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The Battery Balancing Act – Technology vs. Application Needs

Electronics are part of everyday life and are prevalent features in commercial buildings today. Even many public restrooms rely on electronics to power electronic fittings, which have become the norm. Sensing technologies based on electronics are most often used for hands-free activation of plumbing fittings such as faucets and flushometers to improve user accessibility in compliance with the Americans with Disabilities Act (ADA) and improve overall hygiene and restroom cleanliness.

Electronic plumbing fittings offer sanitary, touch-free operation, while conserving water and energy in that they only flush or dispense water when the sensor detects a user. Sensor-activated faucets can also limit water delivery duration.

There are various types of power sources for sensor-activated plumbing, including hardwire, battery and power-harvesting options, such as solar or turbine products. Battery-powered plumbing products often include warning lights that indicate when batteries will soon need to be changed. Some battery-powered flush valves also have mechanical overrides that enable manual flushing when the batteries need to be replaced. If batteries are not practical, then hardwired fittings may be a better choice.

Battery-powered and hardwired systems have advantages and disadvantages depending on the application. When the sensing technology was first introduced, battery-powered fittings were only used in building retrofits where it would either be impossible to hardwire the existing space or a cost-effective addition of the low voltage power was not feasible. Hardwired systems are good for new construction or major re-construction projects where additional electrical service can be more readily run.

Today, good battery-powered systems are used as often as hardwired as they avoid the upfront cost of adding electrical wiring. Further driving acceptance is the ever increasing battery life, which extends the service interval and lowers the total lifetime cost of the product. While choosing battery over hardwire on new construction reduces the initial installed cost, the cost to maintain batteries is pushed onto the facilities management staff – very frequently without their input.

Because there are many different types of batteries available, it is important to understand the advantages and disadvantages of each type to better understand why certain batteries may be preferred. This paper will evaluate the battery options as a means to decipher the differences between the single-use, primary batteries available.

Battery types

All batteries have a set energy density, or capacity, from which power is drawn. High or low current needs, intermittent or steady drain, and temperature are all factors that impact battery longevity. In the case of plumbing fittings, restrooms typically have low current, intermittent drain conditions, and the temperature depends on the location (indoor versus plumbing in more exposed areas, such as a standalone restroom building in a park).

Another consideration is the shelf life of the battery which should not be confused with the service life. The shelf life is the duration of storage under specified conditions at the end of which the battery still retains the ability to give a specified performance (per Duracell). The service life is the period of useful life of a battery before a predetermined end-point voltage is reached. Shelf life relates to the self-discharge rate of the battery where service life is more dependent on the requirements of the device being powered. Sip power, and the service life gets close to the shelf life. Gulp power, and the battery depletes quickly.

The most common type of primary battery is alkaline. It gets its name from its use of alkaline aqueous solutions as electrolytes – based on manganese dioxide, zinc and a caustic potassium hydroxide-zinc oxide electrolyte. The alkaline battery has a high energy density; long shelf life, which is typically seven years; and superior leakage resistance. Its lower internal resistance allows it to operate at high discharge rates over a wide temperature range.

Alkaline batteries have a high rated capacity and deliver their full capacity if the power is used slowly. Under normal, room temperature conditions, the battery will self-discharge at a rate of less than 2% per year. However, if alkaline batteries are stored or used in higher temperatures, they will lose capacity more quickly. For example, at 85°F, they lose about 5% per year; at 100°F, they lose 25% per year. Interestingly, if used under cooler climates, the capacity change is insignificant and really does not affect how long the battery will last. The shelf life is still seven years in environments below normal room temperature. Fortunately, most plumbing fittings are installed in cooler places and make alkaline batteries a good choice.

One disadvantage of alkaline is the possibility of leaking when it is normally discharged below 0.8 V. To minimize that problem, Sloan intelligent power management first warns the user of a “low battery” with an indicator light. After a number of additional activations (allowing time to replace the batteries), it shuts the power off when the battery voltage drops below a critical level. Doing this ensures the fitting does not initiate water flow without enough power to end the cycle.

One of the advantages of alkaline batteries over other batteries is the relatively low toxicity of the ingredients. Therefore, alkaline batteries pose less of a challenge to the environment and can be more readily recycled. Additionally, the cost and availability of alkaline batteries add to the convenience.

