HYDROGEN EMISSION AND WATER CONSUMPTION

While being charged, all wet flooded batteries release some hydrogen (H) gas through the electrolysis of water in their electrolyte.

All electrochemical couples gas more at higher charge voltages. However, the lead acid cell gases both at float and equalize voltages.

In theory, the nickel cadmium cell does not gas below 1.47 v/c and we typically float the batteries at 1.42 v/c. Therefore, in theory, the nickel cadmium cell does not gas at float voltage. In the real world, however, text book theory is many times not realized. Because the nickel cadmium cell is not 100 percent efficient, there is a slight amount of gassing even at float voltage.

In our atmosphere, hydrogen gas becomes combustible at approximately 4% concentration by volume. Therefore, it is necessary to have adequate air flow around the battery to keep any hydrogen concentrations below this level. Hydrogen gas will vent itself upwards if an opening is allowed.

For any type of battery made, one cubic foot of hydrogen gas will be released for each 63 AH of overcharge. In other words, if a cell were 100% charged and a 10 amp constant current were passed through the plates for 6.3 hours, one cubic foot of hydrogen gas per cell would be released at standard temperature and pressure.

Because most batteries are charged with a constant voltage charger, the current into the battery is variable. It is, therefore, somewhat more difficult to know how to calculate the hydrogen emission, both during recharge and at float condition.

Following is a generalized method for calculating hydrogen emission, water consumption, and watering interval for any wet flooded cell.

HYDROGEN EMISSION DURING RECHARGE/EQUALIZE

General Information:

Battery recharge efficiency is a function of many things and varies with different types of batteries and different quality of construction. In general, the following percentages are used regardless of manufacturer.

	Recharge Efficiency	Recharge Losses
Lead Calcium	90%	0.11
Lead Antimony and Lead Selenium	85%	0.18
Nickel Cadmium	70%	0.43

The recharge losses are the reciprocal of the recharge efficiency minus one.

Therefore, the volume of hydrogen gas released on any given recharge can be calculated:

$$\text{Volume in } Ft^3 \text{ H released} = \frac{\text{(AH) (No. of Cells) (Recharge Losses)}}{63}$$

Example: To fully recharge a 100 AH, 120 volt low rate nickel cadmium battery, the hydrogen emissions would be:

$$V = \frac{(100)\ (92)\ (.43)}{63} = 62.7\ Ft^3$$

As is noted from this equation, a lead acid battery will release only about 27% as much hydrogen gas on any specific recharge as the same capacity and voltage of a nickel cadmium battery because of the fewer number of cells and the lower recharge losses. However, most of this amount will again be released each time the lead acid battery is equalized.

HYDROGEN EMISSION AT FLOAT VOLTAGE

$$\text{Volume in Ft}^3\text{ H released/hr} = \frac{(\text{A/AH})\ (\text{AH})\ (\text{No. of Cells})}{63}$$

Typical float currents are:

Nickel Cadmium Sinter Plate	.005 A/AH of cell
Nickel Cadmium Pocket Plate High Rate	.003 A/AH of cell
Nickel Cadmium Pocket Plate Medium Rate	.002 A/AH of cell
Nickel Cadmium Pocket Plate Low Rate	.001 A/AH of cell
Lead Acid Antimony (new)	.020 A/AH of cell
Lead Acid Antimony (old)	.035 A/AH of cell
Lead Acid Plante	.008 A/AH of cell
Lead Acid Tubular	.005 A/AH of cell
Lead Acid Calcium	.002 A/AH of cell
Lead Acid Selenium	.003 A/AH of cell

Example: For the same battery considered earlier:

$$\text{Volume H/hr.} = \frac{(.001)\ (100)\ (92)}{63} = .146\ \text{Ft}^3\text{/Hr}$$

WORST CASE HYDROGEN EMISSION

The absolute worst case for hydrogen emission would result if the battery were fully recharged and for some reason the charger malfunctioned and remained in the high (equalize mode) voltage setting. At his voltage, the current flowing through the battery is approximately eight times higher than the float current referenced above. Therefore, to calculate the absolute worst case hydrogen emission:

Vol. H/hr. = (8) (Hydrogen Emission @ Float Voltage) =.146 Ft^3/Hr (8) = 1.168 Ft^3/Hr

WATERING INTERVAL

To calculate the watering interval of any cell you must first determine the volume of reserve electrolyte in that cell. To do this, you need to know the inside length and width dimensions of the cell jar, the length in inches between the “minimum” and the “maximum” water levels and then subtract the volume displaced by the positive and negative posts which come through this area of the cell.

Without getting too detailed, it is generally true that if you use the outside cell dimensions to calculate the reserve electrolyte volume and subtract 20%, you are certainly close.

Example: For the 100 AH cell being considered, the cell dimensions are 2.1” long x 7.6” wide. The distance between the “minimum’ and “maximum” water levels is 2.0”.

Therefore, the reserve electrolyte is:

$$(2.1)\ (7.6)\ (2.0) = 31.9 \text{ in.}^3 - 20\% = 25.5 \text{ in.}^3$$

Note 1: The distance between the “minimum” and “maximum” water levels varies with different cells, but is typically .5 -.75 inches for lead acid cells and 1-2 inches for nickel cadmium cells.

Note 2: One pint equals 28.875 in.^{3} by volume.

Therefore, the cell in the example has

$$\frac{25.5}{28.875} = .89 \text{ pints of reserve electrolyte}$$

If each cell releases hydrogen gas as follows:

During Recharge:

$$\frac{62.7 \text{ Ft}^3\text{/battery}}{92 \text{ cells/battery}} = .68 \text{ Ft}^3\text{/cell}$$

.68 Ft^3/cell/recharge (3 recharges/yr.) = 2.04 Ft^3/yr.

Note 3: Standard battery specifications assume three discharges per year. Therefore, three each recharges would be required.

During Float:

$$\frac{.146\ Ft^3/battery/hr.}{92\ cells/battery} = .00158\ Ft^3/cell/hr.$$

$$.00158\ Ft^3/cell/hr.\ \frac{(24\ hr.)}{day}\ \frac{(30\ days)}{month}\ \frac{(12\ mo.)}{year} = 13.65\ Ft^3/cell/yr$$

Total hydrogen loss per year per cell

Equals 2.04 + 13.65 = 15.69 Ft^3

Note: One volume of water yields 2734 volumes of H at standard temperature and pressure.

Therefore:
With 25.5 in.^{3} of reserve electrolyte in each cell and with the cell evolving 15.69 Ft^3 of H gas/hr., the cell will need to have water added;

$$\frac{(25.5\ in.^3)\ (1\ Ft^3)}{1728 in.^3} = .014\ Ft^3 \text{ of reserve electrolyte}$$

.014 Ft^3 electrolyte (2734 Ft^3 H)/Ft^3 electrolyte = 38.2 Ft^3 H

$$\frac{38.2\ Ft^3\ H}{15.69\ Ft^3\ H/yr} = 2.43 \text{ years to water}$$

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