Airpax Dimensions, Inc.
4467 White Bear Parkway (651) 653-7000
St. Paul, MN 55110-7626 Fax (651) 653-7600

AN202

APPLICATION NOTE SERIES NOVEMBER 2006

Specifying the Battery, Wiring, & Fusing - Recreation Vehicle

Introduction:
One of more deep cycle auxiliary batteries are recommended for use with a DC to AC power inverter. A deep cycle battery is specifically designed to accommodate repeated deep discharge and re-charge cycles. There are two categories of lead-acid deep cycle batteries; wet and sealed. A wet cell battery has a high tolerance to over-charging, however, it will release hydrogen gas when charging that must be properly vented, and the water level must be checked frequently. Sealed batteries can be either gel cell or AGM (Absorbent Glass Mat). Both the gel cell and AGM battery are maintenance free, have no liquid to spill, and gassing is minimal. The gel cell is the least affected by temperature extremes, storage at a low state of charge, and has a low self-discharge rate. An AGM battery will handle over charging slightly better than the gel cell. Deep cycle battery capacity is rated in amp hours (AH). This industry standard rating is typically defined as current draw over a 20 hour period. As an example, a 100 AH battery will produce five amps for twenty hours before it is exhausted (5 amps x 20 hours = 20 AH). Starting batteries, rated in cold cranking amps, are not recommended for this application.

Sizing the Battery Bank:
After choosing the battery type, it is necessary to determine how much battery capacity is needed.

System Voltage and Maximum Current:
For recreation vehicle applications, the most common system voltage is 12 VDC, however, 24 VDC systems are available. Generally, the practical limit for system DC current is about 250 Amps. Fortunately, this is satisfactory for most 12V inverter applications. In addition, other support system components such as cables and fuses are readily available at this current. Some recreational vehicles applications, however, call for 3000 watts or more continuous power at which a 12 volt inverter would require 300 amps or more of DC current. Not only does this power level push the limits of 12 volt inverter design, it also requires much larger and more costly support system components. A 24 VDC system is better suited for these higher power applications.

Battery Capacity:
Determining the battery capacity required by your application is a critical step. Battery capacity is the rating of how much current any given battery can deliver over a period of time. The rating is expressed in Ampere-hours (AH). As a benchmark, the battery industry rates batteries at the 20 hour rate; that is, how many amperes of current will the battery deliver for 20 hours. As we increase the current drain, the run time is reduced. This relationship is not linear but is more or less according to the chart below:

Battery Capacity Vs. Rate of Discharge

Hours of Discharge	Usable Capacity
20	100%
10	87%
8	83%
6	75%
5	70%
3	60%
2	50%
1	40%

Now that we have an idea of the power available from some common batteries we need to identify our energy needs. This is a survey of the watt rating of all the equipment we regularly use and how long we use it each day. The final figure is watt-hours. For example, suppose we calculated that 3000 watt-hours were consumed each day. From this we can figure battery capacity in ampere-hours required at each system voltage (divide watt-hours by system voltage):

System Voltage	Ampere-hours for 3000 Watt-hours
12V	250
24V	125

Note that this chart shows required battery capacity and NOT a specific battery. (We have assumed that the vehicle engine is off and that none of our energy need is being supplied by the engine driven alternator).

Run Time (minutes) for Various Batteries

One of the frequently asked questions is "How long will my battery last?". To answer this question, we compared two six volt golf cart batteries to a single 12 Volt Group 31 deep cycle battery. You will note that doubling battery capacity results in a three fold increase in run time.

Below are a few additional factors that influence final battery determination:

Discharge Time:

For a 5 hour discharge, about 70% of rated battery Ampere hours is available at 77^{0}F. See Capacity Vs. Rate chart on page 1.

Depth-of-Discharge:

For Lead-Acid batteries the depth-of-discharge directly affects life. It is recommended usage be limited to 50% of available capacity between recharge cycles. Note cycle life chart on the page 3.

