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Information Leaflet

Charger assignments for traction batteries in vented (PzS) and in valve regulated (PzV) design

Today the range of traction batteries for motive power applications is quite diversified. Many traction batteries have been designed for special requirements and constitute a system together with the charger. The correct assignment of chargers to batteries is important for different reasons. The available charging time and the specific battery design basically determine the size and kind of charger, respectively the charging regime.

For the batteries the following basic design features can be defined:

- Vented batteries (flooded electrolyte)
- Vented batteries with periphery (water topping up system, air mix, cooling)
- Valve regulated batteries (Gel electrolyte)

The applications can be differentiated as follows:

- One, two or three shift applications
- Low duty
- Heavy duty
- Opportunity charge operations

Opportunity charges are partial charges in order to prolong the battery operation. Opportunity charges cannot replace regular full charges.

In DIN 41772 features of semiconductor rectifiers (chargers) are described. Here the basic charging characteristics are described e.g.:

- Taper charge characteristics (decreasing current) W
- Constant voltage characteristics U
- Constant current characteristics I

Short notations for additional features

- Charging regimes with automatic switch over 0 (zero)
- Automatic shut off a

So for chargers the following charging regime examples result:

W-characteristics (taper):
W, Wa, W0Wa,WU,WUWa

U-characteristics
U

I-characteristics
I, Ia, I0Ia, IU, IUW, IUIa

Chargers with these characteristics have to respect defined tolerances for current and voltage values.
For I-characteristics according to DIN 41773: ± 2% for the current value, ± 1% for the voltage, for W characteristics according to DIN 41774: ± 0.05 Vpc.

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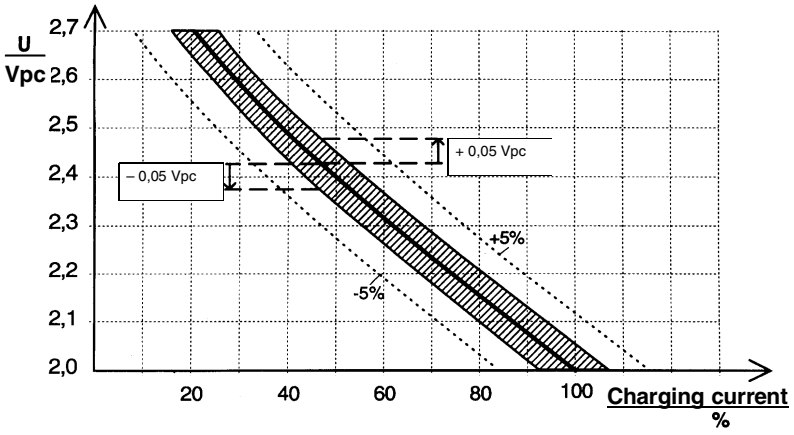
For the charge of lead acid batteries unregulated and regulated chargers are used. Chargers with the taper-characteristics (Wa, Wsa, W0Wa) do not control the charging current.

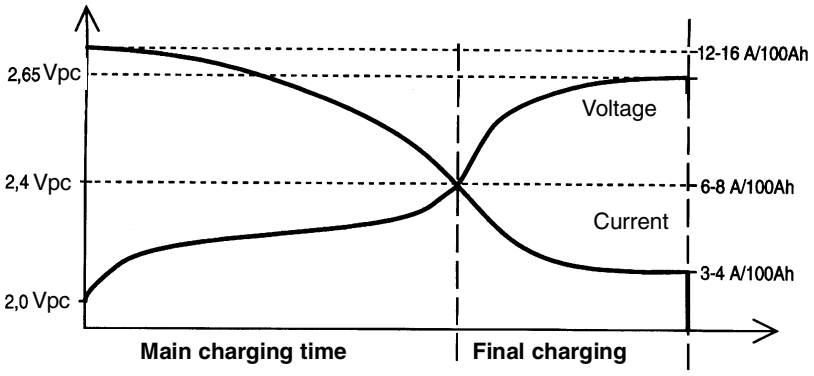
Therefore the current is susceptible to mains voltage variations (see diagram on the right). Regulated chargers with I- or U-characteristics control the respective indicated parameters.

Charging current – voltage relationship for W-(taper) characteristics with the tolerance range of ± 0.05 Vpc and the effect of mains voltage fluctuations of 5 %.

