BENNING

World Class Charging Systems

BELATRON HF

The new benchmark for switch mode charging systems

BELATRON HF charging systems
switch mode technology from BENNING

BELATRON HF charging systems

BENNING has developed and manufactured charging systems for traction applications for more than 50 years. With already more than 10 years of experience in the field of switch mode technology, BENNING introduced in 1997 with the BELATRON HF range a milestone for years. The BENNING exclusive BELATRON principle has been further developed until today.
The latest generation of the BELATRON HF range again sets a new benchmark in terms of efficiency, reliability and availability. Moreover it provides future orientated flexibility in operation and the highest level of information.

The development of this new range has been undertaken with end users requirements uppermost in the design process. Today's purchase decisions are no longer based on the pure investment cost, but are strongly influenced by the life cycle cost. The latter is true for the end user, but even more for operators of large fleets.

Characteristic:	Advantage:
Power factor cos φ close to 1	• **Almost pure real power is taken out of the network**
Sinus shape of the input current (Active power factor correction)	• **Low mains perturbations acc. EN61000-3-2**
Negligible ripple current	• **Reduced temperature raise of the battery and therefore prolonged life expectancy**
Highest efficiency	• **Reduced energy consumption**
Pulse characteristics	• **Ionic mixing of the electrolyte avoids additional hardware for pneumatic acid circulation**
BELATRON characteristics	• **Provides a charging process independent from the age, the temperature, charging voltage and depth of discharge of the battery**
Graphic display	• **Menu driven operation by soft keys, messages in plain text**
Status signalling	• **Large, clear display of the state of charge Clear visibility from larger distances**

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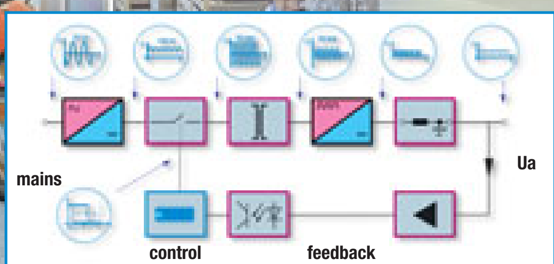
Switch mode technology from BENNING: Highest efficiency in compact design

BELATRON chargers are based on switch mode technology. The rectified input voltage is converted into a high operating frequency of about 50 kHz by means of a HF chopper circuit. This technology reduces the volume and weight of the chargers by a factor of 5. Moreover the efficiency increases substantially compared to unregulated or thyristor controlled chargers.

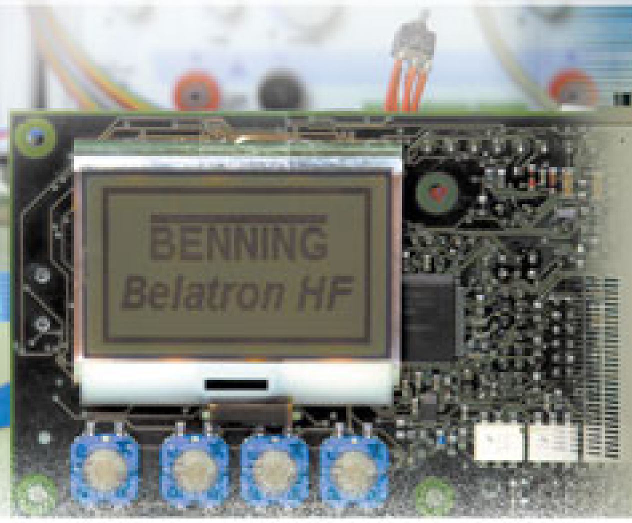
By using the most modern circuit engineering the power factor is 1 for single phase units and 0.9 for 3-phase units. The ideal sinusoidal shape of the input current is achieved by a sinus booster or active power factor correction (PFC). For the installation into 19-inch industrial rack technology and in case of service the BELATRON HF power blocks are mounted in a separate housing. This modularity ensures highest efficiency unlike chargers using two or more modules in parallel.

