5. INPUT

Input voltage	nom.	DC 24V	
Input voltage ranges	nom.	22.5 to 30Vdc	Continuous operation, see Fig. 5-1
		30 to 35Vdc	Temporarily allowed, no damage to the DC-UPS *)
		35Vdc	Absolute maximum input voltage with no damage to the DC-UPS
		0 to 22.5Vdc	The DC-UPS switches into buffer mode and delivers output voltage from the battery if the input was above the turn-on level before and all other buffer conditions are fulfilled.
Allowed input voltage ripple	max.	1.5Vpp	Bandwidth <400Hz
		1Vpp	Bandwidth 400Hz to 1kHz
Allowed voltage between input and earth (ground)	max.	60Vdc or 42.4Vac	
Turn-on voltage	typ.	22.8Vdc	The output does not switch on if the input voltage does not exceed this level.
	max.	23Vdc	
Input current **)	typ.	120mA	Internal current consumption
	typ.	1.1A	Current consumption for battery charging in constant current mode at 24V input See Fig. 8-2 ***)
External capacitors on the input		No limitation	

*) The DC-UPS shows "Check Wiring" with the red LED and buffering is not possible

**) The total input current is the sum of the output current, the current which is required to charge the battery during the charging process and the current which is needed to supply the DC-UPS itself. See also Fig. 5-2. This calculation does not apply in overload situations where the DC-UPS limits the output current, therefore see Fig. 5-3.

***) Please note: This is the input current and not the current which flows into the battery during charging. The battery current can be found in chapter 8.

Fig. 5-1 **Input voltage range**

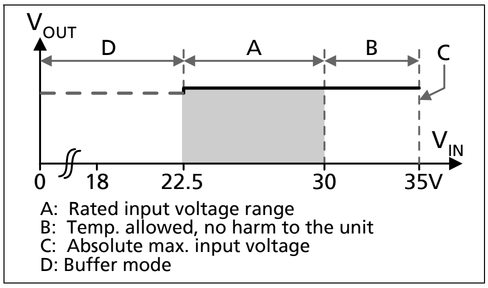
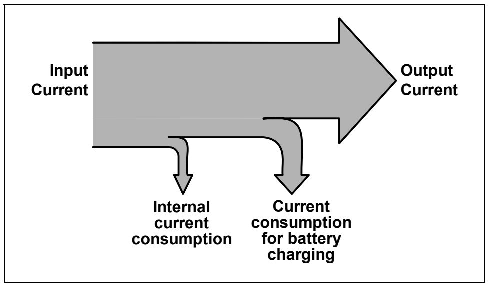


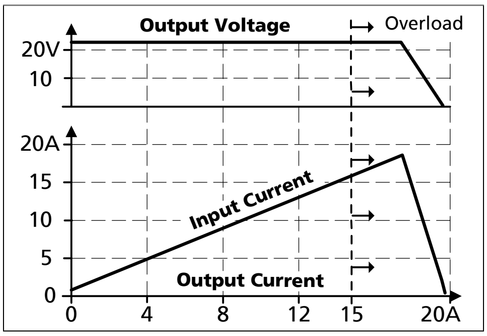
Fig. 5-2 **Input current, definitions**



Electronic output current limitation

The DC-UPS is equipped with an electronic output current limitation. This current limitation works in a switching mode which reduces the power losses and heat generation to a minimum. As a result, the output voltage drops since there is not enough current to support the load. A positive effect of the current limitation in switching mode is that the input current goes down despite an increase in the output current resulting in less stress for the supplying source.

Fig. 5-3 **Input current and output voltage vs. output current, typ. (battery fully charged)**



6. Output in Normal Mode

Output voltage in normal mode	nom.	DC 24V	The output voltage follows the input voltage reduced by the input to output voltage drop.
Voltage drop between input and output	max.	0.3V	At 10A output current, see Fig. 6-1 for typical values
	max.	0.45V	At 15A output current, see Fig. 6-1 for typical values
Ripple and noise voltage	max.	20mVpp	20Hz to 20MHz, 50Ohm *)
Output current	nom.	15A	Continuously allowed
Output power	nom.	360W	Continuously allowed
Short-circuit current	min.	17.9A	Load impedance 100mOhm, see Fig. 6-2 for typical values
	max.	21A	Load impedance 100mOhm, see Fig. 6-2 for typical values
Capacitive and inductive loads		No limitation	

*) This figure shows the ripple and noise voltage which is generated by the DC-UPS. The ripple and noise voltage might be higher if the supplying source has a higher ripple and noise voltage.