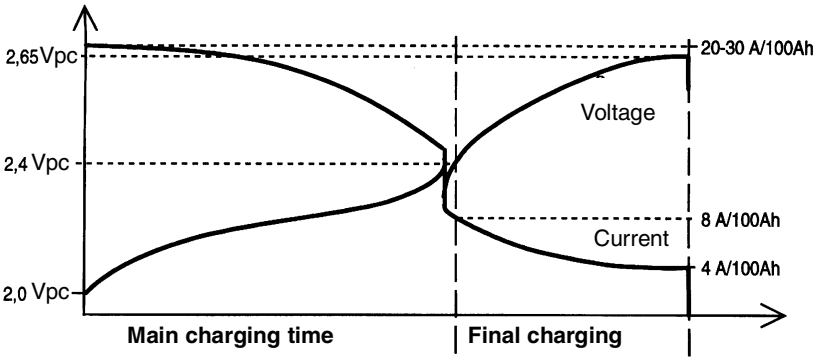


The following diagrams show examples for the different relations of the voltage "U" and the current "I". All values are referred to a battery nominal temperature of 30 ˚C and 80 % depth of discharge. The stated end-of-charge voltage of 2.65 Vpc corresponds to the DIN reference value. In real applications higher or lower values depending on battery technology, temperature and service can be found.

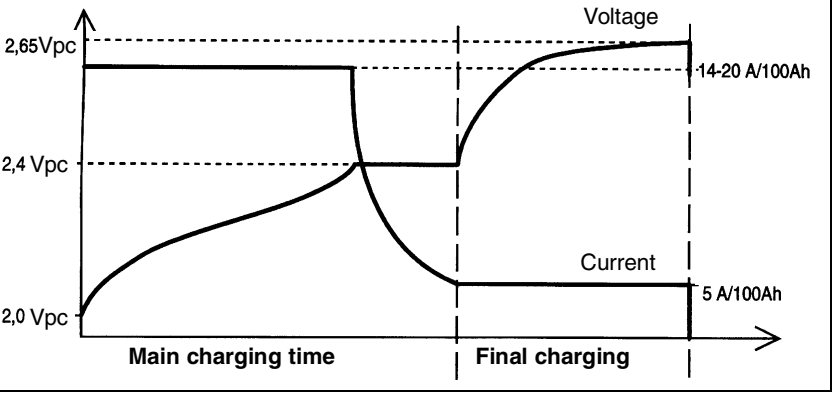
1. Wa-characteristics (taper) for flooded batteries



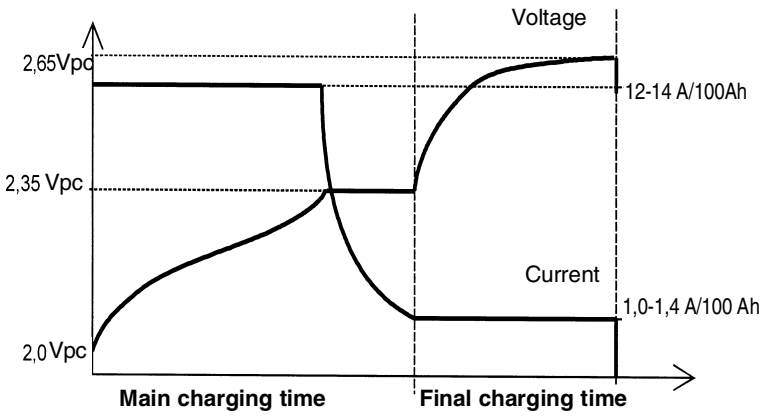
2. WaW0- (double slope taper) characteristics for flooded batteries



3. IUIa-characteristics for flooded batteries



4. IUIa-characteristics for valve regulated batteries



For the assignment of the battery to the charger the following criteria should be respected:

- Battery (nominal voltage and nominal capacity
- Battery technology (e.g. PzS, PzV)
- Battery periphery (e.g. water topping up system, air mix, cooling)
- Breaks or rest times of the battery
- Charging time
- Opportunity charge
- Equalising charge

These factors determine:

- Type of charger, respectively charging regimes
- Nominal voltage of the charger
- Nominal current of the charger
- Periphery of the charger

The assignment of the charger to the battery has necessarily to be made according to the requirements from the battery manufacturer. A wrong assignment with not adapted charging currents and regimes can lead to the following negative effects:

- Deviating charging times
- Excessive battery temperatures
- Excessive gassing
- Shedding of positive active mass
- High water consumption
- Increased corrosion
- Insufficient charges
- Overcharge

All above mentioned negative effects significantly influence the service life of traction batteries.

