Manual for storage and maintenance of 12V wet-charged and dry-charged lead-acid starter batteries, semi-traction batteries, and AGM batteries

Important: Please read these instructions upon receiving the battery, before unpacking and installing the battery. Non-compliance with these instructions voids the warranty of the battery.

This manual provides basic information on the safe handling rules, characteristics, proper transportation procedures, storage, installation, maintenance and charging of lead-acid starter batteries for road vehicles and semi-traction batteries with marked cyclic application and AGM batteries, as well as basic technical information on possible problems when using the batteries. The starter batteries are designed and manufactured in accordance with all the requirements of the EN standard 50342-1:2016. The functional characteristics of the semi-traction batteries comply with the requirements of EN standard 60254-1:2006.

1. Safety instructions

Please follow the safety instructions. This is of utmost importance for your safety and the safety of the people around you.

	• Smoking in proximity to the battery is prohibited. • Use of open flame and other ignition sources is prohibited. • Prevent the occurrence of sparks caused by short circuits or electrostatic discharge. • Do not place any tools on the battery. • Clean only with a damp anti-static cloth.
	• Keep acid and the charged battery out of reach of children. • Do not allow children near the battery when handling it.
	• Read carefully the information on the battery, this battery storage and maintenance manual, battery handling hazards, user manuals, and recharging rules, etc. Read and follow the enclosed instructions.
	• Use eye protection when handling the battery. • If acid gets into your eyes or on your skin, immediately flush with water and seek medical help.
	• When handling the battery, wear a safety mask with the required protection level.
	• Wear protective clothing when handling the battery. • If electrolyte contaminates clothing, clean thoroughly with water.
	• Wear safety gloves with the required protection level when handling the battery.
	• Wear safety footwear with the required protection level when handling the battery.
	• Electrical Shock Hazard.
	• Fire and explosion hazards. The emitted gases are a mixture of oxygen and hydrogen and are highly explosive. Do not cause short circuits. • Do not connect the positive to negative terminal of a battery. • Do not use any material (clothing, gloves, etc.) that can cause electrostatic discharge.
	• Batteries contain electrolyte - sulfuric acid solution. Electrolyte has a strong corrosive effect. Do not tilt the battery, allowing acid to leak through the safety valve openings of the valve regulated batteries.
	• The box and the handles can become breakable over time, especially when you expose the battery to direct sunlight.
	• A discharged battery can freeze under temperatures below 0.
	• The battery is heavy. It is obligatory to observe the rules of manual handling of weights. Always use personal protective equipment and appropriate carrying and handling equipment.
	• Before handling the battery, make an external examination. Check for traces of cracking of the box or the handles.
Pb	• Batteries contain lead.
	• Recycle used batteries. Never dispose of an old battery as if is a household waste. Do not leak electrolyte in the household sewage, soil, and subterranean waters.

Attention:

 Protect your eyes! There is risk of fire, explosion or burns. Do not disassemble! Do not allow heating above 500 degrees Celsius when charging the battery! Keep away from open fire.

 Do not allow sparks when working with cables and electric equipment, as well as sparks coming from electrostatic discharge. Discharge any static electricity from clothing by touching a grounded conductive part.

Clean ONLY with a slightly damp anti-static cloth. A dry-cleaning cloth can accumulate electricity and create sparks.

 **NEVER** connect the positive terminal to the negative terminal of the same battery because this will cause a short circuit, which in turn will cause burns, fire or explosion.

 **Attention:** The acid in the battery has a strong corrosive effect and can cause burns and blindness. Do not tilt wet charged batteries to any side or position by more than 45 degrees, in order to avoid electrolyte leakage through the ventilation openings.

In case of electrolyte leakage neutralize it with an aqueous solution of sodium hydrogen carbonate (natrium bicarbonate) - 100g of soda for 1L of water.

2. Preparation for installation

Flooded and AGM batteries are delivered charged and ready to use.

The battery must be transported in a vertical position, with insulated terminals to protect against short circuits.

Batteries without damage are not classified as dangerous goods, in case they are protected against short circuits, mechanical damage and the conditions for handling the battery are observed.

In case of mechanical damage, observe the accepted standards for handling dangerous goods.

Unpack carefully to avoid the risk of high currents flowing between the terminals in case of involuntarily short-circuiting and high voltage in case of static electricity.

Check the exterior of the battery. It should be clean and dry, and the terminals must be free from signs of distortion or corrosion, apply technical grease.

When cleaning, use only a wet, soft cloth or cotton. Do not use dry fabrics and dusters as they could cause a static electricity accumulation. Do not use any cleaning sprays, chemicals, solvents and abrasive substances.

