The HVAC Industry Guide to Forklift Battery Room Ventilation Systems

Even for commercial HVAC technicians, installing a forklift battery room ventilation system is rarely a common job. Many HVAC workers have never confronted this unique area of the industry. Battery room ventilation can be a difficult field to jump into; because of the risks involved with charging forklift batteries, hoods, ducting, and fans must meet strict criteria in battery charging areas — and determining that criteria takes some extra preparation.

Luckily, with a few helpful resources and experienced parts suppliers, any commercial HVAC provider can break into this corner of the market. Here's what you need to know about ventilation systems for forklift battery rooms, along with a few shortcuts that can make the job much simpler.

Why Do Forklift Battery Rooms Need Special Ventilation Systems?

Forklift batteries produce hydrogen and oxygen gases as they charge. Before we get into the chemical reactions that cause this outgassing, it's important to note the dangers of accumulated hydrogen. When hydrogen blends with air or oxygen to an accumulation of 4 percent, it reaches its lower explosive level, or LEL. At this point, any spark or open flame is likely to cause a devastating explosion.

Hydrogen has another property that makes it particularly dangerous when enclosed. It's the lightest of all the elements — lighter than air — which means it will always pool at the highest point of any room. Without carefully designed ventilation systems, hydrogen produced by outgassing batteries can collect into explosive pockets. This is especially dangerous in battery rooms with false ceilings, skylights, or other deviations from absolute flatness.

So how exactly does a forklift battery produce hydrogen? It's all part of the specific electro-chemical reaction that allows the battery to be charged and discharged again and again. Here's a basic rundown of the process:

- Flooded lead-acid forklift batteries are essentially large tubs of a sulfuric-acid-and-water solution. Immersed in this fluid are positive plates made of lead peroxide and negative plates made of pure lead. Each individual cell within the battery contains seven or more of these plates.
- Positive plates are connected to the positive terminal on the outside of the battery. Negative plates attach to the negative terminal.
- Each cell, then, contains lead, lead peroxide, and sulfuric acid. When the terminals form a circuit, electrons flow through the load, changing the chemical composition of the elements within the battery — and producing the current we use to power forklifts.
- The discharge reaction converts the lead, lead peroxide, and sulfuric acid into a combination of lead sulphate and water. As the battery discharges, the ratio of sulfuric acid to water in the electrolyte diminishes considerably.
- Charging the battery reverses this process. The battery charger forces current through the battery cells, creating a chemical reaction that frees oxygen to bind with lead on positive plates — which is how we get back to lead peroxide. The plates release sulfate, creating sulfuric acid. Finally, lacking sulfate, the lead negative plates return to their state of spongy lead.
- The charging process also affects the water content of the electrolyte. At a certain point, generally around 80 percent charge, the current decomposes water into hydrogen and oxygen. You can actually see the electrolyte bubbling like a boiling pot of water as it releases these gases.

The bad news is that forklift battery outgassing is inevitable in typical flooded lead-acid batteries. On the other hand, that's what ventilation is for. In order to determine how to construct a battery room ventilation system, you just need to know the expected volume of gas, and how quickly you need to replace the air in the room to keep this gas below a dangerous level of accumulation.

Ventilation Requirements for Battery Rooms

Most building safety codes, including the International Fire Code and the National Fire Protection Association's Fire Code, NFPA 1, require ventilation systems in battery rooms to keep hydrogen accumulation to 25 percent of the LEL, or 1 percent by volume. So how do you know exactly how much hydrogen to plan for?

The simple route is to use a trusted online calculator, like the BHS Hydrogen Gas Ventilation Calculator for Forklift Battery Charging Areas. But if you're a pencil-and-paper sort of engineer, or if you just want to understand the calculations behind this calculator, follow these four steps:

1. **Calculate the volume of hydrogen gas each of the batteries is likely to produce during the outgassing phase of the charge.** Use the equation H = ((N x C x O x G x A) / F), where H = the total hydrogen volume; N = the number of batteries of this type charging at a given time; C = the number of cells within each battery; O = percentage of overcharge (assume 20 percent); G = 0.01474, or hydrogen production associated with 1 amp-hour of charge, in cubic feet; A = the battery's 6-hour amp-hour rating; and F = the number of hours it takes to charge the battery from 80 percent to 100 percent charge (assume 4 hours).