Complementary information are supplied in the ZVEI reference sheet „Considerations on the service life of traction batteries“.

Below the charging times in dependence of the charging regime, the charging factor and the battery design are shown. The respective parameters are different depths of discharge (DOD) and charger nominal currents.

Charger assignment for vented PzS-batteries

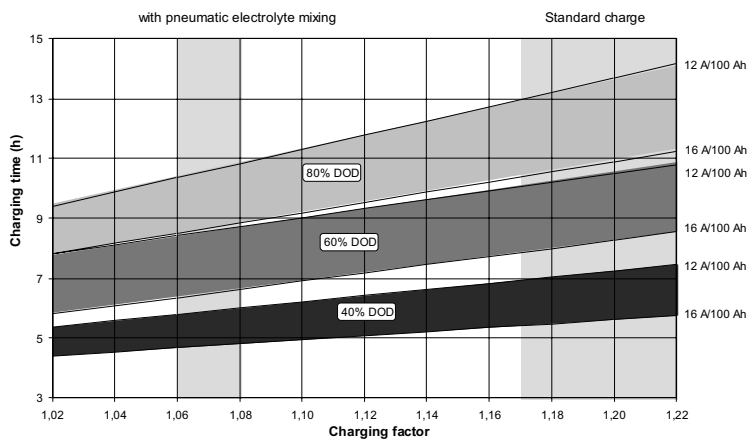
In comparison to the Wa-characteristics the charging regimes W0Wa and IUIa allow a higher nominal current until the gassing voltage of 2.4 Vpc (30 ˚C) is reached.

The charging factor CF is the ratio between the charged and the discharged Ampere hours. In case of a standard charging factor of 1.2, 480 Ah are charged into a 80 % discharged 500 Ah battery.

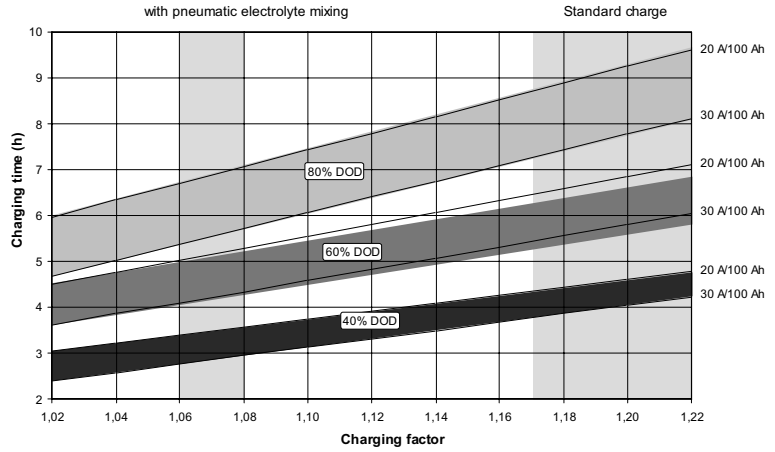
Calculation: 80 % of 500 Ah = 400 Ah, 400 Ah x 1.2 = 480 Ah.

Batteries with air mix only need a charging factor of approx. 1.07. Sophisticated chargers automatically adjust the charge to the preset charging factor, i.e. the final charging time is automatically adapted to the respective depth of discharge of the battery.

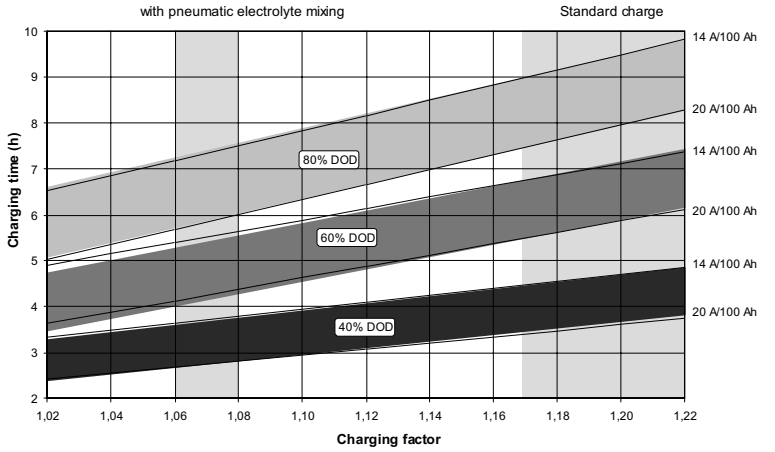
1. Charging times in hours with Wa-characteristics for PzS batteries at 30 ˚C



