Domestic Preparedness: Phase 2 Sarin Vapor Challenge and Corn Oil Protection Factor (PF) Testing of Commercial Powered Air Purifying Respirator (PAPR) Systems and Cartridges

Authors: Lee E. Campbell
Ray Lins
Alex G. Pappas

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Soldier and Biological Chemical Command, AMSSB-REN, Aberdeen Proving Ground, MD 21010-5424

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Lee E. Campbell, Ray Lins, Alex G. Pappas

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Abstract. Results of performance testing of commercial powered air purifying respirator (PAPR) systems and cartridges are described. Three series of tests were performed: (1) breakthrough time determinations of cartridges against Sarin (GB), (2) GB vapor penetration determination of entire PAPR systems using manikin headform and simulated breathing, and (3) corn-oil protection factor determinations of PAPR systems using human subjects. Results indicate that cartridges provide complete penetration resistance against 200 mg/m^3 GB challenge concentrations for 60 minutes, but that unacceptably high levels of GB vapor and corn oil aerosol may penetrate into the breathing zone of the PAPRs.

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Preface

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1. Introduction

In 1996, Congress passed Public Law 104-201 (Defense Against Weapons of Mass Destruction Act of 1996), directing the Department of Defense (DoD) to assist other federal, state, and local agencies in enhancing preparedness for terrorist attacks using weapons of mass destruction. The DoD responded by forming the Domestic Preparedness Program that same year. One of the objectives of the Domestic Preparedness Program is to enhance federal, state and local emergency and hazardous material (HAZMAT) response to nuclear, biological and chemical (NBC) terrorism incidents. As part of an effective response, emergency and HAZMAT personnel who are responding to an incident will use personal protective equipment (PPE) to protect them from exposure to chemical agents or biological agents. The specific PPE that would be used by these federal, state and local emergency and HAZMAT personnel would depend upon the situation encountered and what PPE is held in inventory. In some cases, commercial powered air purifying respirators (PAPR) with canisters/cartridges may be used to enter a contaminated or potentially contaminated area.

This program tasked the Edgewood Chemical Biological Center (ECBC) of the Soldier and Biological Chemical Command (SBCCOM) to perform chemical agent testing of commercial PAPR systems and canisters/cartridges. A cartridge is distinguished from a canister by virtue of the quantity of adsorbent, i.e., a canister contains more than 150 mL of adsorbent and a cartridge contains less.

For this phase of the program, two PAPRs were selected. A PAPR is an air-purifying respirator that uses a blower to force ambient air through air-purifying elements to the inlet. Air-purifying respirator means a respirator with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

A glossary of terms used is included as Appendix A of this report.

2. Objectives and Respirators Descriptions

The objectives of this project were threefold: 1) to determine the protective potential of the respirators against GB vapor; 2) to determine the resistance of the canister/cartridge to GB vapor; and 3) to determine the protection factor (PF) for the respirators. Sarin (GB) is an organophosphorous compound that is used as a standard chemical warfare (CW) agent; it is a cholinesterase inhibitor, thus is a nerve agent, and is the most volatile of the CW agents. By challenging an operating PAPR with GB vapor, one can determine whether the PAPR will protect a user. Entry of vapor into the PAPR headpiece of whatever design can be through a chemical cartridge or a leak in hood material or seams, the face seal, or other leak paths. Cartridges were tested separately to assess their efficiency and to eliminate the cartridge as a leak path if agent is found inside the headpiece when the total assembly is tested.

The National Institute of Occupational Safety and Health (NIOSH) approved PAPRs selected to be tested in this phase of the project were as follows:

- GIAT Industries ARFA Mask using a Micronel blower.
- Safety Equipment America's SE400 pressure demand PAPR, using Sundstrom filters.

3. Chemical Agent Testing

a. Chemical Agent Testing Equipment

(1) Vapor Generator

GB vapor was generated by using a syringe pump to inject liquid GB into a heated tee in the dilution airline. The volume of dilution air and the amount of GB injected were controlled at such rates that the resultant concentration was that specified in the test plan. The GB, vaporized in the heated tee, was carried by the dilution air into a mixing chamber for uniform mixing. From the mixing chamber the mixture was passed into the systems test chamber at the beginning of the test. A Hydrogen Flame Emission Detector (HYFED) was used to monitor the concentration in the test chamber during the test.

