By Michael Ciotti

Fuel Cells Go Live

A closer look at the requirements to create a hydrogen-based warehouse

Managers of distribution centers are always on the lookout for new ways to gain competitive advantage through increased operational efficiency, productivity and worker safety. Around North America, some are finding success by integrating commercially available hydrogen fuel cell systems into their lift truck fleets.

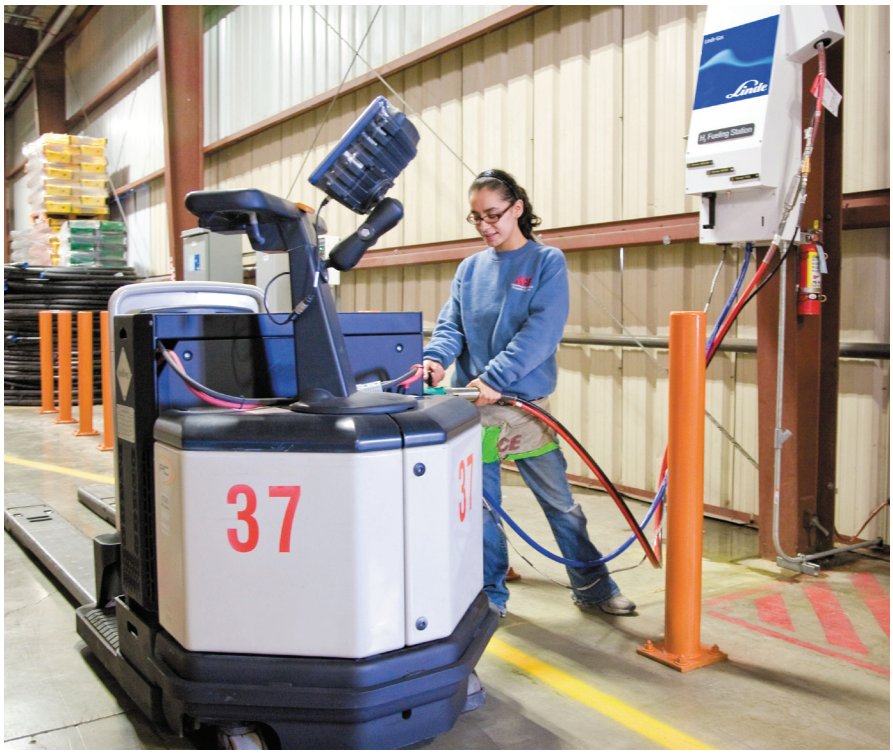
For operations with large fleets of electric lift vehicles, hydrogen-powered fuel cells offer several advantages over the incumbent technology, lead-acid batteries. Although batteries are a well-known entity, they pose several problems, including the steady degradation of power over the working shift, time spent switching out depleted batteries, valuable floor space and personnel dedicated to recharging activities, the greater amount of power needed to charge the batteries compared with the amount of power actually extracted during use, and the problems associated with the storage and handling of toxic materials.

A major economic and workplace safety issue is the hazardous spills caused by cracked battery casings. These are frequent occurrences and require an expensive hazmat cleanup. Also of concern are the rising lifecycle costs of battery ownership. In the last three years, the price of lead has tripled, and the cost of disposal is also on the rise. During charging, batteries emit hydrogen, a flammable gas, into the battery charging area, which must be controlled with expensive ventilation systems.

Fuel Cells

By comparison, hydrogen fuel cells provide constant power, whether the tank is full or not (just like a car), require less than two minutes of refueling time, run for up to 12 consecutive hours, have a life cycle equivalent to that of the lift truck, and eliminate the need for battery rooms, battery handling equipment and handling toxic chemicals.

Fuel cells, first developed in the



Operator makes hydrogen dispenser connections to a Class 3 material handling vehicle.

latter part of the 19th century, have emerged in the last 20 years as a viable alternative for applications that depend on portable, consistent and reliable packaged power. Technological advancements have reduced the size and cost of fuel cells, enabling integrators such as Plug Power, Hydrogenics and Nuvera to economically package fuel cells in a form factor identical to the battery.