In case of liquid on the battery box (electrolyte) or around it, neutralize it with a solution of basic nature - aqueous solution of sodium hydrogen carbonate (natrium bicarbonate) - 100 grams of soda for 1 L of water.

3. Installation of the battery

3.1. Installing the battery in the vehicle

Attention: Install the battery that meets the requirements of your vehicle's electrical system as specified in the vehicle's technical specifications!

Please follow the vehicle manufacturer's operating instructions as well as the following rules:

- Install the battery that is fully charged and undamaged.
- Install the recommended battery type for the specified vehicle. The battery operates at a specific load for the respective type. Continuous discharging and undercharging, as well as systematic overcharging, will shorten its service life.
- Before installing the battery, clean the surface inside the vehicle. Ensure the reliability of the reinforcing elements. The battery must be securely fixed, otherwise it will be exposed to a greater degree of vibration, which in turn will reduce its service life. Friction between the battery box and the attachment area can cause damage and abrasion of the box. The box may have some cracks causing electrolyte leakage.

- Ensure the availability and integrity of the insulation materials provided by the vehicle manufacturer to prevent battery overheating.
- Do not cause short circuits with the tools or cables. Once you have installed the battery in the vehicle, remove the covers from the pole terminals immediately before connecting the cables to them.
- When installing, connect the positive terminal (+) first, then the negative terminal (-). Check the cables and connectors as well as the strength of their connection to the battery terminals. Damaged connections can lead to battery malfunction and can cause terminal impairment (meltdown) or fire. Use the accessories from the previous battery such as hose connections, mounts and terminal covers. In case of cable stripping and deformation of the connecting elements, replace them immediately.
- Valves and gas vents must remain open and not blocked to avoid the risk of explosion.

3.2. Examination of the battery in the vehicle

Always keep the battery clean and dry. If necessary, clean the battery box with a damp anti-static cloth. Clean the pole terminals regularly and apply technical grease.

For the batteries that need maintenance, it is recommended to check the electrolyte level and, if necessary, to refill the battery **ONLY** with distilled water to the levels specified by the manufacturer.

For maintenance-free batteries, the maintenance is carried out only in authorized service centers. **Do not open** this type of batteries.

The voltage supported by the vehicle charging system shall be within the range 13,8V÷14,4V for 12 volt and 27,6÷28,8V for 24-volt systems.

In cases where the open circuit battery voltage is lower than those specified in p. 7.1, charge the battery according to p. 7.

If the battery is subjected to deep discharge, it must be charged as soon as possible.

4. Battery unmaunting and storage

4.1. Unmounting the battery from the vehicle

Some vehicles are equipped with sensitive electrical systems including airbag controls, ABS (anti-lock braking system), stability and traction control devices, on-board computers, etc., where certain procedures need to be followed to unmount a battery, i.e., the electrical components may require the electrical system to be constantly connected or may need to be adjusted after being disconnected. In this case it is recommended to go to a service center.

Please follow the vehicle manufacturer's operating instructions as well as the following rules:

- Turn off the engine and all electrical equipment before unmounting the battery.
- Do not cause short circuits with the tools or cables.
- When unmounting the battery, disconnect first the negative terminal (-) and then the positive terminal (+).
- Detach the fasteners.
- Unmount the battery without tilting it more than 45^0.

4.2. Storage of a new battery (before installation)

The battery should always be stored in a full charged state (see p. 7.1.) in a clean, dry and cool room, away from heat sources, chemicals and direct sunlight. The storage temperature should be between 10°C and 35°C. The battery gradually discharges during storage, so observe the open circuit voltage or specific electrolyte density of a flooded battery every 2-3 months and for AGM battery every 3-4 months.

When storing the battery at higher temperatures, make more frequent voltage measurements and charge as it is necessary (for a flooded battery every 4-6 weeks and for AGM battery every 6-8 weeks).

When storing the battery at lower and freezing temperatures, the charge of the battery is of particular importance as there is a possibility of freezing of the electrolyte.

Attention: If battery needs charging (see p. 7.1 – Charging indicators) follow the instructions in p. 7.

The battery should be stored upright and should not be placed directly on the ground because pebbles or sharp edges on the floor can damage the battery box and can cause leakage.

Check the condition of the battery occasionally regarding its cleanliness at regular intervals and protect the pole terminals and connecting elements from corrosion. It can negatively affect battery functioning and cause a safety hazard.

Attention: The total storage time of the battery until installation should not exceed 6 months, provided that the rules specified in these instructions are followed and the battery charge exceeds the minimum (see p. 7.1.).

