Respiratory Protective Equipment

Respiratory Protective Equipment: Respiratory Protection Program

- Administration
- Knowledge of Respiratory Hazards
- Assessment of Respiratory Hazards
- Control of Respiratory Hazards
- Selection of Proper Respiratory PPE
- Training
- Inspection, Maintenance, Repair of Equipment
- Medical Surveillance

Respiratory Protective Equipment: Types of Hazards

Gas & Vapor Contaminants

- Inert – non-reactive (helium, neon, argon)
- Acidic – pH < 7 (HCl, SO_2) *sour*
- Alkaline – pH > 7 (NH_3) *bitter*
- Organic – compounds of Carbon (CH_4)
- Organometallic – metals + organics; $Pb(C_2H_5)_4$ (tetraethyl lead)
- Hydrides – hydrogen + metals; B_2H_6 (diborane)

Respiratory Protective Equipment: Types of Hazards

Particulate Contaminants

- Dust – solid, mechanically produced particle
- Spray – liquid, mechanically produced particle
- Fume – solid condensation particle
- Mist – fine liquid condensation particle
- Vapors – very fine particle from volatilized liquid
- Fog - mist of sufficient [c] to obscure vision
- Smoke – solid/liquid gas combo that obscures vision

Respiratory Protective Equipment: Selection Criteria

- Nature of hazardous operation/process
- Type of respiratory hazard
- Proximity of hazardous area to non-hazardous area
- Period of time that respiratory protection necessary
- Activities of worker in hazardous area
- Functional and physical characteristics of various types of respirators
- Respirator-protection factor and respirator fit

Respiratory Protective Equipment: Classes of Devices

- Class 1 – Air-purifying
- Class 2 – Atmosphere or Air-supplying
- Class 3 – Combination Air-purifying and Atmosphere-supplying

Note: All above-mentioned respirators must be approved by NIOSH-MSHA

Respiratory Protective Equipment: Class 1 – Air-purifying respirators

- Mechanical-filter
- Chemical-cartridge
- Combination mechanical/chemical
- Gas masks
- Powered air-purifying

Respiratory Protective Equipment: Class 1 – Air-purifying respirators

Mechanical-filter

- Protects against airborne *particulate matter only*
- Quarter, half, and full face models available
- Has fibrous material that traps particles
- Specialization emphasized depending on use

Respiratory Protective Equipment: Class 1 – Air-purifying respirators

Chemical-cartridge

- Protects against certain airborne *gases and vapors only*
- Has chemical cartridge to remove hazards
- Non-emergency protective devices; never use in IDLH atmospheres

Respiratory Protective Equipment: Class 1 – Air-purifying respirators

Chemical-cartridge

- Do NOT use when:
  - Gaseous material is extremely toxic in very small concentrations
  - Harmful gaseous material cannot clearly be detected by odor
  - Gaseous material is present in [c] highly irritating to the eyes w/o proper eye protection
  - Gaseous material is not effectively stopped by chemical fills used, regardless of concentrations

Respiratory Protective Equipment: Class 1 – Air-purifying respirators

Combination mechanical/chemical

- Utilizes both types of filters for atmospheres with both particulates, gases, and vapors
- Filters can be combination all-in-one or independently replaceable

Respiratory Protective Equipment: Class 1 – Air-purifying respirators

Gas masks

- Designed solely to remove specific contaminants from air using a canister
- May be used for *escape-only* from IDLH atmospheres only, not entrance
- Suitable for ventilated areas that are *not* subject to rapid changes in air-contaminant levels
- Canisters come in three sizes: supersize, industrial size, chin-style

Respiratory Protective Equipment: Class 1 – Air-purifying respirators

Gas masks

- Replace canister when:
  - Canister with window indicator shows specified color change
  - Leakage detected by smell, taste, or eye, nose, or throat irritation
  - High resistance to breathing develops
  - Canister shelf life exceeded
  - Uncomfortable heat in inhaled air experienced
  - Wearer has feeling of nausea, dizziness, or ill-being

Respiratory Protective Equipment: Class 1 – Air-purifying respirators

Powered air-purifying

- Utilizes any one or all types of filters, cartridges, combos or canister for atmospheres with particulates, gases, and vapors present individually or as a group
- Uses a power source (battery pack) to operate a blower that passes air across a filter
- Supplies air at positive pressure so any leakage is outward from facepiece

Respiratory Protective Equipment: Class 2 – Air-supplying respirators

- Supplied-air (SAR)
- Self-contained Breathing Apparatus (SCBA)
- Combination-SCBA and Supplied-air

Respiratory Protective Equipment: Class 3 – Combination Air-purifying and Air-supplying

Combination-SCBA and Supplied-air

- Combination air-line respirator w/ auxiliary air-purifying attachment
- Air-line respirator must have respirable air
- Limitations:
  - Use in filtering mode for escape only
  - Not for use in IDLH atmospheres
  - Not for oxygen-deficient atmospheres (<19.5%)
  - Use only approved hose lengths and pressure ranges
  - When airflow is cut, switch to filter and exit to clean air

Respiratory Protective Equipment: Decision Logic

- **Skin Absorption** (SCBA if injury or death possible)
- **Warning Properties** (odor, taste, irritation < PEL)
- **Sorbent Efficiency** (>3 minute breakthrough)
- **Eye Irritation** (Use full face respirator if issue)
- **IDLH** (escape possible <30 minutes without death/permanent health damage)
- **Lower Flammable Limit & Firefighting** (maximum protection pressure-demand SCBAs needed because of IDLH environment)

Respiratory Protective Equipment: Assigned Protection Factors

APF 5	- quarter-face respirator (QF)
APF 10	- half-face respirator (HF)
APF 25	~ powered, air purifying (PAP)
APF 50	- full-face respirator (FF)
APF 100	~ PAP/HEPA or SA/constant
APF 1,000	- supplied air/pressure +/-
APF 2,000	- supplied air/FF/pressure +/-
APF 10,000	- SCBA/FF/pressure +/-

Respiratory Protective Equipment: Assigned Protection Factors

Assigned Protection Factor Reference Guide*

Type of Respirator	ANSI Z88.2-1992	OSHA APFs															NIOSH RDL
		As	Pb	Pb-C	Cd	Bz	Fm	Ar	COV	CD	DBCP	AN	EtO	VC	MDA	BD	MC	
Air Purifying																		
Single Use, Quarter Mask	10	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	5
Half Mask, incl. Disposables	10	10	10	10	10	10	-	10	10	10	-	10	-	10	10	10	-	10
Full Facepiece	100	50	50	50	50	50	10	50	10	100	-	50	50	25	50	50	-	50
Powered Air Purifying																		
Half Mask	50	100	1,000	50	50	-	-	1,000	>10	>100	-	-	-	25	-	50	-	50
Full Facepiece	1,000	100	1,000	50	250	100	-	1,000	>10	>100	-	-	-	25	1,000	50	-	50
Helmet/Hood	1,000	100	1,000	25	25	-	-	1,000	>10	>100	-	-	-	25	-	25	-	25
Loose-Fitting Facepiece (ANSI)	25	100	1,000	25	25	-	-	1,000	>10	>100	-	-	-	25	-	25	-	25
Continuous Flow																		
Half Mask	50	100	1,000	50	50	-	-	10	>10	-	1,000	10	-	1,000	-	-	25	50
Full Facepiece	1,000	100	2,000	50	250	1,000	100	50	>10	-	2,000	50	2,000	1,000	-	-	200(2)	50
Hood/Helmet	1,000	100	2,000	25(3)	25	-	100	2,000	>10	-	2,000	2,000	2,000	1,000	-	25	25	25
Loose-Fitting Facepiece (ANSI)	25	100	2,000	25	25	-	100	2,000	>10	-	2,000	2,000	2,000	1,000	-	25	25	25
Pressure-Demand																		
Half Mask	50	-	1,000	1,000	1,000	-	-	1,000	>10	-	1,000	-	-	-	-	1,000	-	1,000
Full Facepiece	1,000	1,000	2,000	2,000	1,000	1,000	-	2,000	>10	-	2,000	2,000	2,000	-	-	1,000	200(2)	2,000
Self-Contained Breathing App.																		
Pressure Demand Open/Closed Circuit Full Facepiece	(1)	>1,000	>2,000	>2,000	>1,000	>1,000	>100	>2,000	>10	-	>2,000	>2,000	>2,000	>3,600	>1,000	>1,000	>200(2)	10,000

(1) Normally 10,000, but recent studies have indicated that all users may not achieve protection factors of 10,000. For emergency planning purposes where hazardous concentrations can be estimated, an APF of no higher than 10,000 should be used.
(2) For MC, 200xPEL = IDLH Concentration (5,000 ppm).
(3) OSHA has granted an APF of 1,000 to the Bullard models 77 and 88 abrasive blasting respirators for use under the Lead in Construction Standard.

OSHA APFs:
GI: General industry, i.e. substances for which there is no substance-specific standard covering respirator selection.
As: Asbestos 1910.1001
Pb: Lead in General Industry 1910.1025
Pb-C: Lead in Construction 1926.62
Cd: Cadmium 1910.1027
Bz: Benzene 1910.1028
Fm: Formaldehyde 1910.1048
Ar: Arsenic 1910.1018
COV: Coke Oven Emissions 1910.1029
CD: Cotton Dust 1910.1043
DBCP: 1,2-Dibromo-3-Chloropropane 1910.1044
AN: Acrylonitrile 1910.1045
EtO: Ethylene Oxide 1910.1047
VC: Vinyl Chloride 1910.1017
MDA: Methylenedianiline 1910.1050
BD: 1,3-Butadiene 1910.1051
MC: Methylene Chloride 1910.1052

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* This guide is a compilation of Assigned Protection Factors published by various governmental agencies and the American National Standards Institute.
** General Industry numbers are not currently published. The numbers listed on this chart are the numbers that OSHA enforces to the best of our knowledge. For this reason, be sure to consult 29 CFR 1910.134, other established regulatory standards and/or your local OSHA representative. The Assigned Protection Factors herein do not constitute a recommendation by Bullard for the use of any respirator herein for any hazard.

4000004103 (0800)

Respiratory Protective Equipment: Filter Selection

Selection of N-, R-, and P-series filters depends on the presence or absence of oil particles, as follows:

- If no oil particles are present, use any series (N, R, or P)
- If oil particles are present, use only R or P series
- If oil particles are present and the filter is to be used for more than one work shift, use only P series

Respiratory Protective Equipment: Filter Selection

- N for Not resistant to oil
- R for Resistant to oil
- P for oil Proof

Selection of filter efficiency (i.e., 95%, 99%, or 99.97%) depends on how much filter leakage can be accepted.

Examples: N-95 for TB, P-100 for ER, etc.

