Performance Evaluation of Powered Air-Purifying Respirators

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Introduction

Powered air-purifying respirators (PAPRs) are equipped with a battery powered blower to push atmospheric air through a filter into the respirator cavity. In order to maintain positive pressure inside respirator, the supply air flow must be higher than the breathing flow. However, if the supply flow into the mask is too large, the pressure inside the mask would become a respiratory burden. This study aimed to evaluate the performance characteristics of commercial PAPRs, and to make a comparison of different types PAPRs with pressure inside the facepieces to give some advice.

Materials and Methods

Five type of PAPRs were evaluated in the study. The experimental system set-up is shown in Fig. 1. The PAPRs was donned on a head-form connected to a breathing simulator, with adjustable tidal volume (0.5-3 L) and breathing frequency (15-35 times/min), to simulate different breathing conditions. The operating parameters of experiment is shown in Table.1. Pressure transducers is used to monitor the pressure change inside respirator, and the flow rate generated by the blower was measurement by using a air velocity meter.

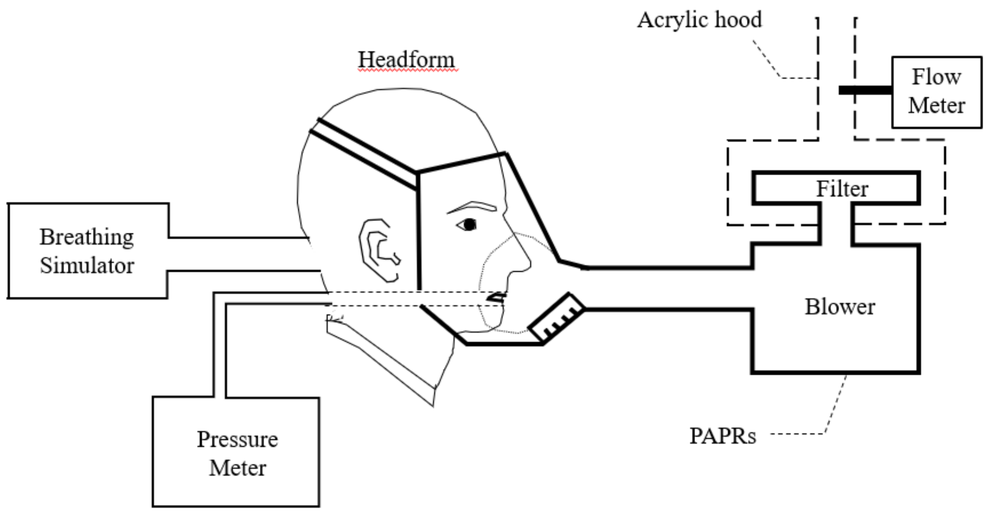

Fig 1. Schematic diagram of the experimental system set-up for evaluation of commercial PAPRs

Table 1. Experimental parameter for evaluation of commercial PAPRs

Parameter	Abbreviation	Range
Tidal volume (L)	V_T	0.5 - 3
Breathing frequency (bpm)	B_F	15 - 35
Breathing flow (L/min)	--	7.5 - 105
Elapsed Time (s)	--	90
PAPR (Type)	--	$PD_{A\&B}$, $CF_{LA\&LB}$, CF_T

* PD_A, PD_B : Pressure demand
CF_T : Constant-flow with tight-fitting facepiece
$CF_{L,A}$ $CF_{L,B}$: Constant-flow with loose-fitting facepiece