4.3. Battery storage after uninstalling or taking the vehicle out of service for a longer period.

When the vehicle is taken out of service (e.g., when used only for a seasonal purpose) and the battery is dismantled it is necessary to charge it and store it in a cool place under the conditions described in p. 4.2. If it is necessary to leave the battery in the vehicle, disconnect the negative terminal.

Clean the battery terminals and clamps. Apply technical grease.

Storing a battery in a discharged state causes sulfation of the plates which significantly worsens the battery's functioning and considerably reduces its service life.

Attention: Check the open circuit voltage of the battery according to the instructions in p. 4.2. If the voltage is less than that specified in p. 7.1 or the storage is more than that specified in p. 4.2, charge the battery according to p. 7.

5. Dry-charged batteries

Before usage, the dry-charged battery must be filled with electrolyte (sulfuric acid solution) by observing the following rules:

- Ensure that there is proper ventilation when handling this battery and observe the safety instructions.
- Remove all valves and sealing caps.
- Fill the battery to the maximum level marked on the outside of the box with electrolyte (sulphuric acid solution) with a density of 1.28 g/cm3 complying with IEC 62877-1:2016

Attention: The preparation of electrolyte (sulphuric acid solution) must be carried out ONLY by authorized and specially qualified personnel.

- Do not exceed the specified level.
- Charge the battery according to p. 7.
- After charging, refill electrolyte if necessary and equalize the level in all cells.
- Place back the valve caps that were removed.
- Wash the battery with warm water. If there is a large amount of electrolyte on the battery box, it is necessary to use an aqueous solution of sodium hydrogen carbonate (natrium bicarbonate) - 100g of soda for 1L of water.

IMPORTANT! Make sure that the soda solution will not penetrate the battery cells. Then wash again with water and dry the battery.

Attention: Do not reinstall the sealing caps because this may cause the explosion during battery operation.

- Clean the battery terminals of oxides and apply a thin layer of technical grease.

Installation in and removal from the vehicle and storage of an electrolyte-filled dry-charged battery shall be carried out in accordance with the instructions in p. 3 and 4 of this Manual.

6. The factors affecting battery performance

6.1. Temperature

- The storage temperature should be between 10°C and 35°C. Higher temperatures will lead to higher water consumption, corrosion and faster self-discharge, as well as reduction of battery life.
- When storing batteries at colder and freezing temperatures, the charge of the battery is particularly important as there is a possibility of freezing of the electrolyte.
- Do not remove the battery insulation materials that were installed by the vehicle manufacturer and observe for obstruction of the engine compartment vents, as it can cause the battery to overheat above 50^0C for standard and 75^0C for high heat batteries - a temperature that can destroy the battery elements and cause the failure of the battery.

6.2. Contamination of batteries

- Dust contamination creates electrical conductivity, which in turn can cause the battery to discharge more quickly and a prerequisite for electrical shock.

6.3. Direct sunlight.

- Direct sunlight burns the battery box and increases fragility of the polypropylene.
- Direct sunlight causes the rise of battery temperature, which in turn increases the self-discharge.

- The battery handles are made of polypropylene and direct sunlight can cause changes in the material leading to a reduction in its strength and respectively to cause breakage of the handles.

6.4. Increased cyclicity.

- Frequent starts and subsequent engine stops, especially in urban conditions, cause multiple discharge cycles and insufficient battery charge time from the vehicle's charging system. This factor leads to consistent use of the battery in an undercharged state, which in turn shortens significantly its service life.
- This commonly happens in urban areas with public or commercial vehicles such as: taxis, courier services, delivery vehicles, etc. For this type of vehicle, we recommend using the higher-class batteries, such as our PREMIUM, EFB and AGM series, designed for increased cycling.

6.5. Additional consumers.

- The additional equipment installed in the vehicle causes the battery to be overloaded, resulting in battery discharge below the manufacturer's recommended state of discharge and an inability to fully charge it.
- The use of consumers when the engine is not running for a long period of time leads to a rapid discharge of the battery and in some cases to the inability to start the vehicle, and untimely shortening of its life.

7. Charge

7.1. Charge indicators

Charging the battery is required when:

- The storage period is longer than specified in p. 4.2. without recharging.
- The open circuit voltage (OCV) of the battery is:

Minimum voltage Umin, V	Normal voltage U, V	Battery type
$U_{min} \leq 12,6$	12,80-13,00	for AGM
$U_{min} \leq 12,4$	12,70-12,90	for SLI
$U_{min} \leq 12,3$	12,65-12,85	for SLI Серия A*(Тропик)

** Note: "Series A" (High Heat) refers to batteries for such markets as Africa, Middle East, South Asia.*

- After continuous and unsuccessful starting attempts, most often due to engine system failures.