(2) PAPR Test Chamber

The test chamber for the PAPRs was a Plexiglas box approximately 2 feet cubed with a removable front panel and four legs on the bottom about 4 inches long, which allowed air to flow under the chamber when it was located inside a fume hood. A test fixture, called SMARTMAN (SiMulant Agent Resistant Test MANikin), which is a human head form, medium size, with a movable face piece and an inflatable peripheral seal, was attached to the floor of the chamber. The mouth orifice of the head form was connected by a large tube to a breather pump; there were also two sampling tubes in the nose, one in the eye, and one in the forehead. All these tubes pass down through the interior of the head form, down through the floor of the chamber, and connect to remote detectors and the breather pump or other monitoring devices, such as pressure gauges. Since agent-air mixture passes through the test chamber during the test, the outlet ports on top of the chamber are covered by military M12A1 filters to scrub agent from the air passing through. Other ports in the chamber walls are used for introducing the agent challenge into the chamber, to attach pressure gauges for monitoring pressure, to introduce oil aerosol for preliminary leak testing of an installed respirator, or to monitor the agent concentration inside the chamber.

(3) Cartridge/Canister Test Chamber

The test chamber for the canister comprises two parts, the base plate and the cover. Both parts are machined from stainless steel. The assembled chamber is a closed cylinder. The base plate has a raised portion and a somewhat wider rim; when the cover is in place the bottom of the cover rests on the rim while the raised portion of the base plate seals against the inside of the cover by means of O-rings. In the center of the base are an orifice and an adapter machined to accommodate a North American Treaty Organization (NATO) thread of a canister. Another orifice is offset from the center and is machined with pipe threads; agent challenge is introduced into the chamber by this means. The chamber, when closed, accommodates a canister up to the size of a C2A1. The center orifice is connected by a line outside the chamber to a vacuum source of a breather pump in order to pull the agent challenge through the chamber. A rotameter and a scrubber filter are placed in this line; there is also a connection between the rotameter and the test chamber for a detector used to monitor GB agent breakthrough.

(4) Breather Pump

The Military Breather Pump E1R1 (Jaeco Fluid Systems, Inc, Exton, PA) was used to simulate breathing through the respirator. This is a reciprocating pump that produces a sinusoidal breathing pattern by means of a reduction planetary gear system that incorporates a Scotch Yoke. With each piston stroke the flow rate starts at zero liters per minute, rises to a peak

flow midway through the stroke and falls back to zero at the end of the stroke. During the initial stroke air is pulled from the test chamber through the respirator (including the canister); on the return stroke this air is exhausted through the exhalation valve of the respirator. The two pump strokes, forward and reverse, produce a complete sine wave pattern. The peak flow produced by this pump is approximately pi times the minute volume. The minute volume (liters pumped in one minute) and the number of strokes per minute (breaths) can be adjusted on this pump.

(5) Leak Detector, TDA-99M

This leak detector is based on generating a polydispersed (<1μm diameter) aerosol of Emery 3004 oil. The aerosol is directed to the outside of the test respirator and a sample of air is taken from inside the respirator back to the detector, where a light scattering chamber detects aerosol particles and compares the concentration to that of the original concentration. The readout is expressed as percentage.

b. Chemical Agent Testing Methods

(1) Respirators

Each respirator system was subjected to a chemical agent vapor test, (see Table 1) wherein the respirator was donned on the manikin headform, SMARTMAN, that was connected to the breather pump through the mouth orifice. The PAPRs were donned on the headform and the blower was activated before the breather pump was activated. The TDA-99M aerosol leak detector was used to check for leaks before the agent test was started. For each respirator test, agent inside the respirator was monitored in the eye area and the nose area, using a MINICAMS®. The challenge GB concentration was maintained at 200 mg/m^3. Two tests were performed for 1 hour, and a third was run for 6 hours for each of the 2 respirator types.

Table 1. Conditions for Testing Respirator Systems

Rate of air flow through exposure chamber	50 L/min
Concentration of challenge GB	200 mg/m^3
Breakthrough concentration limit	0.0001 mg/m^3
Total test time if breakthrough is not observed	60 minutes or 6 hrs.
Precondition of cartridge/canister	25°C/50% RH/6 hrs.
Temperature of test chamber	25±3°C
Flow rate of breather pump	25 L/min
Pump strokes per minute	25
Volume per breath	1 Liter

(2) Cartridges/Canisters

The cartridges/canisters were tested individually by installing them in a test cell, generating a GB challenge concentration, and passing the challenge through the item (see Table 2). The effluent air was monitored by HYFED for breakthrough of agent. The PAPR cartridges were tested at the flow rate they would experience in actual use, i.e., if there were two cartridges and the total flow is 170 liter/min., then each cartridge is tested at 170/2 or 85 liters/min.

