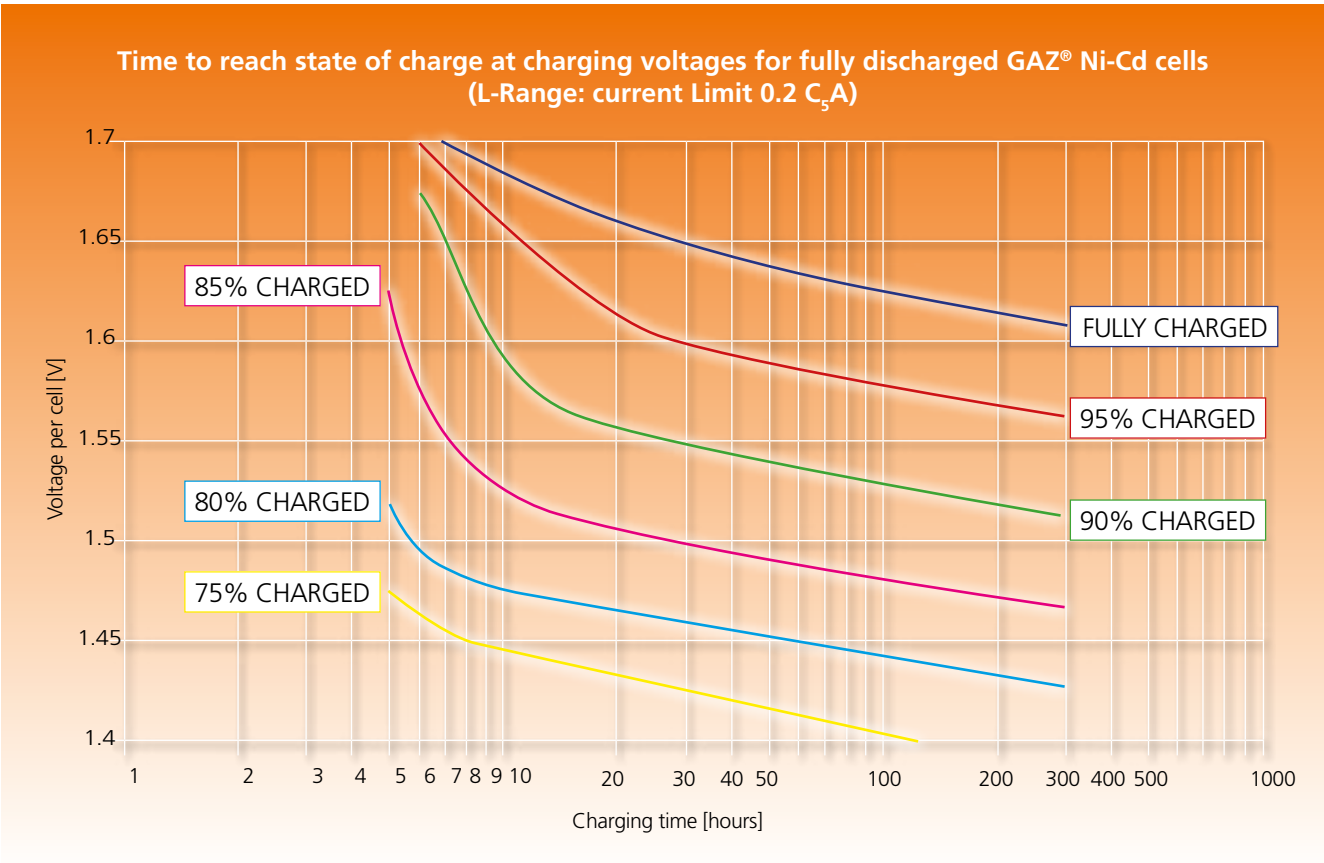