7.2. Safety rules

Safety compliance is of utmost importance for your safety and the safety of people around you. Please observe the following rules when handling batteries:

- Wear protective clothing, footwear, gloves and safety glasses.
- Do not charge the battery close to fire or sparks.
- Do not charge a battery if it is damaged or frozen.
- Fast charge of the battery at higher current and voltage for short period of time is not recommended (p.7.3 – p. 7.5).
- Use only direct current (DC) chargers suitable for charging lead-acid batteries.
- Before charging, make sure the charger is set to the appropriate program for flooded batteries or AGM batteries.
- Do not switch on the charger, before it is connected to the battery; do not switch off the charger before the charging is complete.
- If you are charging more than one battery, arrange the batteries so that there is at least 20 mm between them.
- If you are charging more than one battery in the same circuit, connect only batteries with the same capacity and relatively similar state of charge. Check the open circuit density and/or voltage and group the batteries as per the state of charge.
- Batteries must always be connected in series, i.e., the positive terminal of one battery must be connected to the negative terminal of the next battery so that the positive terminal of the first battery and the negative terminal of the last battery are always open.
- Always use cables with the biggest possible cable cross section and the shortest possible length, so that any possibility for lowering the voltage is avoided.
- Charge the battery according to the specified requirements and modes (see p. 7.3 - 7.5).
- Do not allow direct contact with the electrolyte liquid; in case it happens, please wash thoroughly with water.
- Do not charge a frozen battery or if its temperature is above 50^0C.
- If the battery has accessible ventilation caps, check the level of electrolyte in each cell and add **distilled** water, if necessary. Do not add acid in the battery!!

Attention: Never connect the positive terminal to the negative terminal of the same battery as this will cause a short circuit. Check if the cables' connections have good contact by moving them slightly and pressing them to the terminal at the same time.

Note: *Use chargers ONLY with automatic shut-off.*

7.3. Charging with automatic chargers.

We recommend using an automatic charger with controlled current, based on IU_0U profile of charge. The main stages of charging with an automatic charger are the following:

- Constant current charge – the battery is charged with direct current (DC), automatically set by the charger, after recognizing the type of battery. The charger will apply an appropriate direct current (DC) until the battery is charged around 70%.

- Absorbing charge - the charger applies a constant voltage to the battery, while the current gradually decreases to values close to 0 A when the battery is fully charged.

- Floating charge - after reaching a predetermined value of the charging current reached at the end of the absorbing charge, the device automatically switches to a floating charge with constant voltage. The goal is to keep the battery fully charged.

7.4. Charging of flooded batteries with direct current (DC)

This method requires a specially designed charger that maintains a pre-selected constant current until a certain voltage is achieved. Charging batteries with this type of charger requires constant monitoring of temperature and charge time, therefore it is not recommended. Untimely interruption of the charge can lead to adverse consequences for the battery and in some cases to its destruction.

When charging the battery in manual DC mode, the circuit voltage of the connected batteries will rise slowly during charging, the voltage rises sharply, and the process must be stopped at the voltage limit to a level of 2.65V per cell or 16V for a standard 12-volt battery when single charging. When the specified voltage limit is reached, the process must be stopped.

Attention: Never use a charger without automatic shut-off!

We recommend when charging with direct current, the current value be equal to 1/10 of the nominal capacity of the battery.

Increased charge time can cause battery overcharge and water loss.

Example: *210Ah battery- Charging current: 210 x 0,1 = 21A (10% of the nominal battery capacity).*

Example: *60Ah battery- Charging current: 60 x 0,1 = 6A (10% of the nominal battery capacity).*

A highly discharged battery with an open circuit voltage below 12.0V, the charge current must be equal to 1/20 of the nominal capacity of the battery

Note: *This method is NOT recommended due to the possibility of overcharging the batteries. This method requires caution and timely interruption of charging.*

7.5. Charging of flooded batteries at constant voltage.

For this charging method, the voltage is between 14.4V and 14.8V, and the charging current depends on the power of the device. When the battery is charged for a certain time and the voltage reaches its maximum value, the charging current drops proportionally as the voltage increases. The battery is fully charged when the charging current becomes less than 1% of the battery capacity (A) or the electrolyte density does not change for two hours (for the batteries with maintenance).

