

BUILDING DESIGN FOR HOMELAND SECURITY

Unit VII

Chemical, Biological, and Radiological (CBR) Measures



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Unit Objectives

Explain the five possible protective actions for a building and its occupants.

Compare filtration and collection mechanisms and applicability to the particles present in chemical, biological, and radiological agents.

Explain the key issues with CBR detection.

Identify the indicators of CBR contamination.



Unit VII: CBR Measures

Units I-V discussed Assessments – Risk.

Units VI and VII explain Blast and CBR Weapons and effects.

Units VIII and IX demonstrate techniques for site layout and building design to counter or mitigate manmade threats.



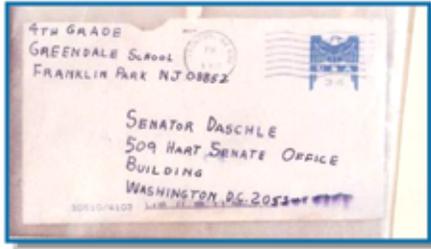
CBR Measures: An Overview

FEMA 426, Chapter 5 is based on best practices for safeguarding building occupants from CBR threats. This module is organized into four sections :

- Protective Actions for Buildings and Occupants
- Air Filtration and Cleaning Principles and Technology
- CBR Detection and Technology
- Non-Technology CBR Contamination Indications



