Technically Speaking

NIOSH Certification of Personal Protective Equipment for CBRN

by John Nordin, PhD

CBRN is an acronym for chemical, biological, radiological, and nuclear agents. NIOSH is the name of a U.S. governmental agency, called the National Institute for Occupational Safety and Health. Another governmental agency, the U.S. Army Soldier and Biological Chemical Command (SBCCOM) is also involved in this certification process. "Certification" means that CBRN agents (at levels established by NIOSH and SBCCOM) will not permeate or penetrate components of personal protective equipment and enter the respiratory system of the user when used correctly. Nuclear agents refer to hazards (in particular radiological hazards) associated with the aftermath of a nuclear explosion.

Certification does not imply absolute protection. No personal protective equipment (PPE) can withstand a nuclear blast or provide protection against the gamma radiation, neutron radiation, or beta radiation or heat that accompanies the nuclear blast. The PPE cannot protect a person from gamma radiation or beta radiation from radioactive isotope dust adhering to the outside of the PPE garments. Also, the PPE cannot protect against any of the agents if the equipment is improperly worn or has been damaged or deteriorated. PPE cannot protect against extreme heat or cold. What we are talking about is protection against inhaling the CBRN agents when PPE is properly used. The PPE also prevents skin and eye contact with the agents.

Before we discuss this topic, let us review some basics on PPE Levels of Protection.

<u>PPE Levels of Protection</u>

Level A: A fully-encapsulating, gas-tight chemical protective suit over self-contained breathing apparatus (SCBA). The suit is usually under positive pressure. Level A provides the highest level of respiratory, skin, and face protection against gases and vapors, liquids and dust

Level B: Level B protection includes SCBA which may be worn outside the protective suit. SCBA worn inside the protective suit is classified as level B if the suit is not gas tight. The protective suit may be a splash suit. Level B is usually intended for liquid or dust hazards rather than gases or vapors.

Level C: The protective suit is the same as Level B or Level A or even a work (splash) suit and boots, but instead of SCBA, an air-purifying respirator is used. Air supplied respirators (air delivered by a supply hose from some

other location) are usually impractical in CBRN incidents because the air supply line impedes mobility.

Level D: No respiratory protection. Usually a work suit, hardhat, and work boots. A simple dust mask worn on the face coupled with a protective garment and boots is classified as Level D and not Level C.

The NIOSH CBRN Certification considers three classifications of PPE. The first is fully encapsulating chemical protective suit used with SCBA. The second is air purifying respirators which is a part of Level C protection. The third is escape systems.

NIOSH further recommends the use of fully-encapsulating suits with SCBA (Level A) when entering an area where the chemical agent or concentration in the atmosphere is unknown or the event is uncontrolled. A Level B suit with SCBA is permitted when the chemical or biological agent is no longer being dispersed to the atmosphere as an aerosol but there may be a splash hazard and/or vapors are in the atmosphere because of evaporating liquid. If the chemical agent is known and the concentrations in the atmosphere are less than IDLH [Immediately Dangerous to Life and Health] levels, an air purifying respirator in conjunction with level C protection can be used. NIOSH does provide for short term contingency use of air-purifying respirators above IDLH concentrations in special case situations.

What are NIOSH CBRN Agents?

After the 9-11 attack, NIOSH developed a list of 151 candidate chemical warfare agents and toxic industrial compounds that pose respiratory inhalation hazards and for which PPE should be certified to provide protection. The list was divided into several categories, which included 61 organic chemicals, 32 acid gas chemicals, 4 basic gas chemicals, and several special case chemicals. Sarin (GB) and mustard (HD) were included in the list of 61 organic chemicals. There was also a category that included particulates, covering 13 biological agents, 16 radiological/nuclear agents, and certain chemicals such as adamsite, sodium azide, and sodium fluoroacetate. Since certification for each chemical would be expensive and time consuming, NIOSH developed a short list of chemicals and tests, that is if the PPE can provide protection against these agents or chemicals and pass certain other tests, the equipment can provide protection against the other CBRN agents.

Certification

Certification covers several classifications of PPE. The first standards were issued in 2001 for SCBA.

Standards for SCBA systems are codified under 42 CFR part 84 [CFR = Code of Federal Regulations]. A letter went out on 28 December 2001 inviting manufacturers to participate,
[copy, http://www.cdc.gov/niosh/npptl/respltr.html].

SCBA system certification:

- The PPE must meet approval under 42 CFR Part 84, Subpart H
- The PPE must comply with National Fire Protection Association (NFPA) Standard 1981 for Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters
- The PPE must pass the special tests under 42 CFR Part 84.63(c), which describe Sulfur Mustard (HD) and Sarin (GB) penetration tests, and a Laboratory Respirator Penetration Level test. This testing is done by the U.S. Army (SBCCOM) at a cost of approximately $35,000 to $40,000 to the manufacturer.