Respiratory Protective Equipment: CBRN Agent Approved

SCBA Respirator

- Look to see if the CBRN Agent Approval label shown below is on the respirator. If an SCBA is CBRN-approved by NIOSH, it will always carry this label. If this CBRN Agent Approval label is **not** on the SCBA, the device is **not** approved by NIOSH for use by emergency responders in CBRN environments. **Check the Label!**

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

Respiratory Protective Equipment: CBRN Agent Approved

SCBA Respirator

- The approval number for an SCBA approved for CBRN environments always includes a **CBRN** suffix (TC-13F-XXXXCBRN). If the approval number does **not** include a CBRN suffix, it is **not** certified by NIOSH for use by emergency responders in CBRN environments.
- The complete CBRN SCBA assembly must be composed of **only** those component parts listed in the row with the CBRN approval number. Part numbers that are found **only** in the rows of the **non-CBRN** approvals **must not** be used as part of a CBRN SCBA assembly.

Respiratory Protective Equipment: CBRN Agent Approved

APR Canister

Sample abbreviated label below shows the structure of a CBRN canister label.

Color of the label must be olive.

This label must be attached to the canister. If the label does not fit on the canister, the portion of the label below the dashed line may be provided in a form that is removable, as long as the Cautions and Limitations in the boxed area are added. Dashed lines are added here for illustration only and should not appear on production labels.

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

NIOSH

Canister P/N 12345XYZ

Approval Number
TC-14G-XXXX

Protections
CBRN Cap 1

CAUTIONS AND LIMITATIONS
AJLMOSRTVWXYZ,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.
O-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.

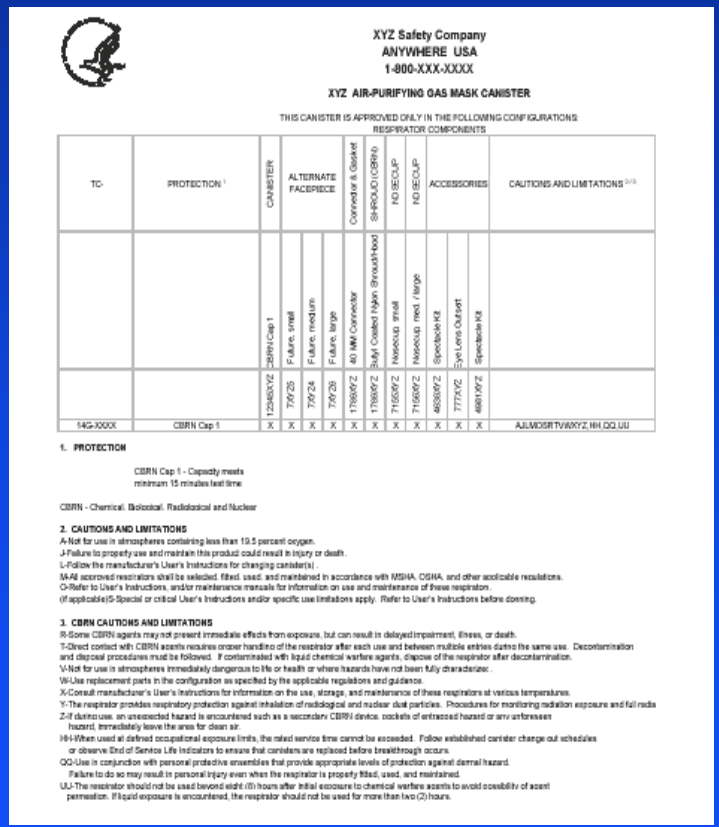
- Look to see if the full canister label is like the one shown in Figure 1. Canister labels will specify the CBRN protection level (CBRN Cap 1, CBRN Cap 2 or CBRN Cap 3).

- If an APR is CBRN-approved by NIOSH, the full canister label will identify the CBRN protection level, part number and if the canister has been approved for use for CBRN protection with an approved CBRN APR facepiece. If the full canister label does **not** identify the above information, the device is **not** approved by NIOSH for use by emergency first responders in CBRN environments.

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

Respiratory Protective Equipment: CBRN Agent Approved

APR Canister



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

XYZ AIR-PURIFYING GAS MASK CANISTER

THIS CANISTER IS APPROVED ONLY IN THE FOLLOWING CONFIGURATIONS:
RESPIRATOR COMPONENTS

TC-	PROTECTION [1]	CANISTER	ALTERNATE FACEPIECE			Connector & Gasket	SHROUD (CBRN)	HOSECUP	HOSECUP	ACCESSORIES			CAUTIONS AND LIMITATIONS [2,3]
		CBRN Cap 1	Future: small	Future: medium	Future: large	40 MM Connector	Butyl Coated Nylon Shroud/Hood	Nosecup: small	Nosecup: med. / large	Spectacle Kit	Eye Lens Outsert	Spectacle Kit	
		12345XYZ	7XY25	7XY24	7XY26	11789XYZ	11789XYZ	71559XYZ	71569XYZ	46539XYZ	77717XYZ	46911XYZ	
14G-XXXX	CBRN Cap 1	X	X	X	X	X	X	X	X	X	X	X	AJLMOSRTVWXYZ,HH,QQ,UU

1. PROTECTION

CBRN Cap 1 - Capacity meets minimum 15 minutes test time

CBRN - Chemical, Biological, Radiological and Nuclear

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.
O-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 radia
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http://www.cdc.gov/niosh/npptl/cbrnaprcheck.html

Respiratory Protective Equipment: CBRN Agent Approved

APR Respirator

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

XYZ AIR-PURIFYING GAS MASK RESPIRATOR

THIS RESPIRATOR IS APPROVED ONLY IN THE FOLLOWING CONFIGURATION:
RESPIRATOR COMPONENTS

TC-	PROTECTION [1]	ALTERNATE FACEPIECE			Connector & Gasket	SHROUD (CBRN)	NO SECUP	NO SECUP	CANISTER	ACCESSORIES			CAUTIONS AND LIMITATIONS [2,3]	
		Rubber, small	Rubber, medium	Rubber, large	40 MM Connector	Butyl Coated Nylon Shroud-hood	Hex assy, small	Hex assy, med, / lg	CBRN Cap 1	Spectacle Kit	Eye Lens Gasket	Spectacle Kit		
		7XXX8	7XXX8	7XXX8	1789XYZ	1789XYZ	7155XYZ	7156XYZ	13348XYZ	4636XYZ	3110XYZ	4561XYZ		
14G-3333	CBRN Cap 1	X	X	X	X	X	X	X	X	X	X	X	A,J,L,M,O,R,S,T,V,W,X,Y,Z, HH, OO, UU	

1. PROTECTION

CBRN Cap 1 - Capacity meets minimum 15 minutes test time

CBRN - Chemical, Biological, Radiological and Nuclear

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 canisters.
M-All approved respirators shall be selected, fitted, used, and maintained in accordance with MSHA, OSHA, and other applicable regulations.
O-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.

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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.
OO-Use in conjunction with personal protective ensembles that provide appropriate levels of protection against dermal hazards. 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.

- Look to see if the full canister label is like the one shown in Figure 1. Canister labels will specify the CBRN protection level (CBRN Cap 1, CBRN Cap 2 or CBRN Cap 3).

- If an APR is CBRN-approved by NIOSH, the full canister label will identify the CBRN protection level, part number and if the canister has been approved for use for CBRN protection with an approved CBRN APR facepiece. If the full canister label does **not** identify the above information, the device is **not** approved by NIOSH for use by emergency first responders in CBRN environments.

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

Weapons of Mass Destruction (WMD)

Potential Types of WMD

- **Biological** – Anthrax, Smallpox, Botulism, Plague, Tularemia, Viral Hemorrhagic fevers, Brucellosis, Ricin, etc.
- **Chemical** – Nerve Gases (VX), Blister/Vesicants (Mustard Gas), Pulmonary Damaging (Phosgene, Chlorine), etc.
- **Radiological** – "Dirty" Bombs

Biological Types of WMD

Biological Types of WMD

- Category A
  - Anthrax
  - Smallpox
  - Botulism
  - Plague
  - Tularemia
  - Viral Hemorrhagic fevers (e.g., Ebola)
- Category B
  - Brucellosis
- Other
  - Ricin

Biological WMD – CDC Category A

- Easily disseminated or transmitted from person to person
- Result in high mortality rates and have potential for major public health impact
- Might cause public panic and social disruption
- Require special action for public health preparedness

Biological WMD - Anthrax

- Early Symptoms:
  - Cutaneous (skin) - boil-like lesion that becomes ulcer with a black center
  - Inhalation - flu-like symptoms
  - Ingestion - acute inflammation of intestinal tract
- Cause: bacterium *Bacillus anthracis*
- *Not contagious person to person (casual)*
- Treatment:
  - *Ciprofloxacin*
  - *Doxycycline*

Biological WMD - Smallpox

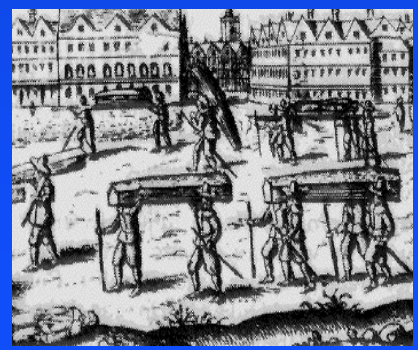
- Early Symptoms
  - high fever, fatigue, head and back aches occur initially
- Prominent Symptoms:
  - Characteristic rash, most prominent on face, arms, and legs follows in 2-3 days. Rash starts with flat lesions that evolve at same rate
- Cause: variola virus
- *Contagious person to person (respirated saliva)*
- Treatment:
  - *supportive care*
  - *Cidofovir (in vitro)*

Biological WMD - Botulism

- Early Symptoms
  - (foodborne) nausea, dry mouth, vomiting, abdominal cramps, and diarrhea
- Prominent Symptoms:
  - Blurred or double vision, difficulty swallowing and speaking, weakness and/or paralysis first in the arms and then the legs can follow
- Cause: *Clostridium botulinum* bacterium toxin
- *Not contagious person to person*
- Treatment:
  - *supportive care*
  - *Trivalent equine antitoxin*

Biological WMD – Plague

- Early Symptoms:
  - (bubonic) – fever, chills, muscle aches, headache, nausea, vomiting, diarrhea, abdominal pain, and extreme exhaustion; swollen and tender near infected flea bite
  - (pneumonic) – pneumonia-like symptoms
- Cause: bacterium *Yersinia pestis*
- *Bubonic - Not contagious person to person*
- *Pneumonic - contagious person to person (sneeze/cough)*
- Treatment:
  - *bubonic – widely available antibiotics*
  - *pneumonic – Streptomycin, Gentamicin*