2. Charging times with W0Wa-characteristics in hours for PzS batteries at 30 ˚C

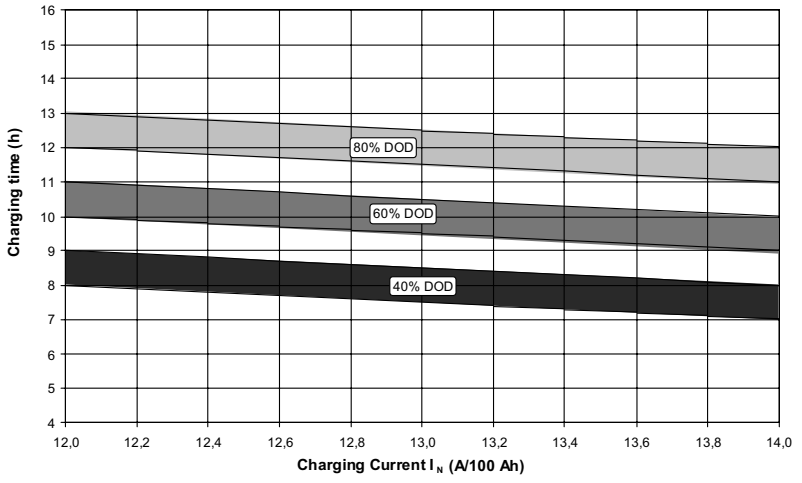


3. Charging times with IUIa-characteristics in hours for PzS batteries at 30 ˚C



Example calculation:
For the Wa-characteristics and a PzS battery without airmix, i.e. a charging factor of 1.2, the charger's nominal current shall be determined: The charging time shall not exceed 12 hours. The battery has a nominal capacity of 800 Ah and is discharged to 80 % DOD. From the graph a nominal charging current of 14 A/100 Ah is read: Therefore the charger's nominal current is 8 x 14 A = 112 A.

4. Charging times with IUIa-characteristics in hours for PzV batteries at 30 ˚C



Charger assignment for valve regulated PzV batteries

For valve regulated traction batteries with gelled electrolyte only regulated chargers with IUIa-regimes as shown in charging diagram 4 can be used. The time of the last charging phase has to be adjusted according to the main charging time. A charge factor based control is not permitted because of recombination effects. For calculations of the energy consumption a charging factor of 1.1 can be used.

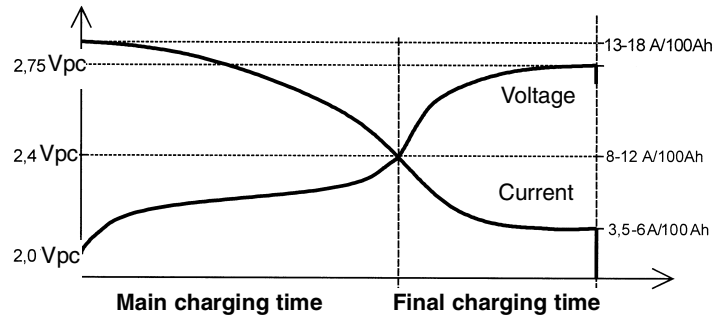
For valve regulated traction batteries an optimised service life can be reached with a depth of discharge of max. 60 % DOD. DODs of 80 % are possible with regard to application and battery size in accordance with the manufacturer's statements.