Fig. 6-1 **Input to output voltage drop, typ.**

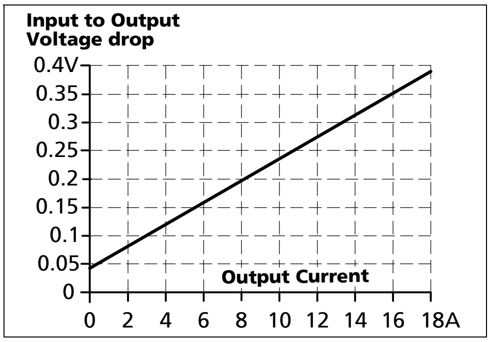
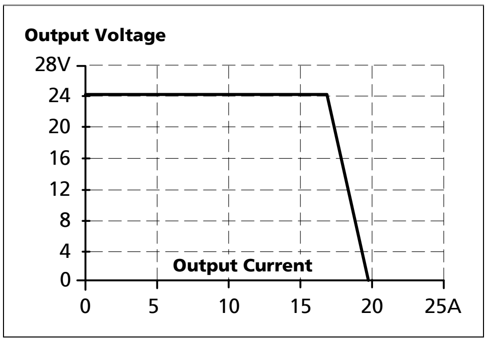


Fig. 6-2 **Output voltage vs. output current in normal mode at 24V input, typ.**



7. Output in Buffer Mode

If the input voltage falls below a certain value (transfer threshold level), the DC-UPS starts buffering without any interruption or voltage dips. Buffering is possible even if the battery is not fully charged.

Output voltage in buffer mode	nom.	DC 24V	Output voltage is stabilized and independent from battery voltage
		22.45V	±1%, at no load,
		22.25V	±1%, at 10A output current
Transfer threshold for buffering	typ.	80mV higher than the output voltage in buffer mode	
Ripple and noise voltage	max.	20mVpp	20Hz to 20MHz, 50Ohm
Output current	nom.	10A	Continuously allowed
		15A	< 5s with full output voltage *)
Short-circuit current	min.	17.9A	Load impedance 100mOhm **)
	max.	21A	Load impedance 100mOhm **)

*) If the output current is in the range between 10A and 15A for longer than 5s, a hardware controlled reduction of the maximal output current to 10A occurs. If the 10A are not sufficient to maintain the 24V, buffering stops after another 5s. The buffering is possible again as soon as the input voltage recovers.

**) If the nominal output voltage cannot be maintained in buffer mode, the DC-UPS switches off after 5s to save battery capacity.

Fig. 7-1 **Buffering transition, definitions**

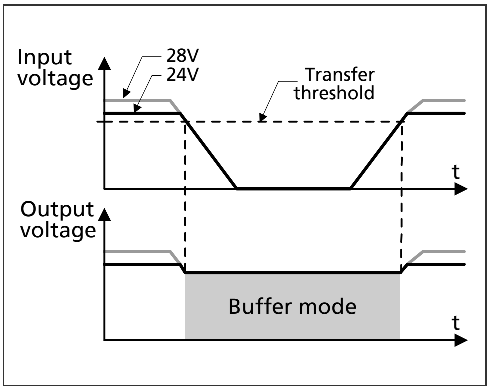


Fig. 7-2 **Transfer behavior, typ.**

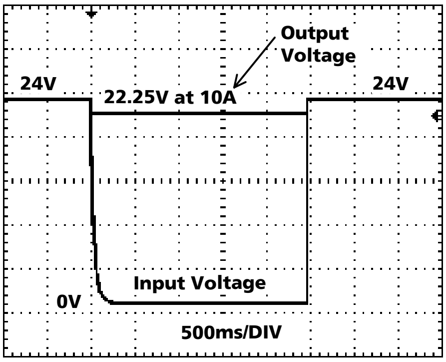


Fig. 7-3 **Available output current in buffer mode**

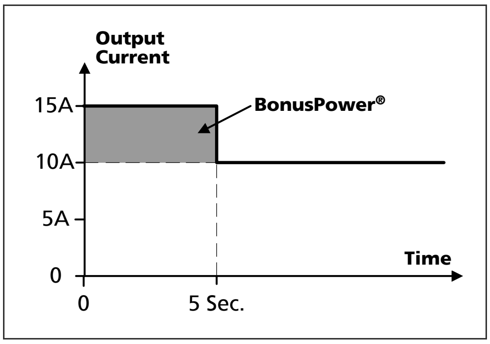
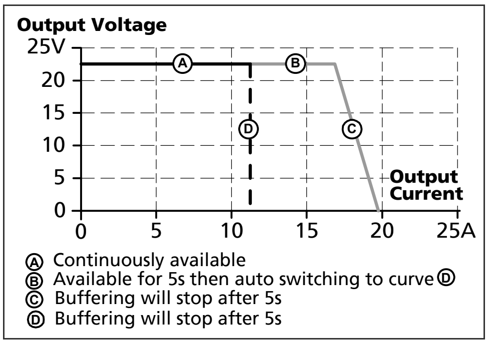