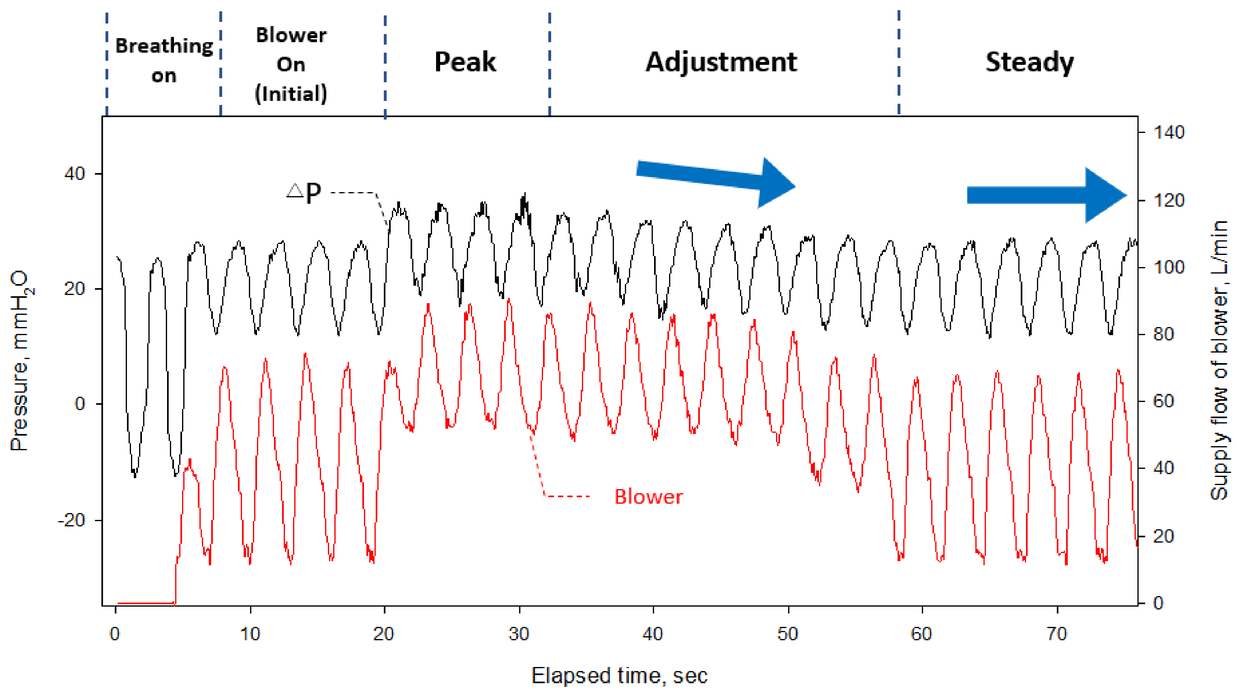

Fig 2. Properties of feeback system of pressure demand PAPRs (V_T = 1.5 L, B_F = 20 bpm)

Results and Discussions

In Fig. 2, In pressure demand auto-feedback PAPRs, The blower first supply a greater flow in order to make sure that pressure must be positive in any breathing condition. After reaching the peak, system would adjust the supplied flow according to different breathing flow. In Fig. 3, The results showed that one set of pressure demand PAPRs can maintain 6-8 mmH_2O in extremely high breathing flow. However, for lower breathing flow, the static pressure inside respirator could be as high as 30 mmH_2O due to the high supply flow. The other set of pressure demand PAPRs can maintain about 4 mmH_2O when breathing flow is below 50 L/min. In Fig. 4, For constant flow PAPRs, the static pressure was less than the pressure demand PAPRs, however, negative pressure occurred under extremely high breathing flow (over 70 L/min). In Fig. 5, From the maximum pressure of exhalation, donning on the tight-fitting facepiece with high supply flow of blower, it may cause the burden of exhalation due to excessive pressure inside respirators.

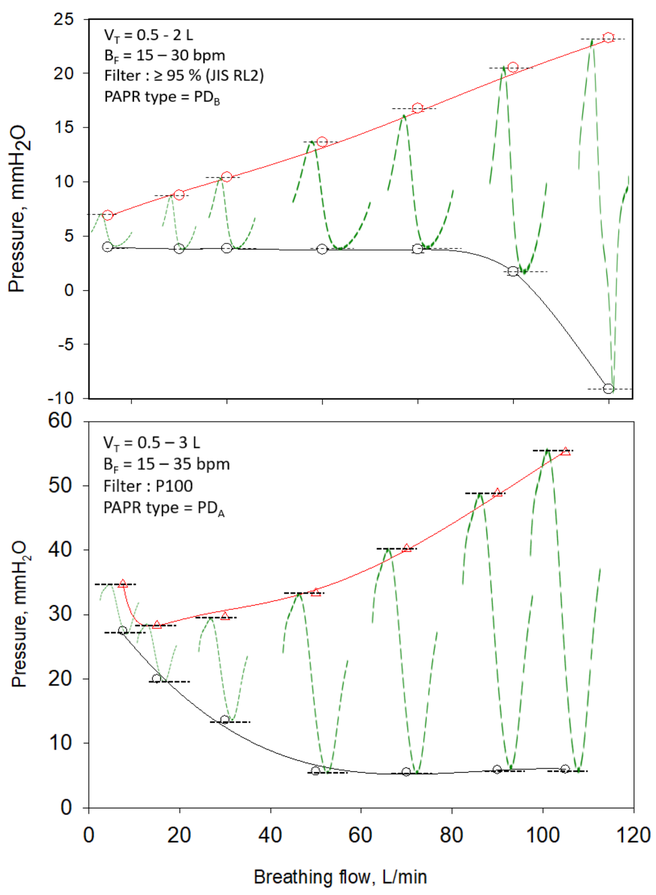

Fig 3. The effect of different breathing flow on pressure in type of PD_A and PD_B