Higher DC power provided by single phase systems

Due to the 20 % higher efficiency the DC output power is higher compared to normal chargers, with a comparatively small mains power. This allows the BELATRON HF 24 V/120 A unit to be a single-phase unit. On one hand single-phase units are more economic than three phase units. This already provides a substantially reduced investment in choosing BELATRON HF. On the other hand high consequential investments in terms of electrical installations of the facilities are avoided. This concerns cross sections of the cabling, the dimensions of the primary plugs and the higher selectivity, as the nominal input current remains below 16 A.



Principle of primary switch-mode technology

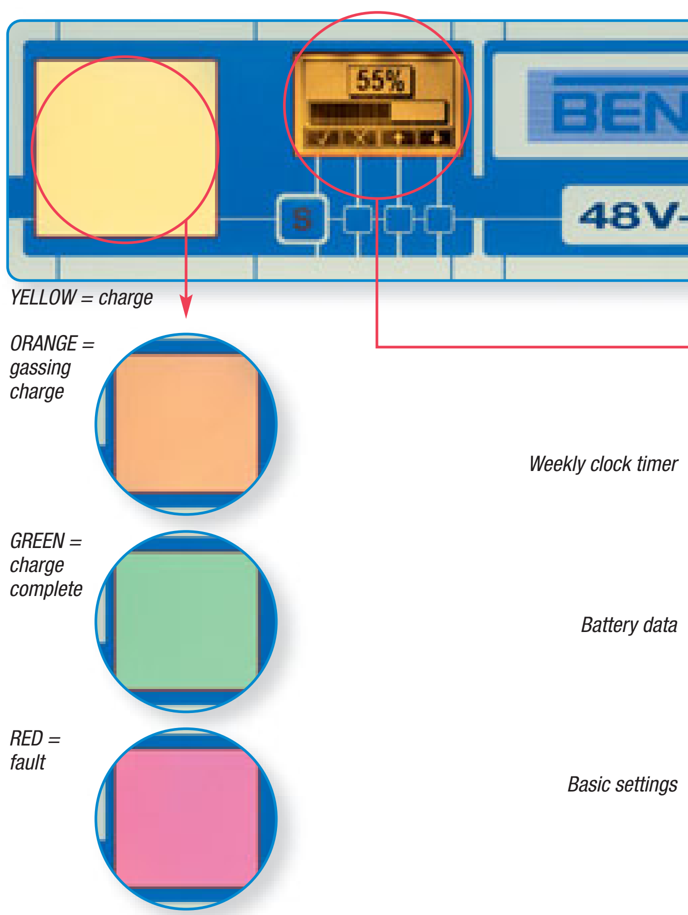


High degree of information and operational safety by a huge status light and graphical display with soft menu

The unique status light offers the increased visibility of the state of the charger from substantial distances, especially in large installations or charging rooms. The actual status of the charging process is clearly visible.

A clearly structured menu is utilised to drive the operation of the charger with soft keys on the front panel. Messages are displayed in plain text in the respective language. The backlit graphical display offers a high contrast and an increased viewing angle.

The menu driven operation affords the end-user easy access to the controls. Important operational parameters like the measuring values of the last charging cycles and charging parameters could be visualised. The set up of the charger can be edited easily, and status and error messages are displayed clearly in a plain text message.



