Table 5.11 Some Typical Float Currents for Fully Charged Lead–Acid Batteries[a]

Charge Voltage (V/cell) 1.215 SG	Charge Current at 25°C (mA/100 Ah)		
	Pb–Sb 1.215 SG	Pb–Ca 1.240 SG	Pb–Sn
2.15	15–60	—	—
2.17	19–80	4	—
2.20	26–105	6	11
2.23	37–150	8	18
2.25	45–185	10	27
2.27	60–230	12	—
2.33	120–450	24	60
2.37	195–700	38	95
2.41	300–1100	58	—

[a] Data from [24].

- Rectifier system output voltage is incorrectly set too high or drifts out of adjustment, exposing all cells to a higher than normal float voltage and overcharge condition.
- A rectifier fails in a mode that causes its voltage to increase and the high-voltage shutdown circuits fail to operate.
- A cell fails, is removed from the string, and a shorting bar is installed in its place to keep the battery in service; unless the float voltage is decreased, this exposes the remaining cells to overcharge as in the first scenario above.

If any of these scenarios occur, the current through the cells is considerably higher than the normal float current, and the hydrogen evolution also is considerably higher.

One estimate for abnormal operation that is commonly used is 0.01 A/Ah (1 A/100 Ah) of cell capacity [that is, $I = 0.01 \times (AH_{8\text{hour}})$ A]. Using this value for float charge conditions

$$Q_H = 2.7 \times 10^{-6} \times (AH_{8\text{hour}}) N_{\text{Cell}} \text{ CFM (float condition)} \tag{5.18d}$$

To convert from CFM to liters/hour, multiply by 1699.

The worst-case float current would be the maximum available rectifier system current; however, the maximum current is not ordinarily used to calculate hydrogen evolution because it is highly improbable that a battery or cell failure will sink the entire current available from the rectifier system. Instead, it is common practice to use one-fourth of the maximum available rectifier current. With this adjustment, Eq. (5.18b) and Eq. (5.18c) become

$$Q_H = 0.46\left(\frac{I_{\text{Max}}}{4}\right) N_{\text{Cell}} \text{ liters/h} \tag{5.18e}$$

$$= 0.00027\left(\frac{I_{\text{Max}}}{4}\right) N_{\text{Cell}} \text{ CFM} \tag{5.18f}$$

where I_{Max} is the maximum current available from the rectifier system when in overload (amperes).

Now that a method has been described to determine the rate at which hydrogen gas is evolved from a battery system, it is necessary to calculate the required ventilation rate. To limit the gas concentration to a particular concentration, the ventilation rate is

$$Q_{\text{VentRate}} = \frac{Q_H}{G_{\text{Limit}}} \tag{5.19}$$

where Q_{VentRate} = fan airflow rate (liters/h or CFM)
Q_H = hydrogen gassing rate (liters/h or CFM)
G_{Limit} = hydrogen gas concentration limit by volume (0.01–0.02)

Example 5.14 Determine (1) the hydrogen evolved during normal (float) and abnormal conditions and (2) the fan capacity to limit hydrogen concentration to 1% by volume during abnormal operation for the following system. Provide the answers in liters/hour and CFM for a cell temperature of 25°C (77°F):

> Remote equipment enclosure: 8 ft (2.4 m) wide × 12 ft (3.7 m) long × 9 ft (2.7 m) high
> 48-V, 24-cell, 150-Ah battery
> Rectifier capacity: 40 A (four 10-A rectifiers in $N + 1$ configuration, $N = 3$)
> Equipment load 12 A

Solution The float current during normal operation is assumed to be 0.01 A/100 Ah × 150 Ah = 0.015 A. Therefore,

$$\begin{aligned} Q_H &= 0.46 N_{\text{Cell}} I = 0.46 \times 24 \times 0.015 = 0.166 \text{ liters/h} \\ &= 0.00027 \times 24 \times 0.015 = 0.000097 \text{ CFM} \end{aligned}$$

During abnormal operation, the calculations give

$$Q_H = 0.46\left(\frac{I_{\text{Max}}}{4}\right)N_{\text{Cell}} = 0.46\left(\frac{40}{4}\right)24 = 110.4 \text{ liters/h}$$

$$= 0.00027\left(\frac{40}{4}\right)24 = 0.065 \text{ CFM}$$

To maintain a concentration no greater than 1% by volume,

$$\begin{aligned} Q_{\text{VentRate}} &= \frac{Q_H}{G_{\text{Limit}}} = \frac{110.4}{0.01} = 11{,}040 \text{ liters/h} \\ &= \frac{0.065}{0.01} = 6.5 \text{ CFM} \end{aligned}$$

As a point of reference, a typical residential bathroom fan is rated 50 to 100 CFM.

Hydrogen is very easily diluted by air, and in small installations (< 100 Ah) it is not always necessary to use fans if the space is equipped with inlet and outlet air vents. For natural ventilation, a common expression for the area of each vent (inlet and outlet) is

$$A_{\text{Vent}} \geq 2800 Q_H \text{ mm}^2 \text{ where } Q_H \text{ is in m}^3\text{/h}$$