

This presentation should not be considered a final statement of NIOSH policy or of any agency or individual who was involved. This information is intended for use in advancing knowledge needed to protect workers. Comments regarding this presentation may be submitted to the NIOSH Docket Office.

National Personal Protective Technology Laboratory

CBRN Air-Purifying Respirator (Gas Mask / APR) Use Guidelines

Holiday Inn Select, Pittsburgh South
Pittsburgh, PA

Mike Bergman
EG&G Technical Services, Inc.

July 19, 2005

CBRN Respirator Standards

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

CBRN APR Overview

- *Statement of Standard for Chemical, Biological, Radiological, and Nuclear (CBRN) Full Facepiece Air Purifying Respirator (APR), Dated March 7, 2003*
- 14G approval under 42 CFR part 84
- 139 identified CBRN threat protections
- NIOSH assigned protection factor = 50



CBRN APR Guidelines

- NIOSH Cautions and Limitations specific to CBRN use
 - CBRN Respirator Use Life (CRUL)
- Canister Capacity (Cap) Selection
- CBRN Canister interchangeability
 - *A crisis provision when supplies are limited*
- Escape contingency from IDLH environments
 - based on 5 min gas life testing at 100 lpm
- Industrial use / CBRN use

OSHA Respiratory Protection Standard Requirements - 29 CFR 1910.134

- **Determination of medical fitness**
- **Fit testing of tight-fitting facepieces**
- **Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators**
- **Canister change schedule for gases and vapors**

CBRN APR Use Conditions

- **All of the following conditions must be met**
 - Types of inhalation hazards and concentrations have been identified
 - CBRN canister is capable of removing the hazard
 - Oxygen is known to be at least 19.5% by volume
 - Contaminant concentrations are less than IDLH and less than the APR maximum use concentration (MUC)
 - Canister change schedule established for gases and vapors
 - Use complies with all NIOSH Cautions and Limitations


OSHA / NIOSH CBRN PPE Selection Matrix


- Interim guidelines for respirator and protective clothing selection
- Available on OSHA website www.osha.gov (follow emergency response links)
- PPE selection is given at defined airborne concentrations for blister agents and nerve agents



CBRN APR Canister Sticker Label

- Shows “Cap” level, protections, approval number, and cautions and limitations

 XYZ Safety Company
ANYWHERE USA
1-800-XXX-XXXX



Approval Number
TC-14G-XXXX

Canister P/N 12345XYZ
Protections
CBRN Cap 1

CAUTIONS AND LIMITATIONS
A, J, L, M, Q, R, T, V, W, X, Y, Z, HH, QQ, UU

REFER TO THE APPROVED USER'S INSTRUCTIONS FOR THE COMPLETE LIST OF COMPONENT PARTS MAKING UP THE APPROVED ASSEMBLY.

2. CAUTIONS AND LIMITATIONS
A-Not for use in atmospheres containing less than 19.5 percent oxygen.
J-Failure to properly use and maintain this product could result in injury or death.
L-Follow the manufacturer's User's Instructions for changing canister(s).
M-All approved respirators shall be selected, fitted, used, and maintained in accordance with MSHA, OSHA, and other applicable regulations.
Q-Refer to User's Instructions, and/or maintenance manuals for information on use and maintenance of these respirators.
(If applicable)S-Special or critical User's Instructions and/or specific use limitations apply. Refer to User's Instructions before donning.