BELATRON HF charging systems
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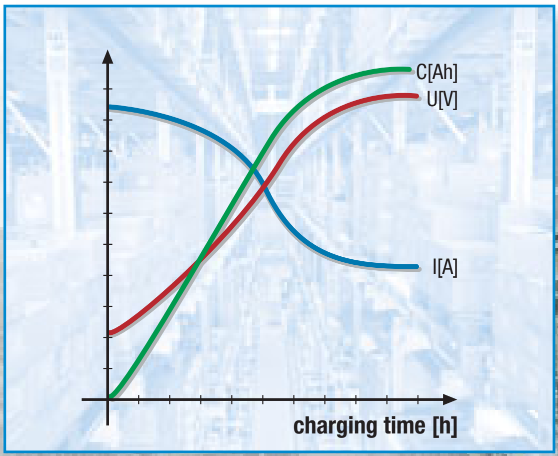
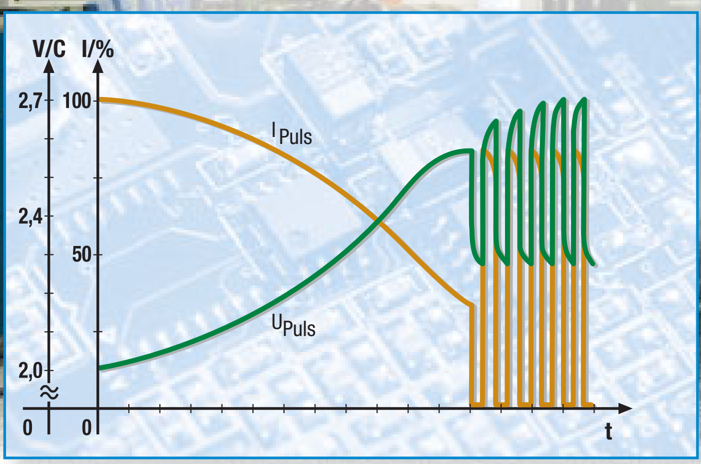
The BELATRON principle: The only charging curve with dl/dt switch off

Compared to unregulated chargers the charger control unit is very important, and is at the heart of the unit and drives the correct charging current level according to the actual status of the battery in terms of capacity, temperature, age, etc. This is to get the best compromise between a recharge in a short time, limited heating of the battery and a life expectancy as long as possible. According to the BELATRON principle the switch off criteria is reached, when the charging current is no longer converted into charging energy, i.e. a constant current is reached. This prevents a harmful over or under charge.

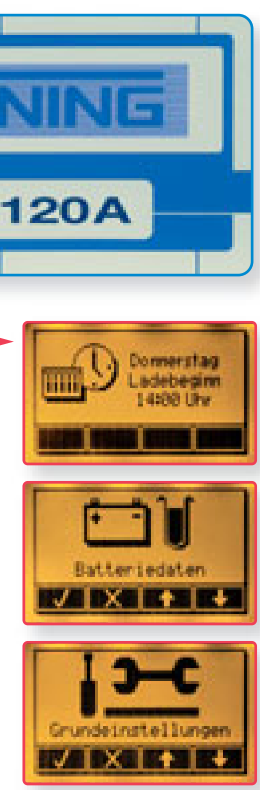
All other switch off criteria are even more a compromise, as all other criteria like battery voltage, Ah balancing, etc. are temperature dependent. Moreover other battery parameters depend on the age of the battery and are therefore not adequately accurate.



Charging according to BELATRON characteristic



Pulse charging curve



Pulse charging curve

The BELATRON HF charger range offers a pulse-charging regime providing the so-called ionic electrolyte circulation. This technology ensures a proper mixing of the electrolyte by means of high current pulses during the gassing phase of the charge. These current pulses generate gassing phases, which mix the electrolyte and prevent the acid from stratification. As a benefit this technology provides recharge times substantially which are reduced to those comparable to systems equipped with pneumatic acid circulation.

The ionic mixing shortens the duration of the gassing phase. Due to the reduced charging factor the maintenance intervals of the battery are prolonged because of a limited release of gas and therefore a limited loss of water. Moreover the temperature development is reduced.

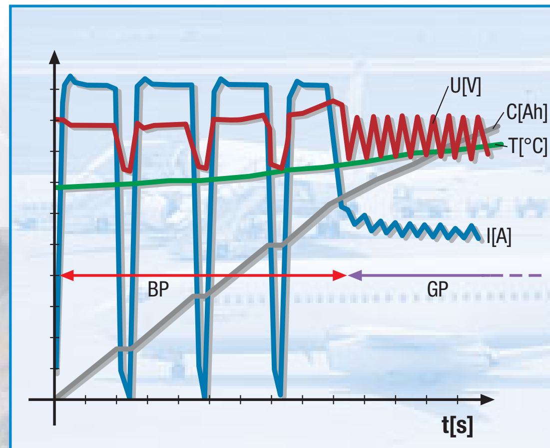
As economical benefits there are less investments and a higher reliability over the lifetime due to the omission of mechanically endangered components like hoses and air connections.