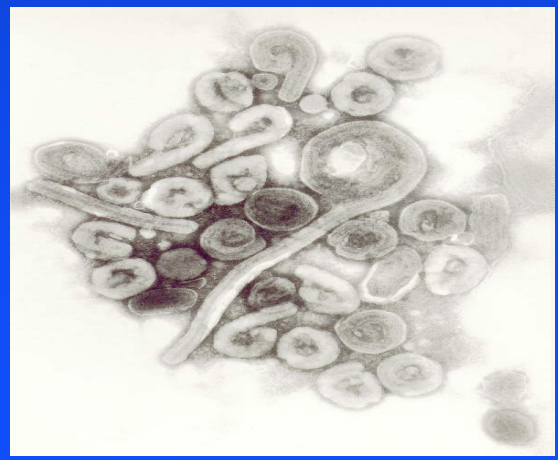


Biological WMD – Tularemia

- Early Symptoms:
  - Skin- Presence of skin ulcer at location where bacteria entered skin and swollen glands
  - Ingestion – throat infection, abdominal pain, diarrhea, and vomiting
  - Inhalation – pneumonia-like illness
  - Eyes – painful swelling of lids, red eyes, visual pain
- Cause: bacterium *Francisella tularensis*
- *Not contagious person to person*
- Treatment:
  - *Streptomycin*
  - *Gentamicin*

Biological WMD – Viral Hemorrhagic Fevers

- Early Symptoms:
  - Overall vascular system is damaged, body's ability to regulate itself is impaired, often accompanied by hemorrhage (bleeding)
- Causes:
  - Arenaviruses (Lassa, Machupo); Filoviruses (Ebola, Marburg); Bunyaviruses; Flaviviruses
- *Can be contagious, depending on type*
- Treatment:
  - *Supportive care*
  - *Lassa fever - Ribavirin*

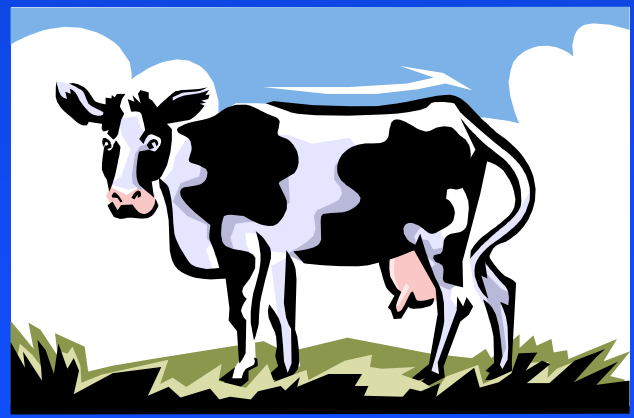


Biological WMD – CDC Category B

- Moderately easily to disseminate or transmit from person to person
- Result in moderate morbidity rates and low mortality rates
- Require specific enhancements of CDC’c diagnostic capacity and enhanced disease surveillance

Biological WMD – Brucellosis (Category B)

- Early Symptoms:
  - similar to flu; may include fever, sweats, headaches, back pains, and physical weakness
- Cause: bacteria of genus *Brucella*
- *Not contagious person to person*
- Treatment:
  - *Doxycycline*
  - *Streptomycin*
  - *Rifampin*



Biological WMD – Ricin

- Early Symptoms:
  - Inhalation: coughing, tightness in the chest, difficulty breathing, nausea, and aching muscles.
  - Ingestion: internal bleeding of the stomach and intestines leading to vomiting and bloody diarrhea.
  - Injection: muscles and lymph nodes near the injection site would die.
- Cause: poison from processing castor beans
- *Not contagious person to person*
- Treatment:
  - *Supportive care*

Chemical Types of WMD

Brief History of Chemical Warfare

- **April 1915** - World War I (Ypres, Belgium) - Over 5,000 allied troops died in first chlorine gas attack; 15,000 wounded
- **World War I -** British and German forces used chorine gas, mustard gas (July 1917), and phosgene (late 1915) heavily before the war ended.
- **World War I** - Overall about 113,000 tons of chemical weapons were used; killing around 92,000; total of 1.3 million casualties.
- **1925 -** Geneva protocol ("Protocol for the prohibition of the use in war of asphyxiating, poisonous or other gases, and of bacteriological methods of warfare") was signed by the league of nations (initial signing 38 nations; now over 130 nations (manufacture and threat of use of chemical weapons not prohibited; protocol is vague on "other gas;" and punishment for use

http://www.geocities.com/CapeCanaveral/Lab/4239/chemweapons/history.html

Brief History of Chemical Warfare

- **World War II -** No chemical weapons used in battle; large amounts of new chemical weapons (nerve agents) developed in 1930's & 1940'S by the Germans were discovered
- **1952 -** United Kingdom - discovers VX based on insecticide research.
- **1961** - Manufacturing of VX begins in US (Ends in 1968)
- **Vietnam War -** Chemical Agents ("Agent Orange", "Agent Purple", "Agent Blue", and "Agent White", were used to defoliate vegetation surrounding the enemy.
- **1980's -** Chemical warfare agents use reported in Laos, Cambodia, Afghanistan, Iran, and Iraq ("Gulf war Syndrome")
- **March 1995 -** Tokyo, Japan - Religious cult releases form of sarin gas in Tokyo's subway system during morning rush hour; attack killed 11 people and injured over 5,500 people (trample).

http://www.geocities.com/CapeCanaveral/Lab/4239/chemweapons/history.html

Clues of Chemical Terrorism

- Unusual increase in number of people seeking care (respiratory, neurological, gastrointestinal symptoms)
- Symptom clustering, unusual age distribution
- Location of release not consistent with chemical's use
- Simultaneous impact to human, animal, and plant populations
- Unusual clustering of patients in time or location

Chemical Types of WMD

- Blister/Vesicants (Lewisite, Mustard Gas)
- Blood (Arsine, Hydrogen Cyanide)
- Pulmonary Damaging (Chlorine, Phosgene)
- Incapacitating (BZ, LSD)
- Nerve (Sarin, VX)
- Riot Control/Tear (Bromobenzylcyanide)
- Vomiting (Adamsite)
- Other Industrial Chemicals

Chemical – Blistering/Vesicant

- Names:
  - Lewisite (L),
  - Mustard gas (H),
  - Nitrogen mustard (HN-1, HN-2, HN-3),
  - Mustard/Sulfur mustard (HD, H),
  - Phosgene oxime (CX)
- Effects:
  - *Severe irritation immediately after exposure*
  - *Causes skin blisters and redness*
  - *Causes tearing, conjunctivitis, corneal damage*
  - *Mild respiratory distress to marked airway damage*
  - *May cause death*

Chemical – Blistering/Vesicant

- Unique Characteristics:
  - Mustard – burning garlic/horseradish odor
  - Lewisite – penetrating geranium odor
  - Phosgene oxime – pepperish/pungent odor
- Decontamination:
  - Immediately remove clothing
  - Gently wash skin with soap and water
  - Do not abrade skin
  - For eyes, flush with plenty of water or normal saline

Chemical – Blistering/Vesicant

- First Aid:
  - Immediately decontaminate skin
  - Flush eyes for 10-15 minutes with water/saline
  - If breathing difficulty, give oxygen
  - Supportive care
- Other Considerations:
  - Mustard has asymptomatic latent period
  - No antidote or treatment for mustard
  - Lewisite – immediate burning pain, blisters later
  - Antidote: injection of British Anti-Lewisite (BAL)
  - Phosgene oxime – immediate pain
  - Possible pulmonary edema

Chemical –Asphyxiant/Blood

- Names:
  - Arsine
  - Cyanogen chloride
  - Hydrogen cyanide
- Effects:
  - *Confusion*
  - *Nausea*
  - *Gasping for air, but more abrupt onset*
  - *Seizures prior to death*

Chemical –Asphyxiant/Blood

- Unique Characteristics:
  - Possible cherry red skin
  - Possible cyanosis (bluish skin)
  - Possible frostbite (liquid arsine, cyanogen chloride)
  - ***Arsine*** - has garlic-like or fishy smell at high concentrations
- Decontamination:
  - Immediately remove clothing if no frostbite
  - If frostbite, wash with warm water to release clothing
  - Gently wash skin with soap and water
  - Do not abrade skin
  - For eyes, flush with plenty of water or normal saline

Chemical –Asphyxiant/Blood

- First Aid:
  - Rapid treatment with oxygen
  - For cyanide
    - Antidote: Sodium nitrite, then sodium thiosulfate
- Other Considerations:
  - Arsine and cyanogen chloride may cause delayed pulmonary edema (fluid buildup)

Chemical – Choking/Pulmonary

- Names:
  - Chlorine
  - Hydrogen chloride
  - Nitrogen oxides
  - Phosgene
- Effects:
  - *Eye and skin irritation*
  - *Airway irritation*
  - *Dyspnea (labored breathing), cough*
  - *Sore throat*
  - *Chest tightness*

Chemical – Choking/Pulmonary

- Unique Characteristics:
  - Chlorine - greenish-yellow gas; pungent odor
  - Phosgene – newly-mown hay or grass odor
  - Possible frostbite (liquid phosgene)
- Decontamination:
  - Immediately remove clothing if no frostbite
  - If frostbite, wash with warm water to release clothing
  - Gently wash skin with soap and water
  - Do not abrade skin
  - For eyes, flush with plenty of water or normal saline

Chemical – Choking/Pulmonary

- First Aid:
  - Fresh air, forced rest
  - Semi-upright position
  - If respiratory distress, oxygen w/wo positive airway pressure may be needed
  - Other supportive therapy, as needed
- Other Considerations:
  - May cause delayed pulmonary edema, even following symptom-free period (duration dependent on dose)

Chemical – Nerve

- Names:
  - Cyclohexyl sarin (GF)
  - Sarin (GB)
  - Soman (GD)
  - Tabun (GA)
  - VX
- Effects:
  - *Miosis (pinpoint pupils), blurred/dim vision*
  - *Headache*
  - *Nausea, vomiting, diarrhea*
  - *Copious secretions/sweating*
  - *Muscle twitching/fasciculations, seizures*
  - *Breathing difficulty*

Chemical – Nerve

- Unique Characteristics:
  - Miosis (pinpoint pupils)
  - Copious secretions/sweating
  - Muscle twitching/fasciculations
  - Tabun - slightly fruity odor; Soman - slight camphor odor
- Decontamination:
  - Immediately remove clothing
  - Gently wash skin with soap and water
  - Do not abrade skin
  - For eyes, flush with plenty of water or normal saline

Chemical – Nerve

- First Aid:
  - Atropine before other measures
  - Pralidoxime (2-PAM) chloride
- Other Considerations:
  - Onset of symptoms from dermal contact with liquid forms may be delayed
  - Repeated antidote administration may be necessary

Chemical – Incapacitating/Behavior

- Names:
  - Agent 15/BZ
- Effects:
  - *Dry mouth and skin*
  - *Initial tachycardia (fast heartbeat)*
  - *Altered consciousness, delusions, belligerence*
  - *Hyperthermia*
  - *Ataxia (lack of coordination)*
  - *Hallucinations*
  - *Mydriasis (dilated pupils)*

