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HAZARDOUS AREA CLASSIFICATION

BATTERY CHARGING AREAS AND ROOMS

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Abstract

The classification of hazardous areas forms part of legislation and provides a process to ensure a safe working environment for the operations. Hazardous Area Classification (HAC) is therefore an important part of the design of a plant and needs to be completed before the selection of equipment is done. HAC can be done by direct example, source of release, risk studies or a combination of the three methods.

Introduction

HAC is normally done for all flammable environments and the flammability of the environment is defined by the flammability if the chemical products by their physical properties.

Batteries present a specific type of source of release that creates a flammable environment. Battery types may include dry or wet cells. In the case of wet cells there are a number of variances i.e. vented cells, valve regulated vented lead acid (VRLA), and fully sealed (gas tight) cells. The more control over the liberation of the gas the safer the cell becomes regarding creation of a hazardous atmosphere.

Definitions

Valve regulated (secondary) cell is a secondary cell which is closed under normal conditions but has an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cell cannot normally receive addition to the electrolyte

Gastight sealed (secondary) cell is secondary cell which remains closed and does not release either gas or liquid when operated within the limits of charge and temperature specified by the manufacturer. The cell may be equipped with a safety device to prevent dangerously high internal pressure. The cell does not require addition to the electrolyte and is designed to operate during its life in its original sealed state.

HAC of Battery Charging Area

The battery charging risks in terms of creating a flammable environment is primarily during and shortly after the charging period and due to the liberation of Hydrogen gas from the electrolyte used in the batteries.

Liberation of Gas

Liberation of gas is calculated as defined by SOUTH AFRICAN NATIONAL STANDARD SANS 63485-2:2012 Safety requirements for secondary batteries and battery installations Part 2: Stationary batteries.

During charge, float charge, and overcharge, gases are emitted from all secondary cells and batteries excluding gastight sealed (secondary) cells. This is a result of the electrolysis of the water by the overcharging current. Gases produced are hydrogen and oxygen. When emitted into the surrounding atmosphere, an explosive mixture may be created if the hydrogen concentration exceeds 4 $\%_{vol}$ hydrogen in air.

When a cell reaches its fully charged state, water electrolysis occurs according to Faraday's law. Under standard conditions i.e. at 0 °C and 1 013 hPA (standard temperature and pressure under International Union of Pure and Applied Chemistry):

− 1 Ah decomposes 0,336g H2O into 0.42 l H2 + 0.21 l O2;

− 3 Ah decomposes 1 cm3 (1 g) of H2O;

− 26.8 Ah decompose 9 g H2O into 1 g H2 + 8 g O2.

When the operation of the charge equipment is stopped, the emission of gas from the cells can be regarded as having come to an end approximately one hour after the charging current is switched off.

The first value to calculate is the ventilation requirements.

Ventilation Requirements

Ventilation requirements are calculated based on the volume of Hydrogen liberated from the total amount of cells in the battery.

Equation 1: Minimum air flow rate for ventilation

$$Q = v \times q \times s \times n \times I_{gas} \times C_{rt} \times 10^{-3}$$

Where

Q = ventilation air flow in m^3/h

v = is the necessary dilution of Hydrogen: (100%-4%) / 4% = 24

q = 0.42 x 10^{-3} m^3 / Ah generated at 0 °C;

Remark: for calculations at 25 °C, the value of q at 0 °C shall be multiplied by factor 1.095.

s = 5 as a general safety factor

n = number of cells

I_{gas} = is the current producing gas in mA/Ah rated capacity for the float charge current I_{float} or the boost charge current I_{boost}. As calculated below using equation 2.

C_{rt} = is the C_{10} capacity of lead acid cells (Ah), U_f = 1.8 V/Cell at 20°C or the C_5 capacity for NiCd cells (Ah), U_f = 1.00 V/cell at 20 °C.

Equation 2: Current producing gas

$$I_{gas} = I_{float/boost} \times f_g \times f_s$$

Where:

I_{gas} = current producing gas (mA/Ah)

f_g = is the gas emission factor, proportion of current at fully charged state producing hydrogen;

f_s = is the safety factor, to accommodate faulty cells in a battery string and an aged battery.

Unless otherwise stated by the manufacturer, the preferred values for I_{float} and I_{boost} with supporting data are given in the following Table 1 of SANS 62485-2:2012.

Inlet and outlet Apertures

In open air, in large halls and in well ventilated rooms an air velocity of ≥0.1 m/s can be assumed and adequate air ventilation is ensured **IF** the available apertures are at least of the following size.

Equation 3: Minimum free area of opening

$$A = 28 \times Q$$

where:

A = is the free area of opening in inlet and outlet (cm^2)

Q = is the ventilation airflow (m^3/h)

The placement of the inlet and outlet apertures is important i.e. inlet at floor level and outlet at ceiling level and across the room from each other to allow ventilation to cross the battery. Hydrogen is lighter than air and therefore will rise upwards from the cell vents. As the Hydrogen will collect at ceiling level the outlet aperture is therefore placed at ceiling level.

