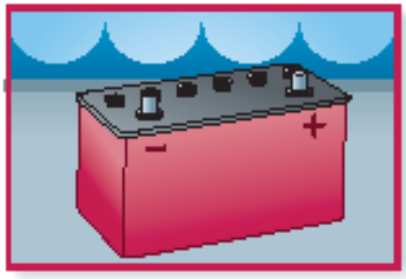
IN DEEP

Trojan, Mastervolt AGMs keeps the lights burning

We used a carbon pile tester from Snap-on Tools (far left) for the reserve capacity test. A row of incandescent light bulbs (foreground) served as the discharge source.

The term "lead acid battery" usually conjures up the image of a standard flooded cell battery commonly found in cars and in 80 percent of all production boats. Actually, there are three basic types of storage batteries used in the marine industry that are constructed of lead and acid: flooded or wet-cell batteries, AGM (absorbed glass mat) batteries, and gel (gelled electrolyte) batteries. Lead acid batteries are further sub-grouped into three application-based categories: starting, deep-cycle, and dual-purpose. We'll focus here on deep-cycle AGM and gel batteries.



SYSTEMS

The most widely installed battery on new, entry-level, production boats is still the flooded cell battery. This is primarily because of its low initial cost when compared to similarly sized AGM and gel batteries. Even though most flooded cell batteries require electrolyte maintenance, contain spillable corrosive acid, and vent explosive gases when severely overcharged, they still provide an energy reserve that is tolerant of a wide range of recharging voltages, and are universally available.

However, boat technology and boating habits are changing. Bow thrusters once reserved for only the largest mega-yachts are now routinely found on vessels under 40 feet, and DC power inverters are almost as common as windlasses. What all of these accessories have in common is an incredible appetite for DC power. As boat manufacturers build larger house battery banks to keep up the load demands, they are faced with two choices: Build a battery bank out of traditional flooded cells, or embrace new technology and opt for a battery bank that is as progressive as their boat design.

ROUND-UP

Valve-regulated lead acid (VRLA) batteries, because of their sealed spill-proof design, can be mounted in

any position, except inverted. If you plan to mount gel battery on its side, expect to lose 10 percent of its amp-hour (Ah) capacity. When faced with a flooded bilge situation, VRLA batteries will continue to operate submerged up to a 30-foot depth. After the first fathom of water, the point is probably moot.

VRLA batteries' low self-discharge rate is far superior to that of flooded lead acid batteries, making lay-up time maintenance free.

Unlike most automotive-grade flooded lead acid batteries, AGM batteries will not drop a plate or disintegrate when subjected to pounding in rough seas or excessive hull vibration. This is because the internal plates on an AGM battery receive additional physical support from the compressed fiber mats sandwiched between each lead plate.

Deep cycle VRLA batteries can cost about double what an average-grade deep-cycle flooded cell battery costs, or about 20 percent greater than a premium-grade flooded cell. If decide to upgrade, remember to factor in the additional costs required to modify your vessel's battery charging system to satisfy the VRLA's demanding charging regime, unless you are going to install spiral cell AGM batteries, which are compatible with most alternators.

It is not recommended to discharge your deep-cycle battery below a 50-percent depth of discharge, which is half of your battery's reserve capacity rating. Each time a deep-cycle battery is discharged 100 percent, the battery will lose at least one cycle against the battery's total lifecycle rating.

The top performing AGM batteries in our test were the Group 31 size Mastervolt ($213) and Group 27 size Trojan ($169).

OUR TEST

We selected 10 of the most popular VRLA deep-cycle batteries in the groups 27-31 (about 100Ah) case size. The test field consisted of three gelled electrolyte batteries, six traditional flat-plate AGM batteries and one spiral cell AGM battery. Our intent was to evaluate each battery's deep cycle reserve capacity.

Because AGM and gel batteries have a sealed case design, and lack liquid electrolyte, the use of a hydrometer to test the charge status of a battery's electrolyte was not an option. Knowing that we would be unable to crack open the batteries' containment cases and evaluate each product from the inside out, for obvious reasons we had to come up with our own non-destructive test.

In consultation with the Rolls/Surrette Battery Co. (a well-respected battery manufacturer that is neutral to our test as they currently do not manufacture a VRLA battery), we decided to follow the SAE J537 "Standard Test Procedures for Storage Batteries" that is endorsed by the Boating Council International. Though written for flooded cells, we felt that it was fair and would return some real life data.