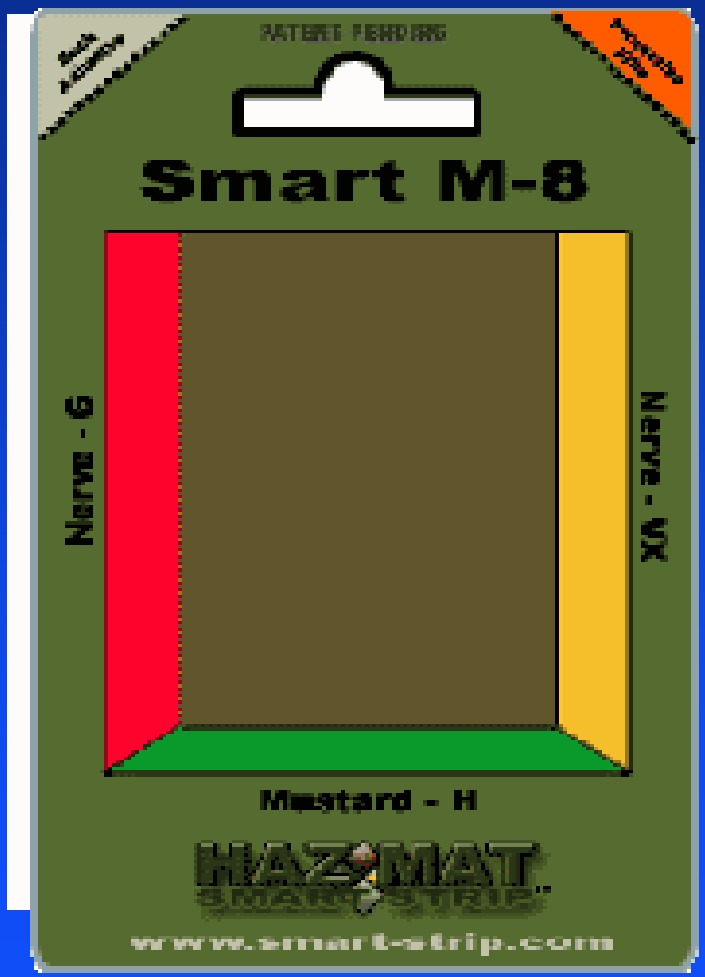
Chemical – Incapacitating/Behavior

- Unique Characteristics:
  - Mass drug intoxication, hallucinations
  - Hyperthermia
  - Mydriasis (dilated pupils)
- Decontamination:
  - Immediately remove clothing
  - Gently wash skin with soap and water
  - Do not abrade skin

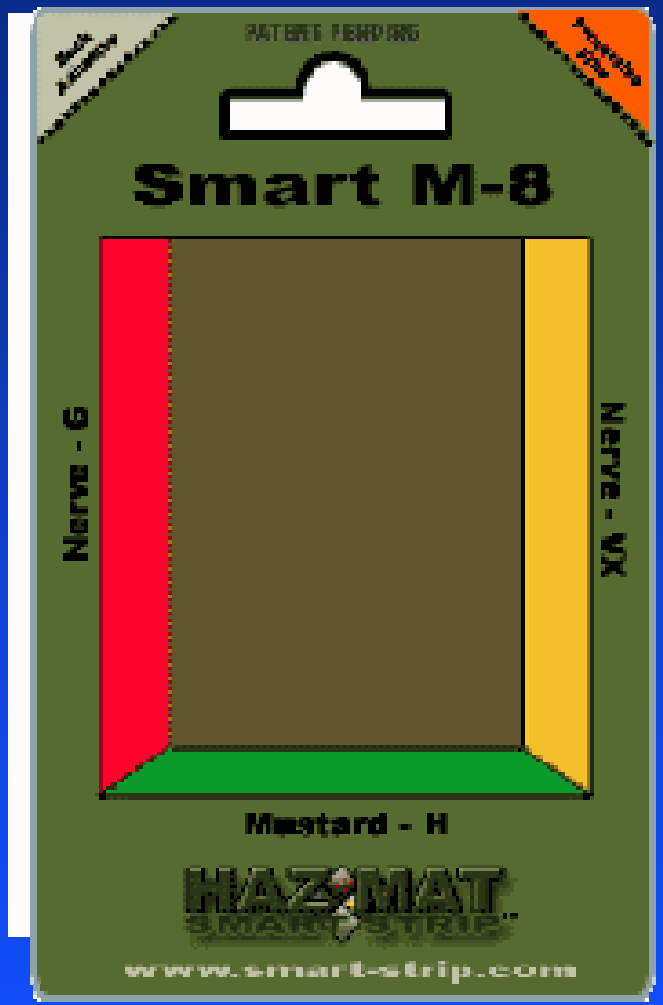
Chemical – Incapacitating/Behavior

- First Aid:
  - Remove heavy clothing
  - Evaluate mental status
  - Use restraints as needed
  - Monitor core temperature carefully
  - Supportive care
- Other Considerations:
  - Hyperthermia and self-injury are largest risks
  - Hard to detect – odorless, non-irritating
  - Possible serious arrhythmias (erratic heartbeat)
  - Antidote - physostigmine

Chemical WMD – Using Colorimetric Devices



Colorimetric – Nerve Agents



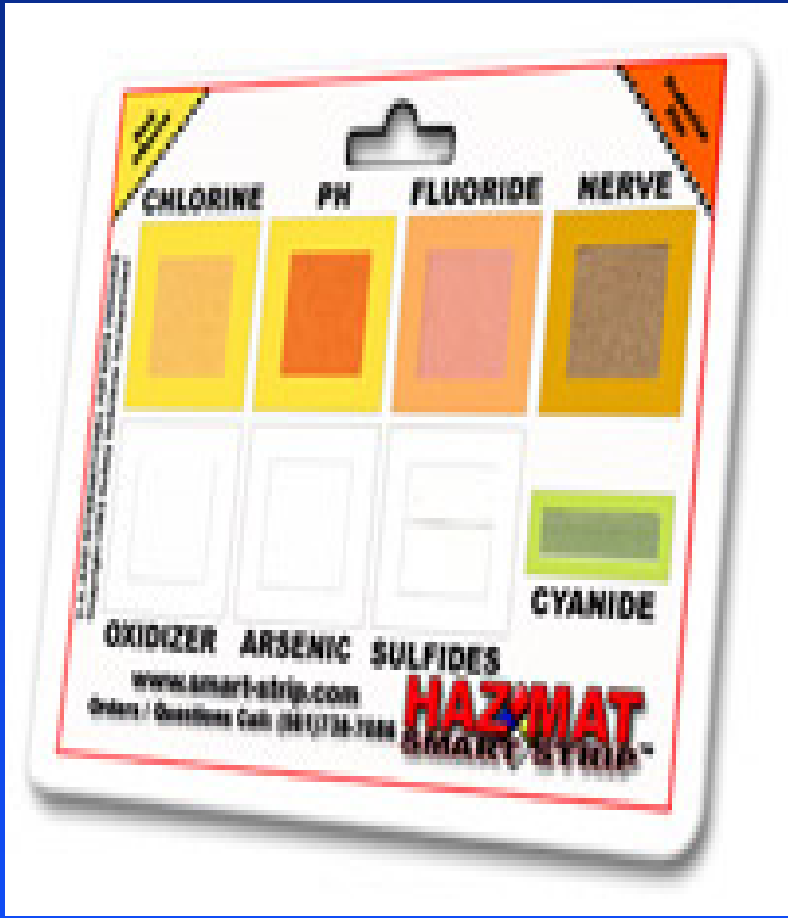
Smart M-8

Nerve Agent Detector

- Instantly identifies nerve (V, G, H) agents with the latest technology.
- Includes clip and peel and stick back.
- Color indicator on each individual card.

http://www.smart-strip.com/order.htm

Colorimetric – HAZMAT



HazMat Smart-Strip

- Instantly identifies nerve, cyanide, hydrogen sulfide, arsenic, acids/caustics, fluoride, oxidizers, and chlorine.
- (12 hour operational timeframe)
- 2 year shelf life.

http://www.smart-strip.com/order.htm

Colorimetric – Civil Defense

Simultaneous Kits for Domestic Preparedness

Draeger has developed an important new detection system that detects up to five different chemical agents simultaneously - in just 5 minutes.

The Draeger CDS Kit provides two CDS sets for detection of eight chemical substances, including nerve, blood, lung, nose and throat irritating agents.

http://www.afcintl.com/kits1.htm

Chemical WMD – Using PIDs

Using PIDs – Function

- A Photo Ionization Detector (PID) uses an Ultraviolet (UV) light source (Photo= light) to break down chemicals to positive and negative ions (Ionization) that can easily be counted with a Detector.
- Ionization occurs when a molecule absorbs the high energy UV light, which excites the molecule and results in the temporary loss of a negatively charged electron and the formation of positively charged ion.

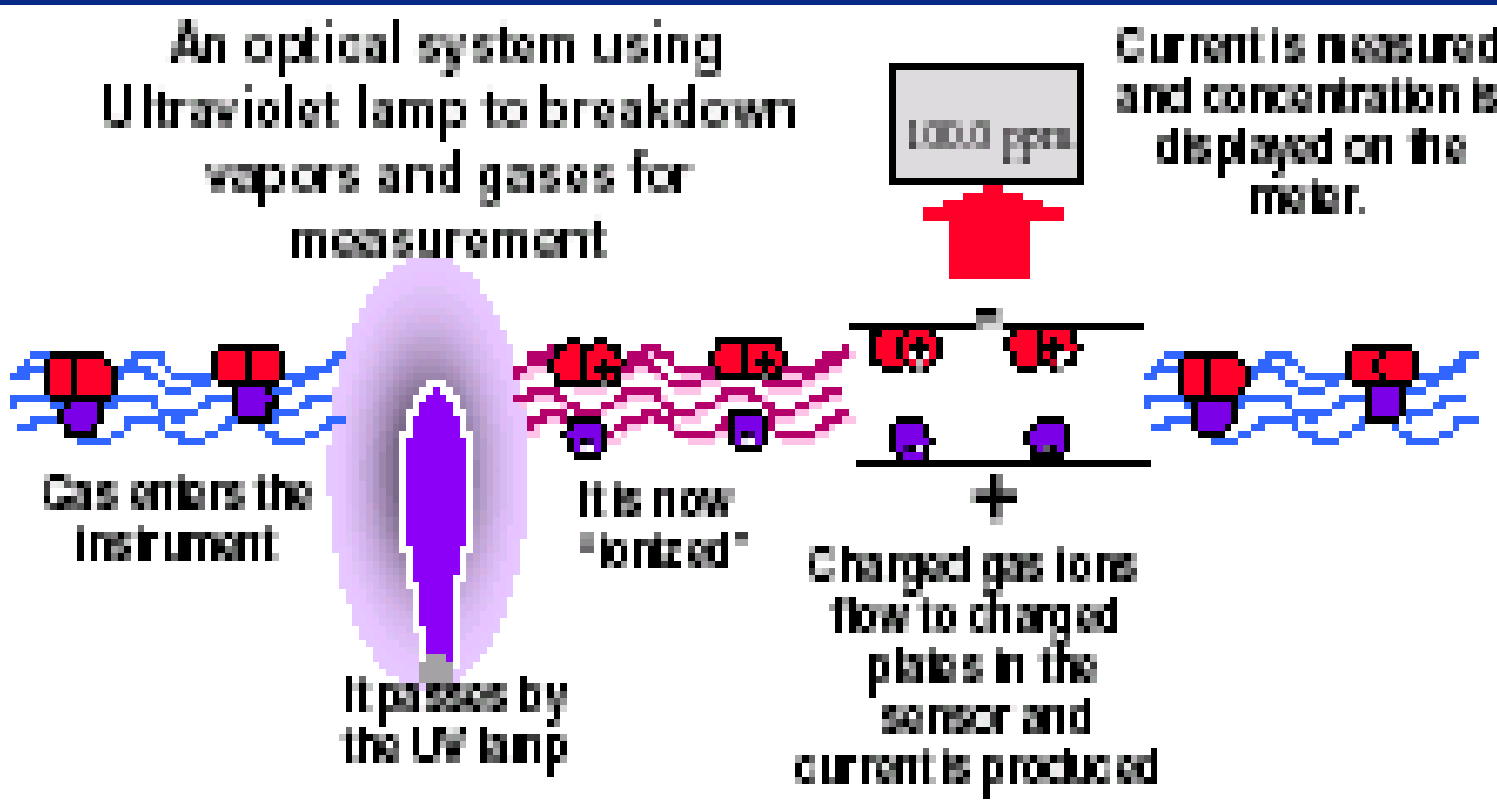
http://www.afcintl.com/pdf/pid.pdf

Using PIDs – Function

- The gas becomes electrically charged. In the Detector these charged particles produce a current that is then amplified and displayed on the meter as “ppm” (parts per million) or even in “ppb” (parts per billion).
- The ions quickly recombine after the electrodes in the detector to “reform” their original molecule. PIDs are non-destructive; they do not “burn” or permanently alter the sample gas, which allows them to be used for sample gathering.
- PID calibrated with isobutylene (benzene in past)