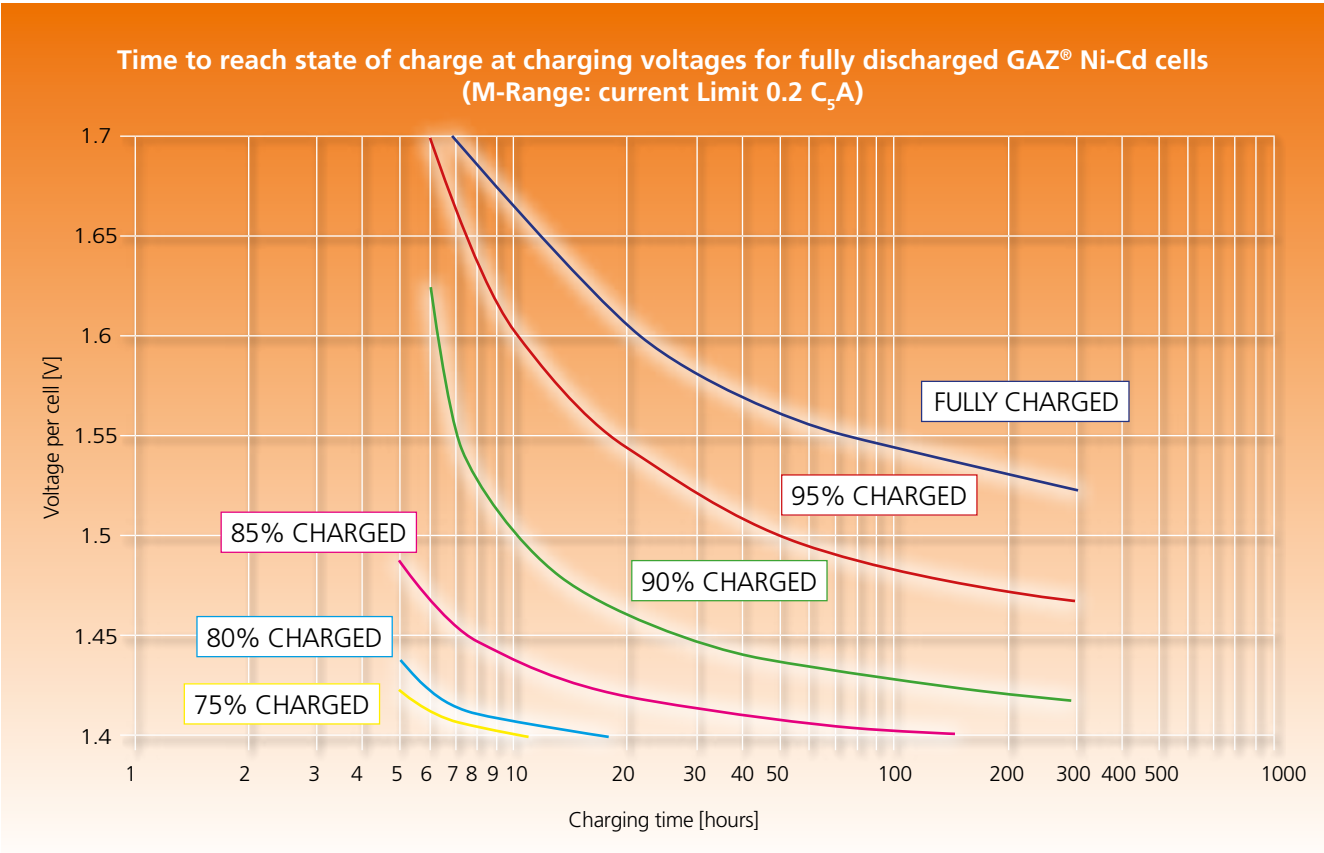
6.1 Constant voltage charge

