PROJECT BOAT RESTORATION

Which battery is best for my boat?

Ali Wood looks at power requirements and the pros and cons of wet, gel, AGM, lead carbon and lithium-ion batteries

After two years on the hard standing, *Maximus*'s batteries were completely unserviceable. We'd borrowed a lead acid battery from our marine electrician, Adam McMenemy, which would get the Maxi 84 afloat and through the lock to Chichester marina. However, now she was nearing the end of her rewire and we had to make a decision on new batteries.

I confess, science has never been my best subject, and if I could have simply gone to a shop and bought exactly the same batteries as *Maximus* had before, I'd have been happy. However, managing power requirements nowadays is something needing careful consideration.

With the help of Raymarine I'd be upgrading my nav gear – running a multi-function display, not just a GPS, and a tiller pilot, and VHF radio with AIS. A fridge would be nice, and enough power to run a tablet and charge phones.

But most importantly, *Maximus* would eventually be kept on a swinging mooring. I needed to be sure her battery could stay topped up without shore power or the engine running, so I needed a solar panel.

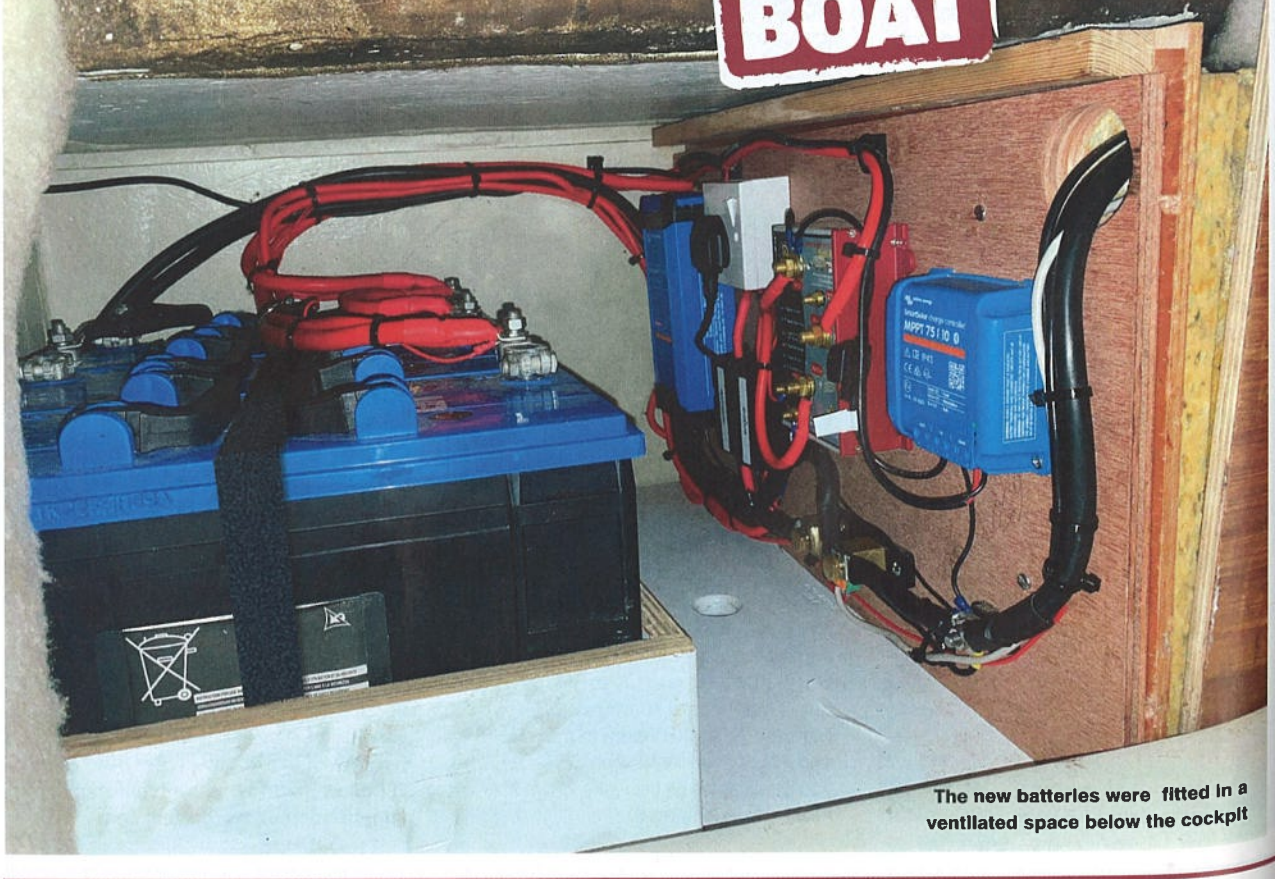
Before I could decide on my batteries, I needed to know how much power I'd be using on the boat.