CBR Terrorist Incidents Since 1970



1972 Typhoid

1984 Salmonella
200 Injured

June 1994 Sarin
7 Dead, 200 Injured

March 1995 Sarin

May 1995 Plague

April 1997 U235

February 1997 Chlorine
14 Injured, 500 Evacuated

March 1998 Cesium-137



1984 Botulinum

1985 Cyanide

1992 Cyanide

March 1995 Ricin

April 1995 Sarin

April-June 1995 Cyanide, Phosgene, Pepper Spray

June 1996 Uranium

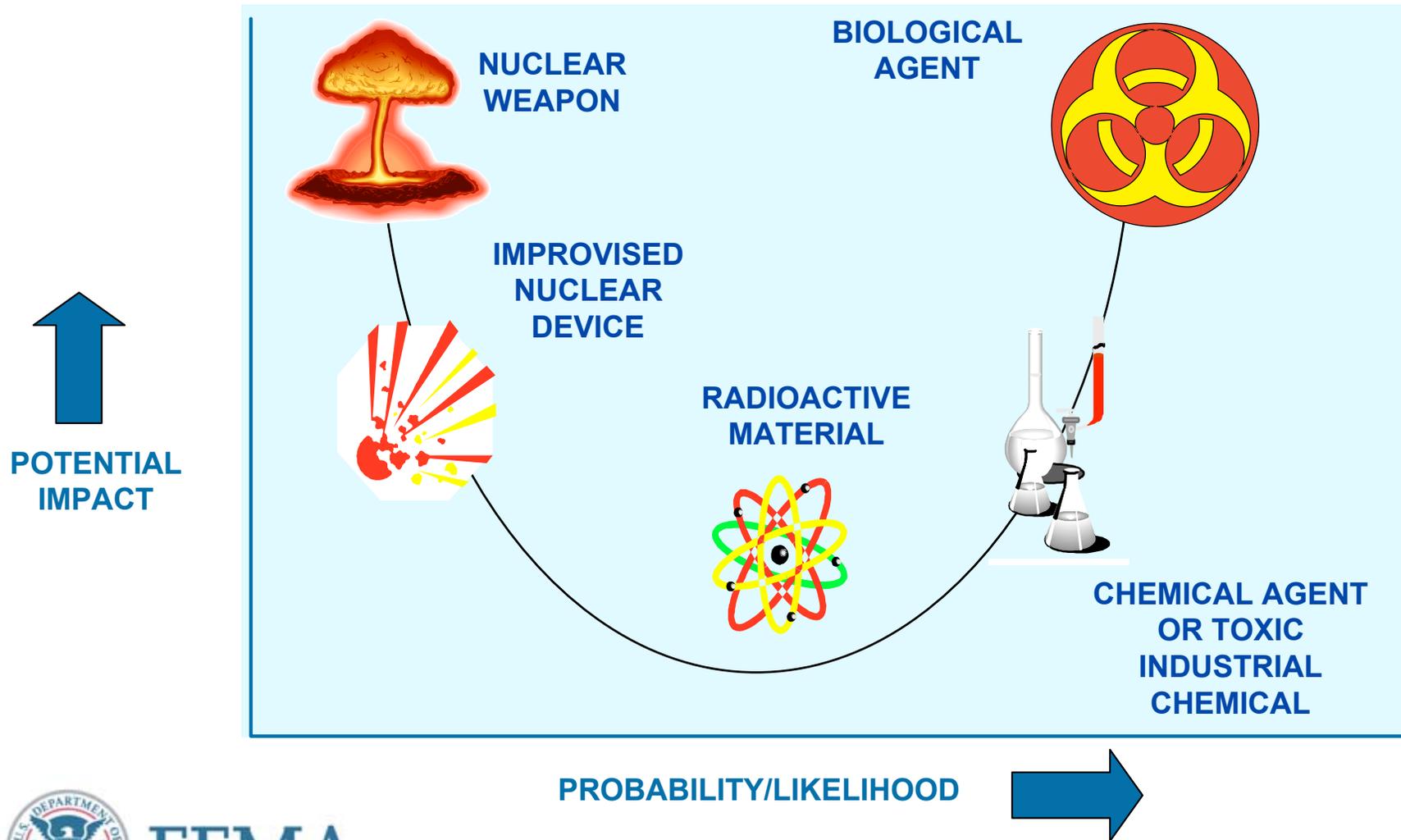
December 1995 Ricin

November 1995 Radioactive Cesium

2001 Anthrax



What is the CBR Threat?



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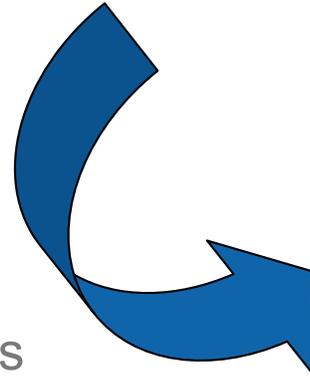
Why Would Terrorists Use CBR?

- Available and relatively easy to manufacture
- Large amounts not needed in an enclosed space
- Difficult to recognize
- Easily spread over large areas
- Strong psychological impact
- Overwhelms resources



CBR Sources

- Laboratory/commercial
- Industrial facilities
- Foreign military sources
 - At least 25 countries possess chemical agents or weapons
 - 10 countries are suspected to possess biological agents or weapons
- Medical/university research facilities
- Nuclear facilities
- Home production



Limitations of CBR Materials

- Effective dissemination is difficult.
- Delayed effects can detract from impact.
- Counterproductive to terrorists' support.
- Potentially hazardous to the terrorist.
- Development and use require skill.