Table 2. Conditions for Testing Cartridges/Canisters

GB challenge concentration	200 mg/m^3
Flow rate, PAPR canisters	Equivalent to use
Breakthrough concentration	0.0001 mg/m^3
Test time if breakthrough is not observed	1 hour
Precondition of cartridge/canister	25°C/50% RH/6 hrs.
Temperature of test chamber	25±3°C
Relative humidity of test air	50±5%

c. Chemical Agent Test Results and Discussions

(1) Powered Air-Purifying Respirators

The GIAT ARFA is a constant flow PAPR operating at 170 L/min. The SE400 is a pressure demand respirator that blows air at a rate that corresponds with the breathing rate of the wearer. Since the test used a breather pump at a rate of 25 L/min, with a peak flow of 78 L/min, the blower provided air at varying rates to meet the demands of the pump. Test results, in ng/L of GB inside the respirators, are tabulated in Table 3 below. Charts for each test are presented in Figures 1 – 6.

Table 3. Concentration of GB Inside Respirator

	1-Hr., ng/L		6-Hr, ng/L	
Respirator	**Eye**	**Nose**	**Eye**	**Nose**
GIAT ARFA, G5T199	0.0	0.0		
GIAT ARFA, G5T200	5.0	5.6		
GIAT ARFA, G5T201	0.0	0.0	0.0	0.0
SE400, G5T205	0.0	0.0		
SE400, G5T203	0.8	1.0		
SE400, G5T204	0.0	0.0	140	150

(2) Cartridges/Canisters

Cartridges/canisters for the PAPRs were tested with GB under the conditions stated above. A total of 22 cartridges/canisters of each type was tested. This number represents 90% reliability at 90% confidence level when no failure occurs amongst the 22 items.[1] All items were tested for 60 minutes each. None of the cartridges/canisters showed any penetration of GB.

(3) Discussion

Each system had an aerosol leak test performed before the agent test to assure that any agent detected inside the respirator did not enter by the sealed surfaces or the exhalation valves. The agent detected in the GIAT ARFA respirator possibly occurred because the hose connection to the mask seemed to be slightly loose. The SE400 tested for 6 hours has a breakthrough concentration curve that indicates that a component, or components, of the system may have allowed permeation of agent; this also is indicated in one of the 1-hour tests.

[1] Amstedter, B.L., Reliability Mathematics, McGraw-Hill Book Company, Table C.2c.

