

TEST CONCEPTS FOR EVALUATING RESPIRATORS FOR NBC PROTECTION

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- ◆ To provide an overview of test concepts applicable to the evaluation of respiratory protective equipment (RPE) used for protection against nuclear/biological/chemical (NBC) warfare agents and high-threat toxic industrial chemicals (TICs)
 - ◆ Emergency responders
 - ◆ Emergency support personnel
 - ◆ Security & law enforcement
 - ◆ Counter terrorism operations
- ◆ Obtain stakeholder feedback



- ◆ **Develop sufficiently robust test guidelines to qualify efficacy of RPE against NBC and high priority TICs**
 - ◆ **Incorporate system level testing**
 - ◆ **Select “worst case” and/or “high threat” agents**
- ◆ **Develop performance criteria for different respirator classes based on analysis of threat scenarios and RPE use restrictions**
 - ◆ **Incorporate a reasonable margin of safety to address uncertainties in predicting potential exposure hazards**
- ◆ **Ensure high-quality end-item**

Scope: Applicable NBC RPE

- ◆ **Air-Purifying Respirators (APRs): Tight-Fitting, Full-Face (FF) Devices Only**
 - ◆ Escape Hood
 - ◆ APR (Canister or cartridge)
 - ◆ Powered APR (PAPR)
- ◆ **Atmosphere-Supplying Respirators (ASRs): FF Devices Only**
 - ◆ Supplied-Air (pressure-demand, demand, or continuous flow)
 - ◆ Open-circuit SCBA (pressure-demand only)
 - ◆ Closed-circuit SCBA (pressure-demand only)

Test	Major Respirator Category					
	Air-Purifying Respirators (Full-face masks and tight-sealing hood devices)			Atmosphere-Supplying Respirators (Full-face devices)		
	Escape Hood	APR	Powered APR	Supplied Air	Open-Circuit SCBA	Closed-Circuit SCBA
1. Protection Level	X	X	X	X	X	X
2. System Agent Testing:						
a. GB vapor	V	V	V	V	V	V
b. HD liquid/vapor	V	V	V	LV	LV	LV
3. Component Agent Testing:						
a. HD/GB liquid swatch	X	X	X	Airline hose section only	-	-
b. GB & CK filter gas-life	X	X	X	-	-	-
c. TIC filter gas-life	X	X	X	-	-	-
d. Particulate efficiency (DOP) ¹	X	X	X	-	-	-
4. Cyclic Storage Testing^{2,3}	X	-	-	-	-	-
5. Human Wear Factors Testing:						
a. Inhaled CO ₂ /O ₂ Depletion	X	-	-	-	X ¹	X ¹
b. Fogging	X	-	-	-	X ¹	X ¹
c. Vision	X	-	-	-	-	-
d. Breathing resistance	X	X ¹	X ¹	X ¹	X ¹	X ¹

KEY: X = Minimum suggested tests

1 = Tested under current protocols in 42 CFR 84

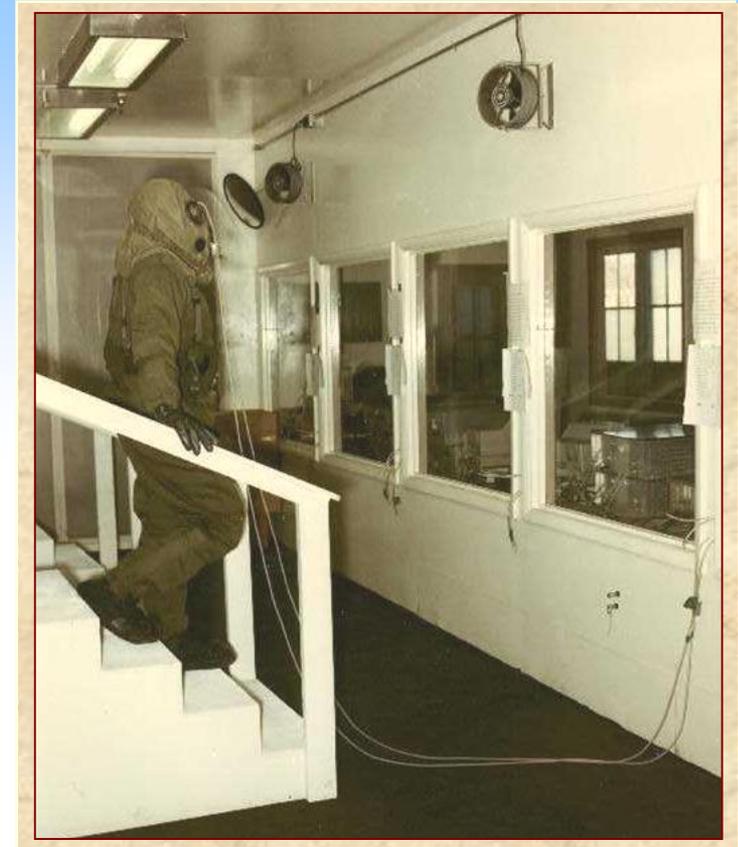
2 = Applies to hermetically sealed units or packaged units with no functional inspection procedure