First we "conditioned" each battery at room temperature by discharging it to a 50-percent depth of discharge (DOD), and then waited six hours for the battery to cool before recharging the battery with Xantrex's new XC5012 series three-bank/50-amp digital battery charger (see "Chandlery," page 29). Each battery underwent four dis-

BATTERY TERMS

If your vessel's house battery bank is frequently and deeply discharged, then gelled electrolyte batteries would yield the longest product cycle life. If your vessel's house bank is not that frequently or not deeply discharged then an AGM battery would provide longer service life.

Measurement of the open circuit voltage can only be taken on a battery that has been disconnected from the circuit (charge or discharge) for 24 hours.

Open Circuit Voltage
Verses Remaining Capacity
AGM & Gel VRLA Battery (77 F)
100 percent capacity = 12.8V
75 percent capacity = 12.6V
50 percent capacity = 12.3V
25 percent capacity = 12.0V
0 percent capacity = 11.8V

PS VALUE GUIDE VRLA DEEP CYCLE BATTERIES

TYPE	MODEL	CASE SIZE	STREET PRICE/ SOURCE	WARRANTY	CCA @ 0(F)	MCA @ 32 (F)
AGM	**Deka Seamate/ 8A27m** $	Group 27	$139/ AMS Batteries	3 yrs. Prorated 1st 12M Free Replacement	580 A	810 A
AGM	**Energy 1/ NSB-G-2700**	Group 27	$225/ Manufacturer	24 Months Prorated	900 A	1150 A
AGM	**Lifeline/ GPL-27TGPL-27T**	Group 27	$209.99/ Defenders	5 Yrs. Prorated 1st 12M Free Replacement	575 A	715 A
AGM	**Mastervolt/ AGM 12/90** ✓	Group 31	$213/ Ocean Options	24 Months Free Replacement	1012 A	NA
AGM	**Optima Yellow top/ D31A**	Group 31	$199/ Battery Outlet	3 Yrs Prorated 1st 18M Free Replacement	900 A	1125 A
AGM	**Trojan/ 27-AGM** ★	Group 27	$169/ Manufacturer	12 Months Free Replacement	560 A	760 A
AGM	**West Marine SeaVolt/ 1231406**	Group 27	$199.99/ West Marine	5 Yrs. Prorated 1st 18M Free Replacement	580 A	810 A
GEL	**Deka Dominator/ 8G27M** $	Group 27	$145/ AMS Batteries	5 Yrs. Prorated 1st 12M Free Replacement	505 A	700 A
GEL	**Mastervolt/ MVG 12/85** ✓	Group 31	$344/ Ocean Options	5 Yrs. Prorated 1st 24M Free Replacement	NA*	NA*
GEL	**Westmarine SeaGel/ 437475**	Group 27	$210.99/ West Marine	5 Yrs. Prorated 1st 18M Free Replacement	505 A	700 A

$ Budget Buy ✓ Recommended ★ Best Choice

charge/charge cycles. Most battery manufacturers state that their products need to be cycled 10-25 times to achieve maximum performance. We opted to scale back the number of pre-conditioning cycles so that we could complete the testing in a reasonable amount of time. Seeing that we had a large number of batteries to test and that each battery that was delivered to us was "new in the box," we were satisfied that all of the products were starting out on equal footing.

After the batteries were conditioned, fully charged, and rested overnight at room temperature, we started the first round of our reserve capacity discharge test. The SAE J537 storage battery Reserve Capacity Test states in Sec 3.5, "Discharge the battery at 25A (+/- 0.1A). During the discharge, using any convenient method, maintain electrolyte temperature within the range of 75 F –90 F. End the discharge when the voltage across the battery terminals has fallen to the equivalent of 10.5V, noting the discharge duration in minutes." When a VRLA battery's voltage falls to 1.75V per cell (a 12V battery has six cells x 1.75V per cell = 10.5V) then its depth of discharge (DOD) is said to be 100 percent.

For our discharge device, we built several racks of 100W 12VDC incandescent light bulb sockets wired into large, wire-wound voltage rheostats. The rheostat potentiometers allowed us to adjust the discharge rate and to compensate as the incandescent load drew less current toward the end of the test cycle due to the falling voltage potential. After each battery was drawn down to 10.5V, the testers removed the battery from the test rack and allowed it to cool overnight before we recharged it. After it was recharged and allowed to cool for six hours, we ran the 25A load test again. The testers took the average of both numbers and logged it as the observed discharge duration.

