

## **Lithium-ion Frequently Asked Questions (FAQ)**

### **What sizes of Lithium-ion (Li-ion) batteries does Yale currently offer?**

Yale offers both 24 V and 48 V trucks with Li-ion batteries.

From June 2017, we have the following SPED options in our price list:

- 1.6-1.8-2.0t Pedestrian Pallet Truck with a 56 Ah battery (single pack). The 112 Ah battery (double pack) can be, instead, ordered through a SPED request (via Contact Management);
- 24V Low Level Order Picker and Tow Tractor models with 300 and 400 Ah battery capacities;
- 48V 3-Wheel and 4-Wheel Counterbalanced trucks (in the capacity range 1.5t /1.6t /1.8t /2.0t) with the following battery sizes: 300 and 400 Ah (Short Wheelbase), 450 and 600 Ah.

Starting from June 2017, the Platform Pallet Truck, Pedestrian Stacker and Reach truck can be ordered raising a SPED request (via Contact Management). These trucks will be available from Q1/Q2 2018.

From October 2017, we shall be adding an 80V Counterbalance solution.

### **What are the types of charger offered?**

On the 24V Pedestrian Pallet Truck we offer a 20 A on-board charger option, which takes less than 3 hours to fully charge the 56 Ah battery.

On 24V Low Level Order Picker and Tow Tractor models, we offer a range of chargers, matched to the battery capacity, offering 1 hour, 2 hour and 4 hour charging.

On the 48V trucks, we offer a range of chargers, matched to the battery capacity, offering 1 hour, 2 hour and 4 hour charging.

### **Is this the breakthrough for Li-ion?**

We are seeing more customer interest and demand. We have taken an order for a fleet of 34 Low Level Order Pickers and we are quoting both 24 and 48 V trucks.

There is growing interest in Li-ion, the sales are small currently but growing rapidly in Europe.

### **Have you a projection for the take-up of Li-ion batteries in Materials Handling Equipment (MHE)?**

We are expecting demand to grow, hence our investment in the technology. At this stage we cannot disclose our commercial targets.

### **What applications are best suited to the Li-ion solutions?**

At present Li-ion solutions are particularly suited to multiple shift applications replacing secondary sets of batteries and reducing handling costs.

A single Li-ion battery can extend its operating range with opportunity charging for which it is very well suited. A key element is using work-breaks, idle time, shift change-over time to charge the battery. These applications are where we predominantly see Li-ion. This represents 25-30% of applications.

Li-ion is also of interest to environmentally sensitive environments, such as in the food production and pharmaceutical industries. As there are no emissions, the batteries are sealed and there is no risk of acid spillage.

### **Is the initial cost of Li-ion batteries higher than Lead Acid?**

The acquisition costs of Li-ion batteries have declined significantly in the last 5 years and are expected to continue falling. The higher initial cost, when compared to lead acid, can be offset in multiple shift applications because no replacement battery set is needed, no change-over equipment is required, and the expense of dedicated change-over and charging rooms that require ventilation can be avoided. Lower energy costs and lower maintenance costs are also to be considered.

### **What about the energy consumption comparing Lead Acid and Li-Ion?**

Higher charging efficiency will yield some savings, as will higher efficiency during discharge. Savings up to 30% in the energy used by the charger can be expected compared with conventional lead-acid battery and charger. In operation, Li-ion batteries can be significantly more efficient in the delivery of energy to the truck due to the impact of the 'Peukert effect' on lead-acid batteries. This effect significantly reduces the efficiency of lead-acid batteries in applications where current draws by the truck are high, such as intensive applications with much traction hydraulic work. This makes Li-ion batteries particularly attractive in more intensive applications where their efficiency advantage over lead acid is greatest. Li-ion does best, where lead acid does worst!

### **What about the energy consumption on the truck?**

We expect this to be very similar to that with lead acid. It should be slightly lower due to energy recovery in deceleration (plugging) but this effect will be very application dependent.

### **So is the lead-acid battery obsolete?**

By no means. It is a proven technology that is cost effective, especially in light and medium predominantly single shift applications and will remain the dominant storage medium for the foreseeable future.

### **How long will a Li-ion battery last?**

The life of a Li-ion battery depends on how it is discharged. As with lead-acid batteries temperature also has an impact on life, very high ambient temperatures being detrimental.

A flooded lead-acid battery is typically discharged to a maximum of 80% and will yield 1200 cycles (discharge charge = 1 cycle). In a standard single shift this may last up to 5 years or slightly more. If we limit the depth of discharge (DOD) to 80% for the Li-ion battery, over 3750 cycles are possible. At 70% DOD, the cycle life increases more. We can say that a Li-ion battery has between 2-3 times the life of a flooded lead-acid battery.

### **What about recycling of Li-ion batteries vs Lead Acid?**

Li-ion is a newer technology and there is still work to do to achieve the levels of recycling seen with lead-acid batteries. However, it should be considered that Li-ion batteries have a typical operational lifetime of two to three times that of lead acid.