Like it or not, I was going to have to get to grips with this, so I started the way I always do... right at the beginning.

Basic electrics

As Simon Jollands says in his new *The Boatyard Book*, 'All boat owners should have a basic knowledge of electrics, both to avoid encountering electrical problems at sea and to stand a chance of solving them should they occur.'

Good advice. This meant getting my head around current, which is the flow of electrons within a circuit (measured in amps); voltage, which is the force that pushes that current through the wire; and watts, the rate of energy



The new batteries were fitted in a ventilated space below the cockpit

ABOVE Some marinas, such as Chichester Marina, require a key code for electrical supply. With others, shore power is included in the price

BELOW Shore power allows you to bring AC electricity on board using a power cable and connectors

WirkinPink Picture Library Alamy

LEFT The engine is started with a cranking battery. Very high loads are delivered for a few seconds and this is restored by the alternator once the engine is running. If the revs drop (as they later did!) this could be an indication the alternator isn't working

consumed by an appliance.

So, for example, a 2,500W electric windlass (200A) might consume electricity at a rate 100 times higher than a 25W light bulb (2A).

Every piece of electrical equipment on a boat should have a label or manual that explains either its demand for amps, its output in watts or both.

Batteries are rated in amp-hours (Ah) to give you an idea of how long they'll provide power. So, theoretically, a battery rated at 100Ah should give you 100 amps for one hour, 50 amps for two hours or 1 amp for 100 hours until completely discharged.

I say theoretically because, if you discharge a battery below 50% (or even 60% or 70%) of its stated capacity it won't last very long.

Therefore, if you actually want 100 amps, you'll be needing a battery bank at least twice that amount (200Ah), as even the best battery chargers or alternators struggle to cram the last 20% of charge back into a battery. Plus, sulfation on the battery banks reduces capacity by a further 10%.

Here's how amps, volts and watts work together:

- Volts x Amps = Watts
(example: 12V x 6A = 72W)
- Watts / Volts = Amps
(example: 300W / 12V = 25A)
- Amps x Time = Ah
(example: 2.5A x 5h = 12.5Ah)

Battery cycle life

Batteries don't last forever. There's an important distinction between shelf life – how long an inactive battery can be stored before it becomes unusable (ie having only 80% of its initial capacity) and cycle life – the number of times the battery can completely charge and discharge (1 cycle) before it becomes unusable.

For a lead acid battery, lifetimes of 500 to 1,200 cycles are typical (double for lithium-ion batteries), but the ageing process results in a gradual reduction in capacity over time.

However, there are other factors affecting cycle life, such as temperature (the ideal temperature is 10°C or less, which isn't easy to achieve on boats, especially if the battery is in an engine room), capacity, and age. All sealed lead acid batteries will eventually exceed their life expectancy.

The number of useful cycles any battery will give you over its lifespan is also governed by how low you take its charge each time, and how quickly you take the power out. This is known as Depth of Discharge (DoD).

Cold cranking amps (CCA) is the number of amps a battery can support for 30 seconds at a temperature of 0°C before the battery voltage drops to unusable levels. When comparing starter batteries, this can be a useful consideration, especially in colder climates. Replacement batteries should equal or exceed the original battery's CCA.

DC and AC systems

Small boats like *Maximus* have a 12V DC (direct current) system, whereas larger boats often run off a 24V system. In addition, some boats have an alternating current (AC) generator to power domestic electrics and charge batteries instead of the engine.

Shore power is your yacht's second electrical system, and this allows you to bring AC electricity on board using a power cord, with the male connector plugging into the power outlet on the pontoon and the other end, a female connector, plugging into the vessel. As well as charging your batteries, this enables you to use low wattage appliances (ideally no more than 2kW) with 3-pin plugs like you get a home.

