VENTILATION FOR BATTERY AREA
REQUIREMENTS

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1. GENERAL

1.01 This section provides recommended criteria for building ventilation requirements for areas with "flooded cell" type batteries to limit the concentration of free hydrogen evolved and vented at each cell. "Valve regulated" cells evolve very little hydrogen and are not covered in the section. Ventilation of transformer vaults, heating plants, engine rooms, and gas meter compartments is discussed in BSP 760-550-151.

1.02 The reasons for reissuing this section are listed below:

(a) To incorporate new data made available from Bellcore Practice BR-781-810-885 "Ventilation of Central Office Buildings"

(b) To incorporate new data made available from ASHRAE Standard 62-1989 "Ventilation for Acceptable Indoor Air Quality".

(c) To provide a standard, simplified approach to calculating ventilation requirements for battery areas.

Due to the extensive nature of the revisions, arrows will not be used to emphasize the changed areas.

1.03 Diffusion of hydrogen at room pressures is very rapid due to its low molecular weight. The accordingly high diffusion rate makes it difficult for hydrogen to accumulate in conventional structures unless the evolved gas rate is high. It can be assumed that a near uniform buildup of hydrogen gas concentration exists in the open areas of the room. The concentration near the battery head is higher than the room elsewhere and is at a nearly constant level following the post-boost, 25 hour high concentration level decay period. To ensure constant air movement and the absence of stagnant air pockets within the room, a small (fractional horsepower) free delivery fan located near ceiling height and directed at the battery strings may be considered.

2. DEFINITIONS

2.01 CFM - Cubic feet per minute of air at standard temperature (70°F) and pressure (14.7 psia).

2.02 Duty Cycle - The time interval in which a device is pre-determined to operate followed by a period of inoperation and then repeated on a regular basis. Often expressed in minutes per hour.

2.03 String - Consists of a specific number of cells interconnected to supply a nominal voltage (i.e. 24V, 48V, 130V) of d.c. power to a connected load. Size of the cells in the battery determines the discharge capacity rating (AH) of the entire battery string.

2.04 Ventilation air - air from an outdoor source.

3. DEDICATED BATTERY ROOMS (UNOCCUPIED)

3.01 Outdoor air is periodically required in a dedicated battery room to limit the concentration of the free hydrogen evolved and vented at each battery cell. The amount of outdoor air required is a function of the hydrogen released by the battery plant.

3.02 The volume of hydrogen gas H, released to the room from battery cells "on-float" can be approximated with the following equation.

$$H = 0.0148 \times FC \times TM \times N.$$

Where:

H = hydrogen release rate in ft^3/hr.
0.0148 = Constant in $ft^3/hr/amp$
FC = Float current in amps (from Table I).
TM = Temperature Multiplier (from Table II)
N = Number of cells

3.03 Calculation of float current is performed differently depending on whether the cells are rectangular lead calcium or antimony or AT&T lead round cells. For non-AT&T round cell batteries, use the following formula and data from Table I:

$$FC = AH/100 \times FC_{100}$$

where FC = Float Current in Amperes at Float Voltage, FV

AH = Ampere-Hour rating of the Battery at 8 hour rate
FC_{100} = Float Current per 100 amps-hours (from table on next page)

Table I: Float Current of Rectangular Batteries per 100 Amp-hours (FC_{100}) at Various Voltages

	FC_{100}	
Float Voltage, FV	Lead Antimony *	Lead Calcium *
2.17	0.080	0.005
2.20	0.105	0.006
2.25	0.185	0.011
2.27	0.230	0.012
2.33	0.450	0.024
2.37	0.700	0.038
2.41	1.100	0.058
2.55	-	0.595

* Amperes per 100 amp-hours at 8 hour rate

Example: Calculate the Float Current for a 1680 rectangular lead calcium battery at 2.17 volts per cell (v/c).

$$FC = 1680/100 \times 0.005 = 0.084 \text{ amps}$$

For AT&T Round Cells, use the following table to determine float current:

Table II: Float Current in Amps of AT&T Round Cells at 2.17 volts per cell (v/c)

Ampere Hour Rating **	Float Current in Amperes
296	0.010
488	0.017
864	0.030
1600	0.060

** Amp-hour rating is based on 1.75 v/c at the 8 hour rate

3.04 The float current ampere values in Table I & II apply when the battery cell temperature is at 77°F. These values will double for every 15°F of temperature rise. Therefore, a multiplier must be used to compensate for the effect of higher cell temperatures.