BELATRON HF charging systems switch mode technology from BENNING

High current pulse charging curve for continuous operation without exchange batteries

This BELATRON specific charging regime provides a full recharge within 2 - 3 hours or the opportunity charge for continuous operation without battery exchange. The basis is a high current pulse-charging curve. The comparatively high current assignment has been proven in long-term experiences, not to lead to any problems for modern batteries. By continuous operation, only interrupted for short opportunity charges, savings in terms of exchange batteries, battery exchange times and travel times as well as battery charging stations and their operation could be achieved.

As a consequence the investment and operating costs could be reduced substantially.
This charging curve has been available in the BELATRON HF systems for many years.



High current pulse characteristic

Charging technology and the influence on the temperature development of batteries

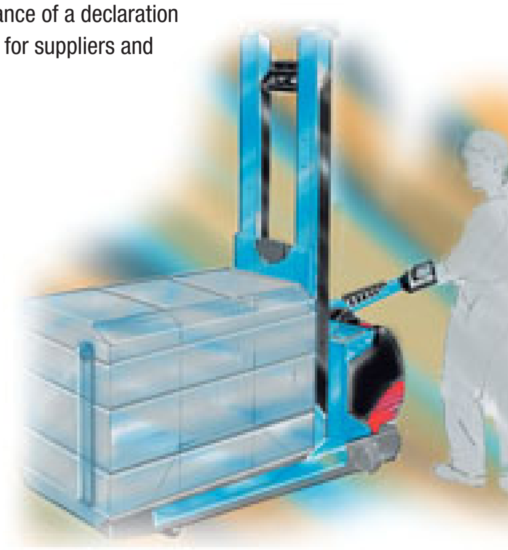
A relatively high portion of the temperature raise during the charging process is caused by “dirty” DC current. With conventional chargers the Dc charging current is superimposed by a low-frequency AC current (“ripple current”) that is converted into heat contributing to a general heating of the battery. This temperature rise influences the chemical reaction rates of the aging processes and therefore the life expectancy of a battery (see ZVEI “Considerations on the life expectancy of traction batteries”).

BELATRON HF charging systems charge the battery with unrecognisable ripple on the charging current. This provides a smoother temperature development of up to 30 % compared to conventional chargers. According the ZVEI paper this results in an increased life expectancy of about 10 %.

Electromagnetic compatibility (EMC) – a standard for product quality

Due to the high technical demands on the BELATRON HF, the power electronics meet all relevant European norms for EMC and mains pollution. The latter pollutes the public network with undesirable harmonics. A measure for compatibility is the power factor cos φ. A typical value for compatible systems is in excess of 0.9. For the efficiency this results in a value of about 90 - 93 %.

An often-unrecognised aspect with non-EMC compatible systems is the exclusion of liability insurances in a case of a damage caused by non-compatible equipment. The technical competence, as documented by the issuance of a declaration of conformity, is regarded as prerequisite for suppliers and operators.



BELATRON HF charging systems
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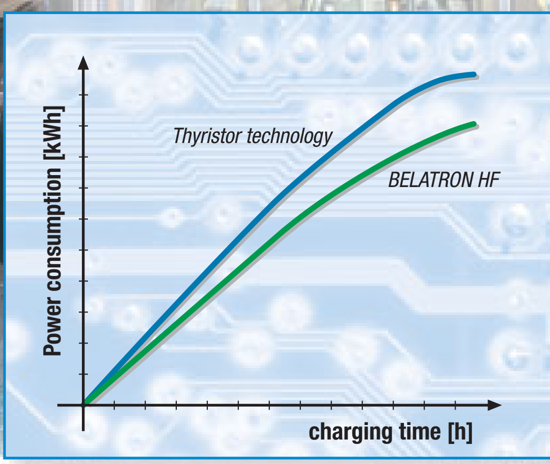
Cost optimisation: Savings of investment and operational costs

Charging systems draw an AC power out of the network providing a DC power on the output side to recharge the battery. The relation between the power provided at the output to the power drawn out of the network is the efficiency.
The new BELATRON HF generation reaches an efficiency of up to 93 % by using the most modern power electronics (Quasi-Resonance-Technology). This is approx. 20 % higher than conventional chargers with comparable output power achieve.
In practice this does not only mean lower losses in terms of heat generation, but also the necessary mains input current provided by the building installation is reduced significantly.

