EXPLOSION RISKS IN BATTERY ROOMS

Introduction

It is common practice to have UPS backed by battery in the modern technology world. However, the ventilation issues are not adequately understood and addressed while designing UPS room. This note highlights few issues concerning explosion risks in battery rooms and design features that need to be incorporated during construction phase.

Photo of a battery room that exploded, resulting in massive property damage. Case study featured next page

Hydrogen gas is evolved during charging phase of battery operation. Explosions can occur due to issues like inadequate ventilation / absence of flameproof equipment. Several battery room explosion incidents support this fact. During risk assessment studies that were conducted in industries and in various official / commercial complexes, by *Cholamandalam AXA Risk Services* the most common discrepancies observed include the ventilation issues in battery rooms, such as:

- No ventilation / fans are switched off in battery rooms (zero air changes)
- Ordinary type exhaust fans, and electrical accessories are provided
- HVAC re-circulated air is supplied to kitchen, lavatories and battery rooms through the common duct.
- Exhaust fans are not provided for rooms where Sealed Maintenance Free (SMF) batteries are installed.

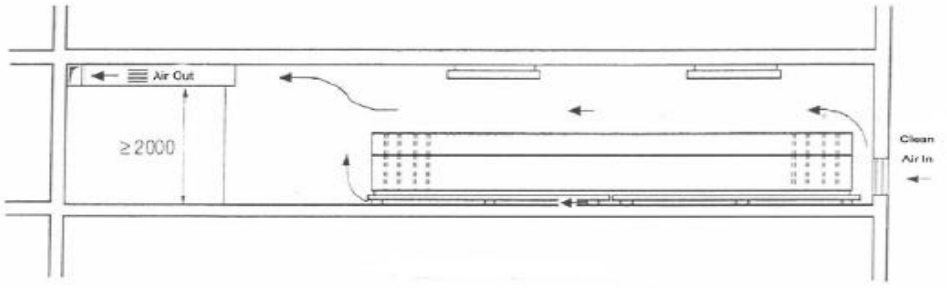
The ventilation requirements for battery rooms as recommended in various applicable standards are given below.

Table 1: Ventilation Requirements

Applicable Standard	Battery room Ventilation Requirements	Comments from Chola AXA Risk Services
NFPA 76	The battery room exhaust fan capacity in Cubic Feet Minute (CFM) should be the room area (in square foot)	-
Tamil Nadu Factory Rules, 2002	The air exchange (fresh air for one air) for a general factory shall be six times the cubic capacity of the work room without dead pockets or undue draught	This is a generic recommendation, mainly from the occupational health point of view, applicable to general factory environments

Applicable Standard	Battery room Ventilation Requirements	Comments from Chola AXA Risk Services
ASHRAE 62	1 CFM per charging ampere to be provided but not less than 6 air changes per hour	-
IS :12332	• 12 air changes per hour for battery room • Forced air supply & positive exhaust system • Use of flameproof electrical fittings • Air inlets to be located near the floor & outlet openings at the high point in the room	Although this standard is for industrial environment, the recommendations can logically be extended to all battery rooms
Document on Battery Rooms by ***EXIDE Technologies*** EN 50272-2 - **Safety requirements for Secondary Batteries and Battery Installations**	<u>Volume of Air Changes per Hour</u>: The following formula is to calculate the hourly exchange of air volume, **Q** in Cubic Meters / hour recommended for battery rooms. **Q = 0.05 x n x I** **(cubic meter / hour)** Where: n = number of cells I = Value for the current from table of EN 50272-2 <u>Minimum Inlet & Outlet Area (A):</u> With natural ventilation, the minimum inlet and outlet area is calculated as follows: **A** should be greater than or equal to **28 x Q** (sq. cm)	

<u>Way of air circulation in battery rooms:</u>



Note:

Sealed Maintenance Free batteries (Valve-Regulated Lead Acid -VRLA) also liberate Hydrogen (lesser than what is liberated from conventional batteries) and are designated to operate in a maximum temperature of 30 degree centigrade. Hence, the SMF battery room risks should also be treated in the same manner as that of rooms with conventional batteries.

Case Study:

The affected building where a major explosion occurred was formerly a large computer / data centre with battery room & emergency generators. The company vacated the building, moved out computer equipment, however the battery back-up system was left behind.

This accident is a very good example of what can happen when you lose ventilation in a battery charging room. The explosion blew a 400 SF +hole in the roof, collapsed numerous walls and ceilings throughout the building, and significantly damaged a large portion of throughout the building, and significantly damaged a large portion of the 50,000 + SF building.

