



WHITE PAPER

The Risks of Unmonitored Hydrogen in Battery Installations

Introduction: Risk—monitored and unmonitored

Both Lead Acid and Nickel Cadmium batteries produce flammable hydrogen gas during normal charging. Overcharging, excessive heat and many other factors can quickly cause batteries to produce even more hydrogen. As hydrogen builds up, the risk of fire, explosion and material degradation increases.

This white paper explores the types of hazards presented by hydrogen, how hydrogen can build up, and the changing regulations and codes that address battery charging stations and installations. A discussion follows on monitoring solutions to meet those regulations and prevent danger. To begin with, some real world cases illustrate the need and effectiveness of direct monitoring.



Forklift Charging Station



Forklift Battery Station



Damage from Hydrogen Build Up

Real-world case

While a routine security patrol was performing its rounds, one of the security guards reported a strong odor of sulfur coming from a battery charging facility. This particular battery charging facility is used for charging the various forklift batteries for the shipping and receiving operation. The facility these were housed in is approximately 450 sq. ft. and has four charging stations. An emergency response was initiated and the incident commander responded to the scene. Initial air monitoring indicated readings above the Lower Explosive Limit (LEL) for hydrogen gas. This level was significant enough to have the local fire department respond and immediately evacuate the area and set up a perimeter to attempt to limit loss in the event of a potential blast. Meanwhile the facilities personnel responded by cutting the main power to the building housing the charging station.

The next action was to ventilate the building and continue monitoring while the levels dropped to a safe condition. The fire department continued to monitor the situation until it was verified to be safe. The incident did not result in property damage or personal injury due to the immediate response by both the security team and the fire department.

The fact that the conditions for this situation are all too common to replicate and if it had just been hydrogen without the sulfur mix, it could have been undetected and catastrophic. It raises awareness that increased consideration must be given to all aspects of the workplace when preparing preliminary hazard assessments. Some hazardous situations appear trivial and may be undetectable by human senses, allowing them to be easily overlooked. The serious consequences can also be misunderstood or not understood at all.





The hazards of hydrogen

Hydrogen is classified among the “extremely flammable” substances.

Compare its properties with methane and petrol in the table below:

Properties	Measurement	Hydrogen	Methane	Petroleum
Ignition limits in air	(vol. %)	4 - 75	5.3 - 15	1.0 - 7.6
Detonation limits in air	(vol. %)	13 - 65	6.3 - 13.5	1.1 - 3.3
Heat of combustion	(kJ/g)	120	50	44.5
Self-ignition temperature	(°C)	585	540	228 - 501
Flame temperature	(°C)	2,045	1,875	2,200
Theoretical explosion energy	(kg TNT/m3 gaz)	2.02	7.03	44.22

The hazards of hydrogen explained

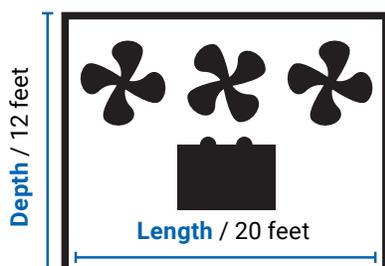
In both Motive Power and Stationary battery system charging, hydrogen is a byproduct during the charging of battery chemistry. This generated hydrogen can subsequently ignite or explode depending on the environmental conditions in the charging area. So the higher the temperature, the more explosive the reaction.

Hydrogen buildup from battery recharging stations is extremely flammable, and it actually begins to accelerate the degradation of materials in the area. Not only do batteries begin to degrade, shortening their life span, but it also causes degradation of all of the other components and hardware. Even a small increase in H₂ production can quickly become dangerous.

Various types of degradation caused by hydrogen

- Hydrogen blistering: absorption of atomic hydrogen on the surface of low resistance materials resulting in blisters
- Hydrogen embrittlement: absorption of atomic hydrogen on the surface of high resistance materials resulting in low ductility and increased internal stress
- Hydrogen induced cracking and hydrogen stress cracking: blister formation that may affect the integrity of materials especially when stressed

Combined, this means that in any facility that has a battery charging system the chance of buildup and ignition is significant. For example, under the right conditions, a typical room where forklifts recharge can take just 6 hours to reach a high enough concentration of hydrogen to cause an explosion in the absence of ventilation. And since it is odorless, it is hard to detect.