Types of boat batteries

Boats usually have two batteries (or banks of batteries) to ensure one is for starting the engine only, and the other to run the domestic systems. Sometimes (though not on *Maximus*) there's a third set of batteries for high power items such as a bow-thruster or electric windlass.

Wet lead acid

Batteries that have liquid electrolyte sloshing around in them are sometimes referred to as 'wet', 'flooded' or 'wet lead acid' batteries.

To start the engine, boats have a

Powermax leisure batteries on offer in a chandlery

Rolls sealed VRLA deep cycle batteries on the Ecobat stand at Southampton Boat Show

starting or 'cranking' battery, like those used in cars, which delivers very high loads for a few seconds. Only a small portion of the battery's capacity is used and this is restored by the alternator once the engine is running.

For powering everything else (ie chartplotter, lights, fridge, etc) boats use a domestic, or 'house' deep-cycle (or deep-discharge/traction) battery bank which draws a much smaller amount of power over a longer period of time.

It's important that wet lead acid batteries are stored in a ventilated area. A disadvantage is that they can 'gas off' (release hydrogen) if faulty, overcharged or getting old.

Pros: cheap, readily available, lots of choice, starter batteries can be bought in automotive stores.

Cons: heavy, can leak, need regular charging, useless once flat, can gas off.

Wet lead acid – dual/leisure battery

An 'in-between' option is the 'dual' or leisure battery. A compromise between starting and deep-cycle batteries, these are popular on boats that carry only a single battery, or prefer to have the same type of battery for simpler charging.

Maximus had a leisure battery for starting the engine (an 85Ah Green Power) and a 100Ah deep-cycle Lifeline Battery for powering the rest of electrical equipment.

Both were flat after being left on board for two years and so could not be revived.

Pros: cheap, readily available, lots of choice, dual-purpose starter and domestic.

Cons: heavy, can leak, need regular charging, useless once run flat, can gas off.

Sealed lead acid batteries (gel & AGM)

Nobody wants battery acid leaking into the bilge, but there's a price to pay if you want more durable batteries.

Sealed lead acid batteries are sometimes referred to as VRLA (valve regulated lead acid) and there are two main types – absorbed glass mat (AGM), where the battery plates are protected by fine-stranded glass mats – and gel, where the liquid electrolyte has been converted into a gel.

AGM batteries can be used for both starter and house applications whereas gel batteries are better suited for house applications only.

Both types can withstand many more charge/discharge cycles than conventional deep-discharge batteries – for example, a 7-10 year lifespan rather than a 4-5.

Pros: leak-proof, longer lifespan than wet lead acid, AGM can be dual-purpose starter and domestic.

Cons: twice the price of wet lead acid, up to 25% heavier, need regular charging, useless once flat.

Lead carbon batteries

Lead carbon batteries are not widely known. Our electrician had never fitted them, and indeed I hadn't considered these until I spoke to Victron Energy. However, they are highly regarded by PBO contributor Paul Sumpner, who fitted Leoch lead carbons to his electric-propulsion narrowboat *Old Nick*.

Paul worked out his requirements, which were a regular DoD of 50%, year-round usage, a minimum of 48V, 600Ah, zero maintenance, a life cycle of 3,000+ discharges, non-vertical mounting and to be able to survive a regular partial state of discharge. Plus, they couldn't "completely

Numax 100Ah marine battery

Rolls R12-110 AGM battery

blow the budget".

"It became clear that only lead carbon or lithium batteries would be suitable," he said, and later confirmed he couldn't be happier with the equipment he chose (you can follow his adventures on **thesumpnersafloat.com**).

Lead carbon batteries are an advanced type of VRLA battery, which has a positive plate (anode) of lead, but a negative (cathode) plate made of carbon composite. According to Victron, the advantages are less sulfation, and a lower charge voltage, meaning higher efficiency and less corrosion of the positive plate. Overall, the result should be an improved cycle life.

Pros: leak proof, longer life, less sulfation.

Cons: more expensive, can't be used for starter motor, larger and heavier than AGM or lead acid.