Natural Ventilation Volume

In open air, in large halls and in well ventilated rooms an air velocity of ≥0,1 m/s can be assumed **IF** the conditions as calculated above are adequate **AND** an adequate free volume as below is ensured.

Well ventilated rooms shall have a free volume of at least:

Equation 4: Well ventilated rooms free volume

$$2{,}5 \ \times Q[m^3]$$

where:

Q = ventilation air flow required in m^3/h

The volume of the enclosure may next be calculated to correlate with the calculated free volume requirement above.

Equation 5: Volume

$$V = l \times b \times h$$

Ensure you calculate or make an assumption on the consumed volume by for example batteries itself, lights, chargers, water refill containers etc. and include in available volume.

Safety Distance

In close vicinity to the source of release of a cell or battery, the dilution of explosive gases is not always ensured. Therefore a safety distance d extending through air shall be observed within which flames, sparks, arcs or glowing devices (maximum surface temperature 300 °C) are prohibited. The dispersion of explosive gas depends on the gas release rate and the ventilation characteristics close to the source of release.

Equation 6: Safety distance

$$d = \sqrt[3]{\frac{3}{2\pi} \times ((v \times q \times s) \times 10^{6}) \times n \times I_{gas} \times C_{rt} \times 10^{-3}}$$

d = safety distance in mm

v = is the necessary dilution of Hydrogen: (100%-4%) / 4% = 24

q = 0.42 x 10^{-3} m^3 / Ah generated at 0 °C;

Remark: for calculations at 25 °C, the value of q at 0 °C shall be multiplied by factor 1.095.

s = 5 as a general safety factor

n = number of cells

I_{gas} = is the current producing gas in mA/Ah rated capacity for the float charge current I_{float} or the boost charge current I_{boost}. As calculated using equation 2.

C_{rt} = is the C_{10} capacity of lead acid cells (Ah), U_f = 1.8 V/Cell at 20°C or the C_5 capacity for NiCd cells (Ah), U_f = 1.00 V/cell at 20 °C.

The calculations above specify the safety distance from the source of release and this is taken as the vents on the cells. It is therefore prudent to define a zone 1 environment at those distances above the cells.

Forced Ventilation

Forced ventilation is one of the methods used to ensure the ventilation requirements are adhered to. If the calculations above prove adequate ventilation then no further ventilation is required. If the calculations above do not prove adequate ventilation then the additional ventilation may be provided by use of forced ventilation.

The minimum air flow rate as calculated in Equation 1: Minimum air flow rate for ventilation above may be used to define the minimum air flow rate for the fan.

In the case where the forced ventilation has failed it is important that the forced ventilation be reinstated first and then allowed to dilute the atmosphere inside the battery room for a calculated value equal to 5 volume replacements of the room volume. In other words let the fan run for at least the calculated time period to replace at least 5 times the air (refer to the safety factor s above in ventilation requirements) inside the room before opening the door.

Forced ventilation usually operates through aperture filters and the filters must be kept in a clean state to allow the calculated air movement. Airflow restrictions due to filters must be allowed for in the air flow curve of the fan. Measurements may be taken using an anemometer or airflow meter to test the airflow.

Zones and Selection of Equipment

Forced ventilation fan must be Ex rated for zone 1 if the fan extracts air. If the fan is for example placed at floor level and outside the battery room and it blows air into the battery room then the fan does not need to be Ex rated. Care needs to be taken in both scenarios where the fresh air is received from and where the Hydrogen is ventilated to i.e. do not ventilate the Hydrogen into the substation next door. In both cases ensure that you do not get flammable atmosphere from anywhere and move it into the battery room.

If the battery room requires forced ventilation then the whole battery room may be a zone 2 with the safety distance as calculated above may be a zone 1. The reason for the zone 2 is that the forced ventilation may fail i.e. in abnormal situations and then the battery room may fill with Hydrogen.

Conclusion

It is of significance that any Hazardous Area Classification must be done by a Subject Matter Expert. Experience has proven that in most cases there is something that is not accommodated during the study and the layman will most probably miss this. Battery charging stations and rooms are no exception. The calculations above are simple to perform and may form the basis of forming an argument in any good hazardous area classification study.

Some additional comments of value:

- Only in the case of gastight sealed cells is a reduction in explosion prevention allowed unless the gas liberation rate and available ventilation proves a reduction
- Even if the Hydrogen liberation rate is tested and proven to be less than the standard it is not allowed to reduce the ventilation
- Recombination technology does reduce the liberation of Hydrogen and this is applied in the calculations by a reduction of charge current by 50%