Traditional lead-acid batteries provide short bursts of power for heavy-duty operations. Their corresponding high mass is beneficial as a counterweight in certain vehicles, but the energy is quickly depleted, decreasing vehicle performance and operator productivity. By contrast, fuel cell power units in lift trucks store hydrogen in a "gas" tank, meting it out at low pressure to the fuel cell, which then provides DC power to recharge metal-hydride batteries—a process similar to that seen in today's hybrid automobiles. As the fuel cell generates power, only water and a small amount of heat are created as byproducts.

How the Hydrogen Fueling Process Works

1. Vehicle operators conduct normal duties during their 8- to 14-hour shifts.
2. A fuel level gauge on the power unit indicates when the system is getting low, e.g. 15 minutes of power remaining, and the operator decides when best to approach the fueling area. Unlike a battery, there is no need to run the hydrogen supply low. The operator can refuel at any time without the memory effect associated with batteries.
3. The driver parks the vehicle at the dispenser and makes three connections with the power unit in a specific order: (1) grounding cable, (2) dewatering cable and (3) hydrogen hose. Unlike road vehicles that blow the waste heat and water into the air or drop water on the ground, these indoor fuel cell vehicles release the clean water outside while the vehicle is fueling.
4. The operator moves to a control panel and initiates fueling by pressing the start button. The dispensing system automatically conducts safety checks of the vehicle tank and dispensing system and proceeds to fuel the vehicle with hydrogen gas, usually in under one minute.
5. Lights on the fuel station control panel indicate when the fueling process is complete, and the operator disconnects the cables and hose and drives away. The entire process takes less than two minutes, and a full tank will power the fuel cell for up to 12 hours of continuous operation.

Testing Results

The first on-site demonstrations of hydrogen fuel cells began in 2004, when Linde and Plug Power began working with distribution centers to show off the fuel cell power units' capabilities. Each demonstration typically lasted one week, using one or two vehicles. Refueling was limited to outdoors. These demonstrations proved to DC managers the solution was reliable and they could realize measurable efficiency gains. Besides that, distribution center managers discovered that operators of the fuel cell-powered lift trucks liked them—a lot.

In the four years since those demonstrations began, rigorous testing has continued at multiple distribution centers throughout the country. The testing scope also has expanded, in some cases to as many as 60 vehicles at a time.