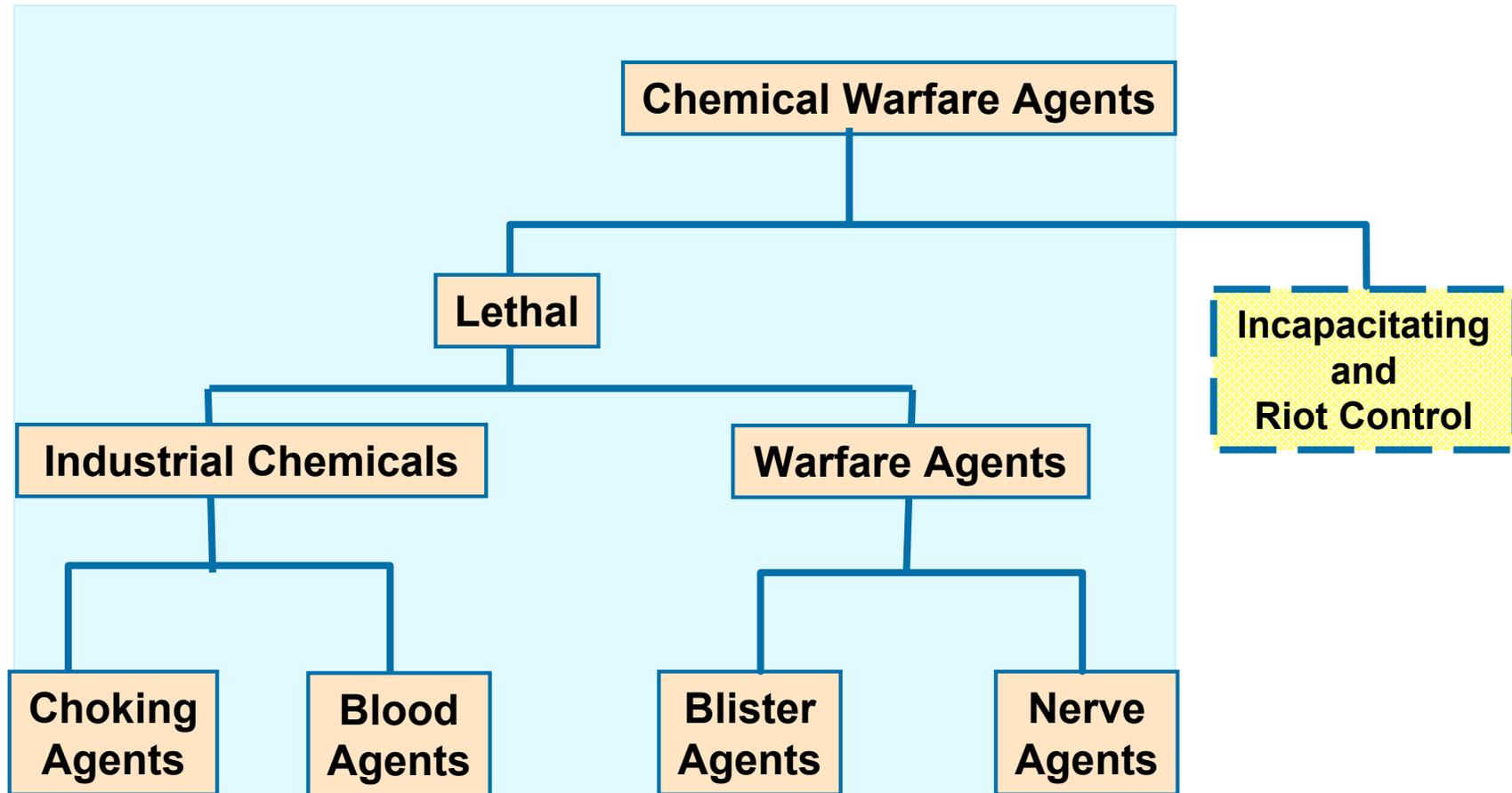


Chemical Agents: Characteristics and Behavior

- Generally liquid (when containerized)
- Normally disseminated as aerosol or gas
- Present both a respiratory and skin contact hazard
- May be detectable by the senses (especially smell)
- Influenced by weather conditions



Classes of Chemical Agents



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Industrial Chemicals

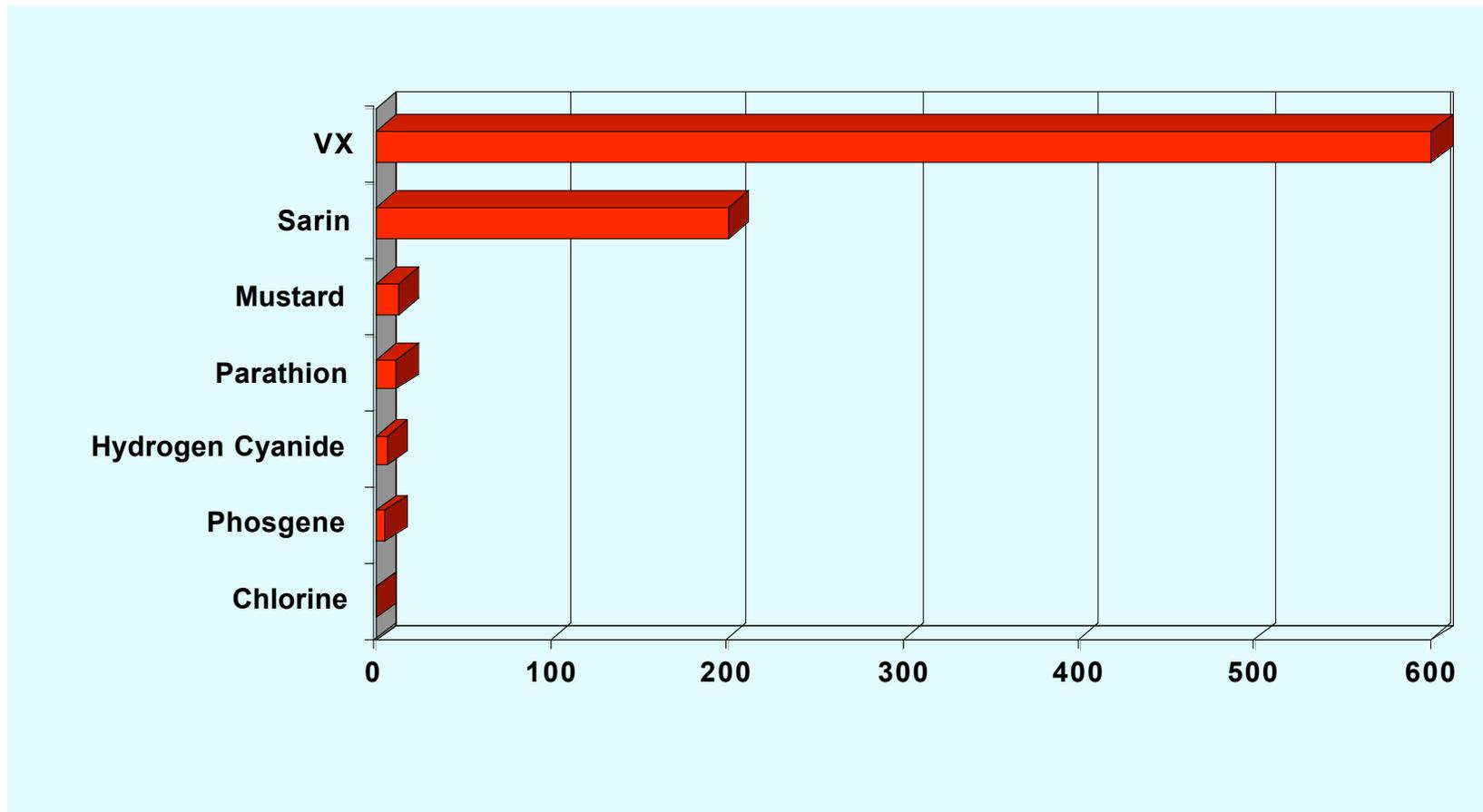
<i>Industrial chemicals previously used as chemical warfare agents</i>	Choking Agents Chlorine/Phosgene	Blood Agents Hydrogen Cyanide/ Cyanogen Chloride
Physical Appearance	Greenish-yellow vapor/ colorless vapor	Colorless Vapor
Odor	Bleach/mown hay	Bitter Almonds
Signs and Symptoms	Coughing, Choking, Tightness in chest	<ul style="list-style-type: none"> • Gasping for air • Red eyes, lips, skin
Protection	Respiratory (skin)	Respiratory (skin)
Treatment	Aeration	Aeration, cyanide kit