As an example, a battery of 24 V/1100 Ah could still be recharged with a single-phase charger. Consequently there are savings in the building installation with regard to the supply voltage (230 V instead of 400 V), smaller cable cross sections, selectivity, costs for the plugs on the input side and last but not least the related overall installation cost.
Especially in new installations there is an enormous potential for cost savings during the project planning phase, or the avoidance of the very costly increase of the mains power for expansions of existing installations.



Comparison of ernergy consumption during charging

Quantification

As following an example of a cost calculation:

- Battery 48 V 600 Ah
- Depth of discharge 80 %
- Average charging voltage 2.37 V/cell
- Charging factor 1.18

The required energy for a full recharge is than 32.2 kWh (P_{out}). The relation between the energy necessary for the full recharge to the energy drawn out of the mains by the charger (P_{in}) is

$$P_{in} = P_{out} / \eta$$

There the energy required on the primary side for the respective charging technology with its efficiency is the following:

BELATRON HF charging system
with $\eta = 0.93$: 34.6 kWh

Conventional unregulated charging system
with $\eta = 0.78$: 41.3 kWh

(typical efficiency of 1- and 2-phase chargers)

The energy savings per full recharge is calculated to 6.7 kWh. This results to a saving of 0.80 € per recharge (assuming an energy cost of 12 cent/kWh) versus conventional chargers.

The service life of charging systems is typically 2 - 3 battery generations. With the a.m. savings a return of invest (ROI) is achieved within the life expectancy of the first battery, taking only the savings of the energy costs into consideration (single shift operation, 240 working days/year).

If the relative maintenance costs acc. VDI are considered as well, one achieves a drastic reduction of the ROI to approx. 2 years. Moreover the recharge by HF technology is gentler to the battery. This results to an additional cost saving because of the prolongation of the battery life, mainly caused by a decrease of the average battery temperature. This leads to a further reduction of the ROI period of less than 2 years.