These two factors are further influenced by duty-cycle. Since the day's energy usage typically is not continuous, the battery will have opportunity to recover and overall performance should be enhanced.

Temperature:

A Lead-Acid battery at 32^{0}F can deliver about 70 to 80% of its rated 77^{0}F capacity. For very cold climates an insulated/heated battery box is recommended.

Battery Life:

A Lead-Acid Deep-Cycle battery is considered to be at end of life when it can deliver 50% or less of rated capacity. We will have to determine what percent capacity reduction is acceptable, over time, for our application and factor it for the initial selection.

Battery Type	Qty	Load (Amps)			
		100	**150**	**200**	**250**
Northern 31 EV	1	24.00	12.66	7.66	4.00
Northern 31 EV	2	65.25	35.83	25.00	16.75
Northern GC 110	2	50.75	26.25	14.75	6.41
Exide GC-5	2	77.00	45.75	29.00	17.00

Below is a chart of some battery sizes for our application. Note the capacity rating for different sizes.

BATTERY SPECIFICATION CHART

BCI*grp Number	Battery Voltage	Battery Amp/hrs	BCI Max Dimensions L	W	H	Weight (LBS)
GC2	6	220	10-3/8	7-3/16	11-3/8	70
27/31	12	105	13	6-13/16	10-5/8	70
4D	12	160	20-3/4	8-3/4	10-5/8	100
8D	12	225	20-3/4	11-1/8	10-5/8	150

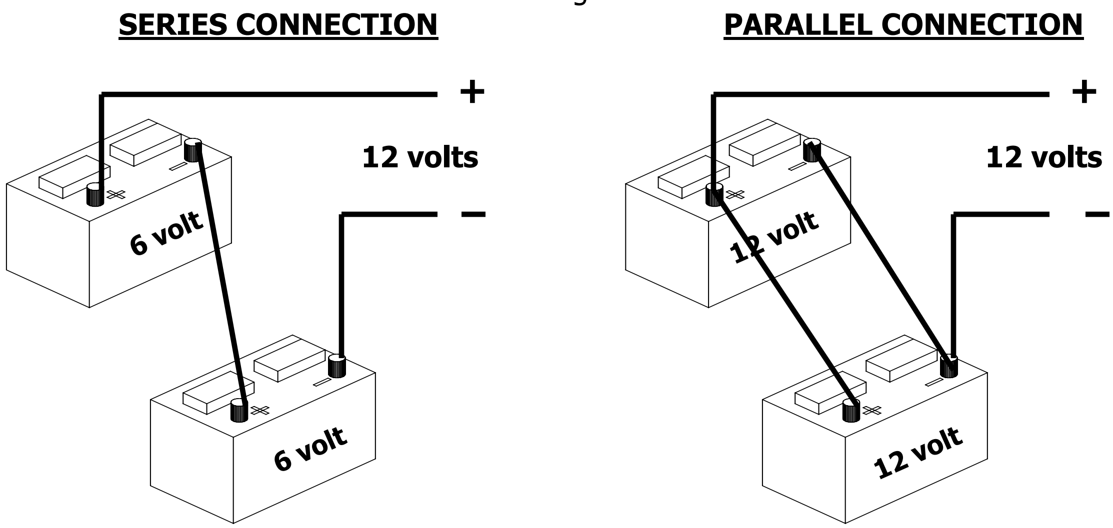
*Battery Council International

Depth of Discharge (%)	CYCLE LIFE Trojan: 27M(12V/105 Ahr)	EV8D(12V/216Ahr)	GC2(6V/220Ahr)
10	1000	1500	3800
50	320	480	1100
80	200	300	675
100	150	225	550

We can say at this point that for Lead-Acid systems our rated battery capacity will have to be a minimum of two times our calculated need. For applications where the battery is subject to extreme stress; and failure is not tolerated, annual or biannual 8D replacement or three year GC2 replacement is recommended. Refer to Figure 1 below for a 12 Volt system solution for our preceding example of 3000 Watt-hours of daily usage.