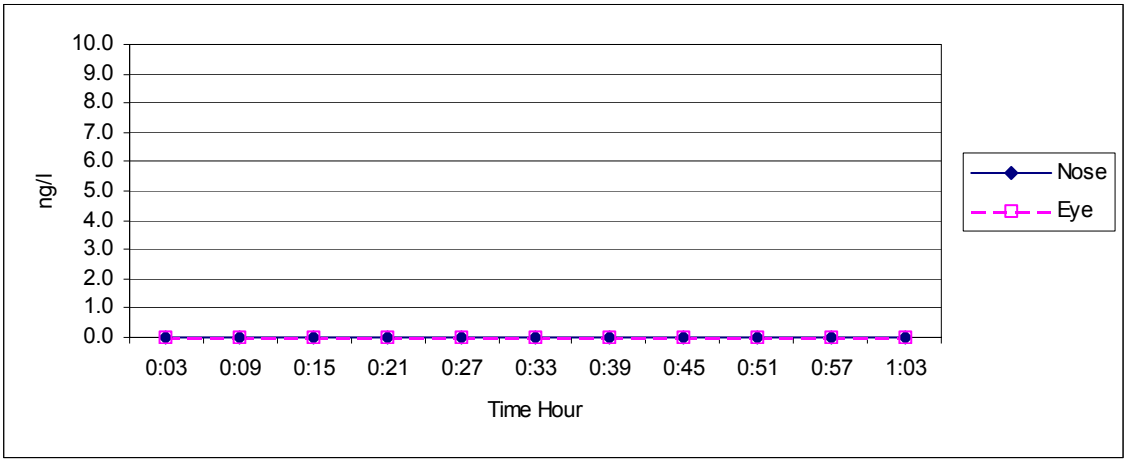

Figure 1. Concentration vs. Time for G5T199 GIAT ARFA, 1-Hour Test

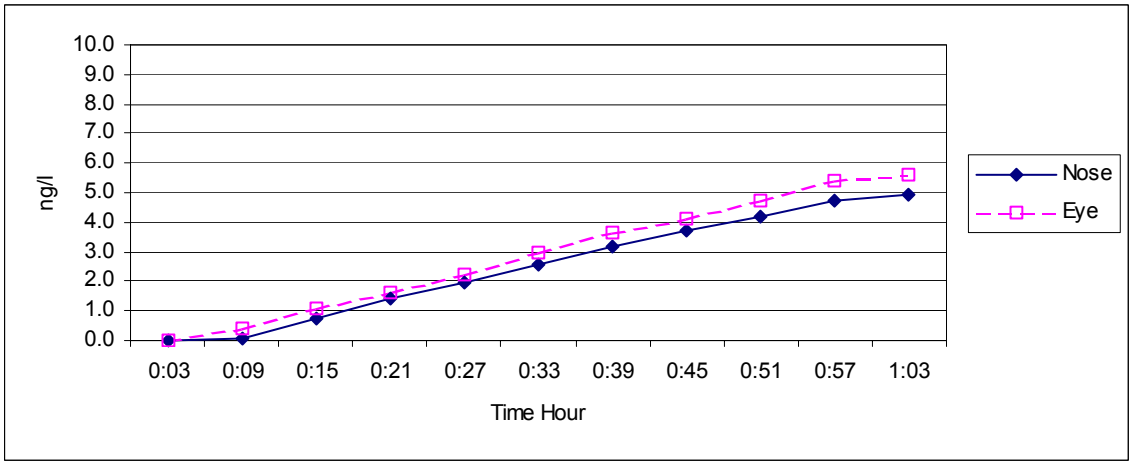

Figure 2. Concentration vs. Time for G5T200 GIAT ARFA, 1-Hour Test

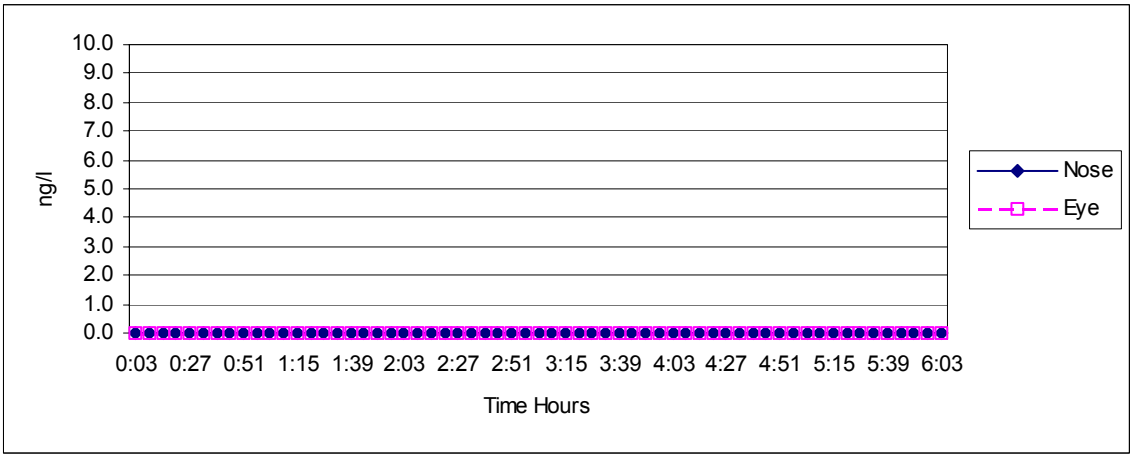

Figure 3. Concentration vs. Time for G5T201 GIAT ARFA, 6-Hour Test

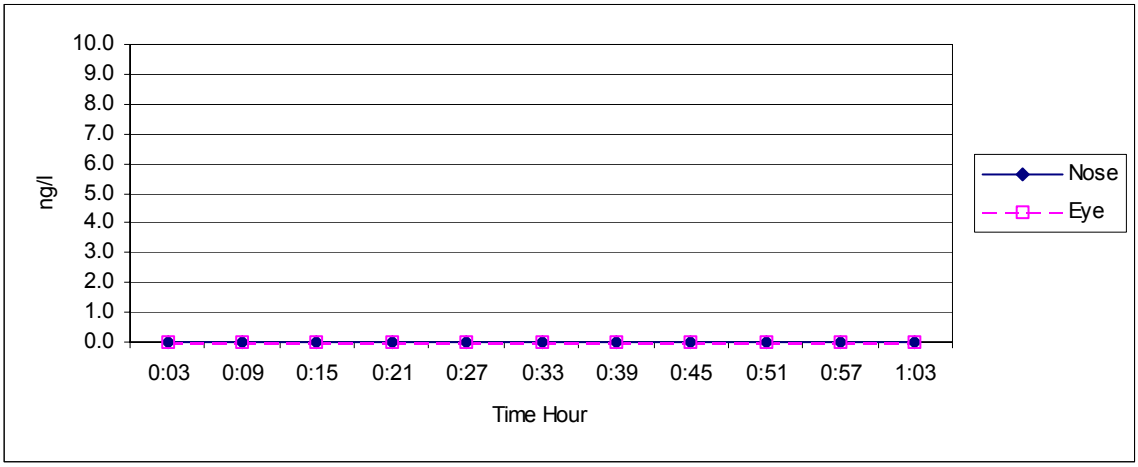

Figure 4. Concentration vs. Time for G5T205 SE 400, 1-Hour Test

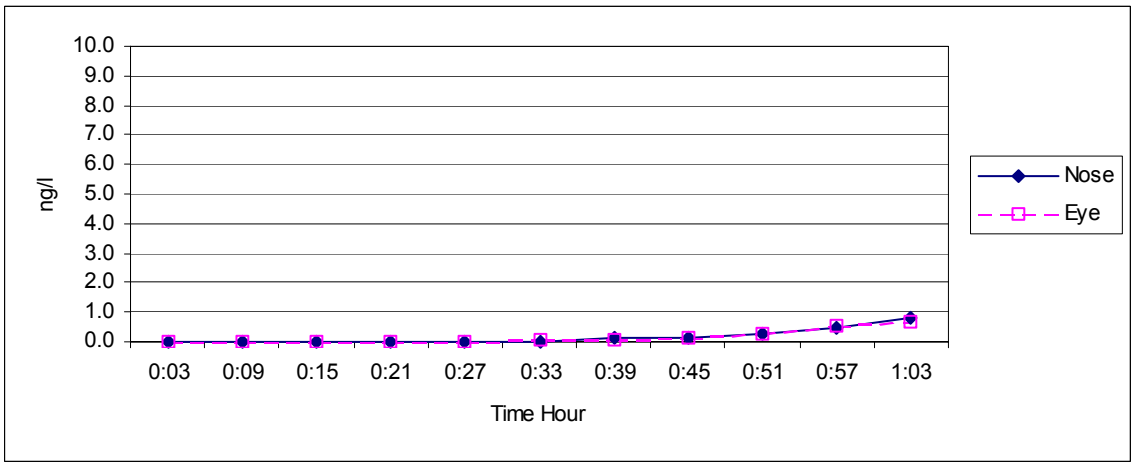

Figure 5. Concentration vs. Time for G5T203 SE 400, 1-Hour Test

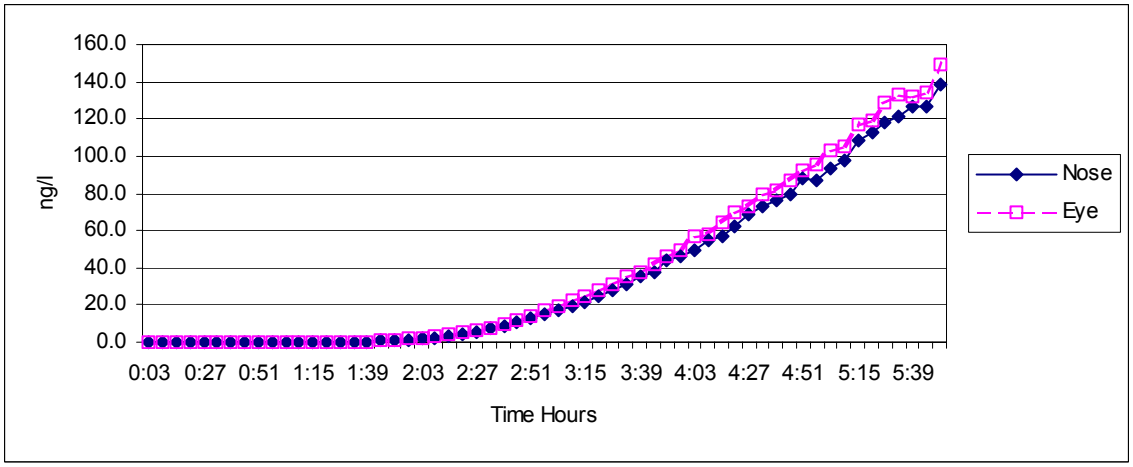

Figure 6. Concentration vs. Time for G5T204 SE 400, 6-Hour Test

4. Protection Factor Testing

a. Corn Oil Test Facilities

A challenge aerosol concentration of approximately 20-40 mg/m³, polydispersed corn oil aerosol having a mass median aerodynamic diameter (MMAD) of 0.4-0.6 microns (the Army Standard) was generated in a 10-ft × 10-ft × 32-ft test chamber. The test chamber challenge aerosol was generated by atomizing liquid corn oil at room temperature using a Laskin nozzle. The Laskin nozzle produced a coarse aerosol cloud, which was directed into an impaction plate to remove the larger particles and yield an aerosol in the desired size range. The concentrated aerosol from the generator was diluted with filtered ambient air to control the challenge aerosol concentration in the exposure chamber.