4 industrial chemicals previously used as chemical warfare agents



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Comparative Toxicity



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How Much Sarin Does it Take?

Structure	Lethal Amount
Domed Stadium	107 kg (26 gals)
Movie Theater	1.2 kg (5 cups)
Auditorium	52 g (1/4 cup)
Conference Room (50-100 seating)	33 g (1 shot glass)

LD₅₀ amounts for one minute exposure to sarin liquid



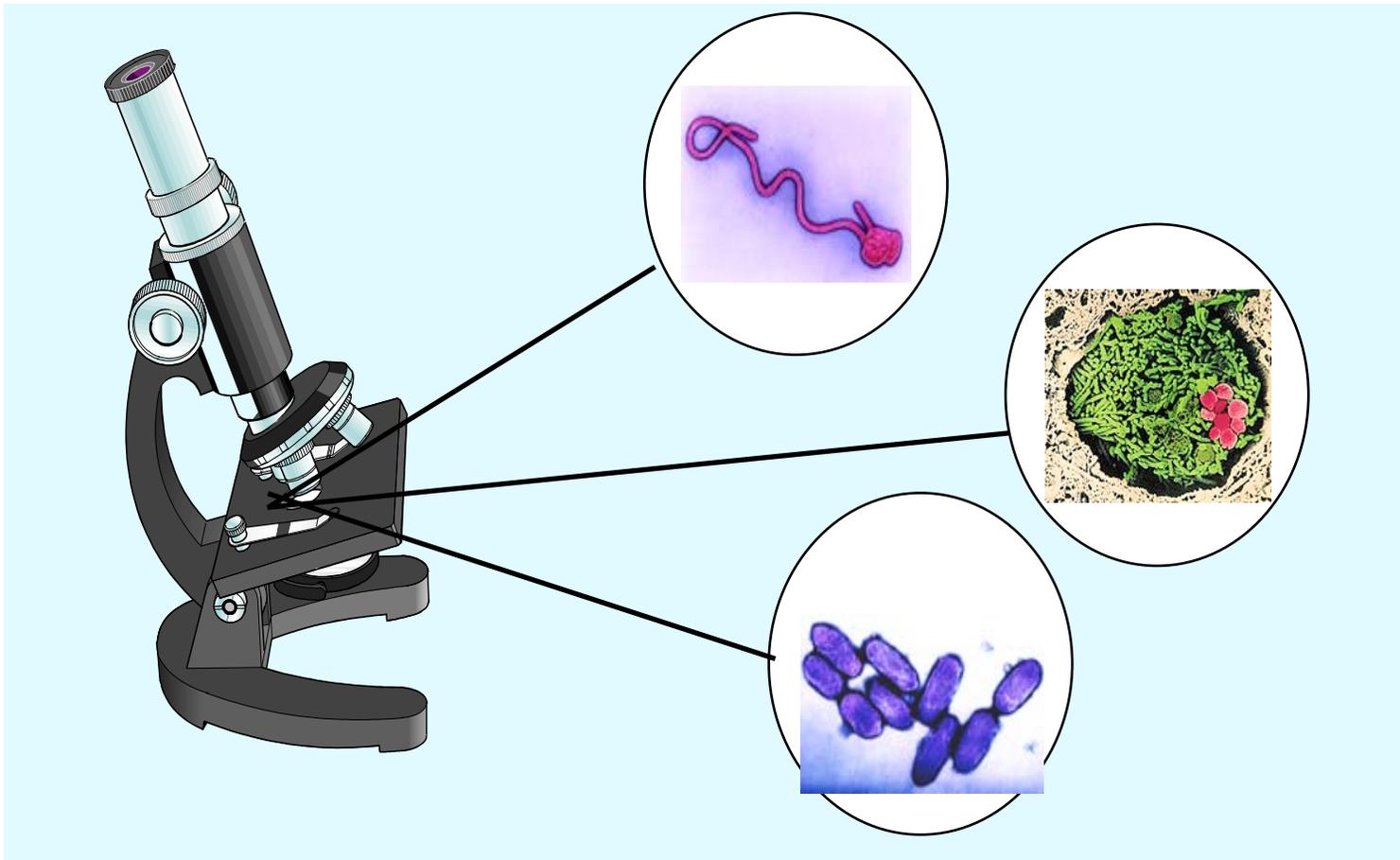
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Chemical Agents Key Points