Example: *210Ah battery- termination criterion is the charge current: 210 x 0,01 = 2,1A (1% of the nominal battery capacity).*

Example: *60Ah battery- termination criterion is the charge current: 60 x 0,01 = 0,6A (1% of the nominal battery capacity).*

Note: *This method is recommended for all types of batteries, as the process ends automatically and there are no prerequisites for overcharging the batteries.*

7.6. Charging of semi-traction batteries and batteries with cyclic application (all flooded batteries).

In automatic mode the charger is programmed. It is necessary to follow the charger settings for one complete charge cycle.

In manual mode at constant current with no voltage limit- with current value equal to 3% of C_{20} (20-hour battery capacity) until voltage stops rising for three consecutive measurements within one hour.

For charging after a full discharge, we recommend a three-step charging to minimize the charge time required for a full charge and to reduce the risk of undercharging the battery:

- Direct current charge approximately 10%-15% of C_{20} (20-hour capacity) to a battery voltage of 14.4 ±0.05 V.

- Absorbing charge at constant voltage 2.4 ± 0.05V until the current decreases to 3% of C_{20}.

- Final charge with a current equal to 3% of C_{20} (20-hour capacity), up to a voltage of 2.55 ± 0.05V. Charging should stop after 2-4 hours.

7.7. Charging of AGM batteries.

To charge valve-regulated lead-acid (VRLA) AGM batteries, in order to maintain optimal performance and lifespan, it is recommended to use a two-step IU method:

- Step 1: DC charging (20% of C_{20}) until the voltage rises to the absorbing voltage of 14.4 V/battery.
- Step 2: Charge at a constant voltage of 14.4 V/battery, where the current slowly decreases until it stabilizes around 0,005 x C_{20}.

The duration of the charge on the second step is not less than 12 hours and the total duration (step 1+ step 2) is at least 24 hours.

7.8. Warnings

The temperature of the electrolyte or the temperature of the battery box must not exceed 50°C for standard batteries and 75^0C for high heat batteries. The Recharging process must be interrupted if this temperature is exceeded and resumed after the battery has cooled down.

We recommend waiting approximately 2 hours after charging to allow the gases to dissipate before removing the connecting wires from the batteries, as some chargers remain charged and can produce sparks. Replace the valve caps and gas tubes if they have been removed. Wash the battery with warm water and dry it.

Always charge the battery according to the amount of charge required. Prolonged charging times, especially DC, can cause the battery to be overcharged, causing excessive water loss during the process.

Avoid fast charging, which is done without controlling the temperature, current or duration, as it can lead to increased gas evaporation, electrolyte leakage, overcharging, plate destruction, explosion and other.

It is possible that a battery with a voltage below the minimum specified in p. 7.1., which remained for a long period of time without recharging, cannot accept a charge or this will be difficult due to damaged plates (sulfation). In these cases, it is not possible to restore the original efficiency of the battery, which is a prerequisite for an appearance of other defects in a short period of usage.

The battery charging area must be ventilated or equipped with a ventilation system as an increase in the concentration of suffocating and explosive gas may occur.

Failure to comply with battery charging requirements can seriously damage the battery and significantly reduce its service life, even leading to battery failure, which is a prerequisite for a denying claim against the manufacturer.

8. Battery defects/Failures

8.1. External defects

8.1.1. Electrolyte leakage and damage/cracks on box and lid:

Characteristic features:

- visible (distinct) cracks on box and lid.
- visible marks of damage on the battery lid.
- cracks near the handles.
- box deformation.
- abrasions (especially on the edges).
- damage to the threads of the filling openings.

Consequence of the box and lids damage is the electrolyte leakage, which results in the destruction of the battery plates when in contact with air. The cell operates at elevated temperature and further, due to contamination of the battery surface with electrolyte, self-discharge increases.

Possible causes of the defect

a) manufacturing defect:

- use of non-compliant (defective) boxes and lids
- poor quality of gluing of the box and lid
- defects in the openings of the filling lids and/or caps
- non-compliant valves/ caps
- absence or blockage of gas vents
- damage of the battery box during formation and storage

b) as a result of storage and handling:

- incorrect handling during transportation, installation, dismantling and storage.
- freezing of the electrolyte in a highly discharged battery.

c) due to incorrect recharging:

- blockage of the gas vents.
- incorrect charging mode (electrolyte leakage from exhaust vents).

8.1.2. Damage of the battery terminals

Characteristic features:

- visible damage of the terminals.
- black-brown color of the positive terminal or humidification of the negative terminal.
- open circuit voltage close to 0V (closed circuit).

Possible causes of the defect

a) manufacturing defect:

- poor manufacturing of the terminals.
- poor quality injection molding of the terminals in the lid.

b) non-compliant operating conditions:

- pressure on the terminals.
- poor connection between the terminals and the vehicle electrical system connectors.

c) due to incorrect recharging:

- poor connection between the terminals and the charger clamps.
- corrosion of clamps and terminals caused by acid fumes due to battery overcharging.