A 6-decade, 45 degree off-axis light-scattering laser photometer, sampling at a flow rate of 1-2 L/min, was used to quantify concentration of the challenge and the in-mask corn oil aerosols. For a given particle size, the quantity of scattered light is proportional to the aerosol concentration. The photometer converted the quantity of scattered light to a voltage, which was then digitized and recorded by a microcomputer.

The respirator sampling port, located in the oronasal area, was connected to the photometer with flexible silicone tubing to measure the amount of aerosol penetrating the mask. A Tygon® sampling tube line was connected from the exposure chamber sampling port to the photometer to determine the challenge aerosol concentration.

b. Protection Factor Test Methodology

(1) Test Procedures

Each respirator was donned by military volunteers and challenged, on separate dates, with the corn oil aerosol. The number of volunteers for each test was 24 each wearing 1 of 12 respirators for 4 trials. Prior to testing, each test volunteer was given an orientation in which the PF test was explained by ECBC personnel followed by signing of a volunteer agreement.

Each PAPR was tested in two modes: unblown and blown. Unblown mode is when the blower that supplies filtered, forced air to the facepiece is turned off, and blown is when the blower is turned on. The unblown mode simulates a blower failure or a battery failure during use, and addresses the question, "Does the PAPR still provide adequate protection in a negative-pressure mode?" All PAPR assemblies were comprised of an organic vapor cartridge with a High Efficiency Particulate Air (HEPA) quality filter.

In these PF tests, each test subject performed the standard ten-exercise routine at least twice for each PAPR model in each mode for a total of 96 trials (24 x 2 x 2). Where fewer trials than 96 are reported it is because the test data were invalidated for some reason unrelated to the respirator design.

All volunteers had anthropometric data measurements taken of their facial features, and then they were given a respirator and asked to wear their normal clothing (Battle Dress Uniform (BDU)). The test volunteers were then led into the aerosol exposure chamber, 8 at a time, by ECBC personnel, hooked up to their photometer stations, and asked to perform a standard Army PF Test devised to stress the face seal of the respirator. In the test, volunteers were asked to

perform the following ten exercises for one-minute each:

1. Normal Breathing
2. Deep Breathing
3. Turn Head Side to Side
4. Move Head Up and Down
5. Recite the Rainbow Passage (Reading a paragraph aloud to stress talking)
6. Sight the Rifle
7. Reach for the Floor and Ceiling
8. On Hands and Knees, Turn Head Side to Side
9. Facial Expressions
10. Normal Breathing

The test equipment operator monitored and communicated with the test volunteers on when to start an exercise, finish an exercise, and exit the aerosol chamber, and monitored their performance. All exercises were completed by the test volunteers without the intervention of test personnel. The raw data was collected by a computer-based system and stored for later analysis.

(2) Data Analysis

Mask performance was quantified in terms of a PF. The PF was calculated by determining the ratio of the challenge aerosol concentration to the in-mask aerosol concentration as quantified by integrating the peak voltage output from the photometer over the time interval (nominally one minute). A PF was calculated for individual exercises (PF_i). The individual PFs were then used to calculate an overall PF for a subject (PF_o) as follows:

$$PF_o = n(\sum_{I\text{-}1 \text{ to } n} 1/PF_i)^{-1}$$

Where n is the number of exercises. The overall PF provides a time-integrated measure of the protection afforded. It is somewhat analogous to calculating the total resistance of resistors in parallel in an electronic circuit. The PF_0 is affected most by the smallest PFs. Under the conditions of this test and the sensitivity of the photometer, the maximum PF that can be reported is 100,000. The PFs were calculated by a computer.

c. Protection Factor Test Results and Discussion

Because these were commercially available respirators there were no Army requirements established for these respirators. Therefore, we took the conservative approach and reported the data in pass and fail percentages for each respirator configuration at selected PF levels. The analyzed data are provided in Table 4 for unblown modes and Table 5 for blown modes. The first column for each PAPR lists the lower limit of each range of PF computed. The second column is the number of test occasions that resulted in calculated PF within the acceptable range. The third column presents the cumulative percentage of test occasions that resulted in a PF below the lower limit of the acceptable range. The fourth column is like the third, but presents the percentages that are above the lower limit of the range shown. The final PF range shown is over 100,000, but the current data acquisition system cannot measure PF over 100,000, so it truncates the data and puts all the remaining occasions in the final range.