A continuous 25A load on a Group 27 or Group 31 battery is a little on the heavy side, and since not all of the batteries are of the same size and amp-hour capacity, we opted for what's known as a 20-hour rate draw. This leveled the playing field for the smaller Group 27 batteries that don't store as many amps.

BATTERY TERMS

AMPERE HOUR (Ah) The amount of current expressed in amps that a battery can deliver at 80 F, multiplied by hours it can deliver the current without falling below 1.75 volts per cell (10.5V on a 12-volt battery).

COLD CRANKING AMPS (CCA) The amount of current expressed in amps that a battery can deliver for 30 seconds at 0 F and maintain a minimum of 1.2 volts per cell (7.2V across the terminals during load on a 12V battery).

MARINE CRANKING AMPS (MCA) Same definition as CCA with the exception that the temperature limit for MCA is 32 F.

RESERVE CAPACITY (RC) The amount of time expressed in minutes that a battery is capable of delivering 25 amps of power at a temperature of 80 F without falling below 1.75 volts per cell (the equivalent of 10.5V on a 12-volt battery).

WEIGHT	RATED AMP HOUR CAPACITY	RATED RESERVE CAPACITY AT 25 AMP LOAD (min.)	OBSERVED RESERVE CAPACITY AT 25 AMP LOAD (min.)	OBSERVED RESERVE CAPACITY AT 20 HR. RATE (h & m)	L" x W" x H"	PERFORMANCE	QUALITY
62.5 lbs.	92 Ah	175 min.	151 min.	19h 59m	12.7x6.7x10	Good	Good
63 lbs.	72.6 Ah	140 min.	113 min.	15h 17m	13x6.5x8.4	Fair	Fair
66 lbs.	100 Ah	186 min.	171 min.	18h 25m	12x6.6x9.2	Good	Excellent
62 lbs.	90 Ah	160 min.	213 min.	24h 11m	13x6.8x9.3	Excellent	Excellent
60.5 lbs.	75 Ah	155 min.	110 min.	15h 31m	12.8x6.5x9.4	Fair	Good
66 lbs.	100 Ah	175 min.	212 min.	23h 40m	12x6.5x9.2	Excellent	Excellent
63 lbs.	92 Ah	175 min.	151 min.	19h 55m	12.7x6.7x10	Good	Good
62.5 lbs.	86 Ah	170 min.	145 min.	18h 50m	12.7x6.7x10	Good	Good
68 lbs.	85 Ah	Not Specified	196 min.	20h 43m	13x6.7x9.3	Excellent	Good
63.2 lbs.	86 Ah	160 min.	144 min.	18h 45m	12.7x6.7x10	Good	Good

* Note: Mastervolt rates its gel cell to Cold Starter Current / DIN standards, which are common in the U.K., but different from the U.S. standard.

The math on this test procedure is easy. If the battery is rated at 100Ah of reserve capacity, you divide 100 by 20 hours. and arrive at 5 amps of current draw. So we repeated the charge, cool down, discharge sequence and noted the 20-hour reserve rate as calculated for each of our batteries. This particular test procedure took a long time—but the data yielded was worth the effort.

DEKA SEAMATE/ DEKA DOMINATOR

East Penn Manufacturing in Pennsylvania manufactures and markets these batteries. East Penn also manufactures the West Marine SeaVolt (AGM) and SeaGel (gel). East Penn is said to be the world's largest "single-site" manufacturing facility. They smelt their own lead, mold their own plastics, and reclaim 98 percent of the raw materials (lead plates, plastic cases, and acid) when processing an old battery through their state-of-the-art recycling facility.

We like companies that are self-sufficient and have direct quality control over the entire manufacturing process. An active recycling program is also laudable.

Bottom Line: The performance numbers on both of the Deka VRLA batteries were adequate, but not stellar. The West Marine batteries are more readily available than the Dekas, and the West SeaVolt's warranty is 24 months longer than the Deka SeaMate. However, both Dekas are less expensive than the West Marine versions.