Fig. 7-4 **Output voltage vs. output current in buffer mode, typ.**



All parameters are specified at an input voltage of 24V, 10A output load, 25°C ambient and after a 5 minutes run-in time unless otherwise noted. It is assumed that the input power source can deliver a sufficient output current.

8. BATTERY INPUT

The DC-UPS requires one 12V VRLA battery to buffer the 24V output.

Battery voltage	nom.	DC 12V	Use one maintenance-free 12V VRLA lead acid battery or one battery module which is listed in the chapter accessories.
Battery voltage range		9.0 – 15.0V	Continuously allowed, except deep discharge protection
	max.	35Vdc	Absolute maximum voltage with no damage to the unit
	typ.	7.4V	Above this voltage level battery charging is possible
Allowed battery sizes	min.	3.9Ah	
	max.	27Ah	
Internal battery resistance	max.	100mOhm	See individual battery datasheets for this value
Battery charging method		CC-CV	Constant current, constant voltage mode
Battery charging current (CC-mode)	nom.	1.5A	Independent from battery size,
	max.	1.7A	Corresponding 24V input current see Fig. 8-2
End-of-charge-voltage (CV-mode)		13.4-13.9V	Adjustable, see chapter 14
Battery charging time	typ.	5h *)	For a 7Ah battery
	typ.	17h *)	For a 26Ah battery
Battery discharging current **)	typ.	21A	Buffer mode, 10A output current, 11.5V on the battery terminal of the DC-UPS, see Fig. 8-1 for other parameters
	typ.	0.3A	Buffer mode, 0A output current
	max.	50µA	At no input, buffering had switched off, all LEDs are off
	typ.	270mA	At no input, buffering had switched off, yellow LED shows “buffer time expired” (max. 15 minutes)
Deep discharge protection ***)	typ.	10.5V	At 0A output current
	typ.	9.0V	At 10A output current

*) The charging time depends on the duration and load current of the last buffer event. The numbers in the table represent a fully discharged battery. A typical figure for a buffer current of 10A is 3h 20Min. for a 7Ah battery.

**) The current between the battery and the DC-UPS is more than twice the output current. This is caused by boosting the 12V battery voltage to a 24V level. This high current requires large wire gauges and short cable length for the longest possible buffer time. The higher the resistance of the connection between the battery and the DC-UPS, the lower the voltage on the battery terminals which increases the discharging current. See also chapter 25 for more installation instructions.

***) To ensure longest battery lifetime, the DC-UPS has a battery deep discharge protection feature included. The DC-UPS stops buffering when the voltage on the battery terminals of the DC-UPS falls below a certain value. The yellow LED will show “buffer time expired” for a period of 15 minutes after the unit stopped buffering.

Fig. 8-1 **Battery discharging current vs. output current, typ.**

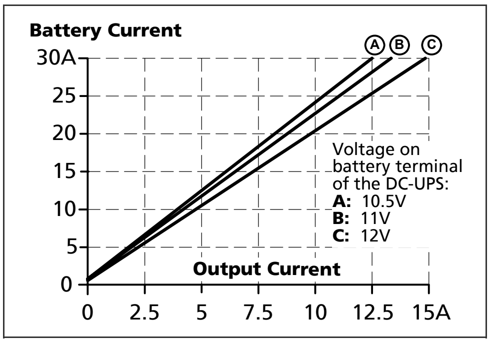
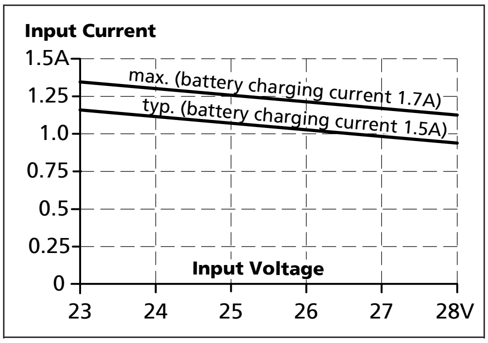