Lithium batteries

Lithium-ion is a broad chemistry of batteries, the most common being

Paul Sumpner

RIGHT *Old Nick*, Paul Sumpner's narrowboat, is electrically propelled and runs off lead carbon batteries. BELOW The extensive lead carbon battery bank for electric narrowboat *Old Nick*

Paul Sumpner

RIGHT Victron's lead carbon batteries were too big for *Maximus*

'Lithium-ion batteries are built to last much longer than any other'

LiFePO4 (Lithium Iron Phosphate). They can withstand four or five times the number of cycles compared to most deep-cycle lead acid batteries (4,000+), can go down to a much lower state of charge, and can keep a reasonable level of charge for up to 12 months.

While lead acid batteries, in practice, only allow 30% of rated capacity, lithium batteries can be discharged to 70-80% of the rated capacity. So really, a 100Ah lithium battery is the equivalent to having a 200Ah lead acid battery, only it will usually charge much quicker, is half the weight and a lot smaller.

A word of warning, though. Although lithium batteries can accept fluctuating voltage (13.6V-14.6V) like lead acid batteries, they should not be directly charged from an alternator because voltage spkes could damage them. A dedicated charger and battery management system is a necessity.

Pros: long-lasting, can use 80% of capacity, easier to manage, small, lightweight.

Cons: expensive (up to 4 x cost of wet lead acid), boat adaptations required.

RIGHT AMPS 100Ah deep cycle lithium-ion battery

Next steps

Having had a brief look at batteries, I called marine surveyor Ben Sutcliffe-Davies. I wondered if there was any possibility of reviving flat batteries.

"I'll be honest with you, start with new batteries," he said. "You're relying on this battery to start the boat. Yes it might pick up, but I guarantee it'll be like a dying swan when you need it."

For domestic systems, Ben likes Numax batteries, which he says a lot of the industry use. For the cranker, he said, any automotive battery would do.

"I went down to my local tyre and exhaust place, and just got four heavy-duty deep cycle leisure batteries and one tidy cranker for the engine," he told me.

Do you need a different cranker battery?

Ben advocates having a high-load starter battery and separate domestic battery for trickle discharging the systems; something around 100Ah.

"You don't want to go too big because if the output on the alternator's not big enough, and you flatten it, it'll take you three hours to charge back up."

Our electrician, Adam, agreed that keeping one battery as a starter-only is important, but said we could still go for three of the same type of battery – for example, 3 x 115Ah flooded dual Exide batteries. The benefit of this would be they're easier to manage and charge (more on that later).

What size battery do I need?

Ecobat, formerly known as Barden, are really helpful when it comes to choosing batteries. I spoke to Gordon Akehurst.

For the cranker battery Gordon said to start by looking at the old one, which would have been specified for *Maximus*'s Volvo MD2020 saildrive. Once I knew the Ah for that (85Ah) then I should be fine replacing like for like.

If I wanted to keep the battery in the same space (ie in front of the engine) then it also made sense to get one of the same dimensions. The 85Ah are a standard 260mm long, he advised, so that shouldn't be a problem.

However, he also added it's not good practice to keep a battery in an engine room where it gets hot, so actually now could be the time to house the domestic batteries elsewhere.

Gordon quoted me for a lead acid, but then also gave me the more expensive option to upgrade to AGM.

"AGM are quite a lot heavier than standard lead acid," he warned, "It doesn't make a huge difference on the starter battery (19kg lead acid vs 21kg AGM), but for the domestic battery we'd be looking at a difference of 6kg (21kg lead acid vs 27kg AGM).

Lithium batteries are half the weight again (13.5kg) but these can only be used for domestic use, not to start the engine.

Domestic battery

It's the house or domestic battery bank where you need to get your calculator out. In order to work out the battery capacity you need to know how much power you're going to draw, and this goes back to the equations I mentioned earlier.