The common method to charge a battery in stationary applications is carried out by a constant voltage system and the recommended solution is to use a two-rate type that is able to provide a constant voltage charge and a lower floating voltage or single rate floating voltage. The two level charger has an high voltage stage to charge the battery properly after a discharge followed

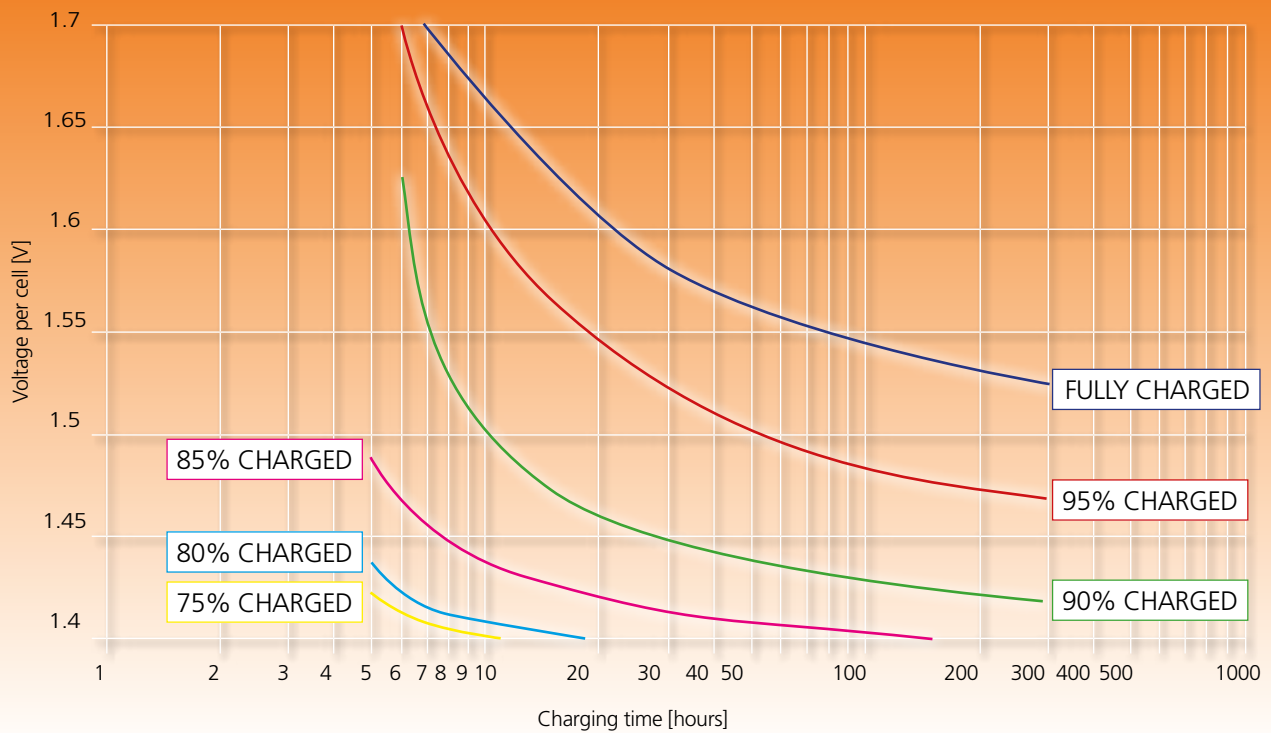
6.2 Charge acceptance

A discharged GAZ® Ni-Cd cell will take its time to reach a full state of charge. On the tables below the

time needed to achieve a certain stage of charge can be found.



Time to reach state of charge at charging voltages for fully discharged GAZ® Ni-Cd cells
(H-Range: current Limit 0.2 C₅A)



6.3 Charge efficiency

The charge efficiency depends mostly on the state of charge of the battery and the ambient temperature as well as the charging current. For much of its charge profile the GAZ® Ni-Cd battery is charged at a high level of efficiency. But if the battery approaches a fully charged condition the charging efficiency decreases.