The lithium manganese dioxide ($LiMnO_2$) and lithium iron disulfide ($LiFeS_2$), or lithium primary, battery is another good source of power for electronic plumbing fittings because they also provide excellent performance at low to medium current applications.

The major advantages of lithium primary batteries over alkaline batteries are their good storage life and discharge performance. Operating temperatures have little effect on operating characteristics because the cell is very efficient. They also provide excellent

performance at low temperatures. Because of chemical stability and the fact that self-discharge is so low, these batteries can be stored several years longer than alkaline batteries. Lithium primary batteries tend to have a smaller form factor which permits more compact product designs that alkaline may not. Energy densities and shelf life can vary widely depending on the style of lithium battery used.

At a self-discharge rate of approximately 0.15-0.5% per year, these lithium batteries typically have a 10- to 15-year shelf life and can last longer than alkaline batteries of the same capacity. Because of the toxicity of the battery content, batteries cannot be easily disposed of and need to be recycled properly. There are instances when local municipalities should be contacted regarding any local disposal requirements.

As a side note, the lithium ion (rechargeable or secondary) battery is the fastest growing battery technology today. Lithium ion batteries are more sensitive to characteristics of the discharge current and can be unsafe when improperly used. Because they also pose hazardous waste issues due to their heavy metals content, they are not recommended for plumbing fittings. Additionally, the electronics in most sensor plumbing fittings are designed to recharge a capacitor, not the batteries. Thus, if rechargeable batteries are used, they would need to be removed from the fitting and recharged on a proper recharging station. This potentially creates additional maintenance for the facility.

Newer to this space is a 25-year battery technology. Its chemistry is lithium thionyl chloride, equipped with a patented hybrid layer capacitor that collects small electrical charges that are discharged every time the faucet is activated. This allows the cell to maintain its power storage. Not all versions of this power system have a hybrid layer capacitor; the capacitor reduces the pulse height of intermittent drain, which reduces the life of the batteries. This hermetically sealed battery has a self-discharge rate of <1% per year.

This type of battery is not recyclable and needs to be returned to the manufacturer for proper disposal. The additional electronics required for this technology add an extra element of concern regarding reliability. The 25-year battery has a rather high replacement cost, and facilities need to purchase them directly from the original equipment supplier. These are not an off-the-shelf solution available to the general consumer.

Power harvesting options

When batteries are used in electronic fittings that employ power harvesting such as solar or turbine technology, it's an either/or situation. That is, the fitting's first option is to activate via the harvesting technology. The battery power is only utilized as a backup for when the harvested power does not have enough "juice" to power up. This offsets the life duration of the battery and can ideally reach its shelf life rating if the harvesting power achieves its full potential.

Although both power harvesting technologies use batteries as a backup, they do not use the backup feature in the same manner. For example, the basic electronics in any sensor-

activated faucet requires constant power, while the solenoid draws power only when water is turned on and off. The solenoid needs much more power to operate than the power demanded for the basic electronics. Because the basic electronics are always "on," however, more accumulated power is used in this application.

A fitting using solar technology only needs the battery to power the solenoid when a storage capacitor is drained. Only in rare cases when there is not enough ambient light to provide energy is the battery also needed to power the basic electronics. The hydro-power turbine fitting relies on the battery for power when there is insufficient use to generate electrical energy or when there is not enough energy stored in the capacitors.

A key difference is between solar- and turbine-powered products is that the turbine-powered plumbing fitting must be used in order to generate any supplemental power.

Recycling

All battery types can be recycled. Each battery has a different chemical makeup, and therefore, requires different disposal and recycle processes. Some toxic heavy metals in batteries can threaten the environment if not properly disposed. Although environmental groups tend to focus more on rechargeable batteries than primary batteries, both types require proper disposal in the interest of environmental protection.