ENERGY 1

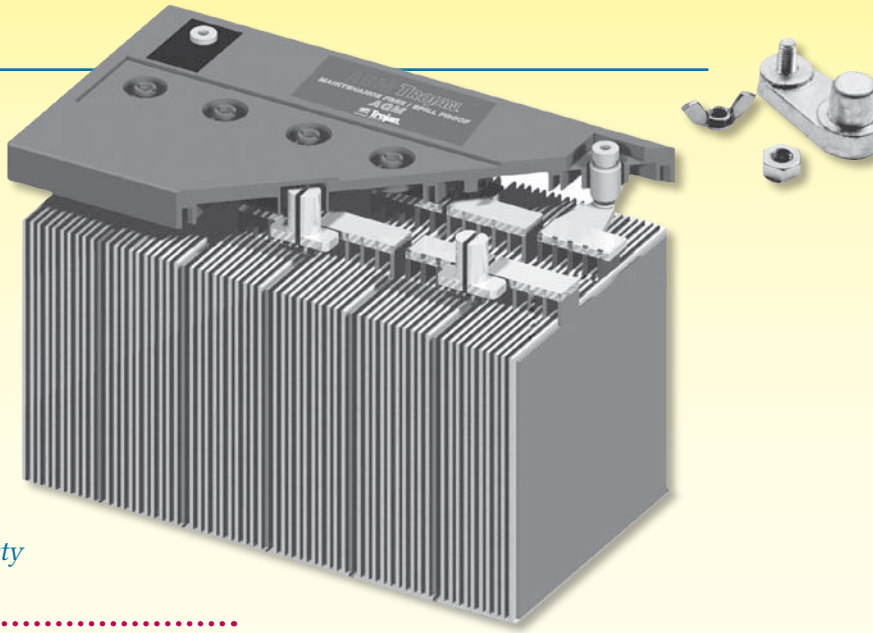
Manufactured by the Northstar Battery Co., Springfield, Mo., the Energy 1 is listed as a Group 27 size battery that weighs 63 pounds, which we verified. Yet this battery's factory-rated reserve capacity is only 72.6 Ah, which would account for its poor performance during our 25-amp load test. The voltage level in the Energy 1 battery fell below 10.5V in less than two hours when subjected to our 25-amp load. This is a full 1.5 hours sooner than the Trojan, which is also a Group 27 battery but has a 100 amp-hour rating.

Energy 1's Allen Harris said the NSB-G-2700 has deep-cycle characteristics but is used mostly as a starting battery. The Energy 1 210FT would have been better-suited for our test. We checked the specs on the 210FT and the sheet shows that this model weighs 128 pounds and is 22 inches long. This hardly qualifies it to be included in our test of Groups 27 and Group 31 batteries. Plus, the specification sheet that was provided with the Energy 1 NSB-G-2700 battery describes the battery as having "long life, 800-plus cycles at 50 percent discharge, 500-plus cycles at 80 percent discharge." — characteristics that we would use to describe a deep-cycle battery, not a starting battery.

During the initial cycling of the Energy 1 battery, we had an incident that almost allowed us to look inside of the battery's case. The carrying handles on the Northstar are not as strong as they look. Instead of the carrying strap that is provided with most of the other batteries in our test, Northstar uses two retractable plastic lift handles, one on each side of the case.

While we were moving these 65-plus pound batteries on and off our bench, one of the handles disconnected from the Energy 1 case, and it almost went crashing to the floor. We could easily duplicate the

Battery technology



An inside look at an absorbed glass mat battery from Trojan shows its layers of lead. The woven glass material between the plates absorbs the battery's pasty electrolyte.

The chemical reaction that occurs inside of the sealed cases of AGM and gel lead acid batteries differs from that of flooded cell batteries. AGM and gel batteries undergo a recombinant chemical reaction during recharging, whereby oxygen and hydrogen recombine "inside" of the battery. This reaction is achieved by a gas phase transfer. Oxygen that is normally formed on the battery's positive plates during a recharging cycle migrates to the battery's negative plates and subsequently gets absorbed.

As a result, hydrogen gas normally produced at the negative plates of a flooded cell battery is suppressed, as the oxygen recombines with the hydrogen to form water. This design prevents the escape of hydrogen and oxygen gases under normal operation and aids in retaining moisture inside of the cell, making the recombining process normally 99 percent efficient. The individual cells of all AGM and gel batteries are fitted with special pressure relief valves. The acronyms (VRLA) valve-regulated lead-acid and (SVR) sealed valve-regulated batteries are often used to describe this group of batteries. Never manually open the ressure relief valves on a VRLA battery, because atmospheric oxygen will enter the battery and contaminate the entire cell, effectively ending your battery's life and warranty.

GELLED ELECTROLYTE BATTERY

Gelled batteries use an electrolyte that has been thickened to the consistency of petroleum jelly by the addition of a silica agent. The agent allows the electrolyte's water to bind with the acid. Once inside, the gel undergoes a chemical reaction, heats up, and liquefies. During the cool-down phase the gel solidifies and tiny hairline cracks form between the gel and the battery's plates. During the charging, oxygen gas from the positive plate combines with the hydrogen gas on the negative plate inside of the cracks, producing water. The gelled electrolyte will then absorb the water, which keeps the closed system hydrated.