- Chemical agents are supertoxic
- Relative toxicity: industrial chemicals < mustard < nerve
- Normal states are as a liquid or a vapor
- Inhalation hazard is of greatest concern



Biological Warfare Agents



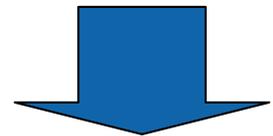
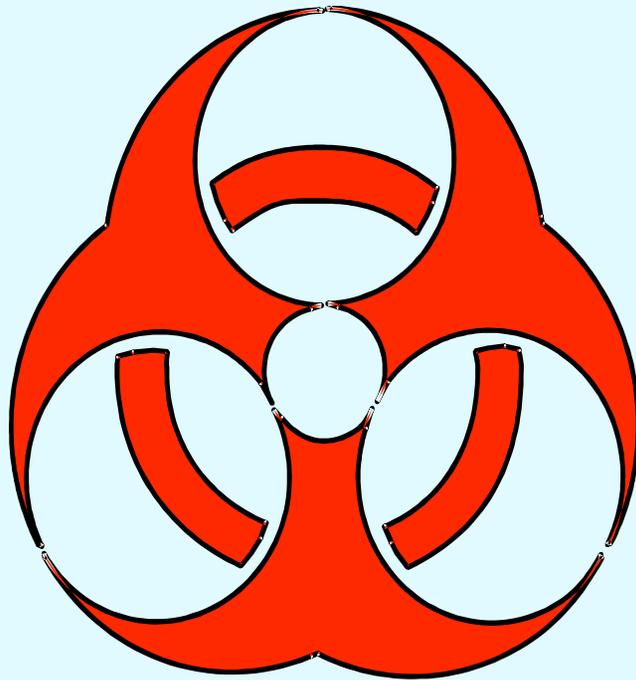
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Classes of Biological Agents

Bacteria

Viruses

Toxins



FEMA 426 - Appendix C contains a CBR glossary and characteristics of biological agents



Bacteria

	Anthrax	Plague
Incubation Period	1 to 6 days	2 to 3 days for pneumonic 2 to 10 days for bubonic
Contagious	NO	YES (pneumonic) NO (bubonic)
Signs and Symptoms	Chills, fever, nausea, swollen lymph nodes	Chills, high fever, headache, spitting up blood, shortness of breath
Protection	Standard Precautions	Standard Precautions and Droplet Precautions
Treatment	Antibiotics and vaccines	Antibiotics and vaccines



Viruses

	Smallpox	Viral Hemorrhagic Fevers
Contagious	YES	YES
Signs and Symptoms	Fever, rigors, vomiting, headache, pustules	Fever, vomiting, diarrhea, mottled/blotchy skin
Protection	Standard Precautions + Airborne + Contact Precautions	Standard Precautions + Droplet + Airborne + Contact Precautions
Treatment	Vaccine, supportive therapy	Vaccines available for some



Toxins

	Neurotoxin (Botulinum)	Cytotoxin (Ricin)
Onset of Symptoms	1 to 3 days	4-8 hours after ingestion 12-24 hours after inhalation
Contagious	NO	NO
Signs and Symptoms	Weakness, dizziness, dry mouth and throat, blurred vision, paralysis	Chills, high fever, headache, spitting up blood, shortness of breath
Protection	Standard Precautions	Standard Precautions
Treatment	Supportive care, antitoxins, and vaccines	Supportive oxygenation and hydration

Note: There are numerous naturally-occurring toxins. For our purposes, we will group them into two categories.



Biological Agents Key Points

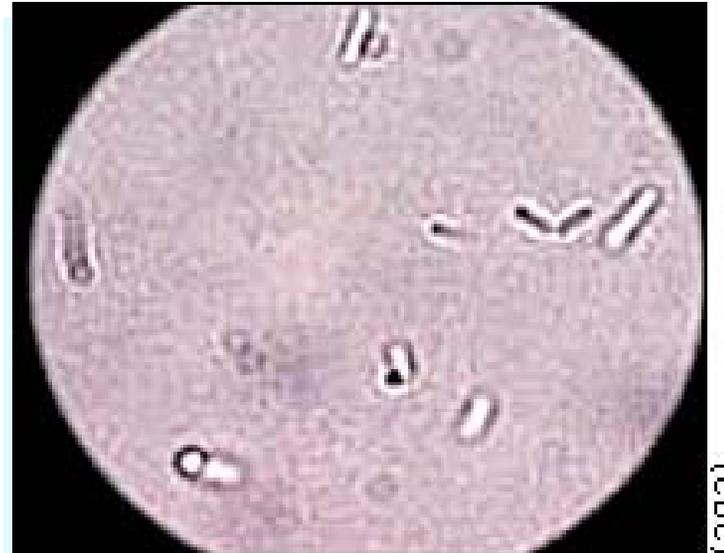
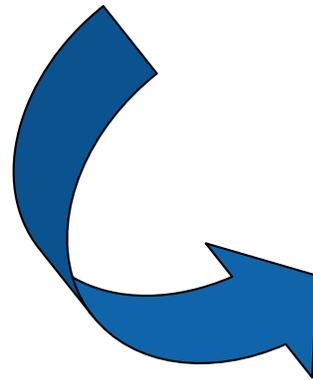
Onset of symptoms