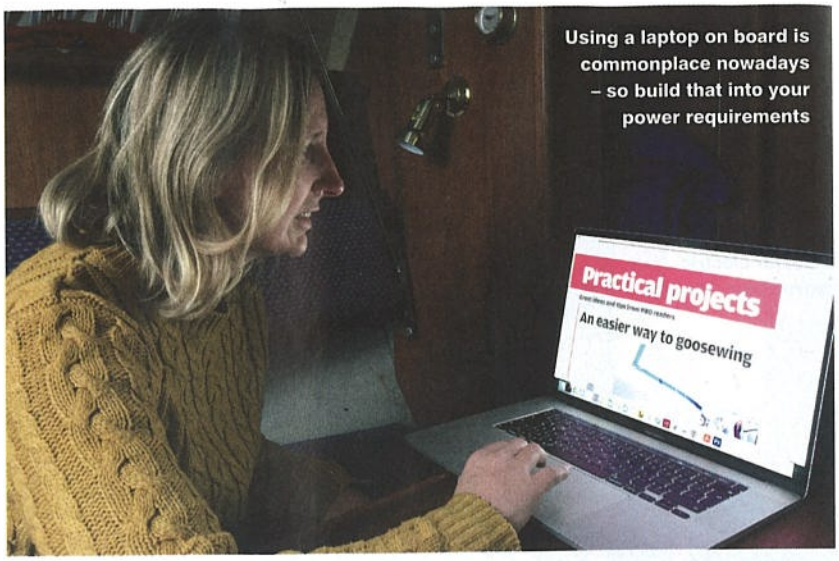
Stu Davies, PBO's engine expert, urged me to consider what might be a daily routine on *Maximus*.

"Would you turn your fridge on as soon as you get on board? Lights on at 6pm till 11pm? TV? Batteries are only good for half their stated capacity in reality."

Stu then advised me to think about making passage. "VHF on standby, MFD for chartplotting, wind and depth? Nav lights for night passage?" he suggested. "The rest doesn't really matter – a solar panel will keep on top of them. I imagine two x 110Ah batteries plus a starter battery is good enough for your needs. Add in a 100W solar panel and you're good."

That sounded good to me, but of course, I needed to do the sums.

If your electrics are already up and running, as most boat owners' are, then you can work this out with a multimeter or, if you have a battery monitor such as Victron's, by turning on the items one at a time and reading the actual current draw.



Using a laptop on board is commonplace nowadays – so build that into your power requirements

With *Maximus* we were starting from scratch so I sourced either the power rating (in watts) or current draw (in amps) for each item I planned to use, and then estimated how long, in a given day I might be running this for.

As long as you know either one of these, you can work out the current draw with the following equations:

- Power (W) = Current draw (A) x System voltage (V)
- Current draw (A) = Watts (W) / System voltage (V)

Then, once you know your current draw, all you have to do is work out the number of hours that piece of equipment will be switched on for.

So, for example, our 3W Osculati tri-light in a 12V system will draw 0.25A (3 divided by 12). If it's switched on for an overnight passage of 10 hours, it will consume 2.5Ah (0.25 x 10). Assuming we replaced all our bulbs with LEDs, here was what I worked out (see table, below).

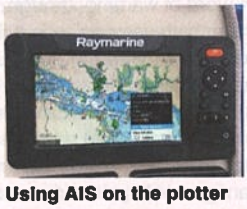
This was the most I could imagine using – it assumed being on night passage for 12 hours, and then at anchor or on a swinging mooring for the remaining 12. I have no plans to cross Biscay just yet...

It was actually a really good exercise because, very early on in *Maximus*'s refit I was having to focus on what items I needed, and which of these should be installed while still in the boatyard. For example, the through-hull transducers for the wind and speed instruments, and the tri-light and steaming light to be fitted while the mast was down.

Electrical accessories and current draw

Item	Current draw (A)	Hours of use	Amp hours (Ah)
Tiller pilot	0.04	12.00	0.48
Bilge pump	5.00	0.05	0.25
Cabin lights (eg. 3 @ 0.6A)	1.80	4.00	7.20
Chartplotter/ MFD	1.25	12.00	15.00
Wind/ depth/ speed	0.14	12.00	1.70
Wind direction/ speed	0.20	12.00	2.40
Instrument transducer converter	0.15	12.00	1.80
Distribution panel	0.10	12.00	1.20
Fridge	4.00	3.00	12.00
Tri light (anchor & nav lights)	0.25	n/a	n/a
Bow light (port and starboard)	0.33	4.00	1.33
Combined steaming/deck light	0.33	4.00	1.33
VHF (standby)	0.60	12.00	7.20
VHF (transmit)	2.00	1.00	2.00
VHF (high power – AIS receiver)	6.00	12.00	72.00
TOTAL	22.20	115.05	125.90