The ventilation for the battery room appeared to be interlocked with the Hydrogen monitoring system. The Hydrogen sensor was in alarm upon emergency responders arriving at the scene (post-explosion). There appears to have been a local alarm, as it was not relayed to the Fire department. Given how slowly batteries generate Hydrogen (1.3×10^{-7} m/s per ampcell), it appears as though batteries were charging for a long period of time with no ventilation. Due to extensive damage caused to the UPS room, it could not be ascertained whether exhaust fan was switched off or failed to operate. There was no dearth of ignition sources in the room since it was full of batteries and electrical equipment.

What could have prevented this accident?

- *Un-interrupted ventilation, interlocked with Hydrogen alarm*
- *Alarm signal relayed to local fire brigade*
- *Periodic checking of the detection and alarm system*

Table 2 *:* Recommended Layout Features of UPS Rooms

Design Aspects	Recommended Considerations
Installation	The electrical installation in battery rooms should be limited to: • Lighting • Charging facilities • Ventilation • Hoisting & lifting provisions
Smoke / Gas Detection	Smoke detectors may be installed in battery rooms. In rooms where vented type lead acid batteries are installed, Hydrogen detectors may be installed. Fan operation may be interlocked with Hydrogen detector actuation. If Hydrogen detectors are not installed, the fan shall run continuously.

Battery Room Ceiling	Preferably the room ceiling should be flat to ensure that pockets of trapped Hydrogen gas do not occur, particularly at the ceiling, to prevent the accumulation of an explosive mixture, as per NFPA 70 E-83.
Ventilation	Refer the table 1 for details. A back up fan also may be considered.
Fire Protection	Carbon Dioxide portable fire extinguishers to be provided.
Lighting	Light fittings should be fixed to the wall or suspended at more than 50 cm from the ceiling, but not vertically above the batteries or charging units. Light fittings as well as any other equipment should be of closed type to prevent accumulation of gas. However, watertight fittings, with flameproof construction are recommended because of possible corrosive & flammable gas environment.
Hoisting Equipment	Electrical hoisting equipment should be used with non-conductive hoisting belts.

Formulae to calculate Hydrogen concentration, Determination of Forced Ventilation & Fan requirement are provided in the following web site. **www.bhs1.com/batteryroom/ventilation.htm**	
Hydrogen Concentration	A Hydrogen –in –air mixture of 4% or greater substantially increases the risk of an explosion. The concentration of Hydrogen should be kept below 1 % to provide a safety factor. Instead of continuously running the fan, its operation may be interlocked with Hydrogen detector activation above 1% (or 20% of LEL, whichever is lower) concentration.
General	1. In addition to above mentioned layout aspects, charging areas must also meet the following criteria. • Persons who handle batteries must be aware of the risks involved and are recognized as a sufficiently trained person. • No goods may be stored in the charging area • No work should take place, which can give off sparks. • No large metal object, such as an Aluminum ladder or scaffold material, may be taken into the battery room 2. Sufficiently trained persons may only be authorized to • connect and disconnect the facilities • density of the electrolyte • charging the battery 3. Safety instructions detailing the hazards of the work to be carried out must be available in charging area. 4. No Equipment should be placed with in 1 m of battery, or directly above it, in which hot surfaces or sparks may occur.

	5. Welding, drilling and grinding work should not be carried out when the charging process is taking place. These works should be carried out 2 hours after the charging has stopped and the ventilation has been running. 6. For large battery storage areas consider providing eyewash fountain. 7. Safety goggles should be provided for operators working in this area. 8. Appropriate warning signs should be displayed near the entrance to the UPS room. 9. UPS room must be laid out in such a way that there is adequate space for work to be carried out with appropriate tools. 10. If it is unavoidable to keep the batteries in the office space, the areas should be indicated by stripes on the floor. 11. PPE may be provided for persons charging the battery 12. Interlock between exhaust fan failure to an alarm or trip battery charger 13. Stick a what to look for note outside and inside of battery room 14. Technicians and company employees to visit the battery room once a week 15. Maintenance as stipulated by battery manufacturers (over charging can release H2 and bursting of valve in VRLA batteries) 16. SMF batteries is to be located in rooms where the ambient temperature will not exceed 30 degree C 17. When mixing electrolyte acid must be added to water never water to acid 18. Switch off battery charger before connecting or disconnecting battery 19. Always disconnect negative terminal first and positive terminal last 20. UPS isolation switch should be identified and located in a accessible location.

References:

1. **IS: 12332** -Code of practice for Ventilation in Petrochemical Plants and Refineries
2. National Fire Protection Association **NFPA 76** – Fire Protection for Telecommunication facilities
3. American Society of Heating, Refrigeration and Engineering (**ASHRAE**) 62 - Ventilation for Acceptable Indoor Air Quality
4. The Tamil Nadu **Factories Rules**, 1950
5. **EN 50272-2** Safety requirements for Secondary Batteries and Battery Installations
6. Battery Room Guidelines by ***EXIDE*** *Technologies*
7. **NFPA 70 E** Electrical Safety Requirements For Employee Workplaces