Introduction: Hydrogen risks in industrial settings

From lead acid to LiOn to NiCad, all 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 and explosion 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 of monitoring solutions to meet those regulations and prevent danger. To begin with, some real world cases illustrate the need and effectiveness of direct monitoring.

Typical forklift charging station examples

Too close for comfort in a distribution company

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 explosion. Meanwhile the facilities personnel responded by cutting the main power to the building housing the charging station.

Ventilation of the building and further monitoring ensued while hydrogen concentrations subsided to a safe level. 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 conditions for this situation are extremely common and this could have gone undetected and been catastrophic had the hydrogen not contained a sulphur mix. It raises awareness that increased consideration must be given to all aspects of the workplace when preparing preliminary hazard assessments. Some hazardous situations appear so trivial and may often be undetectable by human senses, that they can be easily overlooked. However, the serious consequences of such situations are far too often 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:

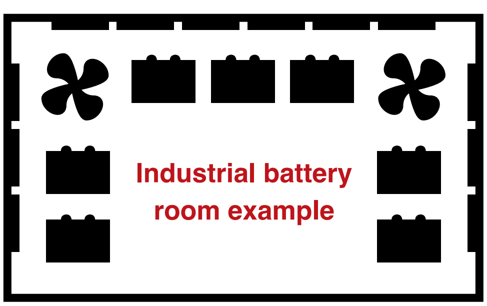
Properties	Measurement	Hydrogen	Methane	Petroleum
Ignition limits in air	(vol. %)	4 - 75	5.3 - 15	1.0 - 7.6
Detonation limits in air	(vol. %)	13 - 65	6.3 - 13.5	1.1 - 3.3
Heat of combustion	(kJ/g)	120	50	44.5
Self-ignition temperature	(°C)	585	540	228 - 501
Flame temperature	(°C)	2,045	1,875	2,200
Theoretical explosion energy	(kg TNT/m^3 gaz)	2.02	7.03	44.22

The hazards of hydrogen explained

Alkaline metals (lithium, sodium, potassium, etc.) and to a lesser extent alkaline earth metals (magnesium, calcium, etc.), all metals commonly used in batteries, react violently with water and generate hydrogen. This hydrogen can subsequently ignite or explode depending on the exothermicity of the reaction. So the higher the temperature, the more explosive the reaction.

In a typical battery charging room, many batteries may be on charge at the same time. As part of the charging cycle the battery is given multiple overcharges which are required to bring the battery back to a full charge and ready for use. During this part of the charge cycle, the battery is given a charge in excess of the "gassing voltage" of the battery. It is at this stage of a typical charging cycle that the battery releases oxygen and hydrogen into the atmosphere.

Special ventilation systems may or may not be required in battery charging rooms. When ventilation is required, the costs may be minimal or become significant not only in the installation process but also during everyday use and may be impacted by whether the area is being heated or air-conditioned. Ultimately, the amount of hydrogen gas generated and the need for specific ventilation requirements depends on the amount and type of equipment being used, the size of the charging area, the number of air changes per hour, and local building codes.



Each year, countless safety concerns are raised by unions and individual employees regarding the possibility of explosive gas. Installing a hydrogen detector on site will eliminate most of these concerns, while also saving management time and money, and increasing safety.

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 H_2 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 handing 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 for 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 hydrogen detection installation solutions

Portable and integrated hydrogen monitoring solutions are two monitoring options often used in battery charging rooms. 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. However, the use of portable monitors to periodically check integrated monitoring solutions is an excellent way to ensure proper operation of an integrated monitoring system. It also is a viable option to periodically check hydrogen concentration levels in areas where permanent detection solutions are not present and where battery forklift trucks, AGV's, and EV's are operating.

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.

Conclusion

In best practices, H_2 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 H_2 explosion. An easily integrated hydrogen detection system minimizes the risks, provides a warning and allows time to prevent catastrophe.

If you have any type of battery recharging system or station installed, ensure you have hand-held monitoring solutions as well as an installed hydrogen monitoring system to help prevent disaster, it is likely the only way to be compliant with current and future building codes.

SBS contact information
Test Equipment Division
N56W16665 Ridgewood Drive
Menomonee Falls, WI 53051-5686

Email: te@sbsbattery.com
Toll free: (800) 554-2243

References

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