http://www.afcintl.com/pdf/pid.pdf

Using PIDs – Function



RAE SYSTEMS

Using PIDs - Measurement

- All elements and chemicals can be ionized, but they differ in the amount of energy they require.
- The energy required to displace an electron and "ionize" a compound is called its **Ionization Potential (IP)**, measured in **electron volts (eV).**
- The light energy emitted by an UV lamp is also measured in eV.

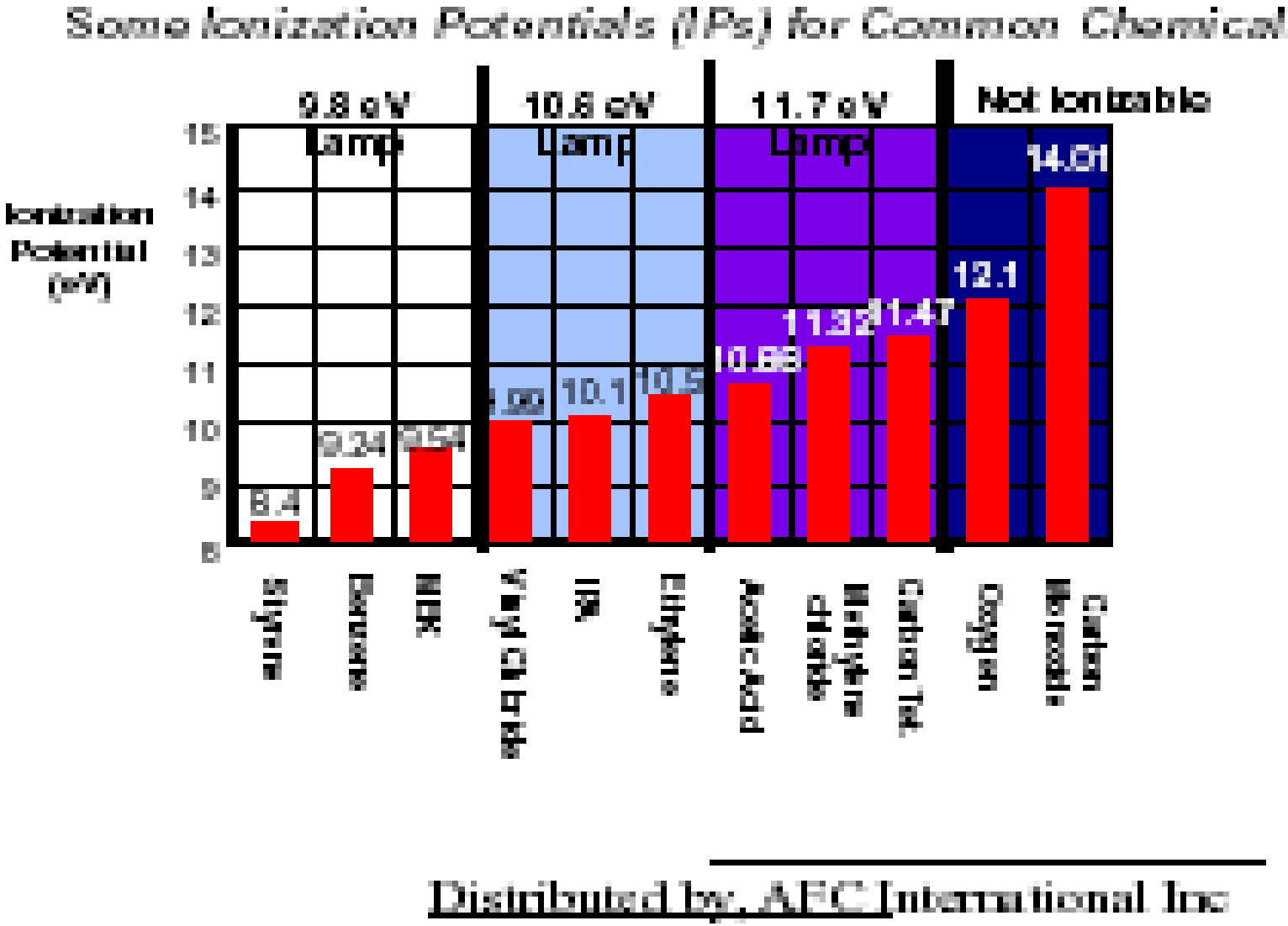
http://www.afcintl.com/pdf/pid.pdf

Using PIDs - Measurement

- **If the IP of the sample gas is less than the eV output of the lamp, then the sample gas will be ionized.**
- If the “wattage” of a gas or vapor is less than the “wattage” of the PID lamp, then the PID can “see” the gas or vapor.
- If the “wattage” of the gas or vapor is greater than that of the PID lamp the PID cannot “see” the vapor.

http://www.afcintl.com/pdf/pid.pdf

Using PIDs – Measurement



Using PIDs - Detectables

Organics: compounds *containing* Carbon (C) atoms:

- **Aromatics –** benzene ring (benzene, toluene, xylene)
- **Ketones & Aldehydes** - C=O (acetone, MEK)
- **Amines & Amides –** nitrogen (diethylamine)
- **Chlorinated hydrocarbons -** TCE, PERC
- **Sulfur compounds –** mercaptans, sulfides
- **Unsaturated hydrocarbons –** butadiene, isobutylene
- **Alcohols-** isopropanol (IPA), ethanol
- **Saturated hydrocarbons –** butane, octane

Inorganics: Compounds *without* Carbon atoms:

- Ammonia, Arsine, Phosphine, Hydrogen Sulfide, Nitric Oxide, Bromine, and Iodine

http://www.afcintl.com/pdf/pid.pdf

Using PIDs – Non-Detectables

- Radiation
- Air (N_2, O_2, CO_2, H_2O)
- Common Toxics (CO, HCN, SO_2)
- Natural Gas (Methane, Ethane)
- Acid Gases (HCl, HF, HNO_3)
- Others- Freons, Ozone (O_3), Hydrogen peroxide
- Non-volatiles: PCBs, Greases

http://www.afcintl.com/pdf/pid.pdf

Using PIDs – eV Bulb Tips

9.8 & 10.6 eV versus 11.7 eV PID Lamps

- 9.8 and 10.6 are more specific
- 9.8 and 10.6 last a few years
- 9.8 and 10.6 are more sensitive
- 11.7 have a shorter life than 9.8 or 10.6
- 11.7 eV bulbs should only be used when compounds with IPs over 10.6 eV are expected: Examples include methylene chloride, chloroform, and carbon tetrachloride

http://www.afcintl.com/pdf/pid.pdf

Chemical WMD – Monitoring

Chemical WMD – Monitoring

Important Terminology:

- **CWA – Chemical Warfare Agents**
- **TIC – Toxic Industrial Chemicals**
- **TIM – Toxic Industrial Materials**
- **SAW – Surface Acoustical Wave**
- **IMS – Ion Mobility Spectroscopy**

Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Monitoring

Important Terminology (military CWA):

- **SAW – Surface Acoustical Wave –** technique in which a high frequency signal, instead of an optical beam, is used to identify substances

- **IMS – Ion Mobility Spectroscopy -** technique that measures vibrational frequencies and the bonds between different nuclei, usually to examine ions of relatively low molecular weight and high ion mobility

Chemical WMD – Monitoring

Important Concepts:

- **"Toxic chemicals in general industry are *more accessible* to terrorists than chemical warfare agents"**
- **"The difference between a HAZMAT incident a terrorist event is *intent* – accident vs. intentional**

Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Monitoring

- **General Industry Agents**
  - **Chlorine – water treatment**
  - **Phosgene gas – various chemical processes**
  - **Parathion – agricultural insecticide**
  - **TDI (toluene diisocyanate) – catalyze urethanes**
- **Chemical Warfare Agents**
  - **Chlorine gas**
  - **Phosgene gas**
  - **Sarin** (Tokyo - 37% sarin, 63% acetonitrile)
  - **Lewisite/Mustard gas mixture**

