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National Personal Protective Technology Laboratory

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

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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

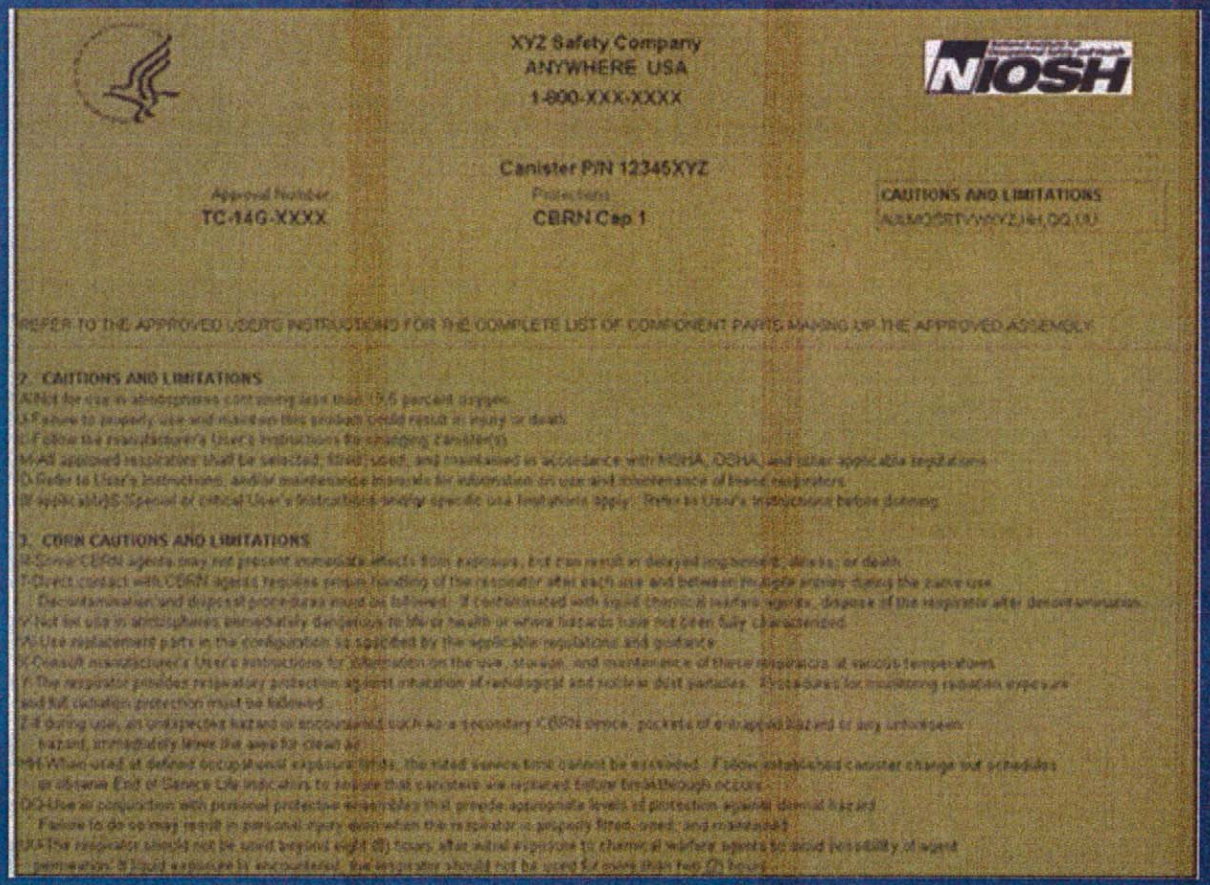
- ***All* of the following conditions must be met**
  - Types of inhalation hazards and concentrations have been identified
  - CBRN canister is capable of removing the hazard
  - Oxygen is known to be at least 19.5% by volume
  - Contaminant concentrations are less than IDLH and less than the APR maximum 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



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.

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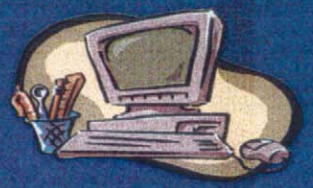

1-800-35-NIOSH

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

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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 mercapatan
acrylonitrile	ethyl chlorothioformate	phenylcarbylamine chloride
allyl alcohol	ethyl phosphorodichloridate	phenyldichloroarsine
allyl chlorocarbonate	ethylene dibromide	phosgene oximedichloroforoxime
bromoacetone	hexachlorocyclopentadiene	sarin
bromobenzylcyanide	hexaethyl tetraphosphate	sec-butyl chloroformate
chloroacetone	iso-butyl chloroformate	soman
chloroacetonitrile	iso-propyl chloroformate	tabun
chloroacetophenone	lewisite	tert-octyl mercapatan
chloroacetyl chloride	methanesulfonyl chloride	tetraethyl dithiopyrophosphate

CBRN Canister Protections

Organic Vapor Family (Continued)

chloropicrin

chloropivaloyl chloride

crotonaldehyde

cyclohexyl methyphosphonate

dibenz-(b,f)-1,4-oxazepine

diketene

dimethyl sulfate

diphenylchloroarsine

diphenylcyanoarsine

distilled mustard

methyl orthosilicate

methyl parathion

mustard, lewisite mixture

nitrogen mustard HN-1

nitrogen mustard HN-2

nitrogen mustard HN-3

n-propyl chloroformate

o-chlorobenzylidene malononitrile

parathion

perchloromethyl mercaptan

tetraethyl lead

tetramethyl lead

tetranitromethane

trimethoxysilane

trimethylacetyl chloride

V-Sub X

diphosgene

o-ethyl-s-(2isopropyaminoethyl)methyl phosphonthiolate

ethyl phosphonothioicdichloride

methyl phosphonic dichloride

phosphorus oxychloride

CBRN Canister Protections

Acid Gas Family

boron tribromide	cyanogen chloride	phosgene
boron trichloride	dichlorosilane	phosphorus trichloride
boron trifluoride	ethyl phosphonous dichloride	silicon tetrafluoride
bromine	fluorine	sulfur dioxide
bromine chloride	hydrogen bromide	sulfur trioxide
bromine trifluoride	hydrogen chloride	sulfuric acid
carbonyl fluoride	hydrogen cyanide	sulfuryl chloride
chlorine	hydrogen fluoride	titanium tetrachloride
chlorine pentafluoride	hydrogen iodide	tungsten hexafluoride
chlorine trifluoride	hydrogen sulfide	bromine pentafluoride*
chlorosulfonic acid		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 tetraoxide	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	Cesium 137
Carbon 14	Promethium 147
Phosphorous 32	Thallium 204
Cobalt 60	Radium 226
Nickel 63	Thorium 232
Strontium 90	Uranium 235 & 238
Technetium 99m	Plutonium 239
Iodine 131	Americium 241