3 = Followed by GB system agent test

V = Vapor only

LV = Vapor exposure from liquid deposition

- ◆ **Purpose:** To quantitatively assess overall protective capability of respirator in a laboratory setting (i.e., qualify person/respirator system performance)
- ◆ **Measurement:** Laboratory Respiratory Protection Level (LRPL) - calculated the same as a Fit Factor
- ◆ **Method:** Photometer/corn oil aerosol (deep probe and high flow) or equivalent

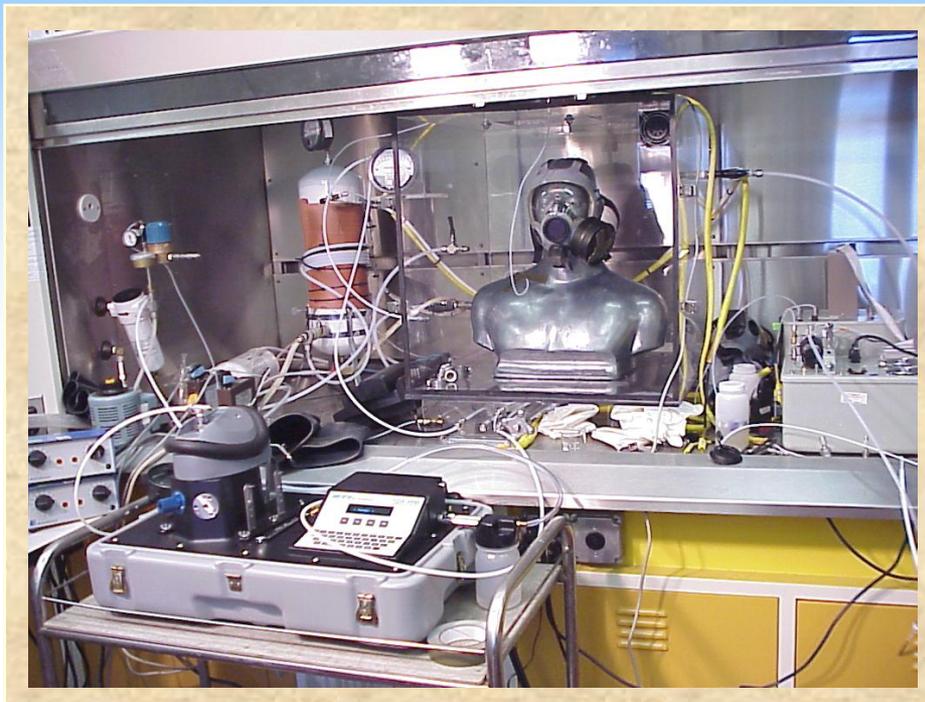


- ◆ **Respirators Tested:** All CB certification categories

- ◆ Provides assessment of person/respirator system performance in operational mode
- ◆ Primary emphasis on effectiveness of face seal

- ◆ **Purpose:** To determine the system level performance in a simulated operational mode against actual threat agents (i.e., assess system integrity)
- ◆ **Measurement:** Breakthrough concentration
- ◆ **Method:** Test head fixture with breathing pump; detector examples: MINICAMS (GC) or HYFED
- ◆ **Test Challenges:** GB and HD