Table III lists multipliers for temperatures in the 77-122°F range. Use the multiplier associated with the highest monthly average cell temperature that is expected or has been experienced.

Table III Temperature Multipliers (to be used with Float Current Ampere values found in Table I).

Cell Temperatures, $^{\circ}F$	Multiplier
77	1.00
80	1.15
82	1.26
85	1.45
88	1.66
90	1.82
92	2.00
95	2.30
100	2.89
110	4.59
120	7.30
122	8.00

The amount of fresh air, A, required to dilute the hydrogen to a 0.2% concentration level in a "closed" room during battery "float" is calculated as follows:

$$A = \frac{H}{60 \times 0.002}, \ ft^3/min$$

Where:

A = Outside air in ft^3/min.

H = Hydrogen Release rate in ft^3/hr calculated in paragraph 3.02.

3.05 The amount of air calculated for A in paragraph 3.04 must be provided by introducing outside air into the battery room. This air can be provided either continuously or periodically, depending on the size of the ventilation fan selected. Do not recirculate the purge air (note: the source for purge air supply may be recirculated air which is provided from building zones other than toilets).

To determine the length of time a ventilation fan must be operated in order to deliver the required amount of fresh air into the battery room, use the following formula.

$$t = \frac{A}{VF} \times 60, \text{ min/hr.}$$

where:

A=Outside air in ft^3/min.

VF=Ventilation Fan Size in ft^3/min.

<u>NOTE</u>: If t is greater than 60 min/hr., the ventilation fan is too small and a layer or additional unit must be installed.

A power plant consisting of one string of 24 lead calcium 1680AH flooded cell batteries operating "on-float" at 2.17 volts residing in a power room at 122°F might be considered a typical "worse case". In this example, the required ventilation rate would be calculated as follows:

$$FC = 1600/100 \times 0.005 = 0.080 \text{ amps.}$$

$$H = 0.0148 \times 0.080 \times 8.0 \times 24 = 0.227 \text{ ft}^3/\text{hr.}$$

$$A = 0.227/(60 \times 0.002) = 1.89 \text{ ft}^3/\text{min.}$$

$$\cong \mathbf{2.0\ ft^3/min.}$$

The **2.0 cfm per string** amount can be used as a general guideline in lieu of the formulas for lead calcium cells and round cells. For multiple strings, multiply the 2.0 cfm accordingly. For new construction, use the design number of battery strings for the 10 year view. For existing facilities, use the actual number of battery strings plus any planned additions in the next ten years. As a minimum, at least one room air change must be made each twelve hours. To ensure effective air dilution the time interval, t, of ventilation fan should not be less than 15 min/hr.

3.06 During an extended charging period or possible overcharged period, additional local ventilation is required to dilute any hydrogen and sulfuric acid evolved. An extended charging period (normally the initial charge) is given to all batteries prior to turnover to SWBT to compensate for self-discharge that has taken place in the interval between cell manufacture and installation. A battery discharge resulting from a power failure or other reasons may require cells(s) to be boost charged.

A guideline rate of **120 cfm per string** batteries can be used in lieu of the formulas. This rate corresponds to a typical "worse-case" situation with batteries at 122^{O}F and being charged at 2.5 volts. However, <u>at least two battery-room air changes per hour must be provided through the use of exhaust fans or room air purges during these periods</u>.
Air movement must be maintained throughout the battery area during these conditions. [<u>Danger</u>: Connections at the battery should not be made or opened and cells should not be handled during initial or boost charge and for 25 hours thereafter in order to reduce the possibility of igniting any potential hydrogen gas concentrated within the battery].

3.07 Battery room air should not be exhausted through any other equipment or administrative space, but should be exhausted directly outdoors away from any building air intake. In an oversized room a separate exhaust duct from the battery area may be required. This exhaust air-flow rate will not generally affect overall building pressurization or system air balancing except in small buildings dedicated primarily to power.

3.08 During all periods of extended service occupancy ($\geq$ 1 hour) outdoor air at a minimum rate of 20 cfm per person shall be continuously supplied to the battery room.

3.09 In the warmer climates where the outdoor air temperature can exceed 85° F for extended periods the ventilation duty cycles may be scheduled for the cooler hours of the day to prevent unnecessary increase in battery cell temperatures. For additional information on the effect of high temperatures on batteries, see Bellcore Practice, BR 790-100-655, "Batteries".

