Protection Evaluation of Dual Cavity Respirator Test Beds During Short-term, Strenuous Exercise

David Caretti
U.S. Army Edgewood Chemical Biological Center

Introduction

This investigation sought to evaluate the performance of third-generation (GEN3) dual cavity (DC) pressurization respirator test bed systems. In brief, a DC mask design isolates the positive and negative pressure swing during a breathing cycle within a separate cavity in the respirator (i.e., the nose cup) while supplying positive pressure to the outer cavity (i.e., eye region). Levels of respiratory protection during the wearing of test bed systems were evaluated under exercise conditions that represent common military activities to quantify technology readiness levels of multiple facepiece pressurization options.

Experimental Conditions

The commercially available Avon C50 was modified to accommodate a fan in the facepiece center module and an exterior-mounted front modular assembly for manual control of airflow delivery in either DC or low-flow powered air-purifying respirator (LPAPR) mode (Fig. 1). Two nose cup options were also fabricated, resulting in a GEN3.1 version (quarter-mask nose cup) and a GEN3.2 version (C50-like nose cup) for testing. The respirator test bed systems and operational modes assessed in this investigation are listed in Table 1.

Simulated workplace protection factors (SWPF) were measured for all configurations worn by 9 volunteers (6 males and 3 females aged 34 ± 8 yrs (mean ± SD)) who completed five tasks that ranged from light to heavy intensity workloads (Fig. 2). In-mask particle counts over the course of the 10 minute mask wear trials were measured within a mask's nose cup using a PortaCount®Plus Respirator Fit Tester Model 8020 mounted to a tactical load bearing vest and carried on the back of the test participant. These data were transmitted from the PortaCount®Plus via a wireless serial server and recorded on-line. A second stationary PortaCount®Plus was used to collect particle counts from the eye region during the walk, run, and stair climb tasks. One additional particle counter was used for monitoring and recording of ambient particle concentrations within a test chamber. Instantaneous respirator SWPFs were calculated post hoc from recorded, synchronized in-mask and ambient particle counts.

Figure 1: Schematic of a GEN3 test bed with the front assembly for filter mounting and the manual control knob (left panel). Pictures of the GEN3.1 nose cup option (center) and GEN3.2 nose cup design (right).

Table 1: Experimental Mask Wear Conditions

Test Bed	Airflow Condition	Fan Mode
GEN3.1	DC	On
		Off
	LPAPR	On
		Off
GEN3.2	DC	On
		Off
	LPAPR	On
		Off

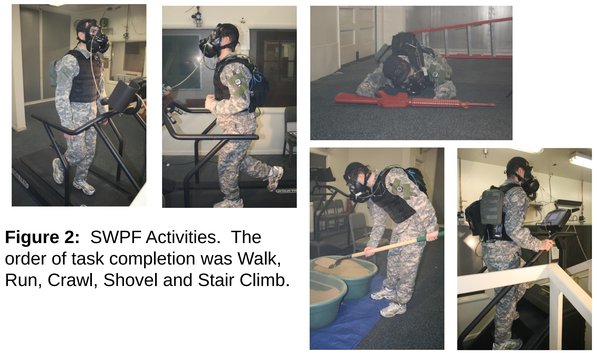

Figure 2: SWPF Activities. The order of task completion was Walk, Run, Crawl, Shovel and Stair Climb.

Results

- Instantaneous in-mask particle counts varied greatly among conditions and tasks (Fig. 3)
- All fan On $SWPF_{Nose}$ values were higher vs. fan Off conditions for all activities
- Average $Log_{10}SWPF_{Nose}$ were highest for the GEN 3.2 DC condition across all SWPF activities (Fig. 4)
- The GEN3.1 DC On condition had the lowest $SWPF_{Nose}$ values of all fan On options
- Average $SWPF_{Eye}$ tended to be higher than $SWPF_{Nose}$ within each fan On condition when compared by task

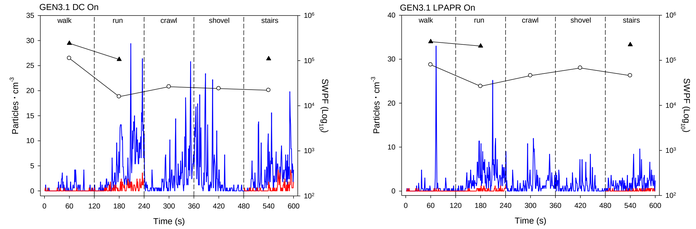

Figure 3: Examples of instantaneous nose cup (blue) and eye region (red) particle counts. $SWPF_{Nose}$ (O) and $SWPF_{Eye}$ (▲) derived for each task.

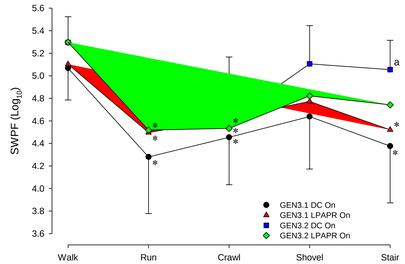

Figure 4: Average (± SD) $SWPF_{Nose}$ by activity for all fan On respirator test bed conditions. a = sig. diff. vs. GEN3.1 DC On; * = sig. diff. from Walk.

Conclusions

- All GEN3 test bed options and modes of operation produced high levels of protection
- Variability in $SWPF_{Nose}$ and $SWPF_{Eye}$ results made it difficult to determine a single best facepiece pressurization option

Acknowledgement: The authors thank the Defense Threat Reduction Agency/Joint Science and Technology Office for their assistance finding for this work under project CB2205. The views expressed in this presentation are those of the authors and do not necessarily reflect the official policy or position of the Department of Defense or the U.S. Government.