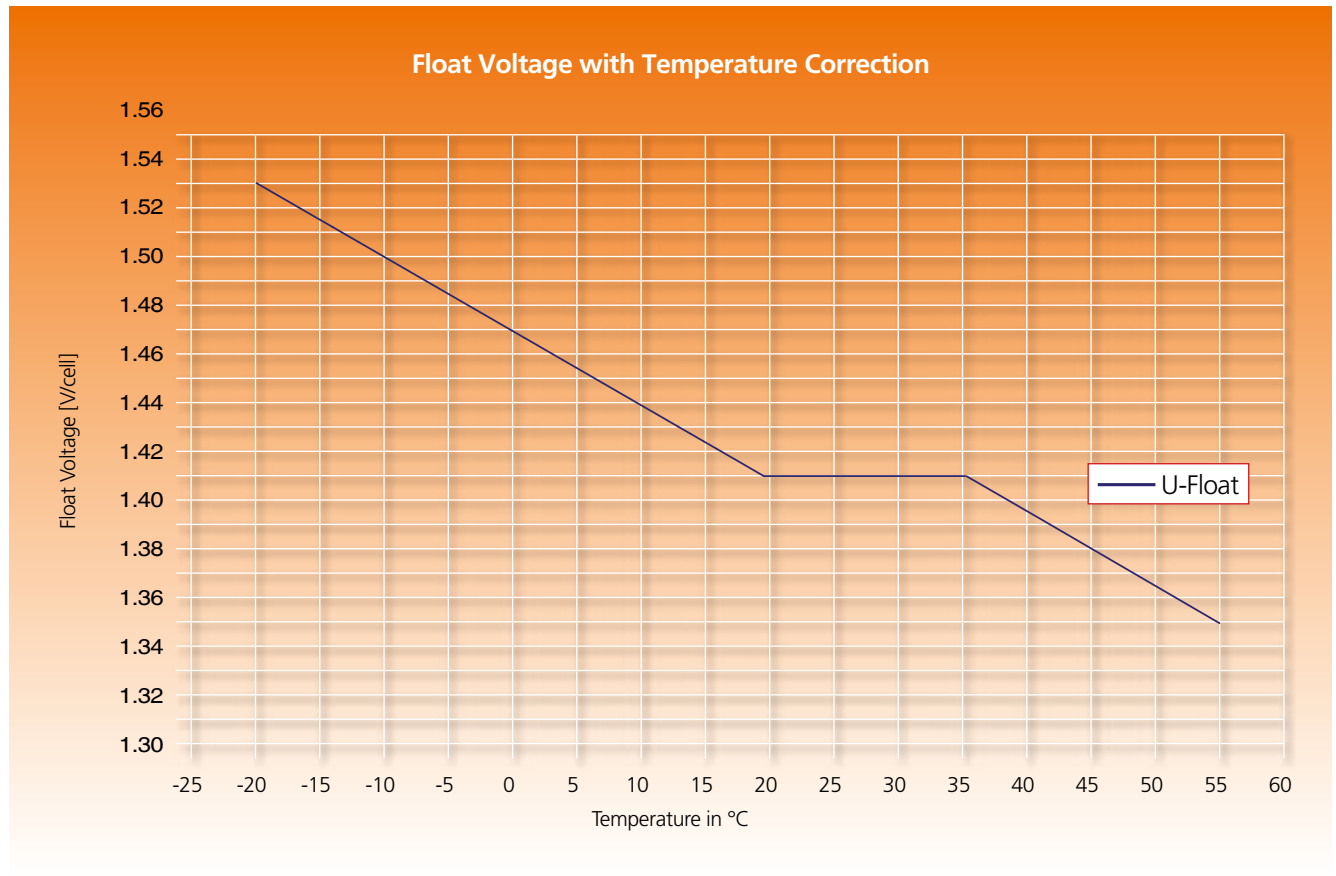
6.4 Temperature influence

The electrochemical behaviour of the battery becomes more active if temperature increases, i.e. for the same floating voltage the current increases. If the temperature decreases the reverse occurs. Increasing the current increases the consumption of water and reducing the current could lead to an insufficient charging.

For standby application it is normally not necessary to compensate the charging voltage with the temperature. In order to reduce the water consumption it is recom-

mended to compensate it at elevated temperature as for example from + 35°C on by use of the negative temperature coefficient of -3mV/K .

For operation at low temperatures, i.e. below 0°C, there is a risk of poor charging and it is recommended to adjust the charging voltage or to compensate the charging with the temperature (-3 mV/K , starting from an ambient temperature of + 20°C).



6.5 Commissioning

A good first charge is essential to prepare the battery for its long service lifetime. Above all it is important for discharged cells since they are in a totally discharged stage (see point 7.3.5 Commissioning)

7. Installation and operating instructions

7.1. Receiving the battery

The cells are not to be stored in packaging, therefore, unpack the battery immediately after arrival. Do not overturn the package. The battery cells are equipped with a blue plastic transport plug. The battery can be delivered

- **Filled and charged** – the battery is ready for installation. Replace the transport plug by the vent cap included in our accessories only before use
- **Filled and discharged** – replace the transport plug by the vent cap included in our accessories only before use
- **Unfilled and discharged** – do not remove the transport plug until ready to fill the battery

The battery must not be charged with the transport plug in the cells as this can damage the battery.

7.2. Storage

The rooms provided for storing the batteries must be clean, dry, cool (+10°C to 30°C - in compliance with IEC 60623) and well ventilated. The cells are not to be stored in closed packaging and must not be exposed to direct sunlight or UV-radiation.

If the cells are delivered in plywood boxes, open the boxes before storage and remove the packing material on the top of the cells. If the cells are delivered on pallets, remove the packing material on the top of the cells.

