

## ***Battery Room Ventilation Code Requirements***

Battery room ventilation codes and standards protect workers by limiting the accumulation of hydrogen in the battery room. Hydrogen release is a normal part of the charging process, but trouble arises when the flammable gas becomes concentrated enough to create an explosion risk — which is why safety standards are vitally important. But what are these ventilation guidelines, who issues them, and where can warehouse managers find them?

In this article, we'll explore some of the most widely used regulations that control hydrogen gas levels in forklift battery charging areas. We'll explain which ones are binding, where, and for whom, ultimately proposing solutions that keep workers safe while also helping the reader comply with rules that could otherwise leave operations open to significant fines for violations.

First, though, it's important to understand the science behind how and why lead-acid forklift batteries emit hydrogen gas—and when this emission is at its highest point during a regular charge. It's all part of the electrochemical reactions that make lead-acid batteries rechargeable in the first place.

### **Hydrogen Gas Production by Charging Forklift Batteries**

You can't stop flooded lead-acid batteries from emitting hydrogen and oxygen, even under the best of conditions. At rest, water evaporation releases small amounts of these gasses. But it's during the charging process that forklift batteries start emitting higher levels of hydrogen.

Chargers supply electricity to the batteries, reversing the discharge process to restore power. Meanwhile, that electrical current also affects the water content of the battery's electrolyte. Through a chemical process called electrolysis, the voltage splits water molecules into its composite elements: one atom of oxygen—and two of hydrogen. The greater the current, the more dramatic the electrolysis.

In order to reach a full charge, voltage above the battery's capacity must move through the cells. Above about an 80 percent charge, then, forklift batteries tend to create a lot of hydrogen and oxygen, which bubbles to the surface of the electrolyte and escapes through the vents.

Because hydrogen is lighter than air—it's the lightest element known to science, in fact—it pools up at the highest point in any enclosed space. That's what creates the explosion risk in forklift battery rooms; unseen, odorless pockets of hydrogen, which become flammable at a concentration of just 4 percent by volume.

Several of the regulations that follow require forklift battery users to keep hydrogen concentrations within their facilities at a safe limit of 1 percent by volume, which is the concentration at which the [BHS Hydrogen Gas Detector](#) (HGD) begins flashing yellow to announce the issue. At a concentration of 2 percent, the HGD will flash red and being sounding the literal alarm.

### **Forklift Battery Room Regulations by Agency**

Many regulatory agencies have addressed the subject of hydrogen gas ventilation in battery rooms, issuing a broad range of codes, standards, and guidelines. Some of these are federal law in the United States, while others come from industrial trade groups and are then adopted by safety agencies, state, and local regulators.

Here's a partial list of the institutions that are concerned with limiting hydrogen gas accumulation in battery rooms, along with the specific rules they've written to guide employers on maintaining safety at their facilities:

### **The Occupational Safety and Health Administration (OSHA)**

Standards from OSHA are [legally binding](#) for private sector employers in all 50 U.S. states, as well as for federal agencies. State and local government groups may not be covered by OSHA rules, but the [22 states](#) that offer OSHA-approved occupational safety departments offer certain protections under the federal [OSH Act of 1970](#).

Regarding hydrogen gassing in battery rooms, three OSHA standards are particularly important. The first of these covers general industry, while the latter two were designed for construction — but safety-minded employers in other businesses often refer to them, as well.

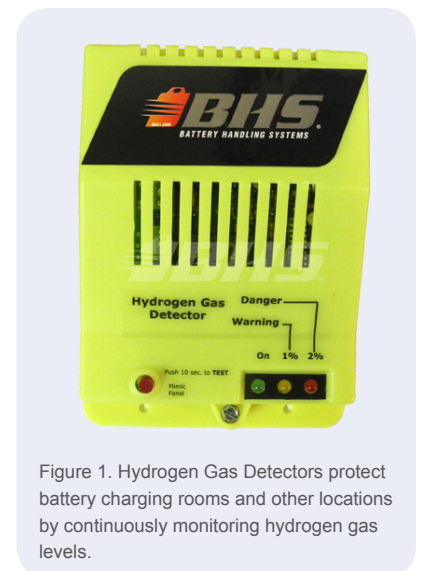


Figure 1. Hydrogen Gas Detectors protect battery charging rooms and other locations by continuously monitoring hydrogen gas levels.