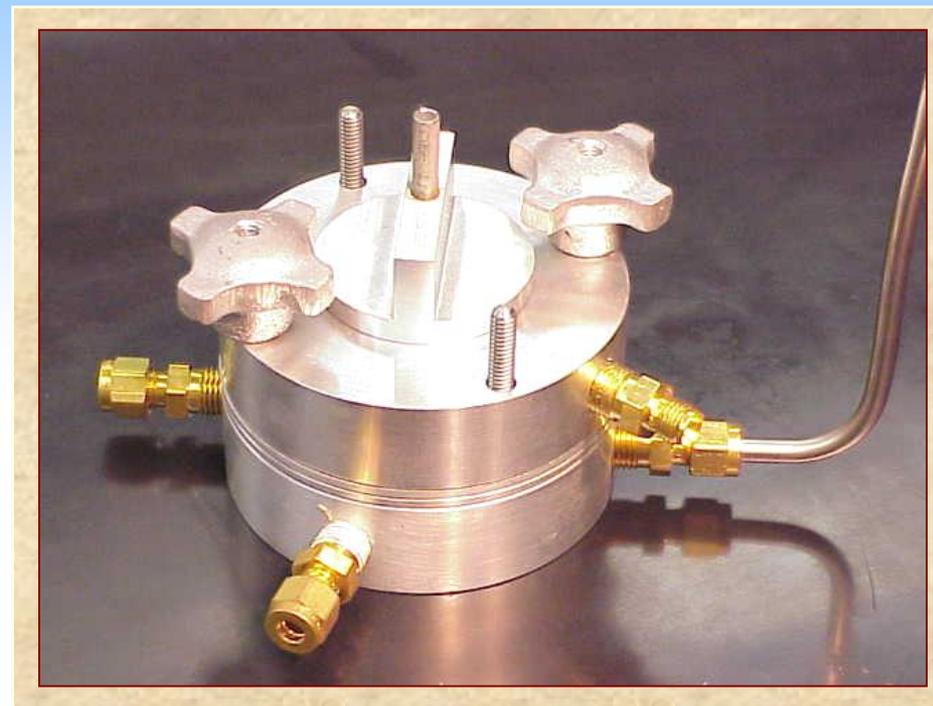
- ◆ **Respirators Tested:**
 - APRs (GB & HD Vapor)
 - ASRs (liquid-vapor test for HD)



- ◆ Provides assurance of functional performance of respirator system against actual agents
- ◆ Assess system quality and integrity (outlet valve, seams, hoses, component interfaces, etc.)

HD & GB Liquid Swatch

- ◆ **Purpose:** To determine resistance of PPE materials against permeation and penetration of liquid chemical agent vapor/gases
- ◆ **Measurement:** Breakthrough concentration
- ◆ **Method:** Closed-cup cell (static diffusion test); detector examples: MINICAMS or HYFED
- ◆ **Test Challenges:** Liquid HD & GB



- ◆ **Respirators Tested:**
 - APRs (face blank, eye lens, hood, seams, etc.)
 - ASRs (air hose section only) - HD material resistance addressed in system agent testing

- ◆ Provides assurance that PRE materials provide a nominal level of agent permeation resistance

GB & CK Canister/Cartridge Gas-Life

- ◆ **Purpose:** To determine service life of respirator canister/cartridge against chemical agents
- ◆ **Measurement:** Breakthrough concentration
- ◆ **Method:** Q250 (GB) and Q95 All Purpose Gas Life Testing Apparatus (CK - intermittent air flow) or equivalent test apparatus; detector examples: MINICAMS or HYFED detector for GB, GC-FID (flame ionization detector for CK)

- ◆ **Test Challenges:** GB & CK

- ◆ **Respirators Tested:**
 - APRs (all)
 - ASRs (if air-purifying filter used)