3. CBRN CAUTIONS AND LIMITATIONS
R-Some CBRN agents may not present immediate effects from exposure, but can result in delayed impairment, illness, or death.
T-Direct contact with CBRN agents requires proper handling of the respirator after each use and between multiple entries during the same use.
Decontamination and disposal procedures must be followed. If contaminated with liquid chemical warfare agents, dispose of the respirator after decontamination.
V-Not for use in atmospheres immediately dangerous to life or health or where hazards have not been fully characterized.
W-Use replacement parts in the configuration as specified by the applicable regulations and guidance.
X-Consult manufacturer's User's Instructions for information on the use, storage, and maintenance of these respirators at various temperatures.
Y-The respirator provides respiratory protection against inhalation of radiological and nuclear dust particles. Procedures for monitoring radiation exposure and full radiation protection must be followed.
Z-If during use, an unexpected hazard is encountered such as a secondary CBRN device, pockets of entrapped hazard or any unforeseen hazard, immediately leave the area for clean air.
HH-When used at defined occupational exposure limits, the rated service time cannot be exceeded. Follow established canister change out schedules or observe End of Service Life Indicators to ensure that canisters are replaced before breakthrough occurs.
QQ-Use in conjunction with personal protective ensembles that provide appropriate levels of protection against dermal hazard. Failure to do so may result in personal injury even when the respirator is properly fitted, used, and maintained.
UU-The respirator should not be used beyond eight (8) hours after initial exposure to chemical warfare agents to avoid possibility of agent permeation. If liquid exposure is encountered, the respirator should not be used for more than two (2) hours.

CBRN APR Threat Protections

- **Minimum of 139 CBRN threat protections**
 - Chemical (110)
 - Biological (13)
 - Radiological and nuclear (16)
- **CBRN canister is tested using 11 Test Representative Agents (TRA)**
 - 10 gases and 1 particulate aerosol
 - Challenge concentration of TRA gases are multiples of IDLH of the TRA

Canister Gas/Vapor Service Life

- **Service life**
 - The length of time required for an air-purifying element to reach a specific effluent concentration
(2004 NIOSH Respirator Selection Logic)
- **Factors which affect canister service life***
 - Quality and amount of sorbent
 - Packing uniformity and density
 - Breathing rate
 - Relative humidity
 - Temperature
 - Contaminant concentration
 - Affinity of gas or vapor for the sorbent
 - Presence of other gases and vapors

* *The Occupational Environment: Its Evaluation and Control* (Respiratory Protection, Sec 5: Chapter 36). Fairfax, VA: American Industrial Hygiene Association Press, 1997.

Canister Capacity (Cap) Selection

- 6 “Cap” levels based on NIOSH gas life testing

CBRN Canister Cap designations	Relative gas/vapor service life compared to a Cap 1 canister*
Cap 1	-----
Cap 2	2X
Cap 3	3X
Cap 4	4X
Cap 5	6X
Cap 6	8X

*At similar exposure conditions (temperature, relative humidity, work rate, and contaminant concentration)

Canister Change Schedule

- **OSHA Requirement**

- 29 CFR 1910.134 (d)(3)(iii)(B)(2)
- Based on *objective information or data* that will ensure that canisters are changed before the end of their service life
- Applies to gases and vapors, not particulates
- Where no end-of-service-life indicator (ESLI) is appropriate, a change schedule is required
- CBRN APR are not currently approved with ESLI

CBRN Canister interchangeability

- **A crisis provision**
 - Use of a different manufacturer's CBRN canister under restricted supply conditions
 - Possible by the requirement of standardized threads and interface connectors
 - *Decision to proceed with interchangeability is the responsibility of the incident commander or other commanding authority under crisis conditions*
 - Assembly with a canister other than specified in the approval assembly matrix is not in its NIOSH-approved configuration

CBRN Use / Industrial Use

- The same facepiece part number may be part of different approved respirator configurations
- An approved configuration will specify either a CBRN canister or an industrial canister (e.g. P100)
- The CBRN canister should not be used for routine industrial use and should remain in its sealed packaging until needed for a CBRN response
- Always properly maintain the system so it can be used for a CBRN response

CBRN Respirator Use Life (CRUL)

- **Use Guidelines**
 - UU: “The respirator should not be used beyond 8 hours after initial exposure to chemical warfare agents to avoid possibility of agent permeation. If liquid exposure is encountered, the respirator should not be used for more than 2 hours.”
 - CRUL time includes decontamination time
 - Dispose entire system (facepiece, canister, and accessories) at end of CRUL time

CBRN Respirator Use Life (CRUL)

Chemical warfare agents applicable to (CRUL):

Nerve Agents

(G and V agents)

including:

- GB (Sarin)
- GA (Tabun)
- GD (Soman)
- GF (Cyclohexyl Sarin)
- VX

Blister Agents

(mustards, Lewisite)

including:

- H (sulfur mustard)
- HD (distilled sulfur mustard)
- Nitrogen mustards
(HN-1, HN-2 and HN-3)
- Lewisite (L, L-1, L-2 and L-3)

Canister Change Schedule

- **Methods**

- CBRN Respirator Use Life (CRUL)
- Software (mathematical models)
- Manufacturer's test data
- Rules of Thumb (not to be used as a sole method)

Canister Change Schedule

- **Methods (cont.)**
 - **CBRN Respirator Use Life (CRUL)**
 - In a CWA environment the 8-hour (vapor) and 2-hour (liquid) maximum system use life applies regardless of a longer calculated canister service life

Canister Change Schedule

- **Methods (cont.)**
 - **Software (OSHA website)**
 - OSHA Advisor Genius 1998
 - Breakthrough Program 2003
 - Corrects for relative humidity
 - Both programs calculate change schedules for individual organic vapors only
 - **Manufacturer's software**

Canister Change Schedule

- **Methods (cont.)**
 - **Manufacturer's test data (for a specific chemical)**
 - The manufacturer may have service life information for a specific chemical

Canister Change Schedule

- **Methods (cont.)**

- **Rules of Thumb for organic vapors***

- If the chemical's boiling point is > 70 °C and the concentration is less than 200 ppm you can expect a service life of 8 hours at a normal work rate
 - Service life is inversely proportional to work rate
 - Reducing concentration by a factor of 10 will increase service life by a factor of 5
 - Humidity above 85% will reduce service life by 50%

* *The Occupational Environment: Its Evaluation and Control* (Respiratory Protection, Sec 5: Chapter 36). Fairfax, VA: American Industrial Hygiene Association Press, 1997.

NIOSH/NPPTL Contact Information

NIOSH, NPPTL
P.O. Box 18070
626 Cochran's Mill Road
Pittsburgh PA 15236



Mike Bergman
NIOSH NPPTL Support
EG&G Technical Services, Inc.
vzb3@cdc.gov



1-800-35-NIOSH

<http://www.cdc.gov/niosh/npptl/default.html>

DISCLAIMER: The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy. Mention of any company or product does not constitute endorsement by NIOSH or NPPTL.

CBRN Threats

- **Chemical (gases, vapors, liquids, particulates)**
 - Chemical warfare agents
 - Toxic industrial chemicals / Toxic industrial materials (TICs / TIMs)
- **Biological (particulates)**
 - Micro-organisms (disease-causing bacteria and viruses) and biological toxins
- **Radiological (particulates)**
 - Particulates carrying radiation dispersed by a radiological dispersive device (RDD) or “dirty bomb”
- **Nuclear (particulates)**
 - Particulates carrying radiation dispersed from a detonation involving nuclear fuel, a nuclear weapon, or weapon’s component

CBRN Protection

- **CBRN respirators meet new design and performance standards, including special CBRN tests**
 - **Live agent tests (LAT)**
 - System testing against GB (Sarin) and HD (distilled sulfur mustard)
 - **Laboratory respirator protection level (LRPL)**
 - Quantitative corn-oil, fit-factor test using human test subjects
 - **Canister gas life tests**
 - Address high physiological demand, need for large sorbent capacity, and protection for multiple respiratory hazards

Canister Capacity

Gas Life Laboratory Test Times

Capacity Level	Test Time (min)	Capacity (ppm-min)
Capacity # 1	15	Test Concentration X 15
Capacity # 2	30	Test Concentration X 30
Capacity # 3	45	Test Concentration X 45
Capacity # 4	60	Test Concentration X 60
Capacity # 5	90	Test Concentration X 90
Capacity # 6	120	Test Concentration X 120

Test Representative Agents

- **Organic vapor family** – cyclohexane
- **Acid gas family** – SO_2 , H_2S , CNCL , COCl_2 , HCN
- **Base gas family** – ammonia
- **Hydride family** – phosphine
- **Nitrogen oxide family** – nitrogen dioxide
- **Formaldehyde family** – formaldehyde
- **Particulate family** – DOP