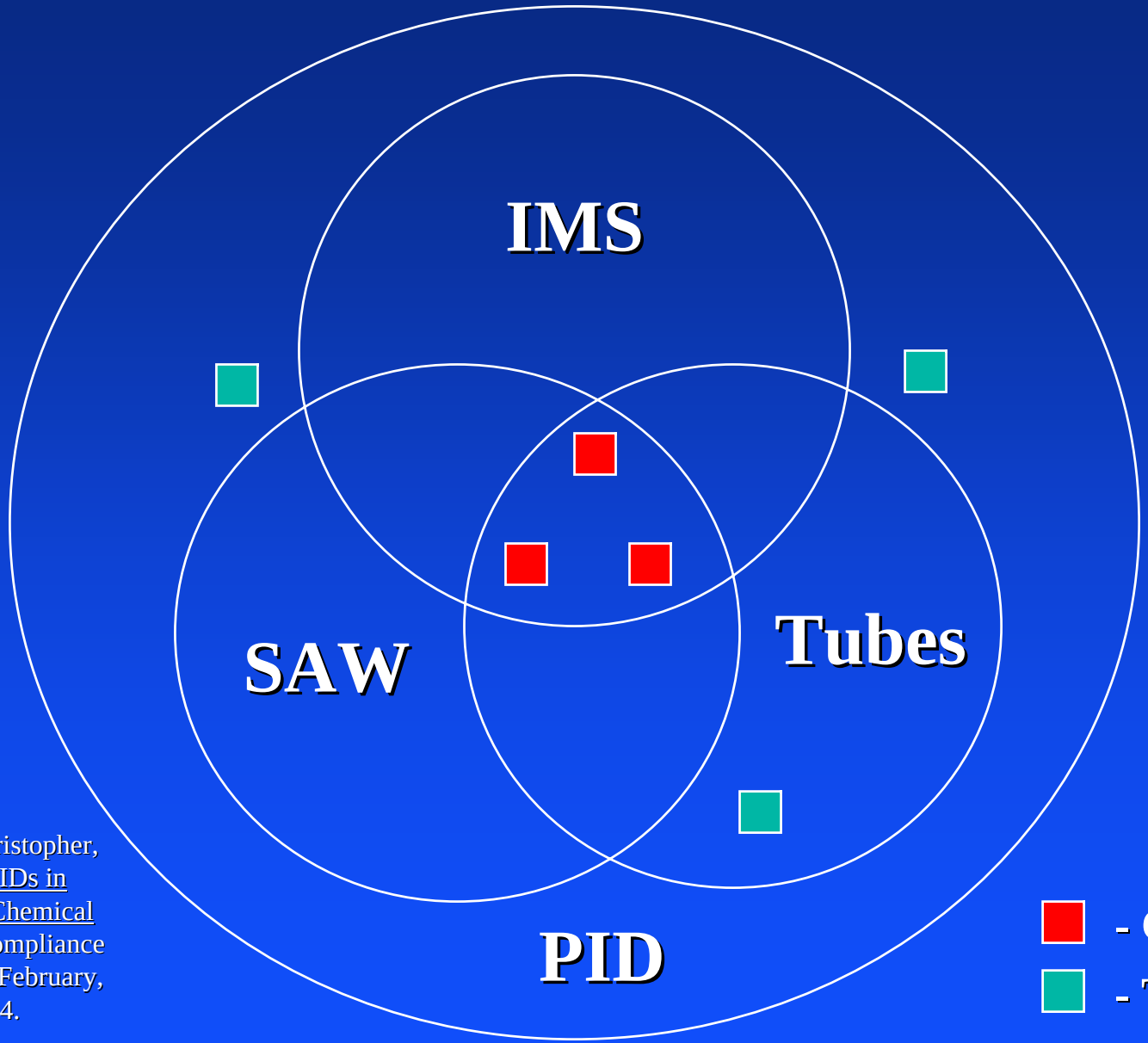
Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Monitoring

- **Low VP Chemicals that Fool IMS algorithms**
  - **Brake fluid**
  - **Diesel additives**
  - **Paint fumes**
  - **Glycol ethers/Vinyl esters - cleaning products**
  - **Wintergreen/spearmint oils – mouthwash/mints**
- **PIDs can measure both CWAs and TICs that are outside of CWA SAW/IMS detectors**
- **Multiple CWA-specific devices are required to account for cross-sensitivity and reliable determination of CWA**

Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Monitoring



Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Monitoring

Table 1

Compound	Structure	m.w.	Vapor Press. (ppmv)	Lamp (eV)	CF	8-h TWA (mg/m³)	8-h TWA (ppbv)	LC50 (ppmvmin.)
Arsine (SA)	AsH_3	78	Gas	10.6	1.9	0.16	0.05	
Cyanogen Chloride	ClCN	61.5		ND**	ND**	0.6 C[1]	300 C[1]	
DMMP	$O{=}P(Me)(OMe)_2$	124		10.6	4.3			
GF	O=PF(Me)(O-Cyclohex)	180		10.6	~3*			
Hydrogen Cyanide	HCN	27	Gas	ND**	ND**	11	10,000	270
Lewisite	$ClCH{=}CHAsCl_2$	207	460	10.6	~1*	0.003	0.35	140
Methyl salicylate	$2\text{-}(HO)C_6H_4CO_2Me$	152		10.6	0.9			
Mustard (HD)	$S(EtCl)_2$	159	95	10.6	0.6	0.003	0.46	
N Mustard (HN-1)	$N(Et)(EtCl)_2$	172		10.6	~1*			
Phosgene	$O{=}CCl_2$	99	Gas	11.7	~2*	0.4	100	2
Sarin (GB)	O=PF(Me)(OiPr)	140	3800	10.6	3	0.0001	0.017	12
Soman (GD)	O=PF(Me)(OCH(Me)(tBu))	182	530	10.6	~3*	0.00003	0.004	9
Tabun (GA)	$O{=}P(CN)(OEt)(NMe_2)$	162	48	10.6	0.8	0.0001	0.015	20
Triethyl phosphate	$O{=}P(OEt)_3$	182		10.6	3.1			
VX	$O{=}P(Me)(OEt)(SetN(iPr)_2)$	267	0.92	10.6	~0.5*	0.00001	0.00091	2.7

* Estimated value. ** ND = Not Detectable by PID. [1]C = ceiling value.%

Low CF = High PID Sensitivity To A Gas

Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Monitoring

- **Gas Monitoring Pyramid**
  - **Chemical specific techniques**
    - **Colorimetric tubes**
    - **Ion Mobility Spectroscopy**
    - **Gas chromatography/Mass spectroscopy**
  - **PID broadband monitoring**
  - **Multi-gas confined space monitors**
  - **Single gas monitors**
  - **Colorimetric tubes**

Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Monitoring

- **Gas chromatography**
  - Multiple contaminants are separated into discrete peaks that are reflected on a chromatogram which facilitates identification
  - Sample injected into column and is carried through with inert carrier gas (N_2, He, H_2)
  - Heated column has packing or coating which attracts contaminants on various levels
  - The greater the contaminant affinity, the slower the flow
  - The contaminant is heated in column which, when ionized, results in formation of a peak

Maslansky, Carol & Steve. Air Monitoring Instrumentation. Van Nostrand Reinhold, New York, 1993.

Chemical WMD – Monitoring

- **Mass spectroscopy**
  - Provides information about atomic and molecular composition of organic and inorganic materials; identifies unknowns and confirms presence of known or suspected contaminants
  - Used in conjunction with gas chromatography, a powerful computer with an extensive analytical library containing thousands of compounds, and sample and calibration equipment in a trace air gas analysis (TAGA) mobile analytical laboratory unit.

Maslansky, Carol & Steve. Air Monitoring Instrumentation. Van Nostrand Reinhold, New York, 1993.

Chemical WMD – Monitoring

- **Multi-gas confined space monitors**
  - Electrochemical sensors have coarse particulate filter, semi-permeable membrane (i.e., Teflon), an electrolyte, and electrodes
  - Gas diffuses through membrane, dissolves in electrolyte that contains sensing electrode
  - Gas reacts with electrode producing ions and electrons
  - Charged particles diffuse across electrolyte to electron accepting or counting electrode

Maslansky, Carol & Steve. Air Monitoring Instrumentation. Van Nostrand Reinhold, New York, 1993.

Chemical WMD – Monitoring

- **Flame Ionization Detector (FID)**
- An FID uses a hydrogen-fed flame to break down ***organic*** chemicals to ions that can easily be counted with a Detector.
- Flame can ionize any organic material with IP<15.4
- IP of materials NOT factor since UV lamp not used
- Instrument response depends on materials present
- FID calibrated with methane

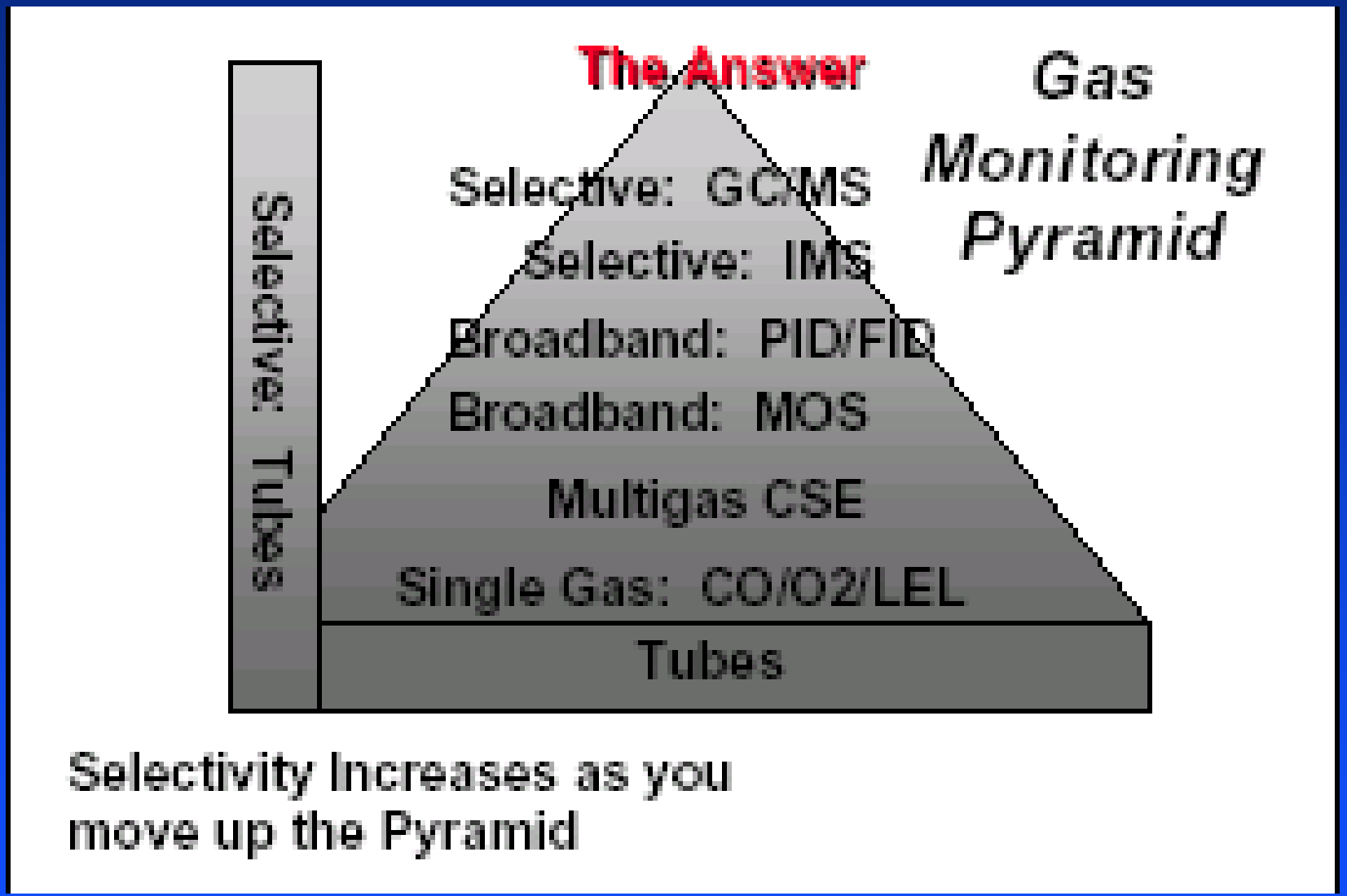
Maslansky, Carol & Steve. Air Monitoring Instrumentation. Van Nostrand Reinhold, New York, 1993.

