Especially for VRLA batteries, it turned out that longer lifetimes can be achieved with the constant current/constant voltage/constant current (IUI_a) charging as shown in Figure 18.23(c) ([4]). After the current drops during the constant-voltage phase below the limit for I_a charging, the charging is continued for a limited time or amount of charge with a constant current. The voltage is not limited during this phase, but the I_a current must be limited in the range of I_{50} to I_{100}. No commercial device in PV applications uses such a scheme these days.

It is necessary to take into account that the batteries in PV systems hardly ever get fully charged due to the limited charging time per day [4]. Therefore, the term full charge has to be distinguished in a real full charge, defined by the point at which the complete active material is converted into charged material, and a practical or solar full state of charge (Figure 18.3). The latter is defined by the maximum state of material conversion that can be achieved during a sunny summer day or the maximum operation time of the back-up generator that is accepted by the system operator. A "solar full charge" requires at least 5 h at a battery voltage of 2.4/cell.

In hybrid systems, a solar full charging can be achieved by operation of the back-up generator or from the PV generator. Full charging every four weeks is recommended. A detailed analysis of the operational data from systems showed that this has little impact on the overall energy balance, but is obviously enhancing the battery lifetime.

For batteries in systems of Class 1, according to Figure 18.6 an end-of-charge voltage of 2.4 V/cell is appropriate. However, the duration per day at this voltage should be limited to two hours. During the rest of the day (if the charging power is available), the battery voltage should be limited to 2.3 V/cell (charging regime as in Figure 18.23(b)).

In systems of Classes 2, 3 and 4, the end-of-charge voltage should be 2.45 V/cell also limited to 2 hours per day. An end-of-charge voltage of 2.35 V/cell for the rest of the day is appropriate (charging regime as in Figure 18.23(b)).

The values are valid for flooded and for VRLA batteries. In addition, for flooded batteries an increase of the end-of-charge voltage up to 2.6 V/cell periodically for a maximum of 5 hours per 14 days is appropriate. This causes gassing and therefore stirring of the electrolyte. Nevertheless, an active electrolyte-stirring system as shown in Figure 18.22 is the best and most efficient solution.

A significant lifetime extension can be achieved if the battery is charged to a really full SOC at least twice a year. This can be achieved by charging the battery normally to a solar-full SOC followed by a complete discharge with approximately I_{10}. The discharge must be followed by a recharge according to the IUI_a charging regime (Figure 18.23c) where the battery gets charged with 110 to 120% of the ampere-hour capacity taken from the battery in the previous discharge or the nominal capacity (whatever value is higher).

The end-of-charge voltage limit depends on the battery-operating condition and on the temperature. All values for the voltage limits given here are for a battery temperature of 25°C. At increasing temperatures, the voltage must be reduced by 4 to 5 mV/(K*cell) but not below 2.25 V/cell. At temperatures below 25°C, the voltage must be increased accordingly but not above 2.6 V/cell. To protect DC loads or electronic devices connected directly to the DC bus bar, it might be necessary to limit the maximum voltage accordingly.