CBRN Canister Protections

61 Organic vapor family

with vapor pressures less than that of cyclohexane

32 Acid gas family

4 Base gas family

4 Hydride family

5 Nitrogen oxide family

1 Formaldehyde family (only member of family)

32 Particulate family

CBRN Canister Protections

Organic Vapor Family

acetone cyanohydrin

ethyl chloroformate

phenyl mercaptan

acrylonitrile

ethyl chlorothioformate

phenylcarbylamine chloride

allyl alcohol

ethyl phosphorodichloridate

phenyldichloroarsine

allyl chlorocarbonate

ethylene dibromide

phosgene
oximedichloroformoxime

bromoacetone

hexachlorocyclopentadiene

sarin

bromobenzylcyanide

hexaethyl tetraphosphate

sec-butyl chloroformate

chloroacetone

iso-butyl chloroformate

soman

chloroacetonitrile

iso-propyl chloroformate

tabun

chloroacetophenone

lewisite

tert-octyl mercaptan

chloroacetyl chloride

methanesulfonyl chloride

tetraethyl dithiopyrophosphate

CBRN Canister Protections

Organic Vapor Family (Continued)

chloropicrin	methyl orthosilicate	tetraethyl lead
chloropivaloyl chloride	methyl parathion	tetramethyl lead
crotonaldehyde	mustard, lewisite mixture	tetranitromethane
cyclohexyl methyphosphonate	nitrogen mustard HN-1	trimethoxysilane
dibenz-(b,f)-1,4-oxazepine	nitrogen mustard HN-2	trimethylacetyl chloride
diketene	nitrogen mustard HN-3	V-Sub X
dimethyl sulfate	n-propyl chloroformate	diphosgene
diphenylchloroarsine	o-chlorobenzylidene malonitrile	o-ethyl-s-(2isopropylaminoethyl)methyl phosphonothiolate
diphenylcyanoarsine	parathion	ethyl phosphonothioicdichloride
distilled mustard	perchloromethyl mercaptan	methyl phosphonic dichloride
		phosphorus oxychloride

CBRN Canister Protections

Acid Gas Family

boron tribromide

boron trichloride

boron trifluoride

bromine

bromine chloride

bromine trifluoride

carbonyl fluoride

chlorine

chlorine pentafluoride

chlorine trifluoride

chlorosulfonic acid

cyanogen chloride

dichlorosilane

ethyl phosphonous
dichloride

fluorine

hydrogen bromide

hydrogen chloride

hydrogen cyanide

hydrogen fluoride

hydrogen iodide

hydrogen sulfide

phosgene

phosphorus trichloride

silicon tetrafluoride

sulfur dioxide

sulfur trioxide

sulfuric acid

sulfuryl chloride

titanium tetrachloride

tungsten hexafluoride

bromine pentafluoride*

hydrogen selenide*

CBRN Canister Protections

Nitrogen Oxide Family	Base Gas Family	Hydride Family	Particulate Family	Formaldehyde Family
nitric acid	allyl amine	arsine	adamsite	formaldehyde
nitric acid, fuming	ammonia	germane	sodium azide	
Nitrogen dioxide	dimethyl hydrazine, 1,2	phosphine	Sodium fluoroacetate	
nitrogen tetroxide	methyl hydrazine	stibine	13 Biological agents	
nitrogen trioxide			16 Radiological / Nuclear agents	

CBRN Canister Protections

Particulate Family Biological Agents

Anthrax

Brucellosis

Glanders

Pneumonic plague

Tularemia

Q Fever

Smallpox

Viral hemorrhagic fevers

T-2 mycotoxins

Botulism

Ricin

Staphylococcus enterotoxin B

Venezuelan equine encephalitis

CBRN Canister Protections

Particulate Family Radiological and Nuclear Agents

Hydrogen 3

Carbon 14

Phosphorous 32

Cobalt 60

Nickel 63

Strontium 90

Technetium 99m

Iodine 131

Cesium 137

Promethium 147

Thallium 204

Radium 226

Thorium 232

Uranium 235 & 238

Plutonium 239

Americium 241