Because these PF tests were performed to provide useful information to the first responder operating in a chemical agent environment, pass percentages based on U.S. Army requirements (available upon request) were included in the summary tables.

Table 4 shows that in unblown mode, the SE400 PAPR with Sundstrom filters had a pass percentage of 73.8% at the 1667 PF level and 50.0% at the 6667 PF level. The unblown GIAT ARFA Mask with Micronel Blower had a pass percentage of 79.2% at the 1667 PF level and 70.8% at the 6667 PF level.

Table 5 shows that in blown mode, the SE400 PAPR with Sundstrom filters had a pass percentage of 60.4% at the 10,000 PF level. The blown GIAT ARFA Mask with Micronel Blower had a pass percentage of 100.0% at the 10,000 PF level.

Because pass percentages of the SE400 PAPR were lower than the GIAT ARFA Mask in the blown and unblown modes without an obvious cause, a series of tests was performed to isolate the source of leakage. A series of PF tests were performed in which successive portions of the mask and blower were isolated from the corn oil environment in the test chamber and were thus tested independently of each other, i.e., by covering with a plastic bag and/or substitution of components. The tests indicated that no leakage was occurring through the blower or the mask, but that oil from the bearings in the warm blower unit was the likely source of particles resulting in the low PF results.

Table 4. Final PF Results, PAPRs (Unblown Mode)

	SE400 PAPR (unblown)			GIAT ARFA PAPR (unblown)		
PF Range	No. of Occasions in Range	Cumulative Rate, Percent	Cumulative Pass Rate, Percent	No. of Occasions in Range	Cumulative Rate, Percent	Cumulative Pass Rate, Percent
0-9	0	.00	100.0	0	.00	100.0
10-49	0	.00	100.0	0	.00	100.0
50-99	0	.00	100.0	2	4.17	95.8
100-199	0	.00	100.0	0	4.17	95.8
200-499	0	.00	100.0	1	6.25	93.8
500-999	0	.00	100.0	1	8.33	91.7
1000-1666	7	16.67	83.3	5	18.75	81.3
1667-1999	4	26.19	73.8	1	20.83	79.2
2000-4999	2	30.95	69.0	1	22.92	77.1
5000-6666	7	47.62	52.4	0	22.92	77.1
6667-9999	1	50.00	50.0	3	29.17	70.8
10000-19999	4	59.52	40.5	1	31.25	68.8
20000-49999	6	73.81	26.2	2	35.42	64.6
50000-99999	7	90.48	9.5	6	47.92	52.1
100000 (+)	4	100.00	0.0	25	100.00	0.0
No. of Trials	42			48		

Table 5. Final PF Results, PAPRs (Blown Mode)

	SE400 PAPR (blown)			GIAT ARFA PAPR (blown)		
PF Range	No. of Occasions in Range	Cumulative Rate, Percent	Cumulative Pass Rate, Percent	No. of Occasions in Range	Cumulative Rate, Percent	Cumulative Pass Rate, Percent
0-9	0	.00	100.0	0	.00	100.0
10-49	0	.00	100.0	0	.00	100.0
50-99	0	.00	100.0	0	.00	100.0
100-199	0	.00	100.0	0	.00	100.0
200-499	0	.00	100.0	0	.00	100.0
500-999	0	.00	100.0	0	.00	100.0
1000-1666	0	.00	100.0	0	.00	100.0
1667-1999	0	.00	100.0	0	.00	100.0
2000-4999	0	.00	100.0	0	.00	100.0
5000-6666	3	6.25	93.8	0	.00	100.0
6667-9999	2	10.42	89.6	0	.00	100.0
10000-19999	14	39.58	60.4	0	.00	100.0
20000-49999	16	72.92	27.1	1	2.08	97.9
50000-99999	8	89.58	10.4	0	2.08	97.9
100000 (+)	5	100.00	0.0	47	100.00	0.0
No. of Trials	48			48		

5. Conclusions

Cartridges/canisters for the two powered air-purifying respirators were tested with GB. A total of 22 cartridges/ canisters of each type were tested. All items were tested for 60 minutes each. None of the cartridges/canisters showed any penetration of GB up to 60 minutes.