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Technical Data

Traction charger range BELATRON HF

Out-put-volt.	(E)PzV-cells	(E)PzS-cells (flooded batteries)				Nominal current	Mains current	Cabinet	Weight	Type
	sealed battery curve chargingtime 12 - 14 h	Pulse curve chargingtime 7.5 - 8 h	Standard curve chargingtime w.o.EC 7 - 8.5 h w.EC 5.5 - 7 h	Standard curve chargingtime w.o.EC 9 - 11.5 h w.EC 7.5 - 10 h	Standard curve chargingtime w.o.EC 12 - 14 h w.EC 10.5 - 12 h					
[V]	[Ah]*	[Ah]*	[Ah]*	[Ah]*	[Ah]*	[A]	[A]		[kg]	
24	120 - 150	110 - 140	90 - 120	130 - 150	170 - 220	20	2.3	FWG 3	22	E 230 G 24 / 20 B-FBHF
	150 - 185	140 - 190	110 - 150	160 - 190	210 - 280	25	3	FWG 3	22	E 230 G 24 / 25 B-FBHF
	210 - 260	190 - 260	150 - 210	220 - 270	290 - 390	35	4	FWG 3	22	E 230 G 24 / 35 B-FBHF
	300 - 370	260 - 360	210 - 290	310 - 390	420 - 560	50	6	FWG 3	22	E 230 G 24 / 50 B-FBHF
	395 - 480	350 - 460	300 - 380	410 - 500	540 - 720	65	8	FWG 3	22	E 230 G 24 / 65 B-FBHF
	515 - 630	460 - 610	390 - 500	530 - 650	710 - 940	85	10	FWG 3	22	E 230 G 24 / 85 B-FBHF
	605 - 740	540 - 710	460 - 590	630 - 770	830 - 1110	100	12	FWG 3	22	E 230 G 24 / 100 B-FBHF
	730 - 890	650 - 860	550 - 710	750 - 920	1000 - 1330	120	14	FWG 3	22	E 230 G 24 / 120 B-FBHF
	910 - 1110	810 - 1070	680 - 880	940 - 1150	1250 - 1660	150	6.5	FWG 6	36	D 400 G 24 / 150 B-FBHF
	1030 - 1260	920 - 1210	770 - 1000	1060 - 1310	-	170	7.5	FWG 6	36	D 400 G 24 / 170 B-FBHF
	-	1030 - 1360	860 - 1120	-	-	190	11	S 22	61	D 400 G 24 / 190 B-FBHF
36	120 - 150	110 - 140	90 - 120	130 - 150	170 - 220	20	3.5	FWG 3	22	E 230 G 36 / 20 B-FBHF
	150 - 185	140 - 190	110 - 150	160 - 190	210 - 280	25	4.3	FWG 3	22	E 230 G 36 / 25 B-FBHF
	210 - 260	190 - 260	150 - 210	220 - 270	290 - 390	35	6	FWG 3	22	E 230 G 36 / 35 B-FBHF
	300 - 370	260 - 360	210 - 290	310 - 390	420 - 560	50	9	FWG 3	22	E 230 G 36 / 50 B-FBHF
	395 - 480	350 - 460	300 - 380	410 - 500	540 - 720	65	11.3	FWG 3	22	E 230 G 36 / 65 B-FBHF
	515 - 630	460 - 610	390 - 500	530 - 650	710 - 940	85	15	FWG 3	22	E 230 G 36 / 85 B-FBHF
	605 - 740	540 - 710	460 - 590	630 - 770	830 - 1110	100	6.5	FWG 6	36	D 400 G 36 / 100 B-FBHF
	730 - 890	650 - 860	550 - 710	750 - 920	1000 - 1330	120	8	FWG 6	36	D 400 G 36 / 120 B-FBHF
	910 - 1110	810 - 1070	680 - 880	940 - 1150	1250 - 1660	150	10	FWG 6	36	D 400 G 36 / 150 B-FBHF
	1030 - 1260	920 - 1210	770 - 1000	1060 - 1310	-	170	14	S 22	96	D 400 G 36 / 170 B-FBHF
48	120 - 150	110 - 140	90 - 120	130 - 150	170 - 220	20	4.6	FWG 3	22	E 230 G 48 / 20 B-FBHF
	150 - 185	140 - 190	110 - 150	160 - 190	210 - 280	25	6	FWG 3	22	E 230 G 48 / 25 B-FBHF
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	605 - 740	540 - 710	460 - 590	630 - 770	830 - 1110	100	8.8	FWG 6	36	D 400 G 48 / 100 B-FBHF
	730 - 890	650 - 860	550 - 710	750 - 920	1000 - 1330	120	10.3	FWG 6	36	D 400 G 48 / 120 B-FBHF
	910 - 1110	810 - 1070	680 - 880	940 - 1150	1250 - 1660	150	12.5	FSG 12	71	D 400 G 48 / 150 B-FBHF
	1030 - 1260	920 - 1210	770 - 1000	1060 - 1310	-	170	14.5	FSG 12	71	D 400 G 48 / 170 B-FBHF
80	120 - 150	110 - 140	90 - 120	130 - 150	170 - 220	20	7.6	FWG 3	22	E 230 G 80 / 20 B-FBHF
	150 - 185	140 - 190	110 - 150	160 - 190	210 - 280	25	9.5	FWG 3	22	E 230 G 80 / 25 B-FBHF
	210 - 260	190 - 260	150 - 210	220 - 270	290 - 390	35	13.3	FWG 3	22	E 230 G 80 / 35 B-FBHF
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	605 - 740	540 - 710	460 - 590	630 - 770	830 - 1110	100	14.3	FSG 12	71	D 400 G 80 / 100 B-FBHF
	730 - 890	650 - 860	550 - 710	750 - 920	1000 - 1330	120	17	FSG 12	71	D 400 G 80 / 120 B-FBHF
	910 - 1110	810 - 1070	680 - 880	940 - 1150	1250 - 1660	150	21	FSG 12	71	D 400 G 80 / 150 B-FBHF
	1030 - 1260	920 - 1210	770 - 1000	1060 - 1310	-	170	25	S 22	96	D 400 G 80 / 170 B-FBHF