Raymarine tiller pilot

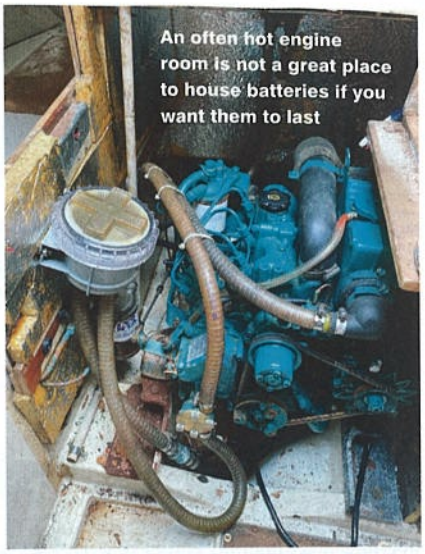


Using AIS on the plotter


Osculati tri-light

*In this instance I've assumed motoring at night so the tri light would not be switched on because I'd be using the bow light (port and starboard) and steaming light

Installing the batteries aft under *Maximus*'s cockpit



An often hot engine room is not a great place to house batteries if you want them to last

Which did we choose

Let's say I needed, at most, 130Ah out of my domestic battery, then I would be wanting house batteries with at least double that capacity (260Ah)

We didn't have the budget for lithium-ion batteries, and as weekend sailors they didn't seem necessary.

We did consider lead carbon batteries, though our marine electrician knew very little about them and I didn't know of a single boat owner who had them, other than *PBO* contributor Paul Sumpner, who fitted them on his narrowboat.

In his article (PBO June 2021), Paul pointed out that they can survive a regular partial state of charge (PSOC) and his Leoch lead carbon batteries had 3,000 life cycles, which – with the exception of lithium-ion – was over three times the lifespan of most other types of battery.

However, we couldn't find space for the 53cm-long 160Ah lead carbon batteries I discussed with Nigel Vincent at Victron Energy, so decided to go with Adam's advice and get three of the smaller Exide batteries which would be easier to manoeuvre into position. Adam rated them highly and had fitted them successfully to many boats our size.

Where to put batteries

Batteries need to be secured. You can make your own box or buy a plastic or polypropylene box which is screwed down and has a strap, like a seatbelt, to keep it in place. Also, if you can avoid it, don't put your domestic batteries in the engine room.

"One thing that does harm batteries is the temperature," said Peter. "If the engine compartment gets very hot it will reduce the lifespan of the battery. The starter battery might have to be there, but the domestic battery should ideally go somewhere where it's 25°C or lower."

Equally, you can't let batteries get too cold. If you own an open boat, such as RIB, or keep your batteries in a cockpit locker, it's a good idea to remove them over winter.

Caring for batteries

Unlike car batteries which tend to be used frequently,boat batteries spend a lot of time idle, and while it's not good for them to be discharged, it's also not good for longevity for them to be constantly charged, advises Adam.

"Batteries like to be charged and discharged," he says. "A solar panel is good because it charges in the daytime and not at nighttime, allowing the batteries to fluctuate.

"If you're in a marina, charge the batteries for a month, then leave the charger off for the next month. Go down and switch the lights and instruments on for a while. Don't be afraid to let them run down. If you take your batteries home for the winter, trickle-charge them for 24 hours, let the acid and electrolytes move around to prevent the plates getting a film over the top."

The three new Exide batteries wouldn't fit in the engine room but we found space for them to the aft of the boat under the cockpit. A box fixed to the boat keeps them secure

Battery comparison table

Type	Usage	Brand	Dimensions (l x w x h)	Ah	Weight (kg)	Price	Other brands
Wet lead acid	Starter	Numax MV26MF	302 x 175 x 225	100	19.5	£95	Trojan, Varta, Powermax, Exide
Wet lead acid	Starter/house	Exide ER550	345 x 175 x 235	115	28	£118	Trojan, Varta, Powermax, Exide
Sealed lead acid/ AGM	House	Rolls R12-100AGM	307 x 169 x237	100	27	£246	Lifeline, Odyssey, Varta, Victron
Sealed lead acid/gel	House	Trojan 31-GEL	329 x 171 x 245	102	31	£350	Exide, Trojan, Leoch, Victron
Lead carbon	House	Victron	532 x 207 x 226	160	55	£460	Leoch
Lithium-ion	House	Sterling AMPs	330 x 215 x 170	100	14.4	£550	Victron, Super B, Mastervolt, Relion

*Batteries chosen to show a range of brands and prices, not because PBO recommends these over others. Prices include VAT and UK delivery, and are taken from online retailers