8.1.3. Battery damage due to explosion

Characteristic features:

- Cracks.
- Detaching parts of the lid and box.

Possible causes of the defect

a) manufacturing defect:

- formation of sparks inside the battery due to disconnection of an inter-element weld, lead bridges, terminal elements or short circuit of the electrical chain.

b) non-compliant operating conditions:

- use of open fire near the battery.
- operations that can create a spark of static electricity.

c) due to incorrect recharging:

- spark formation on the battery terminals due to poor contact with the terminals of the supply wires or a short circuit in the external chain.
- formation of sparks caused by a short circuit between the battery terminals when using tools.
- use of malfunctioning chargers.
- use of the inappropriate charging modes.
- obstruction of the gas vents by dust, dirt, etc. resulting in impaired battery ventilation.

8.2. Internal defects

8.2.1. Circuit break

Characteristic features:

- Complete battery malfunction. Drastic decrease in electrical parameters and even no indication of voltage value at discharge; no or low current value when charging.

Possible causes of the defect

a) manufacturing defect:

- poor inter-element welding of two adjacent cells.
- poor welding of the terminal to the lid bushing.

Note: *these factors mainly occur in the first 6 months of battery operation.*

b) non-compliant operating conditions:

- unregulated high battery consumption, which in turn leads to internal melting of the terminals.
- the battery was subjected to strong vibrations, which in turn caused the breakage of the inter-element welds.

c) due to incorrect recharging:

- poor contact of the terminals with the conducting clamps, leading to melting (breaking) of the terminals.

8.2.2. Short circuit

Characteristic feature:

- lack of voltage or low voltage, low electrolyte density.
- rapid temperature rising at discharge.
- slowly increasing voltage during charging and rapidly decreasing voltage after the charging current is switched off.
- high values of charging current (> 2.0 A), after a prolonged charging process (> 24 hours), during constant voltage charging of rectifiers with UI characteristic.
- lack or delay of "boiling" of damaged batteries when charging them (when visible).
- rapid decrease in voltage and electrolyte density for several days or even hours of rest (in the absence of electrical load).

Possible causes of the defect

a) manufacturing defect:

- very large/unacceptable shifting of the plates during installation, which leads to the upper edges of the plates touching in the bridge with opposite polarity.
- presence of lead droplets in the cells.
- presence of lead remains on bridges.
- damage, drilling, bending or absence of separator.
- sharp edges and/or lead remains on the plate grids.
- improper cleaning of paste residues on the plates, etc.

Note: *these factors mainly occur in the first 6 months of battery operation.*

b) non-compliant operating conditions:

- Corrosion of the grids and subsequent shorting after storing in the warehouse for a very long period of time in an uncharged state (in practice after more than 12 months).
- impaired tightness (punctured box), leading to the decrease in the electrolyte level and overheating of the battery.
- incorrect choice of battery with a mismatch between the requirements of the vehicle's electrical system and the battery's electrical parameters.
- battery temperature rising during operation leading to plate destruction.
- abnormally high consumption (battery discharge), which in turn leads to lifting of the plate edges and short circuit.

c) due to incorrect recharging:

- shorting due to high voltage of the charger and overheating of the electrolyte.

Note: *When the electrolyte density cannot be measured, the following must be considered: The voltage per cell of a fully charged lead-acid battery with a relative electrolyte weight of 1.28 g / dm3 at 25°C is 2.12V. When one cell of a 12 volt battery has a short circuit, the voltage of such a charged battery will be 10.5-10.6V.*

8.2.3. Sulfation of the plates

Characteristic features:

- low battery voltage.
- rapid increase in electrolyte temperature when charging.
- insignificant or slow increase in electrolyte density when charging.
- increased voltage and gas emission in the damaged cells when charging, immediately after switching on the charge. At the end of the charging, the voltage is lower (about 2,4 V) than in operating batteries (2,6-2,7 V).
- low capacity at control discharge
- insufficient starting power

Possible causes of the defect

a) manufacturing defect:

- violation of the recipe and the technological process in the preparation of the paste.
- incorrect plate formation process.
- increased electrolyte density at formation.

b) non-compliant operating conditions:

- storage of the battery for a long period of time (more than 6 months) and/or storage with a voltage lower than specified in p. 7.
- high ambient temperature in the place of storage.

c) due to incorrect recharging:

- increased internal resistance of the terminals, leading to insufficient battery charge.