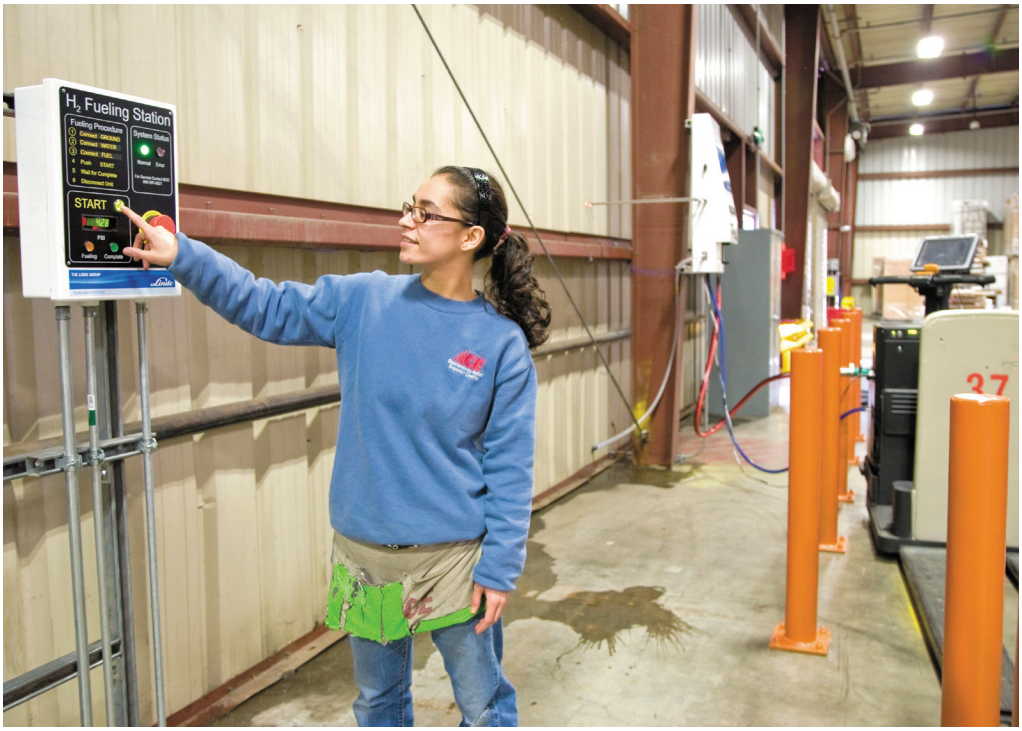
To date, trial data indicate distribution centers realizing at least a two percent increase in productivity (cases per hour), with evidence suggesting productivity increases may actually be as high as seven percent in some situations. Distribution centers also have seen a reduction in the amount of site power consumed, since the electricity required to support the hydrogen infrastructure is less than that required to recharge the lead-acid batteries. The most telling evidence that the fuel cell powered utility vehicle is an improvement over batteries: operators who do not want to give up these units when the trial is over.

There is no limit to the number of dispensers that can be installed, and each dispenser can fuel as many as ten vehicles per hour.

Based on the testing results, hydrogen and fuel cell suppliers have learned a great deal, including how to ensure operator safety and establish safe and more convenient indoor fueling capabilities. As codes and standards for the lift truck industry were developed, jurisdictional authorities also became more familiar with the hydrogen refueling process, leading to faster and easier permitting.

Can Your Customer Use Hydrogen?

Practically speaking, all DCs can support hydrogen fueling as long



Operator initiates dispensing to a Class 3 material handling vehicle.

as adequate space exists outdoors for installation of the hydrogen supply equipment (tube trailer, liquid hydrogen tank or on-site generation equipment) and the compression and storage package. This equipment could require as little as 750 sq. ft. of space on a concrete pad. Inside the DC, dispensers take up minimal floor space and are usually located on opposite ends of the warehouse to reduce the time required to drive to a fueling point. There is no limit to the number of dispensers that can be installed, and each dispenser can fuel as many as ten vehicles per hour. Therefore, smaller DCs might only need two dispensers, whereas large locations might require four or more.

Successful installations depend upon the cooperation of fuel cell power unit providers and industrial gas companies who are experienced in the safe delivery and distribution of hydrogen. The partners must work together to ensure all parties have a full understanding of the project's requirements, including uptime and maintenance targets, so they can design and deliver a safe and reliable fueling solution for gaseous or liquid hydrogen.

Hydrogen fuel cell systems for distribution fleets have moved from testing to fully commercial applications that are reliable and safe. Wal-Mart and other retailers have already incorporated permanent systems at their regional distribution centers and are contemplating conversions of up to 200 vehicles.

Hydrogen Fueling Station Requirements

All hydrogen fueling systems for forklifts require five components:

1. Fuel cell power unit (Class 1, 2 or 3).
2. A source of hydrogen gas. This is usually a tube trailer for demonstrations, but switches to liquid hydrogen or on-site generation as the number of vehicles to be filled increases.
3. A method to increase the pressure of the hydrogen. Gas compressors are the most commonly installed solution, but options exist for liquid pumping as the fueling demand increases.
4. High-pressure storage. Tubes of gas at a pressure greater than storage pressure of the vehicle are maintained for fast filling of multiple vehicles in succession.
5. Dispensing systems. A sophisticated control algorithm is required to safely transfer the high-pressure gas from outside the distribution center to convenient locations inside the building.

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