Analysis of amounts of Air Conditioning for maintaining Negative Pressure in Chemical Hot Cell

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1. Introduction

Chemical hot cell must maintain negative pressure to ensure the safety of operators against internal radioactive dust and harmful gases. As facilities age, it becomes necessary to monitor whether the appropriate amount of air conditioning is maintained for the safe management of negative pressure. This study aims to analyze the amount of air conditioning needed for appropriate negative pressure level and to use the findings as assessment data for the proper operational condition of chemical hot cell.

2. Methods and Results

Based on the chemical hot cell in Chemical Analysis Facility, the conditions were set as follows. Negative pressure was set to 15 mmH_2O; cell volume was set to 6 m^3; the required ventilation rate of the cell was set to 10 times per hour according to the design criteria; and the filter pressure loss was set to 12 mmH_2O, which is the pressure loss of HEPA filters.

$$P_1 + \frac{\rho \cdot {v_1}^2}{2} = P_2 + \frac{\rho \cdot {v_2}^2}{2} + P_L \quad (1)$$

$$P_1 - P_2 = \frac{\rho}{2}\left({v_2}^2 - {v_1}^2\right) + P_L = 15\mathrm{mmH_2O}$$

$$\frac{\rho}{2}\left({v_2}^2 - {v_1}^2\right) = 3\mathrm{mmH_2O} = 29\mathrm{Pa} \quad (2)$$

$$v_2 = \sqrt{{v_1}^2 + 29 \cdot \frac{2}{\rho}} = \sqrt{1.47^2 + 29 \cdot \frac{2}{1.3}} = 6.84\mathrm{m/s}$$

$$Q_1 = A_1 \cdot v_1 \quad (3)$$

$$v_1 = \frac{Q_1}{A_1} = \frac{0.0167}{\pi \cdot 0.06^2} = 1.47\mathrm{m/s}$$

Substituting Eqs. (1) ~ (3) in (4), (5) gives

$$Q_1 = V \cdot n \quad (4)$$

$$Q_1 = 6 \cdot 10 = \frac{60\mathrm{m^3}}{\mathrm{h}} = \frac{0.0167\mathrm{m^3}}{\mathrm{s}} = 60\mathrm{CMH}$$

$$Q_2 = A_2 \cdot v_2 \quad (5)$$

$$Q_2 = (\pi \cdot 0.06^2) \cdot 6.84 = 0.077\mathrm{m^3/s} = 278\mathrm{CMH}$$

P_1 : Supply air pressure [Pa]
P_2 : Exhaust air pressure [Pa]
P_L : Filter pressure loss [Pa]
v_1 : Supply air velocity [m/s]
v_2 : Exhaust air velocity [m/s]
ρ : Air density [kg/m^3]
Q_1 : Supply air volume [m^3/s]
Q_2 : Exhaust air volume [m^3/s]
V : Cell volume [m^3]
A_1 : Supply air duct area [m^2]
A_2 : Exhaust air duct area [m^2]
n : ventilation rate [1/h]

The amount of air conditioning was determined form the negative pressure, filter pressure loss, and ventilation frequency. In particular, the values of negative pressure and filter pressure loss were key factors that determine the amount of air conditioning.

3. Conclusions

The amount of air conditioning for chemical hot cell is 290 CMH. Considering the air conditioning equipment, duct, valve losses and negative pressure, chemical hot cell is operated with the appropriate amount of air conditioning.