- [29 CFR 1910.178\(g\)\(2\)](#) - "Facilities shall be provided for flushing and neutralizing spilled electrolyte, for protecting charging apparatus from damage by trucks, and for **adequate ventilation for dispersal of fumes from gassing batteries.**"
- [29 CFR 1926.441\(a\)\(1\)](#) - "Batteries of the unsealed type shall be located in enclosures with **outside vents or in well ventilated rooms** and shall be arranged so as to prevent the escape of fumes, gases, or electrolyte spray into other areas."
- **29 CFR 1926.441(a)(2)** - "**Ventilation shall be provided** to ensure diffusion of the gases from the battery and to prevent the accumulation of an explosive mixture."

While these standards don't go into technical detail on ventilation systems themselves, they do make the ultimate goal of this equipment clear: Hydrogen must not be allowed to accumulate to a dangerous degree, which we know begins at 4 percent.

## The National Fire Protection Association (NFPA)

The NFPA is an international nonprofit group with a stated goal to reduce "death, injury, property and economic loss due to fire, electrical and related hazards." A large part of this effort involves creating codes and standards, such as NFPA 70, more popularly known (and often cited as) the National Electric Code (NEC).

The NFPA writes all of these codes and standards through a process that's approved by the American National Standards Institute (ANSI). This rigorous development of standards makes the NFPA a common source for regulators studying fire safety issues, but NFPA codes and standards are not themselves legally binding in the U.S. or abroad. Note, however, that all 50 states have adopted NFPA 70 into local building codes and other fire safety laws.

Two primary NFPA codes pertain to battery room ventilation:

- [NFPA 1: Fire Code 2018 Chapter 52, Energy Storage Systems, Code 52.3.2.8, Ventilation](#) - "Where required...ventilation shall be provided for rooms and cabinets in accordance with the mechanical code and one of the following:
  1. The ventilation system shall be designed to limit the maximum concentration of flammable gas to 25 percent of the lower flammable limit (LFL) of the total volume of the room during the worst-case event of simultaneous "boost" charging of all batteries, in accordance with nationally recognized standards.
  2. Mechanical ventilation shall be provided at a rate of not less than 1 ft<sup>3</sup>/min/ft<sup>2</sup> (5.1 L/sec/m<sup>2</sup>) of floor area of the room or cabinet. The ventilation can be either continuous, or activated by a gas detection system..."
- [NFPA 70: National Electric Code 2017, Chapter 480, Storage Batteries, Code 480.10\(A\), Battery Locations, Ventilation](#) - "Provisions appropriate to the battery technology shall be made for sufficient diffusion and ventilation of gases from the battery, if present, to prevent the accumulation of an explosive mixture."

Note that the lower flammable limit of hydrogen is 4 percent by volume. A quarter of that, then, is the 1 percent threshold at which BHS Hydrogen Gas Detectors begin to flash a bright yellow LED, alerting staff to the presence of excessive hydrogen. This helps to comply with NFPA 70, as well, because measuring hydrogen levels is the first step to preventing "the accumulation of an explosive mixture."

## The Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA)

The IEEE is a professional organization that works to advance the role and effectiveness of electronic engineering and associated industries, including computer engineering, telecommunications, and — relevant here — power and energy. Within the broader organization, the IEEE-SA is tasked with writing technological standards for equipment and practice within these areas.

Note that IEEE-SA codes themselves are not legally binding. However, they often do inform local, state, and federal lawmakers as they write their own safety regulations.

The relevant IEEE-SA standard was written specifically for stationary power-storage batteries, like those used in power grids. However, the chemistry of the vented lead-acid batteries described in the standard is identical to that of forklift batteries, leading many thought leaders in the material handling industry to consult the IEEE-SA standards for their own safety requirements.