7.2.1 Uncharged and unfilled cells

Provided the correct storage conditions are met then the cells and batteries can be stored for long periods without damage if they are deeply discharged, drained and well sealed. It is very important that the cells are sealed with the plastic transport plug tightly in place. It is necessary to check after receipt and at least every year. Leaky plugs allow the carbon dioxide from the atmosphere to infiltrate the cell, which will result in carbonation of the plates. That may impair the capacity of the battery.

7.2.2 Charged and filled cells/ discharged and filled cells

Filled cells can be stored 12 months at the most from the time of delivery.

Storage of filled cells at a temperature above +30°C results in loss of capacity. This can be approximately 5% per 10 degrees/year when the temperature exceeds +30°C. It is very important that the cells are sealed with the plastic transport plugs tightly in place. This is to check after receipt of goods. In case of loss of electrolyte during transport, refill the cell until the "MIN" mark with electrolyte before storage.

7.3. Installation

EN 50272-2:2001 "Accumulators and battery installations, stationary battery installations" is binding for the setting up and operation of battery installations. For non stationary installations specific standards are valid.

7.3.1 Location

Install the battery in a dry and clean room. Avoid in any case direct sunlight and heat. The battery will give the optimal performance and maximum service life if the ambient temperature lies between + 10°C and + 30°C.

7.3.2 Ventilation

During the last part of charging the battery gases (oxygen and hydrogen mixture) are emitted. At normal float charge the gas evolution is very small but some ventilation is necessary.

Special regulations for ventilation might be required in your area for certain applications. If no regulations are fixed in your area DIN EN 50272 – 2: 2001 should be met.

7.3.3 Setting up

Always pay attention to the assembly drawings, circuit diagrams and other separate instructions. The transport plugs have to be replaced by the vent caps included in the accessories. If batteries are supplied "filled and charged", the electrolyte level should be checked, and if necessary, topped off as described in point 3.4.

Cell connectors and/or flexible cables should be checked to ensure they are tightly seated. Terminal nuts, screws and connectors must be tightly seated. If necessary tighten with a torque spanner.

Torque loading for:

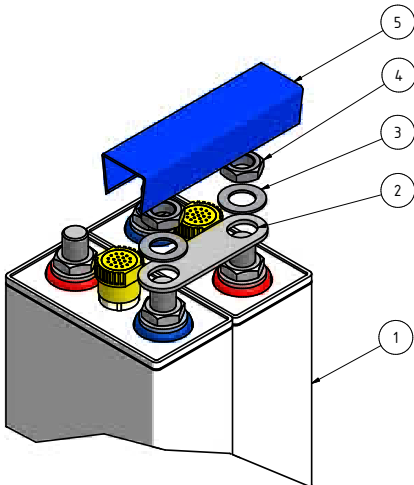
M10: 8 Nm
M16: 20 Nm
M20: 25 Nm

Female thread:

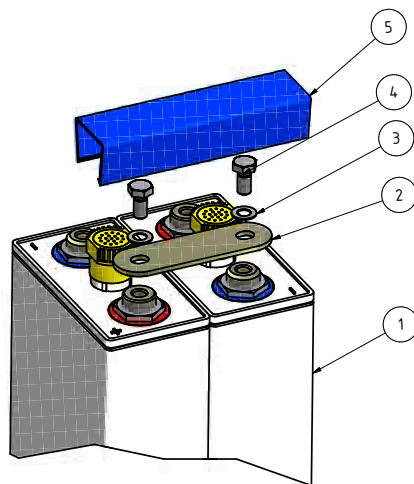
M 8: 20 – 25 Nm
M10: 25 – 30 Nm

The connectors and terminals should be corrosion-protected by coating with thin layer of anti corrosion grease.

nut connection

- 
- 1) cell container
2) cell connector
3) spring washer
4) nut
5) connector cover

screw connection

- 
- 1) cell container
2) cell connector
3) spring washer
4) screw
5) connector cover

7.3.4 Electrolyte

The electrolyte for GAZ® Ni-Cd batteries consists of diluted caustic potash solution (specific gravity 1.20 kg/litre \pm 0.01 kg/litre) with a lithium hydroxide component, in accordance with IEC 60993. The caustic potash solution is prepared in accordance with factory regulations. The specific gravity of the electrolyte does not allow any conclusion to be drawn on the charging state of the battery. It changes only insignificantly during charging and discharging and is only minimally related to the temperature.