We do expect Li-ion batteries to have significant value in 'second life' as although capacity of the battery will diminish over first life, the remaining 60-70% capacity is usable over again in less intensively used trucks in second life. Eventual recycling does have a cost. Costs currently are in the range of a few hundred Euros, as very few are being recycled; expectations are that these costs will decrease somewhat over the next 5 years.

### **Is safety an issue with Li-ion batteries?**

Safety is a consideration for all types of batteries and correct handling and care are essential. Li-ion batteries have a built-in electronic battery monitoring system (BMS) which is constantly monitoring voltages, temperature, over-discharge and overcharge.

Our batteries are certified by our suppliers, and are compliant with industry standards. Also, with integrated Li-ion solutions the battery communicates with the truck via CANbus. This means we can reduce the performance, slow-down the truck, interrupt the lift function and stop the truck in a controlled manner when battery discharge becomes critical.

### **Who supplies your batteries?**

We source the battery for the 24V Pedestrian Pallet Truck from BMZ. For the larger 24V battery sizes as well as 48V and 80V batteries we are working with Midac.

### **Which battery chemistry do you use?**

The battery on the 24 V Pedestrian Pallet Truck is Nickel Manganese Cobalt. The other 24V batteries, 48V and 80V batteries are Lithium Iron Phosphate.

### **Why do you use different chemistries?**

This is not uncommon. The choice of chemistry reflects different properties such as energy density, temperature range, cycle life, charging capability and cost (both initial cost and relative cost). The key is to match the battery to the truck. Nickel Manganese Cobalt is usually used in more compact trucks because of its higher energy density.

### **Do you see other chemistries in the future such as Lithium Titanate?**

The chemistries are evolving and although new technologies are appearing, the issue of commercial viability is a key consideration. Today with our suppliers we are well positioned in the marketplace to adopt the technologies best suited to MHE applications.

### **Are your Li-ion batteries usable in the cold store environment?**

For cold store environments we can supply a battery with a heater through SPED. Of course, batteries should always be charged outside the cold store cell at a temperature above 0°C.

### **Are Li-ion batteries retrofittable on existing trucks?**

As there are some significant changes required for integration with Li-ion batteries, we are initially supplying Li-ion ex-factory, however our software on the trucks allows them to run either on Li-ion or lead-acid batteries. Standard application codes for trucks going forward will be Li-ion capable. In the short term, however, we cannot retrofit Li-ion batteries into existing trucks.

**Can a Li-ion battery be used if the dealer has a second hand truck or if the truck is a stock truck?**

There is no Aftermarket conversion available at this point.

**If the dealer needs to get stock trucks, can the trucks (with the batteries) be not in use for weeks or months?**

The battery will hold its charge for several months, however transport of these batteries is often carried out at a reduced state of charge and we strongly recommend the dealer charge the batteries to full charge as soon as they arrive at the dealership. If batteries were to be held in long term storage for months or years some monitoring and occasional charging would be required.

**If the dealer has to take back the truck and has to change the Li-Ion battery after 5 years and use a lead-acid battery, are modifications mandatory?**

Yale® Li-ion trucks can be operated with standard lead-acid batteries with dealer applied software switches/CDF change. Li-ion battery chargers can be reverted to operation with lead-acid batteries with minor switching/software changes.

**What assurances can the dealer make on life time of the battery?**

Battery life expectations are high. Battery life of Li-ion batteries is more predictable than that of lead-acid batteries (which are more sensitive to maintenance, opportunity charging etc.). Performance of the battery will change over the product life in a roughly linear manner, based on the power throughput – i.e. how much work does the truck perform, and on operating and charging temperature which must be maintained within operating limits. Lower operating temperatures and charging temperatures will maximize the battery life. We do therefore expect second life use and value in these batteries well beyond the 5 year warranty.

**Do we have Marketing material with explanations?**

From Q4 2017, we have a Lithium-ion Sales Tool available on the Dealer Extranet as well as digital and printable marketing material.

**Is there a calculator tool to check if the Li-ion battery is suitable for the application?**

Yes, there is a Lithium-ion Battery Calculator tool for each truck equipped with Li-ion battery. The tool checks the suitability of the Li-ion battery and charger in the application and provides an estimation of the costs and Return on Investment (ROI) in years. There is also a Lithium-ion Application Tool for the Pedestrian Pallet Truck with BMZ Li-ion battery. These tools are available from Q4 2017 on the Dealer Extranet.

## **BMZ battery on Pedestrian Pallet Truck**

### **Where is BMZ based?**

BMZ is based in Germany.

### **Is the BMZ Service team based in several countries?**

Service of the BMZ battery is supplied by HYG. HYG Service organization is ready to support.

### **What about the warranty of the battery?**

A BMZ battery is warranted for 5 years/10,000 hours, recovery of the warranty and part replacement will be through the HYG warranty system.

### **If the battery has a problem, can the dealer try to fix the issue?**

It depends on the issue. Basic diagnosis and connection repairs can be done. There is no expectation that dealers will fix major problems, which require opening the battery.

### **If the battery does not work, how long does it take to get a new one?**

A replacement battery will be available directly from HYG stock, held for us at BMZ in Germany. HYG Aftermarket is setting up that supply arrangement.

