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BATTERY DRY ROOM FACILITY. RELATIONSHIP BETWEEN THE DRY ROOM PARAMETERS AND THE MOISTURE CONTROL UNIT (EXTENDED ABSTRACT)

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Depending on the type of Li cell and the technology employed, the moisture levels in the production dry rooms are maintained between 0.5 and 5% relative humidity (RH). The system under consideration comprises a production dry room connected by means of ducts and fans to the moisture control unit (MCU). The key characteristics of the dry room required by the users of the system, such as: maximum admissible moisture level, dry room volume V, and the number of workers present in it, n, determine the basic parameters imposed on the MCU, namely: air flow rate, D, and drying efficiency, k. The MCU drying efficiency k is defined as the ratio of the humidity in the air entering the MCU to that leaving the MCU.

It is assumed that the air in the dry room is homogeneous because of infinitely fast mixing. It is further assumed that the room walls are vapour tight and that any penetration through ducts and air-locks is insignificant. This leaves human evaporation as the only source of water vapour and assumes that the average rate of water vapour released by an individual, g, is constant.

Denoting the absolute humidity in the dry room by H and the water vapour density by ρ we obtain the following differential equation:

$$\frac{dH}{dt} = \frac{ng}{\rho V} - \frac{D}{V}\left(1 - \frac{1}{k}\right)H \tag{1}$$

The solution of this equation with initial conditions: $t = 0$ and $H = 0$, implying that prior to the workers entering the initial humidity is equal to zero, is:

$$H = \frac{ng}{\rho D(1 - 1/k)}\left[1 - \exp\left(-\frac{D(1 - 1/k)}{V}t\right)\right] \tag{2}$$

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TABLE 1

The necessary air flow rate in $m^3\ h^{-1}$

n	RH (%)			
	0.5	1	2	4
1	1080	540	270	135
4	4320	2160	1080	540
16	17280	8640	4320	2160

From the condition for steady state humidity: $dH/dt = 0$, and by substitution of the absolute humidity, H, with the relative humidity $\mathrm{RH} = (H/H_0) \times 100$, it follows that the steady state relative humidity value will be:

$$\mathrm{RH}_{t\to\infty} = \frac{ng}{\rho D H_0 (1 - 1/k)} \tag{3}$$

where H_0 is the absolute humidity at saturation.

As shown by eqn. (3), under steady state conditions the relative humidity in the dry room is proportional to the number of people, n, present and the water vapour released by one person, g, and is the reciprocal of the air flow rate of the MCU, D. The steady state humidity is independent of the dry room volume, V, and the efficiency of the MCU, k, is a second order parameter. The requirement $k > 10$ is sufficient, since a higher value would have little effect on humidity. From eqn. (3) it is easy to see that even a very low efficiency MCU with $k = 2$ will operate equally as well as an ideal MCU with $k \to \infty$ if the air flow rate of the former is double that of the latter.

In practice we are faced with the reverse problem: we know the max. admissible relative humidity level (RH) in the room, the number of people working in it, and want to assess the necessary air flow rate in the MCU. Table 1 shows the necessary values of the air flow rate in $m^3\ h^{-1}$, calculated from eqn. (3), assuming that the rate of human evaporation per person, g, is equal to $100\ g\ h^{-1}$ and $k = 10$.

It can be seen from Table 1 that to maintain RH = 2% the air flow rate per person should be higher than $270\ m^3\ h^{-1}$, and for RH = 0.5% it should be more than $1000\ m^3\ h^{-1}$. If we also take into account the moisture penetrating the air locks, walls, and tubings, then this value should be raised considerably. Hence, the values shown in Table 1 are the lowest admissible or critical ones.

Taking into account eqn. (3) one can modify eqn. (2) as follows:

$$H = H_\infty \left[1 - \exp\left(-\frac{D(1 - 1/k)}{V} t\right)\right] \tag{4}$$

TABLE 2

The time response of the process in minutes

V/n (m^3)	RH (%)			
	0.5	1	2	4
15	0.85	1.7	3.4	6.8
30	1.7	3.4	6.8	13.6
60	3.4	6.8	13.6	27.2

The time response of the process, t_r, which is a measure of the rate to reach steady state conditions can easily be estimated by eqn. (4):

$$t_r = \frac{V}{D(1 - 1/k)} \tag{5}$$

For $t = t_r$ eqn. (4) yields $H = 0.63\ H_\infty$, showing that the moisture level reached at $t = t_r$ is 0.63 of the steady state value. As seen from eqn. (5) the time response is directly proportional to the dry room volume and inversely proportional to the air flow rate of the MCU. Eqns. (3) and (5) can be used to estimate the time response for various cases of practical interest. Table 2 shows values of the time response in minutes calculated from eqns. (3) and (5), taking into account that the volume necessary for one person in a dry room varies between 15 and 60 m^3. Since the usual requirement for RH is 1 - 2%, and the typical value for the volume required per person is 30 - 40 m^3, one can easily see from Table 2 that, in practice, the time in which the moisture level will reach 0.63 times that of the steady state value is only a matter of minutes.

Tests were performed in two dry rooms with various numbers of people as well as at a constant rate of water vapour generation by an open, electrically powered calorimeter. A comparison of the experimental and calculated curves shows good agreement.

Conclusion

The dry room performance is primarily determined by the MCU air flow rate. The drying efficiency of the MCU only plays a secondary role. The steady state moisture level is directly proportional to the number of people present in the dry room. The volume of the dry room does not affect the steady state moisture level, but it has an impact on the transient period, the duration of which is only a matter of minutes.