- **Battery delivered unfilled and discharged-** if the electrolyte is supplied dry, it is to be mixed according to the enclosed mixing instruction. Remove the transport plugs from the cell just before filling. Fill the cells up to 20 mm above the lower level mark "MIN". Steel cased cells have to be filled up to the top edge of the plates. When using battery racks fill cells before putting up. Only use genuine electrolyte.
- **Battery delivered filled and charged or discharged-** check electrolyte level. It should not be less than 20 mm below the upper level mark "MAX" see 5.2.
- "Only use genuine electrolyte supplied by GAZ®".

7.3.5 Commissioning

A good commissioning is very important. The following instructions are valid for commissioning at 20°C till 30°C. For different conditions please contact manufacturer. Charge at constant current is preferable. If a site test is requested it has to be carried out in accordance with IEC 60623.

According to IEC 60623, 0.2 C₅A is also expressed as 0.2 I_tA.

The reference test current It is expressed as:

$$I_t A = \frac{C_n Ah}{1 h}$$

Example:

0.2 I_tA means 20 A for a 100 Ah battery or
 100 A for a 500 Ah battery

7.3.5.1 Commissioning with constant current

Battery delivered unfilled and discharged – after a period of 5 hours from filling the electrolyte in the battery should be charged for 15 hours at the rated charging current 0.2 I_tA. Approximately 4 hours after the end of charging the electrolyte level should be adjusted to

the upper electrolyte level marking "MAX" by using only genuine electrolyte. For cells with steel cases the electrolyte level should be adjusted to the maximum level according to the "Instruction for the control of electrolyte level". **During the charge the electrolyte level and temperature should be observed, see point 7.5.4. The electrolyte level should never fall below the "MIN" mark.**

Battery delivered filled and discharged-the battery should be charged for 15 hours at the rated charging current 0.2 I_A. Approximately 4 hours after the end of charging the electrolyte level should be adjusted to the upper electrolyte level marking "MAX" by using distilled or deionized water in accordance with IEC 60993. For cells with steel cases the electrolyte level should be adjusted to the maximum level according to the "Instruction for the control of electrolyte level". **During the charge the electrolyte level and temperature should be observed, see point 7.5.4. The electrolyte level should never fall below the "MIN" mark.**

Battery delivered filled and charged and stored for more than 12 months-the battery should be charged for 15 hours at the rated charging current 0.2 I_A. Approximately 4 hours after the end of charging the electrolyte level should be adjusted to the upper electrolyte level marking "MAX" by using distilled or deionized water in accordance with IEC 60993. For cells with steel cases the electrolyte level should be adjusted to the maximum level according to the "Instruction for the control of electrolyte level". **During the charge the electrolyte level and temperature should be observed see point 7.5.4. The electrolyte level should never fall below the "MIN" mark.**

Battery delivered filled and charged-a 5 hours charge at the rated charging current 0.2 I_A must be carried out before putting the battery into operation. Approximately 4 hours after the end of charging the electrolyte level should be adjusted to the upper electrolyte level marking "MAX" by using distilled or deionized water in accordance with IEC 60993. For cells with steel cases the electrolyte level should be adjusted to the maximum level according to the "Instruction for the control of electrolyte level". **During the charge the electrolyte level and temperature should be observed, see point 7.5.4. The electrolyte level should never fall below the "MIN" mark.**

7.3.5.2 Commissioning with constant voltage

If the charger's maximum voltage setting is too low to supply constant current charging divide the battery into two parts to be charged individually.

Battery delivered unfilled and discharged-after a period of 5 hours from filling the electrolyte in the battery should be charged for 30 hours at the rated charging voltage of 1.65 V/cell. The current limit should be 0.2 I_A maximum. Approximately 4 hours after the end of charging the electrolyte level should be adjusted to the upper electrolyte level marking "MAX" by using only genuine electrolyte. For cells with steel cases the electrolyte level should be adjusted to the maximum level according to the "Instruction for the control of electrolyte level". **During the charge the electrolyte level and temperature should be observed, see point 7.5.4. The electrolyte level should never fall below the "MIN" mark.**

Battery delivered filled and discharged-the battery should be charged for 30 hours at the rated charging voltage of 1.65 V/cell. The current limit should be 0.2 I_A maximum. Approximately 4 hours after the end of charging the electrolyte level should be adjusted to the upper electrolyte level marking "MAX" by using distilled or deionized water in accordance with IEC 60993. For cells with steel cases the electrolyte level should be adjusted to the maximum level according to the "Instruction for the control of electrolyte level". **During the charge the electrolyte level and temperature should be observed, see point 7.5.4. The electrolyte level should never fall below the "MIN" mark.**