### **Can we increase the battery capacity (Ah) to get same batteries as competitors?**

Yes, we are now able to quote via SPED a double pack version of this battery with 112Ah capacity.

### **What about the chargers: on board/external?**

Currently, only a 20A high frequency on-board charger is available.

### **Can we use a standard external charger (used for lead-acid battery) or a specific one?**

At present, only the supplied on board charger is equipped with the correct charging profile for this battery. When an external charger is available, it will be different from a charger used for a lead-acid battery.

### **Which is the difference in terms of charging time between on board charger and external charger?**

Current on-board charger takes 2-3 hours.

### **Do we need to ask the customer to have a bigger diameter for the Energy wire?**

Not with current on board charger.

### **What about the charging time in several cases: if the battery is discharged more than 70% or more than 80%?**

The bulk charging rate, using the onboard charger, is 20A per hour. So a 56Ahr battery taken to 90% depth of discharge (50.4Ahr discharged) requires approximately 2.5hrs (50.4Ahr/20A) to return the full discharge. The recharge will be approximately linear. Note that onboard charger output performance, like wall chargers can be hampered by low efficiency grids. We have encountered scenarios with longer than expected times. The root cause was low power factor conversion from the

grid which proportionally extends recharge time. Power factor management is part of standard operating practices in factories, and these losses occur on all trucks in a facility that is unable to achieve a good power factor.

### **Which is the number of cycles compared to lead-acid batteries?**

The number of cycles with Li-ion is expected to be 4000, compared to 1200-1500 for lead-acid batteries. A particular and useful difference with Li-ion is that opportunity charging (partial charge added to a battery in a lunch break for example) does not diminish the life of a Li-ion battery as it does a lead-acid battery.

### **Is there a calculator tool to check if the Pedestrian Pallet truck with Li-ion battery is suitable for the application?**

There is a Lithium-ion Application Tool for the Pedestrian Pallet Truck, which checks the suitability of the BMZ Li-ion battery in a typical application, i.e. unloading lorries. Calculations are based on a number of actual tests. The Lithium-ion Calculator Tool can also be used for this truck and provides an estimation of the costs and Return on Investment (ROI) in years.

Both the tools are available from Q4 2017.

## **MIDAC batteries on 24 V and 48 V Trucks**

### **Where is Midac based?**

Midac is based in Soave Italy near Verona, 2 hours from our Masate Plant.

### **Is the Midac Service team based in several countries?**

Service of the Midac battery is through the Midac Aftermarket system in Europe.

### **What about the warranty?**

A Midac Battery is warranted for 5 years/10,000 hours, recovery of the warranty and part replacement will be through Midac.

### **If the battery has a problem, can the dealer try to fix the issue?**

It depends on the issue. Basic diagnosis and connection repairs can be done. There is no expectation that dealers will fix major problems, which require opening the battery. Midac will support in this case.

### **If the battery does not work, how long does it take to get a new one?**

Battery support will be available directly from Midac.

### **Can we increase the battery capacity (Ah) to get same batteries as competitors?**

Yes, competitive sizes are available.

### **What about the chargers: on board/external?**

External chargers are available, with low, standard and fast charging rates, matched to the battery. On-board chargers are not available at this point: the higher current draw of the chargers makes rapid connection to the mains supply less practical.

### **Can we use a standard external charger (lead-acid battery) or a specific one?**

A Li-ion battery requires a carefully designed charging current profile and for this reason we offer matched chargers and warrant the battery for 5 years only when used with the matched charger. The battery is designed to only accept charge from a suitable charger, and will self-protect when unsuitable chargers are connected. Approval of existing chargers when adapted for Li-ion use may be possible.

### **Do we need to ask the customer to have a bigger diameter for the Energy wire?**

With rapid chargers this may sometimes be necessary. The power requirements will be quoted in our materials for each charger. Overall power requirements do require some planning when larger fleets of rapid charged trucks are being considered.

### **How quickly does the battery charge when it is almost exhausted, compared to when it is 80% or 90% charged?**

The recharge will be approximately linear. It will take on energy at approximately the same rate.



**What is the number of cycles compared to lead-acid batteries?**

The Midac battery has life expectation of 3750+ cycles at 80% DOD, lead-acid is often quoted at 1200-1500 cycles.

**Is there a calculator tool to check if the Li-ion battery is suitable for the application?**

The Lithium-ion Battery Calculator tool is suitable for each truck equipped with Li-ion battery. The tool checks the suitability of the Li-ion battery and charger in the application and provides an estimation of the costs and Return on Investment (ROI) in years. The tool is available from Q4 2017.



## Key benefits of Li-ion

- High energy density vs lead acid
- Longer cycle life – over 3750 cycles at 80% DOD
- No negative effect on battery life on account of opportunity charging – a single battery can replace 2 lead-acid batteries in multi shift operations – no need to change over batteries – time and infrastructure savings
- Fast charging capability during and at end of shift
- Emission free – ventilation of charging room not required
- Better energy efficiency from battery and charger = lower annual energy costs
- Lower CO<sub>2</sub> footprint
- Lower annual maintenance cost – no topping up of lead-acid battery
- No memory effect