Example of buildup time if ventilation system fails or is obstructed

- Facility size: 20' x 12' x 12' room
(typical size found in a warehouse forklift recharging area)
- Battery system: 15, 750Ah batteries
- Charging current: 120 amps (2.38V begin gassing)
- Explosive threshold: 4% H₂ in just 6 hours
(a 90°F, buildup rate would be reached much faster)

Regulations and codes

To address the risks hydrogen buildup presents, regulations on battery systems have been put in place with the help of the National Fire Protection Association (NFPA). More and more, fire marshals and inspectors are requiring H2 monitoring systems even in small battery recharging stations. These regulations impact both unmanned installations such as storage buildings as well as manned applications such as material handling facilities, warehouses, factories and other applications requiring banks of batteries undergoing recharge or discharge. As batteries are becoming increasingly common, states such as Florida, California, Texas and Illinois are also revising their building codes to address the increased risk of unmonitored hydrogen. These regulations and their enforcement are fitting considering the risk of danger inherent to hydrogen.

NFPA 75

Standard for the fire protection of information technology equipment:

- Covers life safety aspects
- Discusses fire threat of the installation to occupants or exposed property
- Covers economic loss from the loss of function, loss of records and loss of value of the equipment
- Regulatory and reputation impact

NFPA 76

Standard for the fire protection of telecommunications facilities:

- Details support of public safety through emergency communications (such as 911), national defense communications requirements, video transmission of critical medical operations, and other vital data.
- Describes viability of service during and after an event or replacement or restoration within a reasonable period post-event.
- Deals with service disruptions or factors that inhibit the ability of the service provider to restore service in a timely manner post-event.

NFPA 90A

Standard for the installation of air conditioning and ventilating systems:

- Details when battery systems need to be ventilated
- Details when equipment and systems require cooling as well as the proper levels

NFPA 111

Standard on stored electrical energy emergency and standby power systems:

- Details performance requirements for stored electric energy systems providing an alternate source of electrical power in buildings and facilities during an interruption of the normal power source
- Covers power sources, transfer equipment, controls, supervisory equipment and accessory equipment needed to supply electrical power to selected circuits
- Covers installation, maintenance, operation and testing requirements as they pertain to the performance of the stored emergency power supply system (SEPSS)

For full descriptions of these regulations, visit the NFPA website

http://www.nfpa.org/aboutthecodes/List_of_Codes_and_Standards.asp?cookie_test=1





Portable vs. full installation solutions

Portable and integrated hydrogen monitoring solutions are two monitoring options often used in both motive and stationary battery testing. Portable monitors are handheld units that give information the moment the readings are taken, but provide no protection between readings. In between readings, if fans fail, ventilation systems get blocked or obstructed, power to cooling systems fails or nature sends temperatures soaring; the danger can be catastrophic. Use of portable monitors to periodically check integrated monitoring solutions is an excellent way to ensure proper operation of an integrated monitoring system.

Permanent (life of the charging stations) integrated hydrogen monitoring solutions continuously monitor the levels of hydrogen. Integrated solutions typically meet all of the regulations and can be tied in with alarm/SCADA monitoring systems to provide early warning and maximum protection. Some hydrogen detectors can also operate a room's exhaust system in order to dissipate hydrogen when it is first detected. Charger manufacturers are currently working to integrate hydrogen detection with control of charging voltages to prevent the continued gas evolution into an area where a build up of hydrogen gas already exists.

Conclusion

In best practices, H₂ monitoring systems should be linked to an auxiliary ventilation system and to fire and building monitoring control systems. This is due to the fact that, at any time, primary and/or secondary ventilation systems can fail causing the heat to rise along with the risk of an H₂ explosion. An easily integrated hydrogen detection system mitigates the risk, provides a warning and allows time to prevent catastrophe.

If you have any type of battery recharging system or station, an installed and permanently mounted hydrogen detection system not only provides protection but will meet upcoming changes to building and safety codes.

For more information:



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References

- http://www.nfpa.org/aboutthecodes/List_of_Codes_and_Standards.asp?cookie_test=1
- <http://www.hydrogen.energy.gov/firstresponders.html>
- http://www.apcmedia.com/salestools/SADE-5TNQZJ/SADE-5TNQZJ_R7_EN.pdf
- http://www.rayvaughan.com/battery_safety.htm
- http://www.aria.developpement-durable.gouv.fr/ressources/etude_h2_gb1.pdf
- <http://www.h2incidents.org>
- <https://www.belvoir.army.mil/safety/inc/battery-explosion.asp>
- *Hydrogen, the energy carrier, TÜV Bayern Group*



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