BATTERY SIZING RECOMMENDATIONS

PRODUCT SEAKEEPER 1, SEAKEEPER 2, SEAKEEPER 3

DESCRIPTION

This Technical Bulletin gives an overview of different battery types, their characteristics, and how to size a battery bank for a given DC Seakeeper Installation. For more information on batteries, wiring, and overcurrent protections, please see the ABYC E-10 Storage Batteries, E-11 AC&DC Electrical Systems on Boats, and TE-13 Lithium-Ion Batteries.

GENERAL BATTERY OVERVIEW

Flooded Lead Acid ("Wet Cell"), Gel Cell, Absorbed Glass Mat (AGM), and Lithium-ion batteries are the most common battery chemistries in the marine market. Table 1 shows the typical specifications for each battery type.

The Flooded Lead Acid battery is the most common, and least expensive, type of battery in use today and has been in use for decades. These batteries tend to be the least efficient, require more maintenance, and only have a life cycle of a couple hundred cycles. Seakeeper does not recommend the use of Flooded Lead Acid Batteries due to their limited cycle life.

Sealed batteries (both Gel Cell and AGM) operate on the same basic principle as the Wet Cell's, but they have a suspension mechanism that is positioned between the plates. These batteries are more efficient than flooded, are less prone to leakage, have a cycle life of around 500 cycles, but are more costly.

Lithium-ion batteries are growing in popularity for their power density but have not yet been widely adopted in marine applications. To operate safely and be used in typical charging systems, lithium-ion batteries require a battery management system to control their charge / discharge. These batteries have a life cycle of around 2000 cycles before performance falls.

Table 1: Outlines the different characteristics of Marine Batteries (Information obtained from manufacturers public data).

BATTERY METRIC	FLOODED ("WET CELL")	GEL CELL	AGM (ABSORDED GLASS MAT)	LITHIUM-ION
	Average Ah	Average Ah	Average Ah	Average Ah
Group 27	105	90	97	80
Group 31	117	100	110	100
Group 8D	185	225	249	273
Battery Factor*	70%	80%	80%	80%

**Battery Factor is a measure of efficiency that includes "Deep Cycle", the Low Voltage Cutoff, and battery characteristics.*

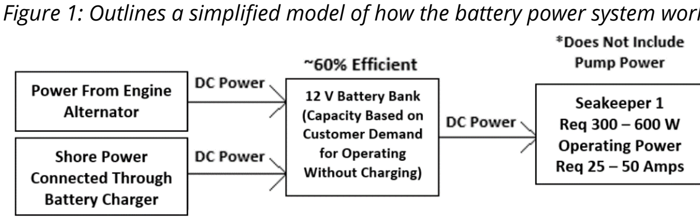
BATTERY SIZING RECOMMENDATIONS

Determining the battery capacity required for a Seakeeper installation is done by considering the following factors:

1. Which DC Seakeeper model is installed and what are the spool-up and operating power requirements? (Shown in table 2)
2. Operation of the Seakeeper system
    a. Spool-up on shore power
    b. Spool-up on battery power
    c. Onboard charging capacity
3. Desired Seakeeper runtime
4. Battery Configuration
    a. Dedicated Seakeeper Battery Bank: Seakeeper and components are the only draws.
    b. Integrated House Battery Bank: Unit is connected to house bank with other draws.
5. Desired battery group size and chemistry

These factors affect the power demand and battery capacity that is required for a given installation. Figure 1 illustrates a flow chart of the energy flow from either shore or engine power, through the battery bank, to the Seakeeper system.

Figure 1: Outlines a simplified model of how the battery power system works



The different DC Seakeeper systems have varied power consumption based on their stabilization capacity and angular momentum. Table 2 outlines the different consumption figures to consider when sizing a battery bank for each model.

Table 2: Outlines the DC Seakeeper Power requirements (Amperage draw at 12 V)

MODEL	SPOOL-UP		OPERATING	CONTROL
	AMPS	HOURS	AMPS	AMPS
Seakeeper 1	50	0.5	25-50	N/A
Seakeeper 2	71	0.58	25-55	10
Seakeeper 3	75	0.83	33-63	10

As Table 2 illustrates, the maximum power consumption is during spool-up. It is important to note whether Seakeeper spool-up will typically be done while connected to shore power (which is recommended) or from the onboard battery bank. The Seakeeper operating power consumption will vary based on the sea state. The typical range is shown in Table 2 and in the model specific operation manuals.