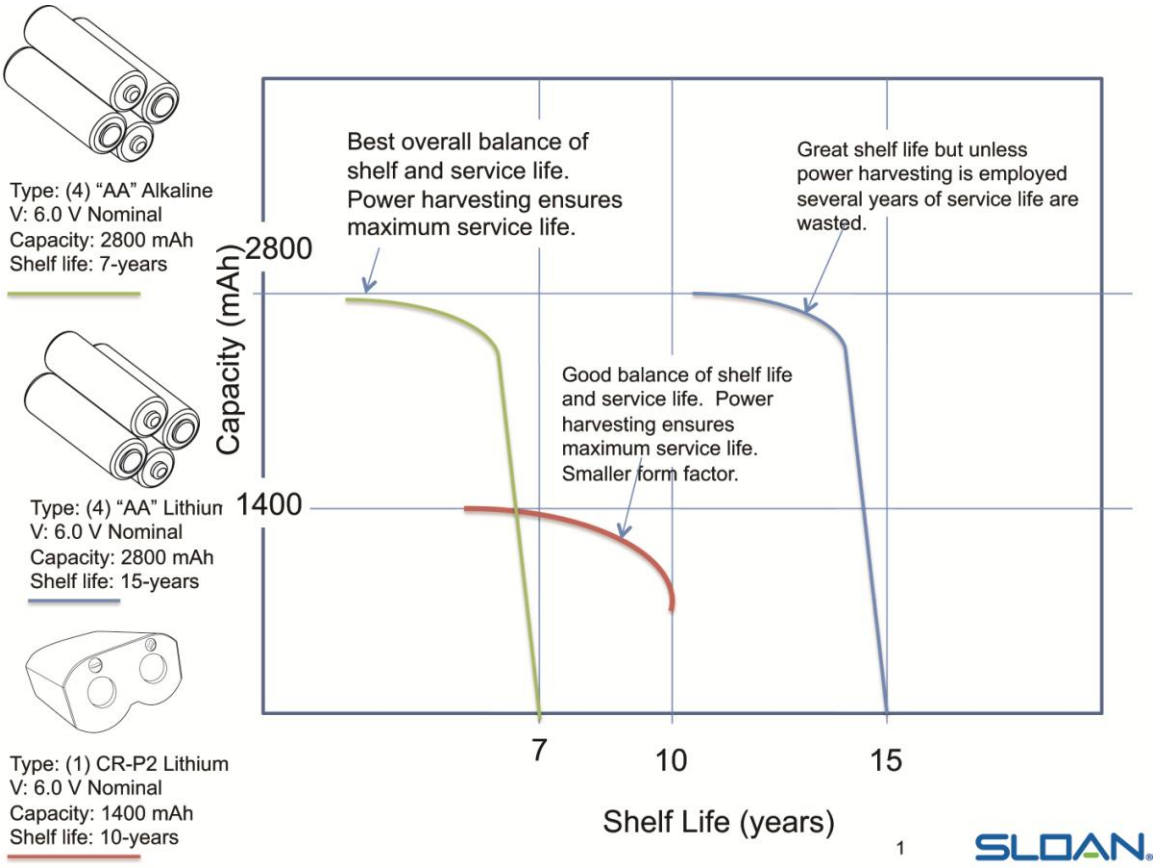
Alkaline and lithium batteries suffer from the same problem; essentially neither has any intrinsic value to help subsidize recycling. The cost to recycle batteries properly is based on the cost to run that recycling process. In fact, the cost to recycle lithium batteries is far greater than a standard alkaline or rechargeable battery. In the lithium battery recycling process, metals from the batteries are collected and sold. The lithium components are separated and converted to lithium carbonate for resale.

The alkaline battery recycling process is simpler: The batteries are shredded, and case metals are separated. Any remaining manganese and zinc is collected, filtered and sold.

It is much more convenient to recycle rechargeable batteries. State laws and groups such as the Rechargeable Battery Recycling Corporation have established national recycling programs with plenty of opportunities to drop off old, rechargeable batteries at participating retailers. Primary batteries can be recycled; however, the process is not as convenient and not free of charge to most consumers.

Conclusion

Keep in mind that battery shelf life and service life are not the same. Maximizing service life entails recognizing and tapping into their strengths and weaknesses. In essence, determining which type of battery to use depends on the application.



High-traffic areas, for example, will consume many more batteries than a low-traffic restroom, unless they make use of a power harvesting method. Realistically, in the case of a high-traffic area, the benefits of using a battery with a longer shelf life may not pay off. Using it only gives a few hours more operating life and carries a higher replacement cost. A low-traffic restroom, on the other hand, can take advantage of a battery with a longer shelf life, and combined with power harvesting techniques, it guarantees long service life.