Fig. 8-2 **Required input current vs. input voltage for battery charging**



9. BUFFER TIME

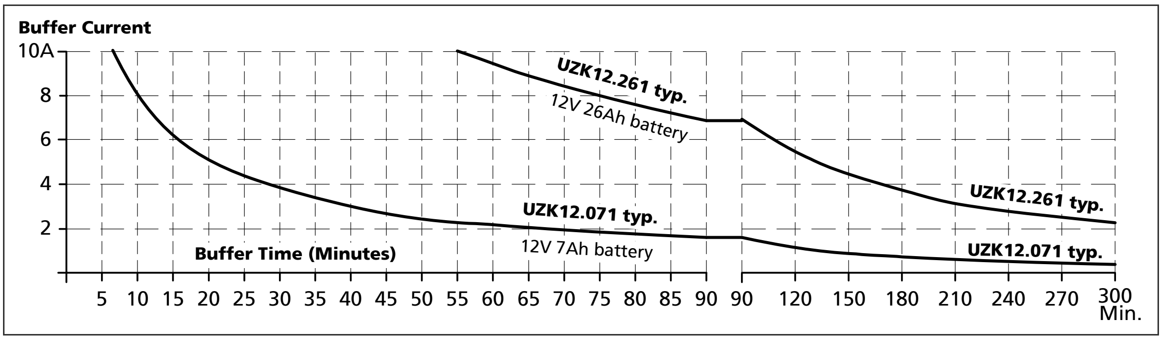
The buffer time depends on the capacity and performance of the battery as well as the load current. The diagram below shows the typical buffer times of the standard battery modules.

Buffer time with battery module UZK12.071	min.	19'12''	At 5A output current *)
	min.	5'42''	At 10A output current *)
	typ.	21'30''	At 5A output current, see Fig. 9-1 **)
	typ.	6'45''	At 10A output current, see Fig. 9-1 **)
Buffer time with battery module UZK12.261	min.	99'30''	At 5A output current *)
	min.	39'	At 10A output current *)
	typ.	130'	At 5A output current, see Fig. 9-1 **)
	typ.	55'	At 10A output current, see Fig. 9-1 **)

*) Minimum value includes 20% aging of the battery and a cable length of 1.5m with a cross section of 2.5mm² between the battery and the DC-UPS and requires a fully charged (min. 24h) battery.

**) Typical value includes 10% aging of the battery and a cable length of 0.3m with a cross section of 2.5mm² between the battery and the DC-UPS and requires a fully charged (min. 24h) battery.

Fig. 9-1 **Buffer time vs. output current with the battery modules UZK12.071 and UZK12.261**



The battery capacity is usually specified in amp-hours (Ah) for a 20h discharging event. The battery discharge is non-linear (due to the battery chemistry). The higher the discharging current, the lower the appropriable battery capacity. The magnitude of the reduction depends on the discharging current as well as on the type of battery. High current battery types can have up to 50% longer buffer times compared to regular batteries when batteries will be discharged in less than 1 hour.

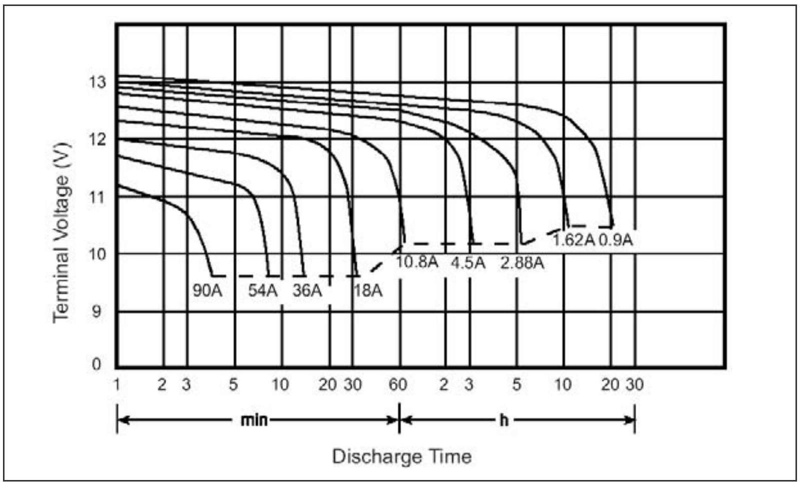
High discharging currents do not necessarily mean high power losses as the appropriable battery capacity is reduced with such currents. When the battery begins to recharge after a discharging event, the process is completed much faster since only the energy which was taken out of the battery needs to be "refilled".