Special Wsa-charging characteristics

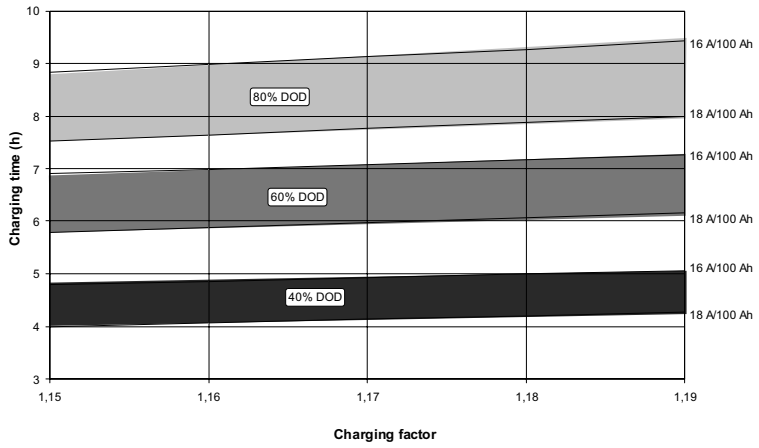
For certain battery ranges e.g. PzS, higher end-of-charge voltages are found because of higher nominal acid densities and lower antimony content of the grids. A consequence of this are longer charging times. These batteries can be charged with a steeper charging characteristics, i.e. higher charging currents in the gassing region. Because of the enlarged stray field of the transformer the charging characteristics is steeper, with the advantage that the charging current is less dependant on variations of the mains voltage. Typically the dependence of the charging current on mains voltage fluctuations at 2.4 Vpc is reduced by 20 % and at 2.65 Vpc by 30 %. With an increased charging current and a steeper characteristics these batteries can be charged within 8 to 14 hour at 30 ˚C depending on the assigned charging current to the nominal capacity ratio, when discharged to 80 % DOD. The charging factor of 1.17 however must not have a higher tolerance than ± 0.02. This can be achieved for example, by Ah-, dU/dt- or dI/ dt-controlled charging algorithms. Additionally a safety cut-off must be implemented by a timer function, in case that the gassing voltage of 2.4 Vpc referred to 30 ˚C, is not reached within 8 h at a charger nominal current of more than 16 A/100 Ah.

Under all circumstances a safety cut-off is necessary.

5. Charging times in hours for Wsa-characteristics
(special taper charge with steeper (s) slope for PzS batteries at 30 ˚C



5. Charging times in hours for Wsa-characteristics for PzS batteries at 30 ˚C



Attention:

Important is the matching of the charger to the battery with regard to the application, considering the permissible tolerances:

Charging factor	± 0.02
Charging time requirement	± 0.5 h
Depth of discharge	± 5 %

The chargers have to be in compliance with DIN EN 50272-3 (replaces DIN VDE 0510-3) and DIN EN 60146 -1 and -2 (replacing DIN VDE 0558), among other standards and regulations.

Appendix

The following table shows the capacity assignment for different charging characteristics and charging times *.

	charging characteristics Wa		charging characteristics Wsa		charging characteristics W0Wa		charging characteristics IUIa	
	charging time 11 h	charging time 14 h	charging time 8 h	charging time 9 h	charging time 8 h	charging time 9 h	charging time 8 h	charging time 9 h
charger nominal current amp.	battery-capacity Ah (C_5)	battery-capacity Ah (C_5)	battery-capacity Ah (C_5)	battery-capacity Ah (C_5)	battery-capacity Ah (C_5)	battery-capacity Ah (C_5)	battery-capacity Ah (C_5)	battery capacity Ah (C_5)
15	90	125	83	93	54	68	75	94
20	125	165	111	123	71	91	100	125
25	155	210	139	154	89	114	125	156
30	190	250	167	185	107	136	150	188
40	250	335	222	247	143	182	200	250
50	310	415	278	309	179	227	250	313
60	375	500	333	370	214	273	300	375
70	435	585	389	432	250	318	350	438
80	500	670	444	494	288	364	400	500
90	560	750	500	556	321	409	450	565
100	625	830	556	617	357	455	500	625
110	680	920	611	679	393	500	550	688
120	750	1.000	667	741	429	545	600	750
130	800	1.080	722	802	464	591	650	813
140	875	1.165	778	864	500	638	700	875
150	930	1.250	833	926	536	682	750	938
160	1.000	1.330	889	988	571	727	800	1.000
170			944	1.049	607	773	850	1.063
180			1.000	1.111	643	818	900	1.125
190			1.056	1.173	679	864	950	1.188
200			1.111	1.235	714	909	1.000	1.250
210			1.167	1.296	750	955	1.050	1.313
220			1.222	1.358	786	1.000	1.100	1.375
230			1.278	1.420	821	1.045	1.150	1.438
240			1.333	1.481	857	1.091	1.200	1.500

***** The charging times refer to a charging factor of 1.2 (1.17 for Wsa), a battery temperature of 30 ˚C, a depth of discharge of 80 % and the charger correctly adapted to the mains voltage. Tolerance ± 0.5 h.

Charging times are determined by the magnitude and the relation of the charging current and the voltage, as well as the DOD (depth of discharge).