Details of test standards for SCBA are
at http://www.cdc.gov/niosh/npptl/respltr.html

Standards for air-purifying respirators were issued by NIOSH on 7 March 2003. A letter went out to manufacturers inviting them to participate [copy, http://www.cdc.gov/niosh/npptl/aprstdsiteltr.html]. Standards can be obtained at http://www.cdc.gov/niosh/npptl/cbrnaprstd.html. The cartridges shall be tested as specified in the standards for ammonia, cyanogens chloride, cyclohexane, formaldehyde, hydrogen cyanide, hydrogen sulfide, nitrogen dioxide, phosgene, phosphine, and sulfur dioxide. The U.S. Army (SBCCOM) shall conduct special tests for sulfur mustard (HD) vapor and Sarin (GB). There is also a Laboratory Respiratory Protection Level test.

Standards for Air-Purifying Escape Respirators and Self-Contained Escape Respirators were issued by NIOSH in 2003. On Oct 8, NIOSH issued a letter to manufacturers [copy of
letter, http://www.cdc.gov/niosh/npptl/esctestlttr.html} describing these standards and inviting them to send in applications for testing starting Jan. 2004. The chemicals to be tested are carbon monoxide, ammonia, cyanogen chloride, cyclohexane, formaldehyde, hydrogen chloride, hydrogen sulfide, nitrogen dioxide, phosgene, phosphine, and sulfur dioxide. Special tests will be conducted for sulfur mustard (HD) and Sarin (GB) by the U.S. Army SBCCOM.

Concepts for certification for Powered Air-Purifying respirators are under development. A draft document issued in Feb. 2004 is available at http://www.cdc.gov/niosh/npptl/paprconfeb6.html

Additional information is at http://www.cdc.gov/niosh/celpapr.html

Federal Register notice: http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/2004/04-6529.htm

A description of the NIOSH Laboratory Respiratory Protection Level test is at

http://www.cdc.gov/niosh/npptl/pdfs/scba-attach-c.pdf

Details of the U.S. Army tests for Sulfur Mustard (HD), Sarin (GB), and the Laboratory Respirator Protection Level test are described in a NIOSH Summary: http://www.cdc.gov/niosh/npptl/esctest-D.html. Full Facepiece Air Purifying Respirator Canister Service Life Tests

This information is from http://www.cdc.gov/niosh/npptl/cbrnaprstd.html (also codified in Title 42 CFR part 84). These are not the only requirements. Particulate filters must meet the requirements of a P100 Particulate Filter as specified under 42 CFR part 84, paragraphs 84.170, 84.179, and 84.181. A common arrangement is to use a combination P100 particulate filter with a second cartridge designed to remove vapors.

The test conditions for the following list of chemicals are 25ºC temperature, 64 liters/minute continuous flow, tests at 25 and 80% relative humidity. Three canisters shall be tested at each humidity and other test conditions and chemicals. The manufacturer specifies a minimum service time in 30 minute increments if the service time is greater than 60 minutes, or 15 minute increments if the service time is less than 60 minutes (e.g. 15, 30, 45, 60, 90, 120, etc. minutes).

Chemical	IDLH, ppm	Test Concentration, ppm	Breakthrough Concentration, ppm
Ammonia	300	2500	12.5
Cyanogen chloride	(50, note #1)	300	2
Cyclohexane	1300	2600	10
Formaldehyde	20	500	1
Hydrogen cyanide	50	940	4.7 (HCN+C2N2)
Hydrogen sulfide	100	1000	5
Nitrogen dioxide	20	200	1 ppm NO2 or 25 ppm NO

Phosgene	2	250	1.25
Phosphine	50	300	0.3
Sulfur dioxide	100	1500	5

Note #1: There is no NIOSH IDLH value for cyanogen chloride. The 50 ppm is calculated from the NIOSH Pocket Guide listing for cyanides as 50 mg/m^3 [50(61.47/26.02)/2.52 = 47 ppm, round off to 50 ppm; 61.47 is the molecular weight for cyangen chloride, 26.02 is the molecular weight of cyanide, and 2.52 is the conversion factor from ppm to mg/m^3].

Special tests are performed by SBCCOM on manufacturer's cartridge using sulfur mustard (HD) and Sarin (GB). SBCCOM uses an upper-torso manikin connected to a breathing machine operating at an air flow rate of 40 liters/minute, 36 respirations per minute, and 1.1 liters tidal volume (amount of air per breath). The test cycle for sulfur mustard is 8 hours long, with HD vapor delivered to the chamber containing the torso fitted with the mask for a period of 30 minutes at which time a 50 mg/m^3 of HD vapor challenge concentration is achieved. After 30 minutes, the concentration inside the test chamber starts to decrease because HD vapor is no longer added to the chamber. After 6 hours, liquid HD (0.43 ml for a single respirator mounted canister, 0.86 ml for a double mounted canister) is applied to the canister. The test is over at 8 hours. The canister passes the test (3 systems tested) if the maximum peak excursion and integrated breakthrough concentration requirements are both satisfied. The GB test is similar, with GB delivered to the chamber over a period of 30 minutes at with time a 210 mg/m^3 vapor challenge concentration is achieved. After 30 minutes, the concentration inside the chamber begins to drop because GB vapor is no longer added. The test continues for 8 hours except that liquid agent is not applied at 6 hours.