Because none of the cartridge/canister tests showed any GB penetration, it is unlikely that any of the GB detected inside the PAPRs during the system tests penetrated the cartridges/canisters up to 60 minutes. Each system had an aerosol leak test performed before the agent test to assure that any agent detected inside the respirator did not enter by the sealed surfaces or the exhalation valves. The agent detected in the GIAT ARFA respirator possibly occurred because the hose connection to the mask seemed to be slightly loose, but a replacement respirator was not available to retest to validate this assumption. The SE400 tested for 6 hours has a concentration curve that indicates that a component, or components, of the system may have allowed permeation of agent.

PF testing was performed wearing the PAPRs for a total of 90-96 trials for each respirator in accordance with the U.S. Army PF testing standard (available upon request) for positive and negative pressure respirators used in a chemical-biological environment. Table 6 summarizes the pass percentages at selected PF levels for the 2 PAPRs tested.

Table 6. Summary of Pass Percentages for Powered Air Purifying Respirators at Selected PF Levels

PF Level	PAPR in Unblown Mode		PAPR in Blown Mode	
	SE400 PAPR with Sundstrom filters	GIAT ARFA Mask with Micronel Blower	SE400 PAPR with Sundstrom filters	GIAT ARFA Mask with Micronel Blower
1667	73.8%	79.2%	--	--
6667	50.0%	70.8%	--	--
10000	--	--	60.4%	100.0%

An additional series of tests was performed which indicated that the low PF pass percentages for the SE400 PAPR may be attributed to migration of oil particles from bearings in the blower unit.

Appendix A.
Glossary

Breather Pump

A pump used to simulate human breathing through a filter. The pump is a piston pump designed to begin the stroke at zero flow, rise to a maximum (peak) flow at midstroke, and decrease to zero at the end of the stroke. The resultant flow is sinusoidal, that is, shaped like a sine wave when plotted. The pump stroke can be adjusted to change the volume of air per stroke over a finite range; some pumps are capable of changing the number of strokes per minute.

Canister (Air-Purifying)

A container filled with sorbents, catalysts and filters that removes gases, vapors, and/or particulates from air drawn through the unit. Canisters rely on a variety of mechanisms for contaminant removal such as chemical absorption, adsorption, catalytic action, neutralization, and mechanical filtration.

Cartridge

A container filled with sorbents, catalysts, and filters that remove gases, vapors, and/or particulates from air drawn through the unit. Cartridges are smaller than canisters (<150 ml capacity) but are designed to work on the same principles.

Exhalation Valve

A device that allows exhaled air to leave a respiratory device and prevents outside air from entering through the valve while inhaling.

Facepiece

The portion of a respirator that covers the wearer's nose and mouth (a full facepiece also covers the eyes). The facepiece should make a gas-tight or dust-tight seal with the face. The facepiece is supported by headbands, and contains inhalation valves, exhalation valves, and connectors for the air-purifying cartridges or filters.

Filter

A fibrous medium used in respirators to remove solid or liquid particulates from the air before it enters the facepiece (this term may be used interchangeably with cartridge).

Hydrogen-Flame Emission Detector (HYFED)

A detector in which organophosphorus chemical compounds are burned in a hydrogen flame. Phosphorus compounds are formed that emit electromagnetic radiation whose wavelengths can be isolated and quantified.

Inhalation Valve

A device that allows air to enter the facepiece through the filtering media but prevents exhaled air from leaving the facepiece through the intake openings.

MINICAMS®

Trade name for a chemical agent detector in which the agent is adsorbed from a specified volume of air onto an adsorbent tube which is then desorbed into the injection port of a gas chromatograph for analysis (quantitation). The acronym stands for "Miniature Continuous Air Monitoring System."

PAPR

Powered Air-Purifying Respirator with a tight or loose fitting facepiece with some kind of hose connected to a turbo unit or blower. The blower produces 4-6 cubic feet per minute of filtered airflow into the facepiece.

Particulate Matter

A respirator of fine solid or liquid particles in air, i.e., dust, fog, fume, smoke, or sprays. Particulate matter suspended in air is commonly known as an aerosol.

Protection Factor

The overall protection afforded by a certain type of respirator as defined by the ratio of the concentration of contaminant outside a facemask or hood to that inside the mask while in a contaminated atmosphere. The PF as used in this report is the overall factor calculated from individual fit factors determined on a number of human volunteers for each of several exercises performed while wearing the respirator.

Sarin

An organophosphorus nerve agent, known by the military symbol GB. The chemical name is isopropyl methylphosphonofluoridate. GB reacts with the enzyme cholinesterase, thus interfering with the transmission of nerve impulses.