The next important step to consider is how the batteries will be configured, as this affects battery capacity requirements based on load and desired runtime. One configuration is to have a dedicated Seakeeper battery bank with the Seakeeper isolated from other house loads. The alternative is an integrated house bank with the Seakeeper and house loads sharing a common source. With an integrated house battery bank, the installer should account for the power consumption of house systems (lighting, pumps, sanitation, instruments, stereo, communication equipment, refrigeration, air conditioning, etc.) to determine the combined house loads. The equations below show the relationship between power, voltage, and amperage.

$$Power = P\ (Watts) = V\ (Voltage) * I\ (Amperage)$$

$$Amperage = I = \frac{P}{V} \qquad I_{SK1} = \frac{P_{SK1}}{V_{SK1}} = \frac{600\ Watts}{12\ Volts} = 50\ Amps$$

These can be useful in determining the power consumption of systems based on the specified wattage. The next aspect of sizing your battery bank is to determine the size and type of battery used. As Table 1 outlines, there are benefits and drawbacks to each type, but in general AGM and Gel batteries are recommended by Seakeeper. The below equations show how to calculate the amp hours and the usable Ah value from a battery based on its efficiency.

$$Amp\ Hours = Hours\ of\ Operation\ x\ Required\ Amps \qquad Ah = 4\ h\ x\ 50\ A = 200\ Ah$$

$$Usable\ Amp\ Hours = Battery\ Amp\ Hours\ x\ Battery\ Efficiency \qquad Usable\ Ah = 200\ Ah\ x\ 0.80 = 160\ Ah$$

For sizing a bank, the amount of needed Ah is directly related to the system demands (Seakeeper power, House power, etc.). If using a "Deep Cycle" battery, which is recommended by Seakeeper, the battery can usually be used up to 85 - 95% of its stated capacity. In the case of Li-Ion batteries, the manufacturers do not recommend discharging the battery below 20% state of charge. This is usually recommended to prolong the battery life.

The next factor is the desired runtime of the system without recharging or running the engines. If there is a net discharge on the batteries, the draw from the systems will drain the bank by the total Amps per hour until it is below the recommended state of charge. However, before the system is completely drained the Seakeeper DC Low Voltage Shutdown will activate. The Seakeeper unit, which continually monitors battery voltage, will run at full power until it detects 11.1 VDC at the unit. This reflects approximately 11.3-11.5 VDC at the battery bank and the unit will begin incrementally decreasing its consumption to ensure that its measured voltage does not decrease below 11.0 VDC, which extends the runtime of the Seakeeper at low battery voltages.

During this decrease in power consumption, if the measured voltage at the Seakeeper does not increase above 11.1 VDC, then the unit will continue to de-rate power consumption until it reaches 67% of its flywheel target speed. At this point, an alarm will trigger and the Seakeeper will shut itself down. This is a

safety feature to allow for the user to know that their batteries are low and to decide whether to shut down the Seakeeper and/or to recharge the batteries. The DC Input Voltage Low alarm (code: 111) is designed to alarm before any other system to maintain enough battery power to run navigation and other critical equipment.

Please note that the DC Seakeeper low voltage shutoff alarms are ineffective when used with Li-Ion batteries due to the different voltage drop rate. Li-Ion batteries can be used with the Seakeeper system and will work properly, but an external battery management system is required to prevent excessive discharge. This will be addressed in a future software update.

Considering the above factors and information an installer should be able to determine the battery (Ah) and charging (A) configuration to support any DC Seakeeper installation. Seakeeper recommends the charging current matches or exceeds the spool-up load of the Seakeeper unit outlined in Table 2. This applies to both alternator output and battery charger capacity. Recommendations for charging equipment and components can be found in the DC Installation Kits Technical Bulletin (90575).

BATTERY AND RUNTIME CALCULATOR

Seakeeper has developed a simplified Battery & Runtime Calculator (90721), based on the information outlined in this Technical Bulletin. The calculator allows a user to determine the battery requirements for a desired runtime, or the expected runtime given a battery configuration, based on basic system information (Seakeeper model, battery type & size, spool-up power condition, integrated or independent bank, etc.). The minimum battery capacity recommended by Seakeeper for each model, based on the calculator, is outlined in Table 3.

Table 3: Outlines the minimum recommended battery bank capacity.

MODEL	MINIMUM CAPACITY AMP HOURS (Ah)	EXPECTED BATTERY DISCHARGE TIME	
		SPOOL-UP: SHORE POWER (h)	SPOOL-UP: BATTERY POWER (h)
Seakeeper 1	150	2.8	2.6
Seakeeper 2	200	3.1	2.7
Seakeeper 3	200	2.6	2.1

The above configuration uses an independent battery bank to show the minimum Ah capacity that should be considered for each Seakeeper model. If using an integrated battery bank, this minimum capacity should be increased based on the demands of the house loads. Additionally, if more runtime is desired without recharging, the total Ah capacity should be increased. Battery charger recommendations can be found on the final page of the DC Installation Kits Technical Bulletin (90575).