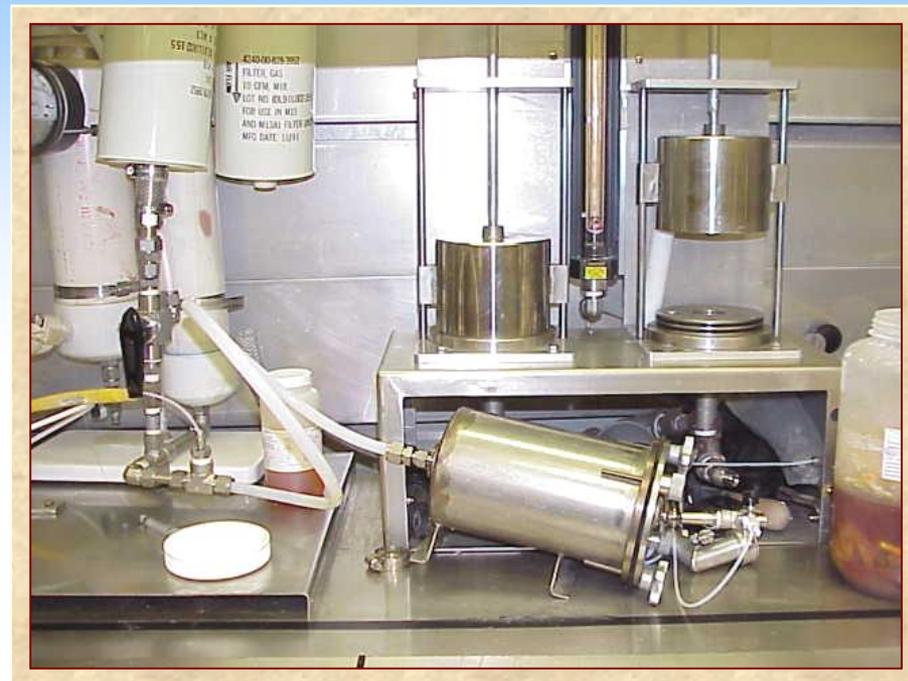


- ◆ Provides assessment of filtration capacity for “worst case” nerve and blood agents
- ◆ As received and pre-humidified filters
- ◆ Statistically significant sample size

TIC Canister/Cartridge Gas-Life

- ◆ **Purpose:** To determine service life of respirator canister/cartridge against toxic industrial chemicals (TICs)
- ◆ **Measurement:** Breakthrough concentration
- ◆ **Method:** To be determined based on TIC
- ◆ **Test Challenges:** To be determined

- ◆ **Respirators Tested:**
 - APRs (all)
 - ASRs (if air-purifying filter used)



- ◆ Provides assessment of filtration capacity for “high threat” TICs
- ◆ As received and pre-humidified filters
- ◆ Statistically significant sample size

Particulate Filtration Efficiency

- ◆ **Purpose:** To assess collection efficiency of particulate filter
- ◆ **Measurement:** Percent penetration
- ◆ **Method:** P-100/HEPA category filters only ($\geq 99.97\%$ efficiency), tested in accordance to 42 CFR 84
- ◆ **Test Challenge:** ~ 0.3 micron DOP aerosol



- ◆ **Respirators Tested:**
 - APRs (all)
 - ASRs
(if air-purifying filter used)

- ◆ P-100 category applicable to non-powered APRs
- ◆ HEPA category currently applicable to PAPRs
- ◆ Addresses need to provide maximum protection against particulate radionuclides & biological agents

Purpose: To assess condition and operational performance of the respirator after accelerated storage under cyclic temperature/humidity conditions

- ◆ Applies to hermetically sealed units or packaged units with no functional inspection procedure (e.g., single-use escape hoods)
- ◆ Cyclic conditions: Hot/dry, Cold, Hot/humid
- ◆ Visual inspection for defects followed by GB vapor system test

Purpose: To assess key physiological and system design parameters relevant to the operational performance of the respirator

Test	Method	Respirator Type
Inhaled CO ₂ & O ₂ content	Per 42 CFR 84	Escape hoods & SCBAs
Lens Fogging	Ambient & cold exposure	Escape hoods only
Vision	Binocular visual acuity & field-of-view	Escape hoods only
Breathing Resistance	Per 42 CFR 84	All CB certification categories