For this reason, the buffer time cannot be calculated using the Ah capacity value. The equation "I x t" = capacity in Ah generally leads to incorrect results when the discharging current is higher than C20 (discharging current for 20h). The battery datasheet needs to be studied and a determination of the expected buffer time can be made according to the following example:

Example how to determine the expected buffer time for other battery types and battery sizes:

Step 1 Check the datasheet of the battery which is planned to be used and look for the discharging curve. Sometimes, the individual discharging curves are marked with relative C-factors instead of current values. This can easily be converted. The C-factor needs to be multiplied with the nominal battery capacity to get the current value. E.g.: 0.6C on a 17Ah battery means 10.2A.

Fig. 9-2 **Typical discharging curve of a typical 17Ah battery, curve taken from a manufacturer's datasheet**



Step 2 Determine the required battery current. Use Fig. 8-1 "Battery discharging current vs. output current" to get the battery current. Fig. 8-1 requires the average voltage on the battery terminals. Since there is a voltage drop between the battery terminals and the battery input of the DC-UPS, it is recommended to use the curve A or B for output currents > 3A or when long battery cables are used. For all other situations, use curve C.

Step 3 Use the determined current from Step 2 to find the appropriate curve in Fig. 9-2. The buffer time (Discharging Time) can be found where this curve meets the dotted line. This is the point where the DC-UPS stops buffering due to the under-voltage lockout.

Step 4 Depending on Fig. 9-2, the buffer time needs to be reduced to take aging effects or guaranteed values into account.

Example:

The buffer current: is 7.5A and a battery according Fig. 9-2 is used. The cable between the battery and the DC-UPS is 1m and has a cross section of 2.5mm^2. How much is the maximum achievable buffer time.

Answer:

- According to Fig. 8-1, the battery current is 18A. Curve A is used since the battery current is > 3A and the length of the cable is one meter.
- According to Fig. 9-2, a buffer time (Discharging Time) of 30 Minutes can be determined. It is recommended to reduce this figure to approximately 24 minutes for a guaranteed value and to cover aging effects.

10. Efficiency and Power Losses

Efficiency	typ.	97.8%	Normal mode, 10A output current, battery fully charged
Power losses	typ.	2.9W	Normal mode, 0A output current, battery fully charged
	typ.	5.5W	Normal mode, 10A output current, battery fully charged
	typ.	5.0W	During battery charging, 0A output current
	typ.	18.5W	Buffer mode, 10A output current