Chemical WMD – Monitoring

- **Combustible gas monitors**
  - Wheatstone bridge – Filter-protected sensor contains two filaments:
    - Sensing filament - treated with catalyst
    - Compensating filament – no catalyst
  - Battery heats both filaments to same high T^o
  - Combustible gas crossing filter and encountering both filaments is oxidized by sensing filament causing T^o increase
  - T^o increase causes increase in resistance and decrease in current flow for sensing filament

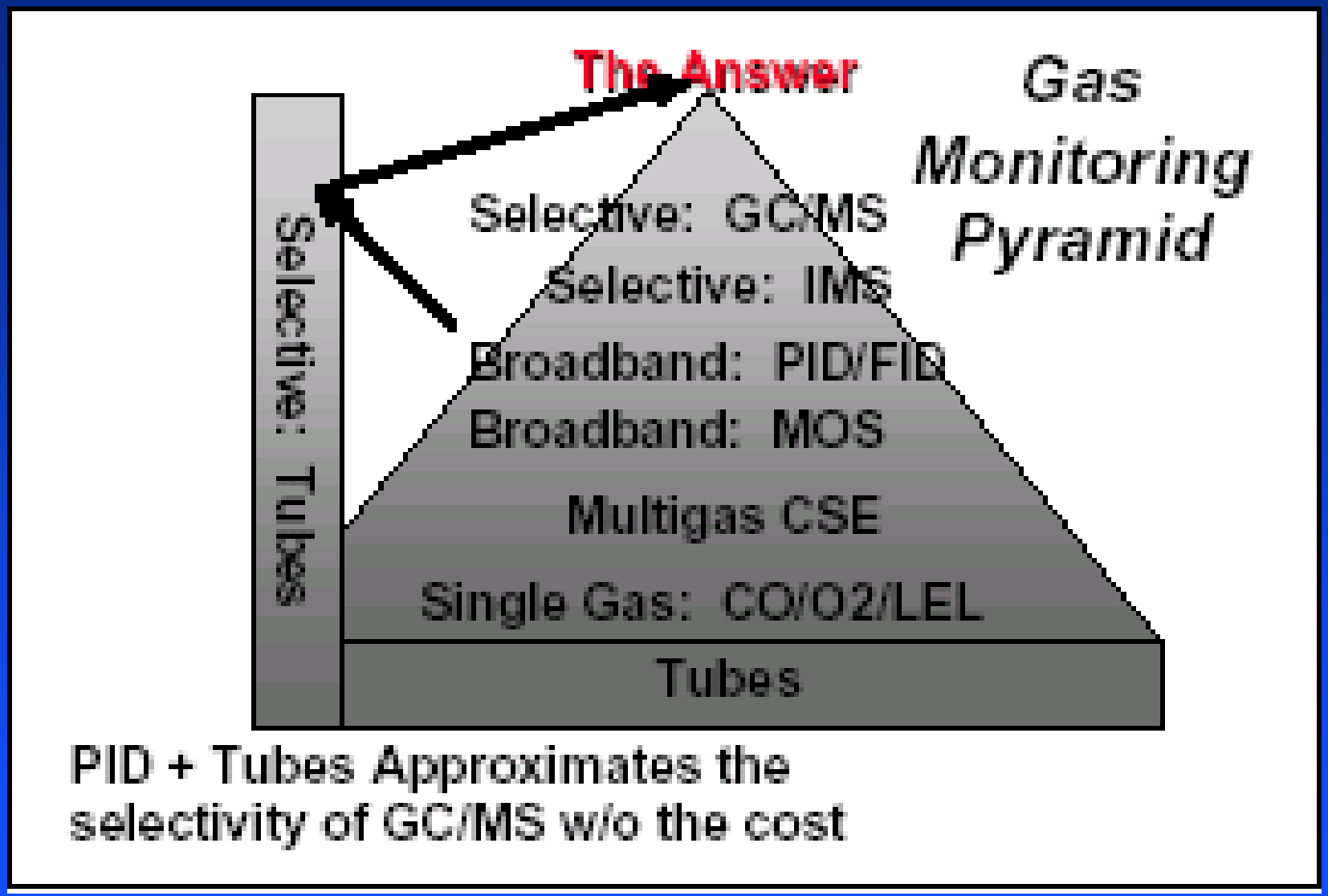
Maslansky, Carol & Steve. Air Monitoring Instrumentation. Van Nostrand Reinhold, New York, 1993.

Chemical WMD – Monitoring



http://www.afcintl.com/pdf/rae/ap216.pdf

Chemical WMD – Monitoring



http://www.afcintl.com/pdf/rae/ap216.pdf

Chemical WMD – Monitoring

- **Commonly Used Screening Devices**
  - **PIDs**
- **Less Frequently Used Screening Devices**
  - **CWA detection methodologies**
    - **M-256**
    - **SAW**
    - **CAM**

Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Monitoring

- **WMD Teams Using PIDs**
  - **US Army National Guard Civil Support Teams (CST)**
  - **City HAZMAT Teams**
  - **Marine Corps' CBIRF Team**
  - **FBI HAZMAT Team**
  - **US Secret Service**

Christopher Wrenn is the product applications manager for RAE Systems

Wrenn Christopher, Using PIDs in Terrorist Chemical Attacks, Compliance Magazine, February, 2004.

Chemical WMD – Using PPE

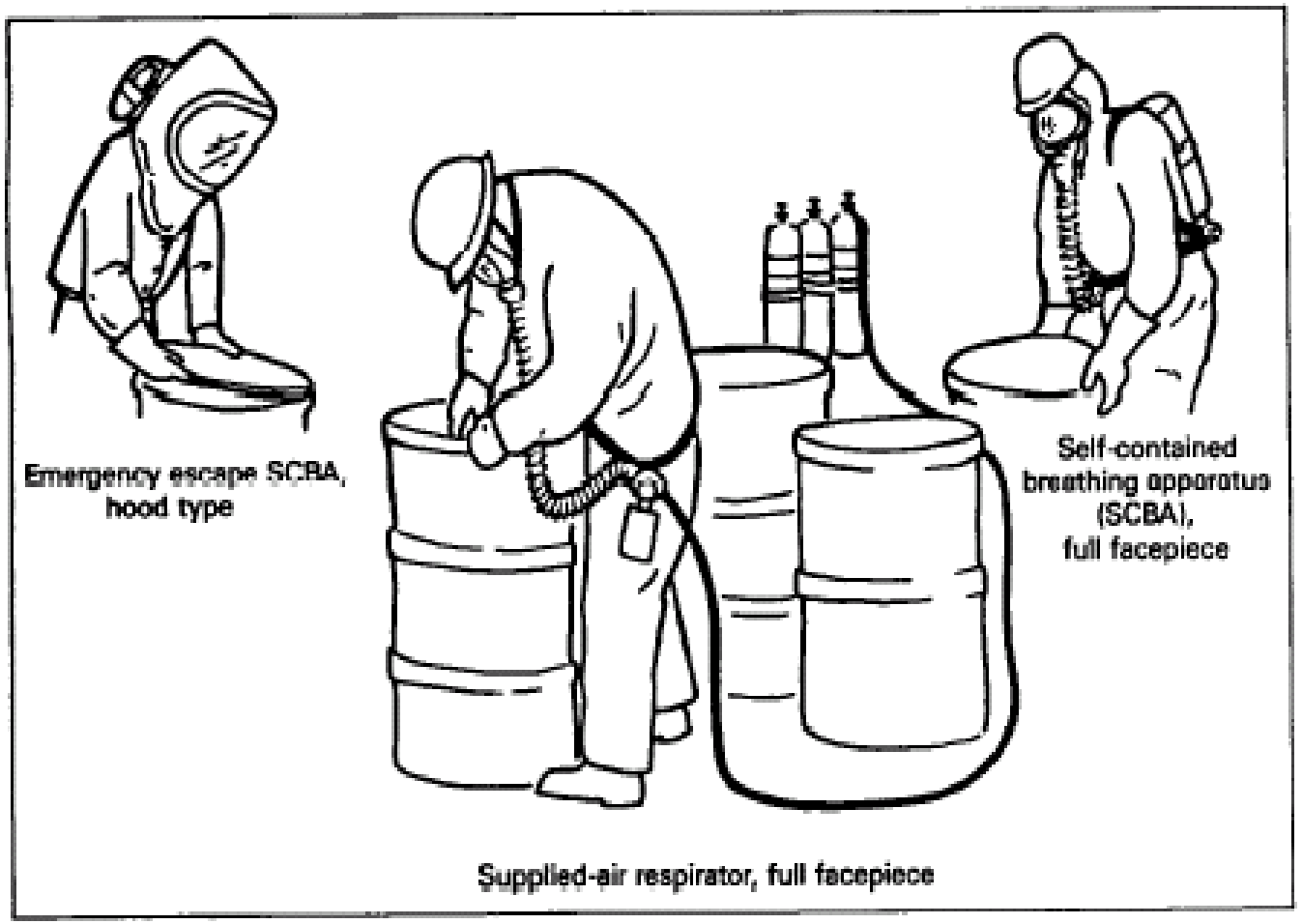


Figure 8-1. Types of Atmosphere-Supplying Respirators.

Chemical PPE – Suits

- **Level A**
- Level A protection should be worn when the highest level of respiratory, skin, eye, and mucous membrane protection is needed.
- It consists of a fully encapsulating chemical-resistant suit and self-contained breathing apparatus (SCBA).
- This suit can be worn only for 15 to 30 minutes because the person wearing it can quickly become overheated.
- Special training is required to utilize the suit.

http://www.unmc.edu/bioterrorism/equipment.htm

Chemical PPE – Suits

- **Level A**
- Positive pressure (pressure demand), self contained breathing apparatus (NIOSH approved), or positive-pressure supplied air respirator with escape SCBA.
- Fully encapsulating chemical protective suit.
- Gloves, inner, chemical resistant.
- Gloves, outer, chemical resistant.
- Boots, chemical resistant, steel toe and shank; (depending on suit boot construction, worn over or under suit boot.)
- Underwear, cotton, long-john type.*
- Hard hat (under suit).*
- Coveralls (under suit).*
- Two-way radio communications (intrinsically safe/non-sparking).*

* Optional

http://www.ehso.com/OSHA_PPE_EPA_Levels.htm#LEVELA

Chemical PPE – Suits

- **Level B**
- Level B protection should be selected when the highest level of respiratory protection is needed but a lesser level of skin and eye protection is sufficient.
- It differs from Level A only in that it provides splash protection by use of chemical-resistant clothing (overalls, long sleeves, jacket, and SCBA).

http://www.unmc.edu/bioterrorism/equipment.htm

Chemical PPE – Suits

- **Level B**
- Positive-pressure (pressure-demand), self-contained breathing apparatus (NIOSH approved), or positive-pressure supplied air respirator with escape SCBA.
- Chemical resistant clothing (overalls and long-sleeved jacket, coveralls, hooded two-piece chemical splash suit, disposable chemical resistant coveralls.)
- Coveralls (under splash suit).*
- Gloves, outer, chemical resistant.
- Gloves, inner, chemical resistant.
- Boots, outer, chemical resistant, steel toe and shank.
- Boot-covers, chemical resistant (disposable).*
- Two-way radio communications (intrinsically safe).*
- Hard hat. *
- Faceshield.*