Note: *During the discharging process, lead sulfate is formed on the positive and negative plates. The longer the battery is left in a state of discharge, the more the small lead sulfate crystals increase, and it becomes difficult to convert them back to lead dioxide. Sulfation slows the chemical reaction between the acid (electrolyte) and the active substance on the plates and prevents the battery operation. Even after charging, in most cases the voltage will be low (approximately between 10.9V and 12.4V). In most cases, this damage is irreversible, and the battery cannot be in service. Sulfation can cause other defects due to malfunctioning of the plates. Sulfation and its caused defects are not manufacturing defects.*

8.2.4. Fast self-discharge

Characteristic features:

- low starting ability / power;
- rapid decrease in the voltage and electrolyte density in affected batteries;
- rapid loss of capacity;

Possible causes of the defect:

a) manufacturing defect:

- internal leakage.
- the presence of incompatible ingredients in the used materials.

b) as a result of storage and handling:

- storage of batteries at temperatures beyond the range specified in p. 4.2.
- contamination of the battery surface.

c) due to incorrect recharging:

- battery overcharging (high charger output voltage, high charging currents, long charging duration).

8.2.5. Low state of charge

Low state of charge is the first stage of deep discharge. At low state of charge, the active substance will not suffer any damage. The battery can still be charged with a standard charger.

Characteristic features:

- low starting current (insufficient starting capability).
- open circuit voltage according to the table in p. 7.1.
- reduced electrolyte density.

Possible causes of the defect:

a) manufacturing defect:

- Prolonged shelf life in the manufacturer's warehouse.

b) non-compliant operating conditions:

- discharged battery (irregular check of electrolyte density or battery charge level).
- malfunctioning alternator.
- low voltage output current from the regulator.
- high contact resistances caused by loose cable connections or contamination of cable terminals.
- loose alternator drive belts.
- insufficient engine run time due to short travel times.
- additional electrical equipment.
- malfunctioning equipment causing continuous discharge.
- prolonged downtime (a lead-acid battery is an open electrochemical system with parameters that are NOT constant and depend on downtime, temperature, and other external and internal factors), i.e., the battery has a natural self-discharge characteristic during downtime.

c) due to incorrect recharging:

- malfunctioning of the charger.

8.2.6. Stratification of the acid

Characteristic features

- high battery voltage with open circuit, but low starting power and capacity.
- difficult charging of the battery at constant voltage.

Possible causes of the defect:

a) as a result of storage and handling:

- Long stay in the warehouse without recharging.

Note: *Acid stratification is a common cause of battery damage. In a stratified battery, the electrolyte is concentrated on the bottom, and the upper half of the cell has very little acid. Stratification occurs when the*

battery is kept at low charge (below 80%) and never fully charged. Acid stratification reduces the overall efficiency of the battery.



Image 1.



Image 2.

Image 1 shows a normal battery in which the acid is evenly distributed from top to bottom. This battery has good efficiency because the acid is evenly distributed on the plates with the right concentration. Image 2 shows a stratified battery in which the acid concentration is low on top and high on the bottom. The low concentration limits the activation of the plates, accelerates corrosion, and reduces efficiency. On the other hand, the high concentration of acid at the bottom artificially increases the voltage in the open circuit. The battery appears to be fully charged but provides low starting power. The high concentration of acid also leads to sulfation and further reduces the already low conductivity. If this goes unnoticed, it will eventually damage the battery. Fully recharging or shaking of the battery may fix the problem.

8.2.7. Low staring power (CCA)

Cold cranking amps (CCA) is the current the battery can deliver at -18 °C for 30 seconds while maintaining a voltage above 7.2 V.

Difficulty starting the engine, especially at low temperatures, is usually a sign of battery end of service life caused by normal battery usage. This is due to the gradual corrosion processes of the grid and the loss of active mass on the positive plate. Usually at moderate temperatures these signs go unnoticed, and a sudden cold weather can cause the battery to fail starting the engine.

The premature occurrence of such a problem is most likely caused by overcharging and/or excessively high temperature, as well as by deep battery discharge and systematic undercharging of the battery. In this case, it is extremely important to check the condition of the alternator so that this does not happen again with the new battery. However, even with an upright alternator, when travelling short distances (frequent engine starts), the alternator cannot fully charge the battery and a deep discharge process occurs.

Characteristic features:

- a direct method for measuring the CCA parameter that is indicated on the label. It is secured by the battery design and confirmed ONLY by actual laboratory testing at -18^{0}C, according to EN 50342-1:2016 standard. For this method, the battery must meet the requirements of p. 6.2 of the above standard.
- an indirect method of measuring the CCA parameter, which is indicated on the label is to use portable electronic analyzers. Due to the nature of data processing and non-standard measurement conditions, the results* of these measurements are indirect and ONLY indicative. For deviations greater than 10% of the CCA noted on the label, consideration must be given to: state of charge, down time, storage temperature, and other conditions, some of which are mentioned in the note below.