Battery delivered filled and charged and stored for more than 12 months-the battery should be charged for 30 hours at the rated charging voltage of 1.65 V/cell. The current limit should be 0.2 I_A maximum. Approximately 4 hours after the end of charging the electrolyte level should be adjusted to the upper electrolyte level marking "MAX" by using distilled or deionized water in accordance with IEC 60993. For cells with steel cases the electrolyte level should be adjusted to the maximum level according to the "Instruction for the control of electrolyte level". **During the charge the electrolyte level and temperature should be observed, see point 7.5.4. The electrolyte level should never fall below the "MIN" mark.**

Battery delivered filled and charged-a 10 hours charge at the rated charging voltage of 1.65 V/cell must be carried out before putting the battery into operation. The current limit should be 0.2 I_A maximum. Approximately 4 hours after the end of charging the electrolyte level should be adjusted to the upper electrolyte level marking "MAX" by using distilled or deionized water in accordance with IEC 60993. For cells with steel cases the electrolyte level should be adjusted to the maximum level according to the "Instruction for the control of electrolyte level". **During the charge the electrolyte level and temperature should be observed, see point 7.5.4. The electrolyte level should never fall below the "MIN" mark.**

7.4. Charging in operation

7.4.1 Continuous battery power supply

(with occasional battery discharge)

Recommended charging voltage for ambient temperatures + 20°C to + 25°C

Do not remove the vent caps during float-, boost charge and buffer operation. The current limit should be 0.3 I_A maximum in general.

7.4.1.1 Two level charge

Floating 1.40 – 1.42 V/cell

Boost charge: 1.55 – 1.70 V/cell

A high voltage will increase the speed and efficiency of recharging the battery.

7.4.1.2 Single level charge

1.45 – 1.50 V/cell

7.4.2 Buffer operation

Where the load exceeds the charger rating.

1.45 – 1.55 V/cell

7.5. Periodic Maintenance

The battery must be kept clean using only water. Do not use a wire brush or solvents of any kind. Vent caps can be rinsed in clean warm water if necessary but must be dried before using them again.

Check regularly (approx. every 6 months) that all connectors, nuts and screws are tightly fastened. Defective vent caps and seals should be replaced. All metal parts of the battery should be corrosion-protected by coating with a thin layer of anti-corrosion grease. **Do not coat any plastic part of the battery, for example cell cases!**

Check the charging voltage. If a battery is connected in parallel it is important that the recommended charging voltage remains unchanged. The charging current in the strings should also be checked to ensure it is equal. These checks have to be carried out once a year. High water consumption of the battery is usually caused by improper voltage setting of the charger.

7.5.1 Equalising charge

It is recommended to carry out an equalising charge once a year to maintain capacity and to stabilise the voltage levels of the cells. The equalising charge can be carried out for 15 hours at 0.2 I_A or with the boost charging stage in conformity with the characteristic curve of the available charging implement. The electrolyte level is to be checked after an equalising charge.

In order to equalize the floating derating effect it is recommended to charge the battery once a year for 15 hours at the rated charging current 0.2 I_A. Then discharge the battery down to 1.0 V/cell and charge again for 8 hours at the rated charging current 0.2 I_A.

7.5.2 Electrolyte check and topping up

Check the electrolyte level and never let the level fall below the lower level mark "MIN". Use only distilled or deionized water to fill the cells in accordance with IEC 60993. Experience will tell the time interval between topping-up. Refilling with electrolyte is only permissible if spilled electrolyte has to be replaced. If during refilling electrolyte has been splashed onto the cell cover or between the cell cases clean this off and then dry the area. See MSDS for how to properly clean-up spilled material.

NOTE: Once the battery has been filled with the correct electrolyte either at the factory or during the battery commissioning, there is no need to check the electrolyte density periodically. Interpretation of density measurements is difficult and could lead to misunderstandings.