* Optional

http://www.ehso.com/OSHA_PPE_EPA_Levels.htm#LEVELB

Chemical PPE – Suits

Level C

- Level C protection should be selected when the type of airborne substances is known, concentration is measured, criteria for using air-purifying respirators are met, and skin and eye exposures are unlikely.
- This involves a full-facepiece, air-purifying, canister-equipped respirator and chemical-resistant clothing.
- It provides the same level of skin protection as Level B, but a lower level of respiratory protection.

http://www.unmc.edu/bioterrorism/equipment.htm

Chemical PPE – Suits

Level C

- Full-face or half-mask, air-purifying respirator (NIOSH approved).
- Chemical resistant clothing (one piece coverall, hooded two piece chemical splash suit, chemical resistant hood and apron, disposable chemical resistant coveralls.)
- Gloves, outer, chemical resistant.
- Gloves, inner, chemical resistant.
- Boots, steel toe and shank, chemical resistant.
- Boot-covers, chemical resistant.*
- Cloth coveralls (inside chemical protective clothing).*
- Two-way radio communications (intrinsically safe).*
- Hard hat. *
- Escape mask. *
- Faceshield.*

* Optional

http://www.ehso.com/OSHA_PPE_EPA_Levels.htm#LEVELA

Chemical PPE – Suit Material

- **Material**
  - (Type of Garment)
    - Substances Commonly Used Against

- **Saranax / Tyvek SL**
  - (coveralls; labcoats, sleeve protectors; aprons; hoods; Level B Suits)
    - aerosols, liquids; solvents
- **Tychem BR /; Tychem TK**
  - (Full Level A and Level B Suits)
    - highly toxic chemicals, gases, aerosols
- **CPF**
  - (Full Level A and B suits; splash suits)
    - highly toxic chemicals; gases, aerosols
- **PVC**
  - (Full Level A suits)
    - highly toxic chemicals; gases, aerosols

Chemical PPE – Gloves

- **Glove Material**
  - Resistant to:

- **Viton**
  - PCBs, chlorinated solvents, aromatic solvents
- **Viton/Butyl**
  - acetone, toluene, aromatics, aliphatic hydrocarbons, chlorinated solvents, ketones , amines and aldehydes
- **SilverShield and 4H (PE/EVAL)**
  - morpholine, vinyl chloride, acetone, ethyl ether, many toxic solvents and caustics
- **Barrier**
  - Wide range of chlorinated solvents, aromatics, acids
- **PVA**
  - ketones, aromatics, chlorinated solvents, xylene, MIBK, trichloroethylene; *DO NOT USE WITH WATER /AQUEOUS SOLUTIONS*
- **Butyl**
  - aldehydes, ketones, esters, alcohols, most inorganic acids, caustics, dioxane

Chemical PPE – Gloves

- **Glove Material**
  - Resistant to:

- **Neoprene**
  - oils, grease, petroleum -based solvents, detergents , acids, caustics, alcohols, solvents
- **PVC**
  - acids, caustics, solvents, solvents, grease, oil
- **Nitrile**
  - oils, fats, acids, caustics, alcohols
- **Latex**
  - body fluids, blood, acids, alcohols and alkalis
- **Vinyl**
  - body fluids, blood, acids, alcohols and alkalis
- **Rubber**
  - organic acids, some mineral acids, caustics, alcohols; *not recommended for aromatic solvents, chlorinated solvents*

Chemical PPE – Respirators

- **Atmosphere-Supplying Respirators**:

- **Self-Contained Breathing Apparatus (SCBA)**
  - Closed circuit
    - Compressed or Liquid Oxygen; Oxygen Generating
  - Open Circuit
    - Demand; Pressure-Demand; Continuous Flow
- **Supplied Air Respirators (SAR)**
  - Hose Mask
    - With or Without Blower
  - Airline Respirator
    - Demand; Pressure-Demand; Continuous Flow
- **Combination Airline Respirator with auxiliary air supply**

Chemical PPE – SCBA Respirator

- **Self-Contained Breathing Apparatus (SCBA):**

- **General Advantages**
  - Provides highest available level of protection against airborne contaminants and oxygen deficiency
  - Provides highest available level of protection under strenuous work conditions
- **General Disadvantages**
  - Bulky, heavy (up to 35 pounds)
  - Finite air supply limits work duration
  - May impair movement in confined spaces

Chemical PPE – SCBA Respirator

- **Open Circuit (SCBA): ENTRY & ESCAPE**

- **Advantages**
  - Warning alarm sounds when 20-25% of air supply remains
- **Disadvantages**
  - Bulky, heavy (up to 35 pounds)
  - Finite air supply (30-60 min.) limits work duration
  - Size of tank and work rate of individual vary operating time

Chemical PPE – SCBA Respirator

- **Closed Circuit (SCBA): ENTRY & ESCAPE**

- **Advantages**
  - Warning alarm sounds when 20-25% of air supply remains
  - Longer operating time (up to 4 hrs.)
  - O_2 depleted before CO_2 supply; no CO_2 breakthrough
- **Disadvantages**
  - CO_2 break through may occur at very cold T^o
  - Unit retains heat from exhalation – heat stress
  - When worn outside of suit contamination of breathing bag possible

Chemical PPE – SCBA Respirator

- **ESCAPE ONLY (SCBA):**

- **Advantages**
  - Light weight (10 lbs.), low bulk
  - Available in pressure demand and continuous flow modes
- **Disadvantages**
  - Cannot be used for entry
  - Provides only 5-15 min of protection depending on model/breathing rates

Chemical PPE – SAR Respirator

- **Supplied Air Respirators (SAR):**

- **Advantages**
  - Enables longer work periods than an SCBA
  - Less bulky and heavy than SCBA (5-15 lbs.)
  - Protects against most airborne contaminants
- **Disadvantages**
  - Not approved for IDLH or O_2 deficient areas
  - Impairs mobility
  - MSHA/HIOSH hose length limited to 300 feet
  - Length of hose may be compromised by:
    - Air flow, damage, contamination, degradation
    - Necessity to retrace steps to exit environment
    - Necessity of air supply line supervision and monitoring

Chemical PPE – APR Respirator

- **Atmosphere-Purifying Respirators (APRs):**

- **Advantages**
  - Enhanced mobility
  - Lighter in weight than a SCBA (<2 lbs.)
- **Disadvantages**
  - Cannot be used in IDLH or O_2 deficient area
  - Limited duration of protection (indicator?)
  - Chemical and concentration specific
  - Requires monitoring of contaminant/O_2 levels
  - Contaminants must have adequate warning properties or trigger end of service indicator

Radiological Types of WMD

Radiological Types of WMD

- **"Dirty" Bombs** – Consists of a conventional explosive that is packaged with radioactive material that scatters when bomb explodes
- Risk would only be to immediate area of explosion and can be remediated in a short time.

Radiological Types of WMD

- Note: No instrument can measure all types of radiation at all levels of exposure
- Quickly move away from immediate area, at least several blocks (reduce inhalation of radiation)
- Tune in to local radio or TV broadcasts for more info
- Potassium iodide not necessarily protective because radioactive iodine not necessarily isotope used in device and is only specific to thyroid; must be taken before or right after exposure

Radiological Types of WMD

The three basic ways to reduce radiation exposure are through:

- TIME
  - **Decrease** the amount of time you spend near the source of radiation.
- DISTANCE
  - **Increase** your distance from a radiation source.
- SHIELDING
  - **Increase** the shielding between you and the radiation source.

Radiological Terrorism Tips: *AIHA Synergist - December 2003 (University/Hospital Site)*

- Personnel who can neither hear nor see an explosion are probably not at risk.
  - Stay put if indoors
  - If outdoors, go inside to await further information and instructions
  - Driving away is discouraged, because driving is likely to be more dangerous than staying put

Radiological Terrorism Tips

- After going indoors, personnel should:
  - close open doors and windows
  - wash their hands and face (taking a shower if possible)
  - change their outer clothes if they can
- Contaminated injured people should have serious injuries treated without regard to contamination levels—they do not endanger emergency response or medical personnel
  - If injuries are not serious, it may be possible to decontaminate the victims before transporting, or wrap them in a sheet to minimize contamination
  - Depends on the extent of injuries and contamination

Radiological Terrorism Tips

- You may need to perform surveys to establish radiological boundaries for high radiation or high contamination levels.
  - Radiation surveys are relatively easy to perform, and boundaries often established fairly easily
  - Contamination boundaries are more difficult to establish because surveys can be difficult and time-consuming
- According to regulations:
  - the limit for removable contamination in an unrestricted area is 1,000 dpm/100 cm^2
  - radiation levels in uncontrolled areas cannot exceed 2 mrem in one hour.

Radiological Terrorism Tips

- In some cases, it may be best to simply set contamination control boundaries a few hundred meters downwind and then expand or collapse them as you survey to confirm them.

Radiological Survey Tips

- Be “low and slow”: The detector should be:
  - held no more than a half inch (1 cm) from the surface being surveyed (avoid contamination and false “low”)
  - moved no more quickly than 1–2 inches per second (3–5 cm/second). (avoid missing contaminated area)
- While surveying, keep the audible response turned on so you can watch the probe itself.
- Listen to the count rate:
  - If you hear an increase, pause for a moment to see if the increase is sustained
  - If so, look at the meter face to see what the count rate is at that location.

Radiological Survey Tips

- When logging results, and in decontamination, you must convert from counts per minute (what the meter reads out) to disintegration per minute (the amount of contamination present).
- Divide the count rate by the meter efficiency, which should be determined when the meter is calibrated.
- For example, if a Geiger counter has 40 percent percent detection efficiency for P-32, a count rate of 80 cpm above background levels corresponds to a disintegration rate of 200 dpm (80 ÷ 0.4 = 200).

Radiological Survey Tips

Table 1: How to Choose a Survey Meter

Type of Radiation Emitted	Example Isotopes	Type of Survey	Type of Detector to Use
Alpha	U-238, Pu-238, Pu-239, Ra-226, Po-210, Am-241	Direct frisk, smear wipe	Zinc sulfide (ZnS) or proportional counter
Low-energy beta	H-3, C-14, S-35, Pu-241	Smear wipe	Liquid scintillation counter, proportional counter
Medium- to high-energy beta	P-32, Sr-90, I-131	Direct frisk, smear wipe	Geiger counter, liquid scintillation counter, proportional counter
Low-energy gamma	I-125, I-129, Am-241	Direct frisk or smear wipe	Thin-crystal (1″ x 1 mm) sodium iodide
Medium- to high-energy gamma	I-131, Cs-137, Co-60, Ir-192	Direct frisk or smear wipe	Thick-crystal (1″ x 1″ or larger) sodium iodide, Geiger counter

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