APPLICATION NOTE NUMBER 24

ALL ABOUT SIZING CHARGERS FOR ENGINE-STARTING BATTERIES

What is the correct output ampere rating of a battery charger used in engine-starting applications?

Let's start with an example. The prime mover for a medium size generator set, in this example 500 KW electrical output, would be powered by an engine of about 15 liter displacement. The starter motor of an engine this size draws roughly 650 amps during the crank cycle. If the crank lasts ¼ of a second, which is typical, the total battery capacity consumed for this crank, in ampere-hours, is (650 x 0.25)/3600, or 0.045 ampere hours. This is less than 1/20th of an ampere hour.

Yet, chargers for this size of generator are frequently rated six to ten amps. Why, when each crank consumes such little battery capacity, are relatively high ampere chargers employed?

NFPA 110, the Standard for Emergency and Standby Power Systems, paragraph 5.6.4.7 (2) states that, *"The charger shall be capable of returning the* ***fully discharged*** *battery to 100 percent of its ampere-hour rating within the time specified in Table 5.6.4.2, item."* (Bold font emphasis is added.)

In practice this means that in applications that must comply with NFPA 110 the actual cranking duty cycle is immaterial. NFPA requires that the charger be capable of bringing a fully discharged cranking battery back to full charge within either 24 hours (NFPA Level 1 installations), or 36 hours (NFPA Level 2 installations). The charger ampere output rating therefore must be computed based on the battery's capacity, and not on the actual capacity that needs to be returned to the battery after a given crank cycle.

Compute Charger Size Using Battery Ampere-Hours.

Only Ni-Cd starting batteries are rated in ampere-hours. To size the charger, start with the battery's ampere-hour rating if this is available. Divide the battery's ampere-hour capacity by the number of hours allowed to recharge. Add some charger capacity to offset inefficiencies in recharging. Also add additional charger capacity when fixed DC loads are present. The following formula may be used:

((AH x K)/T) + L = I where

AH is the ampere-hour capacity of the battery

K is the battery recharge inefficiency constant (1.15 for lead-acid and 1.4 for Ni-Cd)

T is the desired recharge time

L is the number of amperes consumed by the fixed load

I is the ampere rating of the battery charger

Using a Ni-Cd battery maker's sizing software we find that a 15 liter engine requires a Ni-Cd battery rated 45 AH to crank a 15 liter engine for the NFPA mandated minimum cranking time of 45 total seconds. We assume NFPA Level 1 recharge performance of 24 hours is required. We further assume a hypothetical continuous DC load of 0.8 amps. The charger ampere capacity required for this instance is computed as follows:

((45 x 1.4)/24) + 0.8 = 3.425 amps

The minimum charger size required for this application is 3.425 amps. Since chargers are not available in this exact ampere output rating we would choose the next larger ampere rating, which is probably 6 amps.

Sizing the Charger Using CA or CCA tables

Lead- acid SLI (Starting Lighting and Ignition) batteries are not typically rated in ampere-hours, meaning that the ampere-hour method to size the charger cannot be used.

SLI batteries are typically rated in Cranking Amps (CA) or Cold Cranking Amps (CCA). Conservative sizing guidance based on CCA rating of typical cranking batteries is shown in the tables below:

The following assumptions relate to the tables.

1. Charging duty is to NFPA 110 Level 1 (i.e. recharging a fully discharged battery in 24 hours).

2. Automatic boost charging is employed, preferably Dynamic Boost™ that automatically computes the ideal boost duration for each discharge event.

3. There is no constant DC load. When there is a constant DC load, size of charger must be increased by the number of amps constant draw. For example, from the Flooded lead-acid battery table nearby, an 8D battery rated at 1425 CCA requires a 9.3A charger. If there were a 1A continuous DC draw in the generator set, the charger size would need to increase to 10.3A. Since there is no 10.3A rated charger, the next larger size charger should be chosen. That would be either 15 or 20 amps.

Recommended Charger Ampere Rating vs. Battery CCA
- AGM lead-acid batteries -

Group	CCA	Charger Amps
U1	200	1.6
22NF	350	2.9
24	525	4.3
27	580	4.7
31M	800	6.5
4D	1110	9.1
8D	1450	11.9

Recommended Charger Ampere Rating vs. Battery CCA
- Flooded lead-acid batteries -

Group	CCA	Charger Amps
3ET	500	3.3
4D	1050	6.9
4DLT	850	5.6
8D	1425	9.3
8D	1400	9.2
8D	1100	7.2
17TF	530	3.5
28	550	3.6
30H	650	4.3
31	1000	6.5
31	950	6.2
31	760	5.0
31	650	4.3
31	730	4.8
31	700	4.6

For larger 12V starting systems, two 12V lead-acid battery blocks may be connected in *parallel*. When batteries are connected in parallel, you must scale the charger amps by the number of blocks. For example, two 4D flooded battery blocks (1050 CCA each) connected in parallel would require a 12V charger rated at for at least 13.8 amps. This would likely be a 15 or 20 amp rated charger.

For 24V starting systems, two 12V battery blocks will be connected in *series*. Connecting batteries in series increases the voltage, but not the CCA. Using the same 4D battery blocks described above connected in series would require a 24V charger delivering at least 6.9 amps.

Very large systems may have multiple battery blocks connected in series and parallel. Using six 8D 12V battery blocks (1400 CCA each), there would be three parallel strings of two blocks connect in series. Two blocks connected in series requires a 24V charger. Three strings at 1400 CCA each is 4200 CCA total. This requires a 24V charger rated 9.2 amps x 3 = 27.6 amps. A 30 or 35 amp charger is the recommend solution.