Contagious

Signs and symptoms

Protection

Treatment



(CDC)

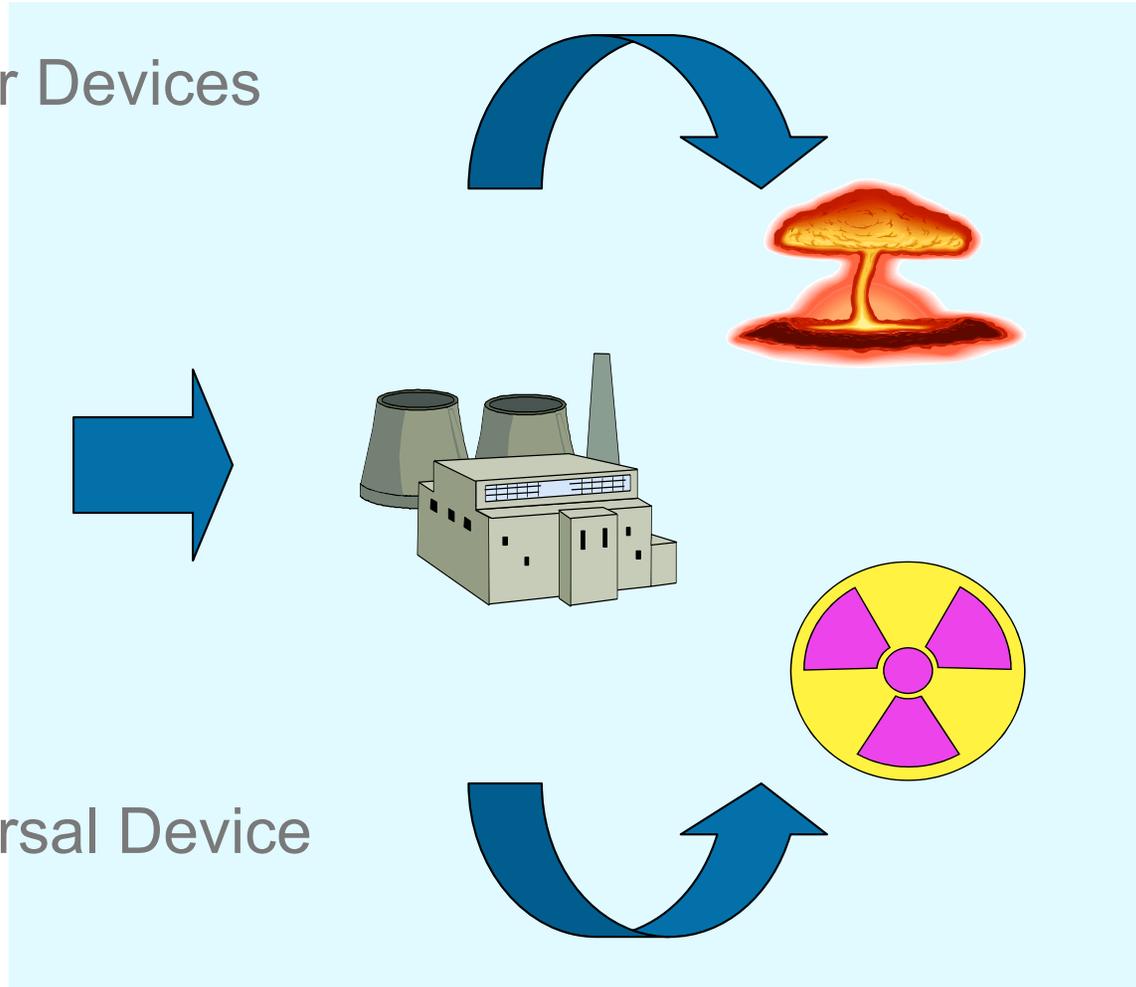


Nuclear/Radiological Materials

Improvised Nuclear Devices

Nuclear Plants

Radiological Dispersal Device



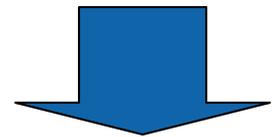
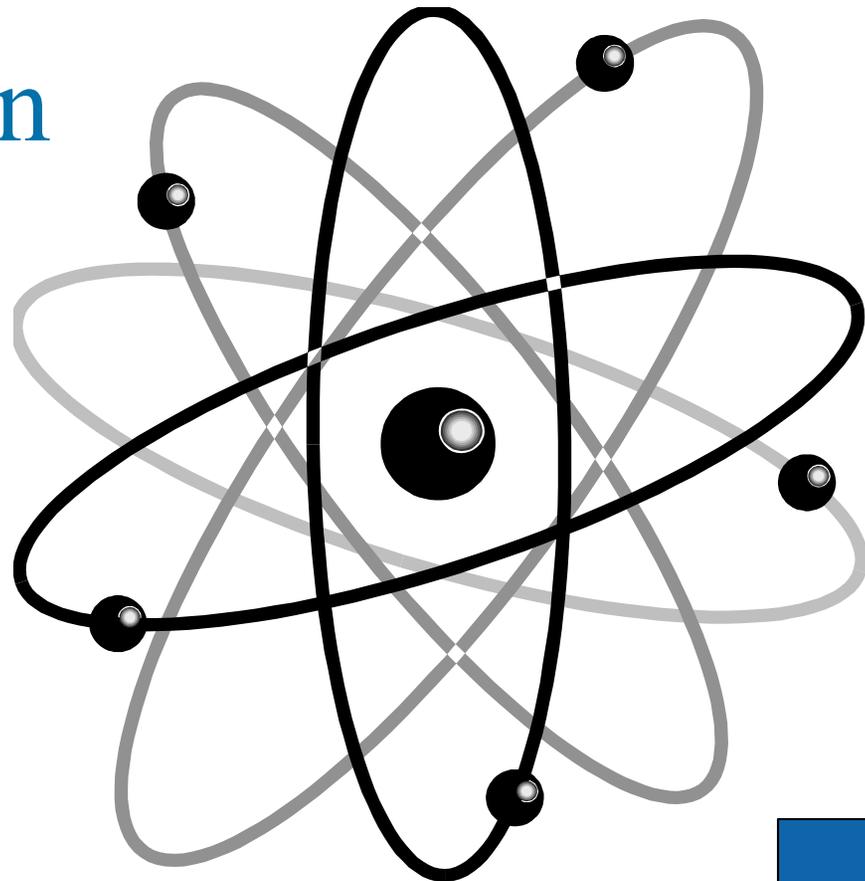
Ionizing Radiation

Alpha particles

Beta particles

Gamma rays

Neutrons



There are also non-ionizing types of radiation – fluorescent lights, lasers, and microwaves. In these examples, the radiation can cause burns, but it does not cause molecular change or ionization



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Common Radiation Exposures

Average annual exposure

360 mrem per year

Chronic

Chest x-ray

10 to 30 mrem

Flight

0.5 mrem every hour

Smoking 1.5 packs per day

16,000 mrem per year

Mild radiation sickness*

200,000 mrem

Acute

Lethal dose*

450,000 mrem

* single acute exposure



Health Hazards in an Incident

- Exposure to radiation source (external)
- Contamination (possible internal and/or external)