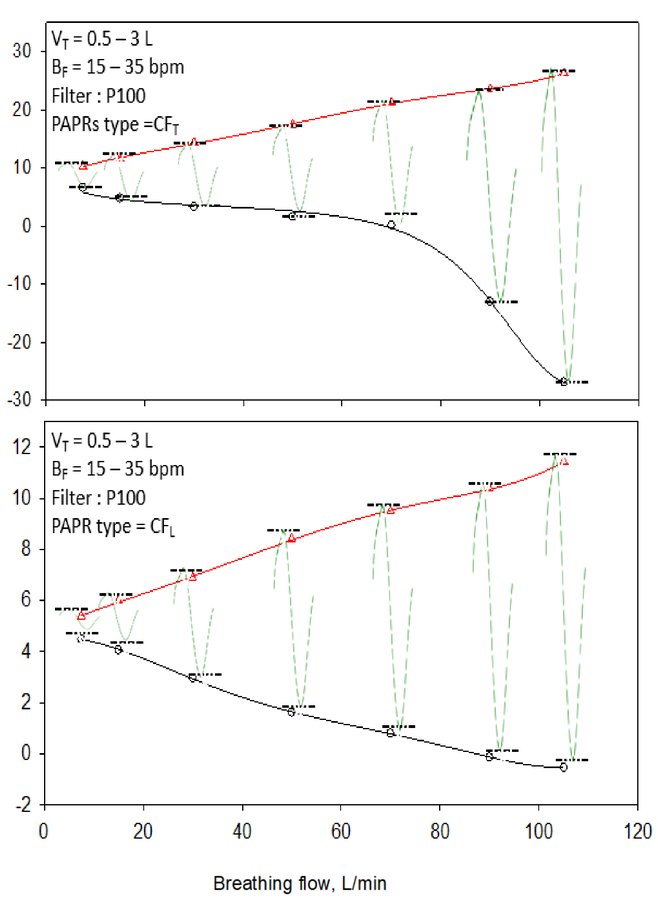

Fig 4. The effect of different breathing flow on pressure in type of CF_T and CF_L

Conclusions

The pressure demand PAPRs is apparently designed for heavy working conditions. With the excessive supply air flow, the too high static pressure inside respirator is uncomfortable to the wearer. Therefore, considering the protection and level of comfort, the one PAPRs, with pressure demand and half-mask, is more suitable to use. In addition, the study will continue the way of reduce the exhalation pressure.

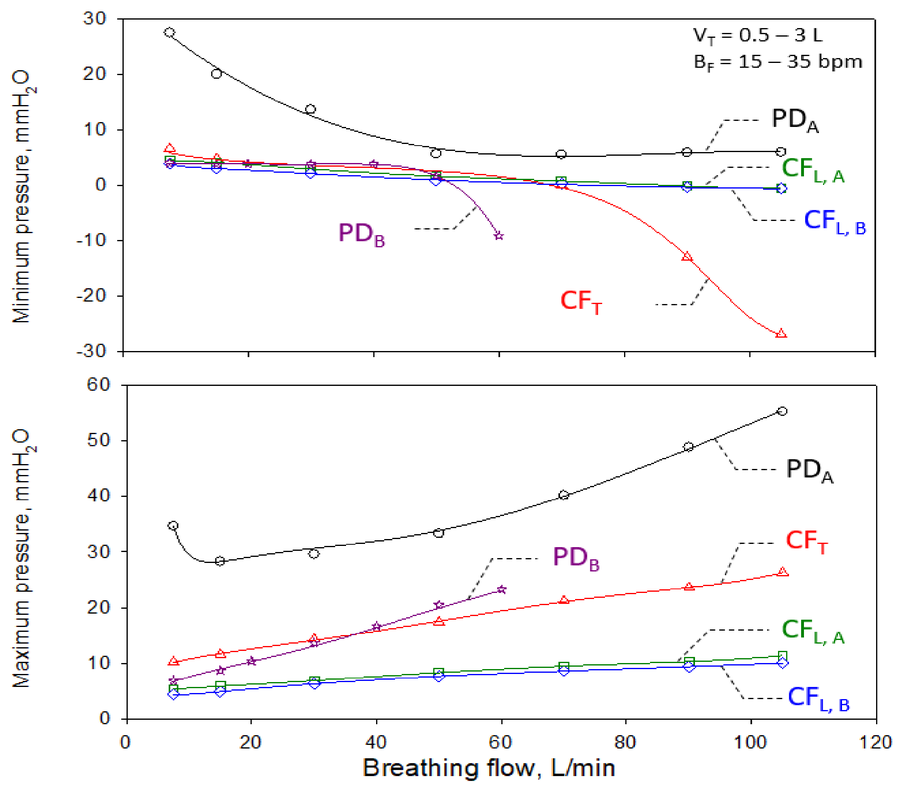

Fig 5. The effect of different breathing flow on pressure in different types of PAPRs