Possible causes of the defect:

a) manufacturing defect:

- Increased internal resistance due to unwelded plates.
- Deviation in technological operations during production.
- Undercharged batteries.

b) as a result of storage and handling:

- Low state of charge due to long downtime.
- Low temperature during testing with electronic portable tester.

**** Note:** When measuring the CCA using a portable tester (indirect method), deviations from the stated CCA values are allowed within ± 10% of the declared values on the label at 100% state of charge and at an electrolyte temperature of 25^{0}C in the battery, noting also the acceptable measurement error (for most instruments ± 5%), which is specified in the operating instructions of the manufacturers of portable testers. In the case of measurement of CCA with portable testers, in the technical characteristics of which there is no data of the allowed error in the measurement of CCA, the results of the measurements are only for reference.*

In case of decrease of the CCA parameter by more than 10%, which indicates for increased internal resistance of the battery, it is necessary to make sure that the measurement is correct (100% charge level, temperature 25^{0}C, setting mode of the tester). Decreased charge may occur due to self-discharge (prolonged battery life in storage).

In case of impossibility to observe the temperature requirements when measuring CCA by means of portable testers, it is recommended to use the data from the graphs below to correlate the results. When measuring CCA with portable testers at a charge level of less than 100% (due to storage of the battery in warehouse), the following graphs are used to correlate the measured data.

8.2.8. Deep discharge

The battery is deeply discharged when its capacity is fully deplated. The longer the battery remains in this state, the greater will be the damage done to the active substance. The plates begin to sulphatize and charging becomes impossible. This damage is irreversible.

When the battery is subjected to a deep discharge (i.e., over 40%) and then a rapid charge, the process of releasing active substance from the plates is accelerated. In addition, if during charging the battery is not sufficiently recharged after the discharge cycle, the battery will quickly lose its capacity. Even after charging, the voltage will be low (below 12.4V- for standard type of battery, but the cells will have high electrolyte density. Possible causes of deep discharge are:

- See "Causes of low state of charge".
- The headlights and additional lights.
- Using other electrical equipment when the charging system (vehicle alternator) is switched off.

8.2.9. Overcharging

If the voltage regulator on the charger/vehicle is not working or is not set correctly, the battery may be subjected to excessive charging. It will overheat and begin to evaporate the water from the electrolyte, increasing its density; the active substance will dissolve and settle on the separator or the cell sides; severe corrosion of the grid will occur. The high temperature leads to lower internal resistance inside the battery, causing an increase in charging current, which further increases the effect of overcharging. Ultimately the battery will lose its capacity.

9. Natural deterioration and how to increase the life of your battery?

To increase the service life of your battery you should follow the rules described in this manual as well as:

- Check the charging system at least twice a year with a multimeter at 2000 rpm, then the voltage should be 13.8 to 14.4 V. If the voltage is below this, the battery may not be charging due to a problem with the charging system.
- Do not use unnecessary consumers when the car is stopped with engine on (lights, audio system, etc.) When the engine is running at low speed, the charge is weak, and the consumed capacity cannot be restored.
- When starting the engine, do not hold the starter for more than 7 seconds and a maximum of 2-3 attempts every 30 seconds. If the engine does not start, the problem needs to be fixed for a trouble-free start.
- In winter, BEFORE starting the engine, do a battery "warm up" procedure. We recommend turning the lights on for approximately 4-5 seconds, then turn off and start. This procedure results in a more efficient start in winter.
- During winter, the alternator fails to charge the battery fully due to high consumption (heating, headlights, etc.). It is recommended to remove the battery from the vehicle and charge it fully once during winter.
- DO NOT allow the battery to remain in a discharged state in the vehicle at freezing temperatures. It is possible for the low-density electrolyte to freeze, resulting in battery destruction.
- Always select a battery with recommended parameters from the vehicle manufacturer. A battery with lower parameters is likely to overcharge systematically, larger ones may not charge sufficiently.

10. MANUFACTURER'S WARRANTY

The manufacturer guarantees the correct operation of the batteries in regions with normal and tropical climates only if all the conditions for storage, transport and maintenance described in these instructions are met.

Claims can be submitted for defects that are detected during the warranty period of operation or storage, due to the manufacturer's fault, only if it is determined that all the conditions described in this manual have been correctly observed. Described technical problems caused by inappropriate storage or operating conditions should not be treated as manufacturing defects and are therefore not covered by the warranty.