   This will give you H: The battery charging system's volume of hydrogen production in cubic feet per hour

2. **Determine the volume, in cubic feet, of the battery room.** Use the formula R = W x L x T, where R = the total volume, W = the width, L = the length, and T = the height of the room. Note that this formula is only accurate for battery rooms with flat ceilings.

3. **With figures for the room volume (V) in cubic feet and hydrogen production (H) in cubic feet per hour, you're ready to calculate the total ventilation requirement for the battery room.** That's this formula: E = ((R x P) / H) x 60, where E = the span of minutes in which you must completely exchange the room's air to keep hydrogen levels to 1 percent or below; R = the room volume; P = the maximum hydrogen percentage (so 1 percent), H = the total hydrogen production in cubic feet per hour; and 60 represents the 60 minutes of an hour, which breaks the product down by minutes rather than hours.

   This gives you E, the time limit, in minutes, that the ventilation system must exchange the battery room's air to keep hydrogen production below 1 percent during outgassing.

4. **Of course, most HVAC technicians are more used to calculations of cubic feet per minute (CFM), not minutes to total air exchange.** In order to convert E into a proper exhaust rate, use the formula B = R/E, where B = the recommended battery room exhaust rate in CFM, R = the battery room's total volume, and E = the required time limit, in minutes, for a total air exchange.

   Once you have your target exhaust rate, B, you can look for systems and fans that are rated for this standard in CFM.

Again, you can always just use the BHS Hydrogen Gas Ventilation Calendar to save some time and reduce the chance of computational errors. This calculator provides the estimated percentage of hydrogen accumulation in your battery room after an hour of outgas charging. It also provides the length of time, in minutes, you would need to completely exchange the room's air to keep hydrogen below the 1 percent threshold. Finally, it tells you the exhaust rating, in CFM, fans would need to fully vent the room.

Components of the Forklift Battery Room Ventilation System

Generally speaking, an adequate ventilation system for gassing batteries includes an uptake ducting system and one or more exhaust fans with adequate displacement ratings. However, this simple arrangement assumes the system will run continuously. Not only continuous operation increase energy costs and wear out parts much faster, it also contributes considerably to heating and cooling expenses.

A better option is to incorporate a third element to the battery room ventilation system: The Hydrogen Gas Detector. Wire the detectors to exhaust fans; then, if the concentration of hydrogen in the room hits a certain threshold, the fans can turn on automatically. Once the room is sufficiently aired out, the fans turn back off until you need them again.

This dynamic is central to the cost-saving Battery Room Ventilation System from BHS. This system includes four components:

- Ventilation ducts installed near the ceiling above battery stands; these vent hydrogen gas even when fans aren't operating.
- Hydrogen Exhaust Fans, a unified bank of four non-sparking fans with a total exhaust rating of 3,400 cubic feet per minute; custom models meet any required rating.
- Supports for all ducting attach to battery and charger stands, rather than requiring new infrastructure close to the ceiling. This is particularly helpful in battery rooms with high ceilings.
- Finally, the Hydrogen Gas Detector serves double duty, warning staff when hydrogen levels are beginning to approach the danger point and automatically activating the Hydrogen Exhaust Fans at a hydrogen concentration of 1 percent by volume. For even greater protection, users can connect Hydrogen Gas Detectors to their charger bank's electrical distribution system, automatically shutting down chargers when the concentration of hydrogen reaches 2 percent.

Figure 1. The BHS Hydrogen Gas Detectors (HGD) protect battery charging rooms and other locations where motive and stationary batteries are present by continuously monitoring hydrogen gas levels.

It is certainly possible to design a battery room ventilation system that runs continuously, using standard ducting and exhaust fans designed for other applications. But these systems are unlikely to realize the energy savings, redundancy of safeguards, and ease of installation afforded by the BHS Battery Room Ventilation System, which is designed and constructed expressly for the purpose of venting hydrogen in battery rooms.

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