- [IEEE Standard 484-2002 - IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications](#)

IEEE standards like this one are hidden behind paywalls and protected by copyright, so we can't reprint the exact technical details contained therein. A public [Regulatory Guide](#) from the U.S. Office of Nuclear Regulatory Commission does refer in detail to the IEEE standards, though, shining some light on the guide's ventilation requirements through suggested improvements for in-house use.

- "In Subsection 5.4 [of IEEE 484-2002], 'Ventilation,' revise the second sentence to be consistent with [NRC] Regulatory Guide 1.189, as follows," the NRC Regulatory Guide reads. **"The ventilation system shall limit hydrogen accumulation to one percent of the total volume of the battery area."**

This suggests both that the hydrogen limit recommended by IEEE 484-2002 is higher than one percent, and that the NRC prefers a stricter standard. In general, the 1 percent mark is the safest time for battery room ventilation equipment to begin removing hydrogen from the room, as accumulation can vary from place to place, and a leap from 1 percent to 4 percent might occur quickly in some situations.

## Complying with Battery Room Ventilation Codes

There are no shortcuts to venting hydrogen gas from forklift battery charging areas. Unless batteries can be charged outside, which poses its own obvious challenges, every facility that runs electric forklifts will need a robust ventilation system installed.

At the minimum, a battery room ventilation system must include:

- Hydrogen gas detectors with integrated alarms
- Ventilation ducting leading out of the building
- **Exhaust fans** to force ventilation when hydrogen levels become too high
- Supports and collection ducts covering system stands

The **BHS Battery Room Ventilation System** contains each of these components, along with fully integrated elements that automatically activate Hydrogen Exhaust Fans when the concentration of the dangerous gas reaches 1 percent or more.

(Leaving fans on at all times would quickly become cost-prohibitive, as the constant venting climate-controlled air would lead to exorbitant electricity costs — also, note that this design fully complies with NFPA 1: Fire Code 52.2.3.8.)

When this complete Ventilation System is integrated with a **BHS Electrical Distribution System (EDS)**, which simplifies the routing of power to battery charging equipment, a further protection becomes possible.

A Charger Shutdown option allows the EDS to communicate with Hydrogen Gas Detectors, automatically powering down charging devices when the concentration of gas in the air reaches 2 percent. This will stop the production of hydrogen while the Exhaust Fans clear the room of the gas, quickly bringing concentration back down to safe levels.

Ventilation is crucial for the battery room, as the standards listed above clearly demonstrate. BHS equipment ensures compliance with all relevant battery room ventilation codes — and, most importantly, a safer battery room overall.

## References:

"[29 CFR 1910.178 - Powered industrial trucks](#)." OSHA. Occupational Safety and Health Administration, n.d. Web. 28 Nov. 2017.

"[29 CFR 1926.441 - Batteries and battery charging](#)." OSHA. Occupational Safety and Health Administration, n.d. Web. 28 Nov. 2017.

"[IEEE Std 484-2002 \(Revision of IEEE Std 484-1996\) - IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications](#)." IEEE. IEEE-SA, 2009. Web. 28 Nov. 2017.

"[NFPA 1: Fire Code](#)." NFPA. National Fire Protection Association, 2017. Web. 28 Nov. 2017.

"[NFPA 70: National Fire Code \(NEC\)](#)." NFPA. National Fire Protection Association, 2016. Web. 28 Nov. 2017.

O'Donnell, Cary and Michael Schiemann. "[Hydrogen Gas Management for Flooded Lead Acid Batteries](#)." Battcon. Hoppecke Batterien GmbH & Co KG, 2008. PDF. 28 Nov. 2017.

"[Regulatory Guide 1.128 - Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants](#)." NRC. U.S. Nuclear Regulatory Commission, Feb. 2007. PDF. 28 Nov. 2017.



Figure 2. Battery Room Ventilation System is designed for detecting hydrogen gas at low levels and dissipate the gas to prevent accumulation.