Fig. 10-1 **Efficiency at 24V, typ.**

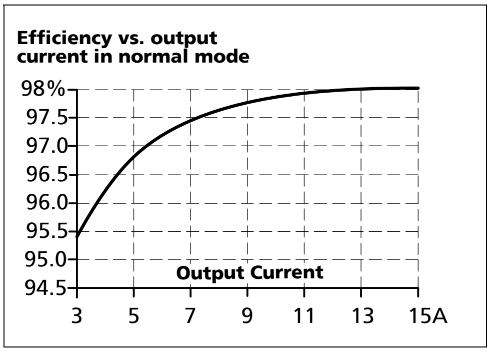
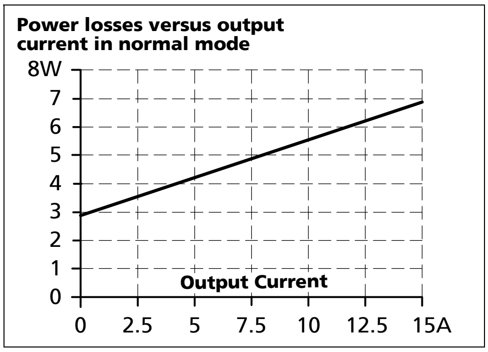
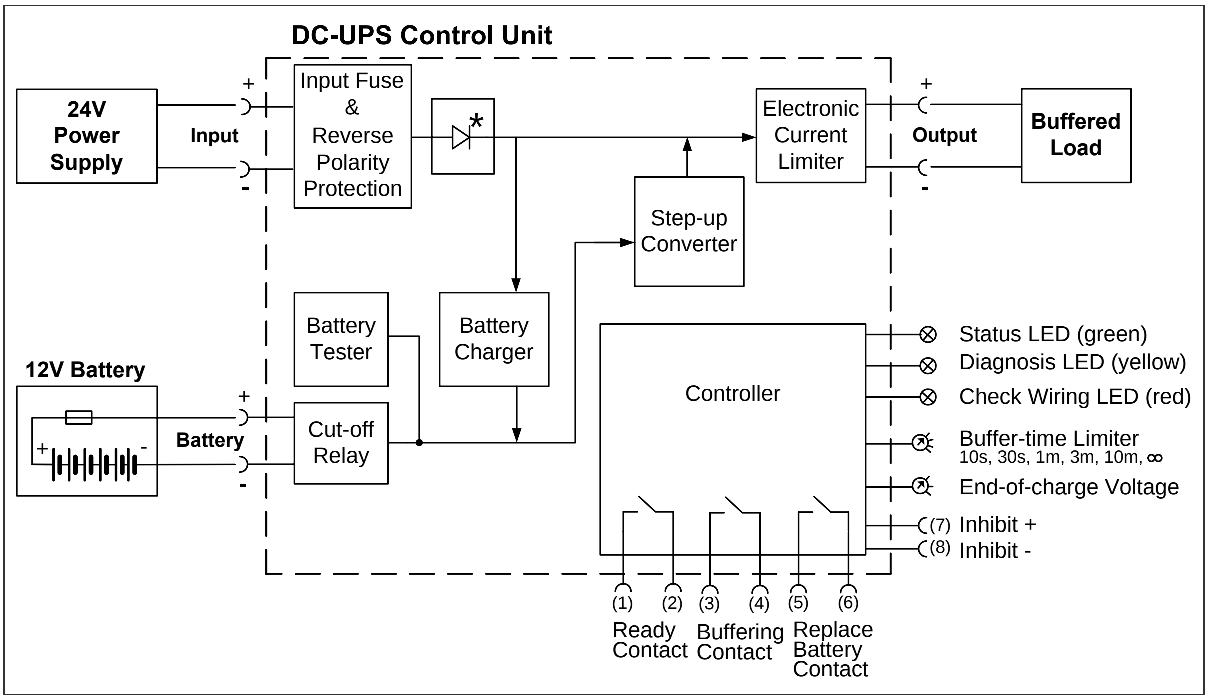


Fig. 10-2 **Losses at 24V, typ.**



11. Functional Diagram

Fig. 11-1 **Functional diagram**



*) Return current protection; This feature utilizes a Mosfet instead of a diode in order to minimize the voltage drop and power losses.

12. Check Wiring and Battery Quality Tests

The DC-UPS is equipped with an automatic “Check Wiring” and “Battery Quality” test.

“Check Wiring” test:
Under normal circumstances, an incorrect or bad connection from the battery to the DC-UPS or a missing (or blown) battery fuse would not be recognized by the UPS when operating in normal mode. Only when back up is required would the unit not be able to buffer. Therefore, a “check wiring” test is included in the DC-UPS. This connection is tested every 10 seconds by loading the battery and analyzing the response from the battery. If the resistance is too high, or the battery voltage is not in range, the unit displays “Check Wiring” with the red LED. At the same time the green “Ready” LED will turn off.

“State of Health” (SoH) test:
The battery has a limited service life and needs to be replaced in a fixed interval which is defined by the specified service life (acc. to the Eurobat guideline), based on the surrounding temperature and the number of charging/discharging cycles. If the battery is used longer than the specified service life, the battery capacity will degrade. Details can be found in chapter 27.1. The battery SoH test can not determine a gradual loss in capacity. However, it can detect a battery failure within the specified service life of the battery. Therefore a SoH is included in the DC-UPS.

The battery quality test consists of different types of tests:

- During charging:
  If the battery does not reach the ready status (see chapter 14) within 30h, it is considered to be defective. The reason could be a broken cell inside the battery.
- During operation:
  Once the battery is fully charged, a voltage drop test and a load test is performed alternately every 8 hours. Three of the tests must consecutively produce negative results to indicate a battery problem.

A battery problem is indicated with the yellow LED (replace battery pattern) and the relay contact “Replace Battery”. Please note that it can take up to 50 hours (with the largest size of battery) until a battery problem is reported. This should avoid nuisance error messages as any urgent battery problems will be reported by the “Check Wiring” test and create a warning signal. The battery tests require up to 50h uninterrupted operation. Any interruptions in the normal operation of the DC-UPS may result in the “Replace Battery” test cycle to start over.

When “Replace battery” is indicated, it is recommended to replace battery as soon as possible.