AGM and gel batteries require a well-regulated charging system. Gel batteries are extremely sensitive to charge voltages above 14.1V DC at 68 degrees F. If you don't have a voltage regulated, three-stage battery charger with temperature compensation or an alternator with a three-step regulator, then you should expect to get about half of the battery's rated life cycle.

The upside of gelled electrolyte batteries is that they recharge much faster than flooded cell batteries, provided that a regulated charge voltage is temperature compensated and at least 13.8V DC, but no more than 14.1 V DC. (These voltages are an average; each battery manufacturer has its own recommended voltage levels, which must be strictly adhered to.)

In addition, the gel's self-discharge rate is extremely low. Flooded cell batteries self-discharge one percent per day or 30 percent per month (at 68F), while VRLA batteries self-discharge generally less than 2 percent per month. This can be quite an advantage when laying up your vessel at the end of the season.

AGM BATTERY

Absorbed glass matt (AGM) batteries use the same chemical recombination reaction as a gelled battery. But the AGM battery is fitted with an absorbent, matted glass fiber insulation material that is machine compressed between each of its lead plates. Unlike the gel cell whose pasty electrolyte is loose inside the case, the AGM's electrolyte is 95 percent "absorbed" into the glass fiber separation mats by capillary action.

AGM batteries, like most VRLA's, require precise, voltage regulated, temperature compensated charging routines. AGM batteries can accept a charge rate of up to 75 percent of their rated amp hour capacity. Thus, a 200Ah AGM battery will readily accept a 150-amp voltage regulated charge. Because AGM batteries normally require a higher re-charge voltage (about 14.2V absorption, 13.5V float, see specific battery manufacture for recommended voltages), they end up having a higher terminal voltage and subsequently higher cranking amp capacities than other types of battery technology.

One type of AGM battery breaks ranks with an unconventional internal design and has a remarkable range of recharging voltages: the spiral cell AGM battery like the Optima and Exide's Orbital. Each cell consists of two long thin plates of high purity lead (one positive and one negative) with a layer of electrolyte laden absorbent glass mat in between. The materials are then rolled up tightly into a cylindrical shape and pressed into the battery's "six pack." containment case.

Spiral cell recharging requirements are much more liberal than other VRLA designs. Optima recommends that its deep cycle model be recharged at a constant voltage of 14.7V, with no current limits as long as the battery's temperature stays below 125 degrees F. These parameters are much in-line with the output from a standard alternator. Neither Optima nor Orbital offer a VRLA battery larger than a 75 Ah group 31.

The three gel cells in our test were the Mastervolt MVG 12/85, the West Marine SeaGel, and the Deka Dominator.

motion that causes a handle to dislodge, which would be similar to the motion exhibited when trying to wrestle a battery out of a battery box. As soon as you twist the battery into place, the handle will flex and disengage from the case.

Bottom Line: This battery tested poorly among the Group 27s, and its carrying handles are inadequate.

LIFELINE AGM

The Concorde Battery Co. manufactures Lifeline batteries, a recognizable and trusted trade name in the marine market. Concorde has a long history of providing batteries to the custom motor coach (land yacht) market. Lifeline also has a good relationship with many of the top-tier boatbuilders from coast to coast, which is affording Lifeline a good share of the new-boat market.

The Lifeline Group 27 AGM battery that was shipped to us made a good first impression as we unloaded it from the shipping container. The unit arrived almost fully charged and was shipped with an owner's manual and a warranty card. The battery posts on this battery are high quality, and the specification sticker on the battery clearly states what charge voltages should be applied to the battery. The color of the Lifeline battery—gray case with a black top — black carry strap, and silver specification plate — are all nice extra features.

Bottom Line: Lifeline batteries are quality products that are readily available nationwide and come with a good 5-year pro-rated warranty. The Lifeline performed better than the Deka / West Marine batteries and the Optima and Energy 1 batteries, but it fell short of the Mastervolt and the Trojan AGMs.

MASTERVOLT AGM / GEL

The Mastervolt VRLA batteries are installed on some of the world's finest custom yachts. From our initial experience with two of its entry-level products, we can see why. Mastervolt manufacturers the normal range of VRLA battery sizes, the same as Lifeline and Trojan, but the company also manufactures a line of high amp-hour, marine-grade, two-volt cells. Some of these two-volt units have capacity ratings of more than 2000 Ah per cell, which can yield a 12V storage bank with an excess of 12,000 Ah. That's a serious amount of stored energy.