Chemical	Challenge concentration, mg/m^3	Maximum Peak Excursion, mg/m^3	Maximum Breakthrough Concentration Integrated over Minimum Service Life, mg-min/m^3	Minimum Service Life, hours
HD Vapor	50	0.30	3.0	8
HD Liquid	0.43 to 0.86 ml	0.3	3.0	2
Sarin (GB)	210	0.044	1.05	8

Note that the test conditions for Air Purifying Respirators are well above IDLH conditions. List of NIOSH Certified PPE

NIOSH publishes a list of PPE which has passed the certification tests. This list is an on going activity with additions made frequently. This list can be found at the following NIOSH websites:

For SCBA Systems, CBRN Certification:

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

This list contains links to manufacturer's websites and PPE descriptions.

For Air-Purifying respirators, CBRN Certification:

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

or list at http://www.cdc.gov/niosh/npptl/cbrnaprcheck.html#list

General NIOSH Certified Manufacturer List (all classes, not just CBRN):

http://www2a.cdc.gov/drds/cel/

General NIOSH Certification Manufacturer List Search Page (all classes, not just CBRN):

http://www2.cdc.gov/drds/cel/cel_form.asp

NIOSH Approved Particulate P100 Disposable Respirator Cartridges

http://www.cdc.gov/niosh/npptl/respirators/disp_part/p100list1.html Certification Label

SCBA Systems certified for CBNR can display the following label:

The above NIOSH Respirator Branch label is the approved NIOSH Chemical, Biological, Radiological and Nuclear Agents (CBRN) Approval label for all NIOSH Approved CBRN Open Circuit Self-Contained Breathing Apparatus (SCBA) in accordance with the Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, National Personal Protective Technology Laboratory (NPPTL) letter to all respirator manufacturers, dated 12/28/2001.

The CBRN Label is required to be placed in a visible location on the SCBA back plate. NIOSH has authorized respirator manufacturers to use this additional label along with previous approved NIOSH labels required by 42CFR84.

❖ The label for air-purifying respirators (respirator cartridges) shall conform to the following NIOSH requirement:

In accordance with the requirements of paragraph 84.33 of 42 CFR, Subpart D, approval labels shall be marked with a CBRN Rating as determined by paragraph 4.2 Service Life, of the Statement of Standard for Chemical, Biological, Radiological and Nuclear (CBRN) Full-Facepiece Air Purifying Respirator (APR) dated March 7, 2003. For example, canisters tested for 30 minutes are marked CBRN 30. CBRN canisters shall comply with color requirements of ANSI Z88.7. The canister/label color shall be olive (Munsell notation 7.5 Y 5/6). For canisters where the color markings are achieved by labeling, the canister body can be any color. Facepiece assemblies shall be permanently marked with "CBRN ”."

A sample copy of an air-purifying respirator label may be found at the website,
http://www.cdc.gov/niosh/npptl/pdfs/03-09-04-label%20examples-cbrnAPR-1.pdf

Can Air Purifying Respirators Ever Be Used At Concentrations Above IDLH?

The military has its own rules and is not subject to NIOSH or OSHA rules.

OSHA never allows air-purifying respirators to be used at concentrations above IDLH in the workplace. The same is true for air supplied respirators (air is delivered from some area other than the workplace through a supply hose connected to a front piece).
NIOSH recognizes that a CBRN incident is an uncontrolled and unknown situation and that emergency responders need to promptly enter the incident location to save lives or contain the agent. Concepts for use at concentrations above IDLH are under development [see http://www.cdc.gov/niosh/npptl/crbnconpmay31.html]. Air purifying respirator use at concentrations above IDLH or at very high breathing rates is called "crisis use" or "crisis provision". As part of the certification procedure, respirator cartridges are tested for selected chemicals at airborne concentrations much above IDLH conditions.

NIOSH recommends the use of fully-encapsulating suits with SCBA (Level A) when entering an area where the chemical agent or concentration in the

atmosphere is unknown or the event is uncontrolled. If the chemical agent is known and is not being dispersed from a source and the concentrations in the atmosphere appear to be less than IDLH levels, an air purifying respirator in conjunction with level C protection can be used. If emergency responders do enter the contaminated area and find that concentrations are above IDLH or if there is a secondary source of agent being dispersed, NIOSH does provide for short term contingency use of air-purifying respirators above IDLH concentrations.