3.10 The flammability limits for hydrogen in air are 4.0 to 74.2%. The specified ventilation air purge rates provide conservative margins of safety against the formation of a flammable concentration of free hydrogen in the battery room.

BATTERY CELLS LOCATED WITH OTHER EQUIPMENT

4.01 In a central office building battery cells are also located in environmentally controlled areas with other equipment. During normal operation, with float charge conditions, equipment rooms (other than power rooms) containing battery cells should be provided with ventilation air at a rate of 20 cfm per person (when occupied) or one air change every four hours or 2.0 cfm (See paragraph 3.03) per string, whichever is greater.

4.02 During extended periods of charging, equipment rooms containing battery cells should be provided with ventilation air at a rate of 120 cfm per string (See paragraph 3.06) or 2 air changes per hour, whichever is greater. If air cannot be exhausted directly outdoors from the immediate area of the cells a higher room air ventilation rate must be provided during these periods. During extended charging, the greater rate of 240 cfm of outside air intake per string or 4 air changes per hour will provide sufficient gross room area dilution of any hydrogen and sulfuric acid evolved. This ventilation rate is based on a cell size of 1600 amp-hours. For smaller cells, proportionately less ventilation is needed to meet this requirement.

5. SUMMARY OF REQUIRED VENTILATION RATES

5.01 Table IV provides a summary of ventilation rates for battery areas as discussed in the previous paragraphs.

Table IV: Summary of Battery Ventilation Requirements

(NOTE: Always use the greater ventilation rate listed for a particular case. Also, local codes that exceed these rates should be followed)

	Formulas: (See 3.01-3)	Guidelines Rate:	Minimum:
DEDICATED BATTERY ROOMS			
- UNOCCUPIED			
- On-Float	varies	2 cfm/string	1 air chng/12 hr
- Recharging	varies	120 cfm/strng	2 air chng/hr
- OCCUPIED			
- On-Float	varies	20 cfm/person	1 air chng/12 hr
- Recharging	varies	20 cfm/person	2 air chng/hr
BATTERIES LOCATED WITH OTHER EQUIPMENT			
- UNOCCUPIED			
- On-Float	varies	2 cfm/strng	1 air chng/4 hr
- Recharging-Direct Exhaust	varies	120 cfm/strng	2 air chng/hr
- Recharging-No Direct Exhaust	varies	240 cfm/strng	4 air chng/hr
- OCCUPIED			
- On-Float	varies	20 cfm/person	1 air chng/12 hr
- Recharging-Direct Exhaust	varies	20 cfm/person	2 air chng/hr
- Recharging-No Direct Exhaust	varies	20 cfm/person	4 air chng/hr

6. OTHER REQUIREMENTS

6.01 Local codes that exceed the ventilation rates specified here should be followed. 20 cfm of outside air per person is now usually considered to be sufficient in non-smoking, occupied areas to dilute odors and minimize the potential for adverse health effects.

6.02 A ventilation rate of 20 cfm per person corresponds to about 0.14 cubic feet per minute of fresh air makeup for each square foot of occupied space or three quarter air changes per hour. When the supply fan is operating, a rate this low can possibly occur as a result of leakage through the closed outside air intake dampers of switching equipment rooms having a large capacity outdoor air economizer damper. <u>At installations where it is intended that the ventilation requirement be met with the outside air dampers closed the actual leakage rates should be determined during system air balancing when the supply and return fans are operating in all their possible modes</u>. In some cases, local practices permit unoccupied areas to receive no air circulation for extended periods.

6.03 Ventilation requirements should be specified and provided independent of the airflow required for equipment cooling. Where outside air is brought into building areas for cooling telephone equipment, it should not be assumed that this ventilation is uniformly distributed and will meet all building ventilation needs. Outside air intake for telephone equipment cooling should be discontinued whenever it results in equipment room relative humidity greater than 55 percent, or less than 10 percent. This is accomplished by high- and low-limit humidistats located in the equipment room, or in the return airflow to control outside air-intake dampers. Outside air should not be brought into the equipment room until the equipment room temperature is at least 10°F (5°C) above the outside air temperature. All outside air, including ventilation air taken into telephone equipment rooms, must be adequately filtered to prevent damage to equipment.

6.04 In locations with pollution, it will usually be desirable to minimize outside air intake. While heating, ventilating, or air-conditioning fan systems are operating, some building pressurization is desirable (0.05 inches of water gauge static positive pressure is usually more than sufficient). It is of prime importance to ensure that the operational sequencing of the building fan systems does not create a negative pressure within the building.