SPECIFYING BATTERY TO INVERTER WIRING AND FUSING:
In order to minimize voltage drop in the system, large size wiring and heavy duty connections are required. Refer to the table on the following page (as well as the inverter owner's manual) for the proper fuse selection and the correct gauge wire for a given distance between battery and inverter.

Figure 1



NOTE: In the above Figure 1, the batteries shown are connected in either series or parallel. A series configuration increases the voltage while keeping the AH capacity constant. For example: two 6 Volt batteries @ 220 AH each connected in series, results in a total output of 12 Volts (6 Volts + 6 Volts) @ 220 AH. A parallel configuration increases the AH capacity while keeping the voltage constant. For example: Two deep cycle batteries 12 Volt @ 105 AH each connected in parallel, results in a total output of 12 Volt @ 210 AH (105 AH + 105 AH). A convenient way to multiply capacity is to connect the batteries in a series/parallel configuration, but it is recommended that only two parallel strings be used. There are problems associated with multiple parallel connections as the batteries age. It is better to use a higher capacity battery than paralleling many smaller capacity units.

RECREATION VEHICLE INVERTER INPUT WIRE AND FUSING GUIDE FOR 5% VOLTAGE DROP AT FULL OUTPUT

Inverter Model	Full Load Amps	Wire/Footage (Inv to Batt)[1] 1-10	11-15	16-20
12/140	14	12	10	10
12P2.5	25	10	10	10
12/300	30	8	6	6
12/400	40	8	6	6
12/500	50	6	4	4
12W6	60	6	4	4
12/700	70	6	4	2
12W8	80	6	4	2
12/1000	100	4	2	1
12/1100	110	4	2	1
12U12, 12/1200	120	4	2	1
12/1500	150	2	1	1/0
12X16, 12/1600	160	2	1	1/0
12/1800	180	2	1	1/0
12X20, 12L20	200	1	1/0	2/0
12/2200	220	1	2/0	3/0
12/2300	230	1	2/0	3/0
12/2400, 12L24	240	1/0	2/0	3/0
12X25, 12/2500	250	1/0	2/0	3/0
12/2600	260	1/0	3/0	4/0
12/2800, 12L28	280	1/0	3/0	4/0
12X30, 12/3000	300	2/0	3/0	4/0
12/3100, 12L31	310	2/0	3/0	4/0
12/3500, 12L35	350	3/0	4/0	NR
12X36, 12/3600	360	4/0	4/0	NR
24/100	5	14	14	12
24/500	25	10	10	10
24/1300	65	6	4	4
24X15	75	6	4	2
24/2000	100	4	2	1
24/2200	110	4	2	1
24X25	125	2	2	1
24/2600	130	2	2	1
24/3200	160	1	1	1/0
24/3300	165	1	1	1/0
24X36	180	1	1	2/0
24/4800	240	2/0	2/0	3/0
24/5600	280	3/0	3/0	4/0

Determine Wire Size from table at left, then select fuse[2] from the table below:

Wire Gauge	Fuse Amps
10	80
8	100
6	150
4	200
2	250
1	300
1/0	350
2/0	400
3/0	500
4/0	500-600

NR - Not Recommended

1 Wire gauge is based on 135^0C insulation; for lower temperature rated insulation and/or applications inside engine spaces use next larger gauge.

2 Use Bussmann fuse type ANN and fuseblock #3576.

These wire gauge recommendations, especially for 12 Volt systems, are **minimum**. For large motor loads and other applications with high peak currents, use a wire gauge 1 to 2 sizes larger than shown and keep the wire runs between battery and inverter as short as possible. Make highest quality connections and use heavy gauge AC wiring to the loads.

APPENDIX A (BATTERY SUPPLIERS)

Airpax Dimensions, Inc.
St. Paul, MN 55110
(800) 553-6418
www.airpaxdimensions.com

Interstate Batteries
Dallas, TX 75251
(800) 541-8419, Ext. 6701
www.interstatebatteries.com