There are colored polarity "rings" under each of the battery posts. These rings take the guesswork out of which terminal is the positive one. This is helpful particularly when you are working with a battery that is installed in an area with restricted vertical clearance and you cannot get a good look at the polarity symbols stamped on a battery's case.

Bottom Line: Both the AGM and the gel racked up excellent performance numbers. The Mastervolts are pricey for most applications, but if we were building a high-capacity, multiple battery bank, and wanted a product that had the highest probability of delivering the longest cycle life, Mastervolt would be our choice, hands down.

OPTIMA SPIRAL CELL

Optima manufacturers three different base models of its spiral cell AGM battery. The Red Top spiral for starting applications, the Yellow Top spiral as an automotive deep cell, and the Blue Top spiral as a marine deep cell.

We tested a Yellow Top Optima, but the product specifications are identical to the Blue Top Optima, with the exception that the Blue Top Optima comes with both SAE post and stud connections, whereas the Yellow top has only SAE studs.

The Optima is a physically large battery (Group 31) with a meager 75Ah reserve capacity rating. Although the spiral design looks good on paper, this battery does not have enough reserve capacity to be a serious contender for a house bank.

Bottom Line: Because the spiral design is tolerant to a wide range of recharging voltages, this battery would be a good choice for a day-sailer that needs its flooded cell batteries replaced. The strict charging profiles of the conventional flat-plate AGM batteries could be disregarded and the vessel would benefit from

The Energy 1's carrying handles detach from the case too easily.

Optima's low self-discharge rate. This would be extremely beneficial when the vessel is set on a mooring for extended periods of time.

TROJAN AGM

Founded in 1925, the Trojan Battery Co. is a third-generation family business that specializes in the design and manufacture of deep-cycle batteries. Trojan makes a complete line of deep-cycle batteries in both flooded cell and VRLA (AGM and gel) chemistries, in sizes that range from the smaller Group 24 to the heavyweight 8D battery. Although Trojan batteries are well identified by their trademark maroon case, the latest line of AGM batteries (which went into production in 2004) is manufactured with standard black cases.

There is nothing standard about the Group 27 AGM Trojan we tested. This battery smoked every Group 27 battery in our test group and it even went toe-to-toe with the larger Group 31 Mastervolt AGM.

Bottom Line: This battery is powerful and priced right. It appears that Trojan's new line of AGM batteries are well engineered and supported by a company that knows battery design and technology. We are a little disappointed by the short one-year warranty, but from what our test numbers showed a warranty should not be too much of an issue with this battery.

SEAVOLT SEAGEL

Private labeled by the East Penn Manufacturing Co. exclusively for West Marine, the West batteries are clones of East Penn's Deka line of VRLA cells. Although the SeaVolt and SeaGel each come with a 5-year pro-rated, "No Hassle" warranty, the extra warranty when compared to East Penn's Deka line will set you back approximately $60 per battery.

Bottom Line: When the Group 27 SeaVolt battery is compared to the Group 27 Lifeline battery, the SeaVolt stores a little less capacity. Given that both batteries are priced right around the $200 mark, and the Lifeline's warranty is also 5 years pro-rated, we'd opt for the LifeLine. We feel that the Lifeline is manufactured to a little higher standard than the East Penn, and as a result should yield a little longer life cycle.

CONCLUSIONS

When we evaluated the numbers from our performance test, it became clear that both Mastervolt batteries and the Trojan battery easily exceeded their factory reserve capacity ratings. Although battery reserve capacity is the primary component for determining the merits of a good deep-cycle battery, we also ran an amps-per-pound ratio for each tested battery and then factored in the battery's cost and warranty period.

In the end, we fel Trojan's 100Ah Group 27 AGM earned the Best Choice honors, though in testing it performed slightly below the Mastervolt AGM, which was our best Group 31 battery. Our Budget Buys, the Deka batteries, will satisfy money-concscious sailors who want to upgrade, but don't need the very best.

The Optima would be a good choice as a house battery for a small sailboat with an outboard or only a basic charging system. And Optimas are a nice alternative to a flooded battery for some applications (a big RIB, for instance) because they're spill-proof and can better take a pounding at high speed. A battery, unlike an engine, cannot be opened up and overhauled or repaired.

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