7.5.3 Replacing of electrolyte

In most stationary applications the electrolyte will retain its effectiveness for the total lifetime of the battery. However, under special battery operating conditions, if the electrolyte is found to be carbonated, the battery performance can be restored by replacing the electrolyte. **Only use genuine electrolyte supplied by GAZ®!**

It is recommended to change the electrolyte when reaching a carbonate content of 75 g/litre. It is possible to test the electrolyte in the works laboratory. For this a minimum quantity of 0.2 litres of electrolyte in a clean glass or polyethylene container should be sent in, paying strict attention to the valid dangerous goods regulations. Expediently the sample of electrolyte is taken half an hour after charging has ended and from several cells of the battery. It is pointless to take the samples immediately after topping up. The electrolyte sample and the cells should be closed immediately after the electrolyte has been taken.

CAUTION – caustic potash solution is corrosive! Safety regulations shall be applied, goggles and gloves shall be used!

7.5.4 Electrolyte temperature

The temperature of the electrolyte should never exceed 45°C as higher temperatures have a detrimental effect on the function and duration of the cells. In the course of charging an electrolyte temperature of $\leq 35^{\circ}\text{C}$ should be aimed for. On exceeding 45°C the charging should be temporarily interrupted until the electrolyte temperature falls down to 35°C. The temperature measurements are to be made on one of the cells in the middle of the battery.

Low ambient or electrolyte temperatures down to -25°C do not have any detrimental effect on the battery; they just cause a temporary reduction in capacity.

7.6. Additional warning notes

GAZ® Ni-Cd batteries must not be used or stored in the same room as lead acid batteries. In addition to this the charging gases from lead acid batteries must be kept away from Ni-Cd batteries by suitable precautions such as ventilation or hermetic isolation of the rooms. Tools for lead acid batteries must not be used for Ni-Cd batteries

Do not place electrically conductive objects such as tools etc. on the battery!

Risk of short circuit and fire: No rings or metal bracelets should be worn during the assembly of the battery – **Risk of injury!**

Open the doors of the battery cabinet during charging so that the charging gases can escape. The charging gases from batteries are explosive. Do not allow open fire or ember in the vicinity of the battery!

Risk of explosion: Caution – caustic potash solution is corrosive!

Caustic potash solution is used as electrolyte. Caustic potash solution is a highly corrosive liquid which can cause severe damage to health if it comes into contact with the eyes or the skin (risk of blinding). If even small quantities are swallowed there is a possibility of internal injuries.

When working with electrolyte and on cells, rubber gloves, safety goggles with side guards and protective clothing must always be worn!

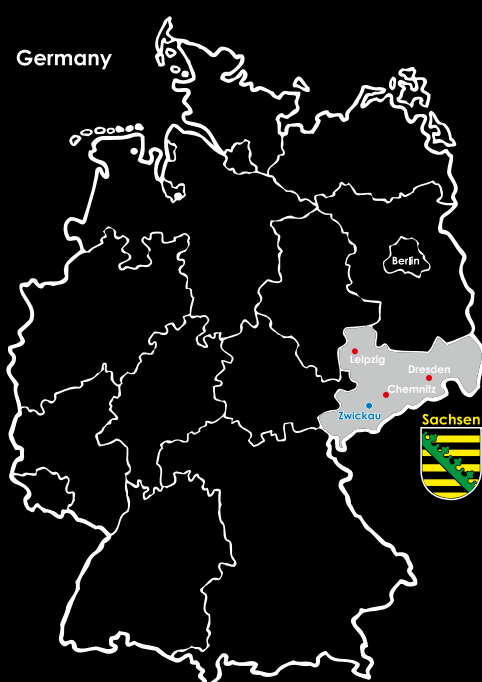
Contact with the eyes: Flush out immediately with copious amounts of water for 10 – 15 minutes.

If necessary consult an eye clinic.

Contact with the skin: Remove splashed clothing immediately and wash the affected skin areas with copious amounts of water. For any discomforts consult a doctor.

Swallowing: Rinse out the mouth immediately with copious amounts of water and keep drinking large amounts of water. Do not provoke vomiting. Call an emergency doctor immediately.

In the event of injuries: Rinse thoroughly for a long period under running water. Consult a doctor immediately.



GAZ Geräte- und Akkumulatorenwerk Zwickau GmbH

Reichenbacher Straße 62/68
D-08056 Zwickau

Postfach 20 04 57
D-08056 Zwickau

Telefon: +49 (0) 375 / 86-0
Telefax: +49 (0) 375 / 86-440

www.gaz-gmbh.com
sales@gaz-gmbh.com

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