** Reference values. Generally, the current battery sizes of the battery manufacturers are valid*
Technical details are subject to change without notice

Cabinet

Type	Dimensions [mm]		
	Hight	Width	Depth
FWG 3 *)	443	392	278
FWG 3T *) **)	443	392	428
FWG 6 *)	560	392	278
FWG 6T *) **)	560	392	428
FSG 12	780	458	452
S 22	1093	553	410

**) Dimensions without cable holder*
***) T-cabinet type with special options*

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19 inch rack mounted technology: Industrial standard with BELATRON HF from BENNING

Charging rooms for big fleet operators often contribute heavily to high investment costs and operating costs. By a modular mechanical construction of BELATRON HF 19 industrial charging systems the one-off costs as well as the operating costs could be decreased drastically. Based on the compact BELATRON HF power blocs, almost any configuration of power could be integrated into very confined space.
The spectrum reaches from a six fold charging system, e.g. 6 x 24 V/120 A up to 80 V/600 A, integrated into 19 inch industrial racks.

This technology allows with a decentralised installation to foresee future chargers in advance. The 19 inch plug-in module could be fitted and put into operation later on easily. Due to the unique feature of the BELATRON HF charging system to compensate the voltage drop on the charging cable up to 50m without any adjustment of the plugs and cable cross sections, this system provides a high degree of flexibility and future orientation.

Moreover such a system provides a higher degree of reliability in operationally critical areas, where the availability of the trucks have to be ensured by all means, because in case of failure the exchange of a defective power bloc could be realised within minutes. Re-programming of the charger is not necessary.

Ready for the future means BELATRON HF: Features and options

Features:

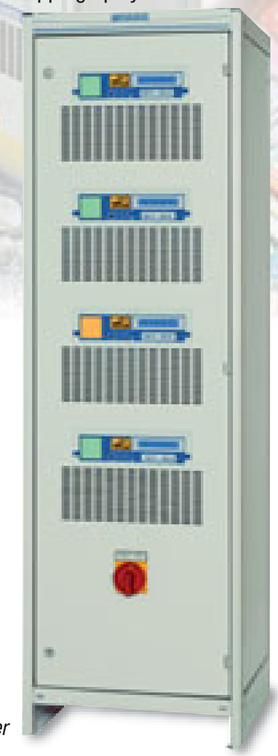
- Large display for state of charge signalling
- Graphical display with soft keys
- BENNING Plug & Charge: fully automatic charging process
- USB interface
- Real time clock for time controlled delay of start
- Service and operating software
- Self log on power blocs, i.e. no reprogramming necessary in case of exchange

Ready for the future by:

- 19 inch industrial rack technology
- Update through flash-EEprom
- Extension of the functionality by BatCom
- Management integration

Options:

- Electrolyte mixing system
- Automatic topping up system



BHF-19" quad charger

All what your HF system needs:

The quality class and power of a charging system is not just defined by the applied HF technology in the product name, but only the sum of perfect details results to the expected customer benefit as well as to a future oriented investment.

In order to facilitate a comparison, please find here a checklist that helps to compare important criteria for your specific operational needs.

Yes / No

➔ [X] [ ] [ ] Large state of charge display
[ ] [ ] Graphical display with menu driven operation and help function
[ ] [ ] Cos $\varphi > 0.9$
[ ] [ ] Single phase up to 24 V/120 A, 48 V/65A
[ ] [ ] dI / dt shut off criteria for exact determination of a fully recharged battery
[ ] [ ] Efficiency ≥ 93 %
[ ] [ ] I x R compensation up to 50 m without alteration of plugs and cable cross sections
[ ] [ ] Temperature driven recharge as option
[ ] [ ] Programmable delay of start
[ ] [ ] Programmable weekly time switch
[ ] [ ] Communication with battery controller
[ ] [ ] Management integration

And in case of emergency

You could reach immediate help from BENNING via our service hotline ++ 49 (0) 28 71 / 93 - 555.
BENNING own contact partners trained to the technology are at your disposal 24 hours/7 days per week.

BENNING

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