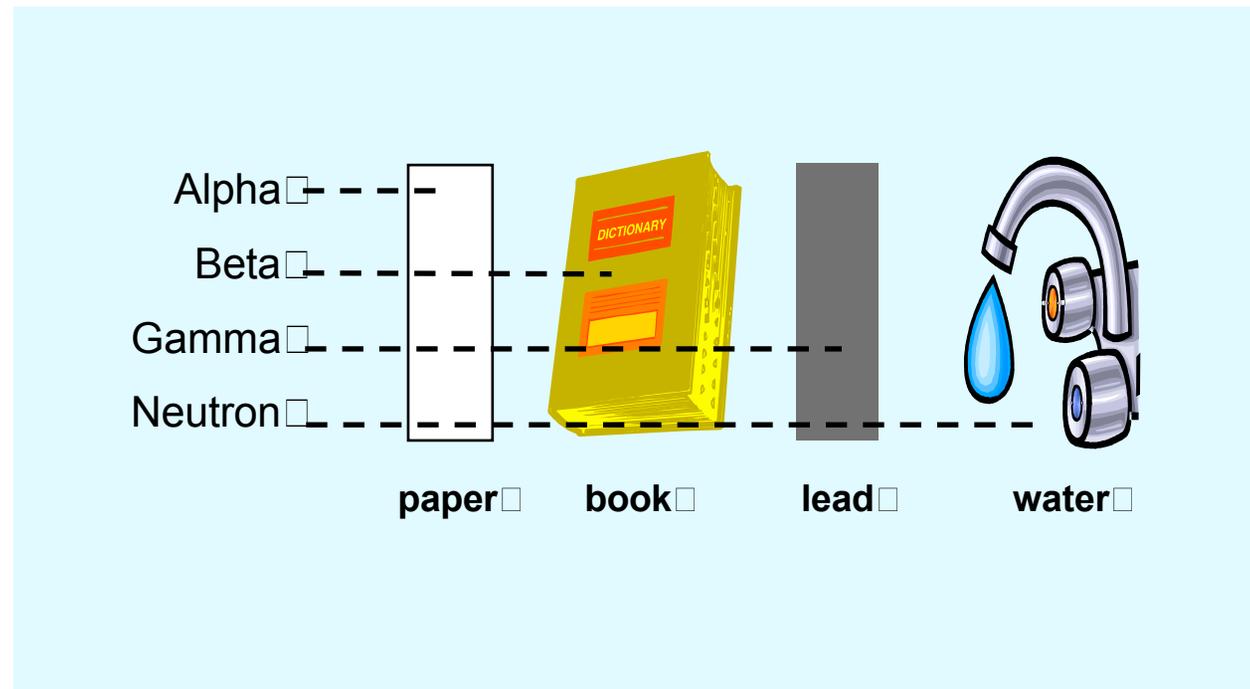


Protection from Radiation Exposure

Time

Distance

Shielding



CBR Detection

Radiological <input type="checkbox"/>	<input checked="" type="checkbox"/>
Chemical <input type="checkbox"/>	<input checked="" type="checkbox"/>
Biological <input type="checkbox"/>	<input type="checkbox"/>



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Chemical Incident Indicators (1)

Dead animals, birds, fish	Not just an occasional roadkill, but numerous animals (wild and domestic, small and large), birds, and fish in the same area.
Lack of insect life	If normal insect activity (ground, air, and/or water) is missing, check the ground/water surface/shore line for dead insects. If near water, check for dead fish/aquatic birds.
Physical symptoms	Numerous individuals experiencing unexplained water-like blisters, wheals (like bee stings), pinpointed pupils, choking, respiratory ailments, and/or rashes.
Mass casualties	Numerous individuals exhibiting unexplained serious health problems ranging from nausea to disorientation to difficulty in breathing to convulsions to death.
Definite pattern of casualties	Casualties distributed in a pattern that may be associated with possible agent dissemination methods.



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Chemical Incident Indicators (2)

Illness associated with confined geographic area	Lower attack rates for people working indoors than those working outdoors, and vice versa.
Unusual liquid droplets	Numerous surfaces exhibit oily droplets/film; numerous water surfaces have an oily film. (No recent rain.)
Areas that look different in appearance	Not just a patch of dead weeds, but trees, shrubs, bushes, food crops, and/or lawns that are dead, discolored, or withered. (No current drought.)
Unexplained odors	Smells may range from fruity to flowery to sharp/pungent to garlic/horseradish-like to bitter almonds/peach kernels to new mown hay. It is important to note that the particular odor is completely out of character with its surroundings.
Low-lying clouds	Low-lying cloud/fog-like condition that is not explained by its surroundings.
Unusual metal debris	Unexplained bomb/munitions-like material, especially if it contains a liquid. (No recent rain.)



Biological Incident Indicators

Unusual numbers of sick or dying people or animals	Any number of symptoms may occur. As a first responder, strong consideration should be given to calling local hospitals to see if additional casualties with similar symptoms have been observed. Casualties may occur hours to days or weeks after an incident has occurred. The time required before symptoms are observed is dependent on the biological agent used and the dose received. Additional symptoms likely to occur include unexplained gastrointestinal illnesses and upper respiratory problems similar to flu/colds.
Unscheduled and unusual spray being disseminated	Especially if outdoors during periods of darkness.
Abandoned spray devices	Devices will have no distinct odors.



Radiological Incident Indicators

Unusual numbers of sick or dying people or animals	As a first responder, strong consideration should be given to calling local hospitals to see if additional casualties with similar symptoms have been observed. Casualties may occur hours to days or weeks after an incident has occurred. The time required before symptoms are observed is dependent on the radioactive material used and the dose received. Additional symptoms likely to occur include skin reddening and, in severe cases, vomiting.
Unusual metal debris	Unexplained bomb/munitions-like material.
Radiation symbols	Containers may display a radiation symbol.
Heat emitting material	Material that seems to emit heat without any sign of an external heating source.
Glowing material/particles	If the material is strongly radioactive, it may emit a radioluminescence.



CBR Protection Strategies

Protective Actions:

- Evacuation
- Sheltering in Place
- Personal Protective Equipment
- Air Filtration and Pressurization
- Exhausting and Purging



Evacuation

Most common protective action

In most cases, existing plans for fire evacuation apply

- Assembly should be upwind and at least 1,000 feet away



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Sheltering in Place (1)

A building can provide substantial protection against agents released outside if the flow of fresh air is halted or significantly reduced

The amount of protection varies with:

- How tight the building is
- Duration of exposure
- Purging or period of occupancy
- Natural filtering

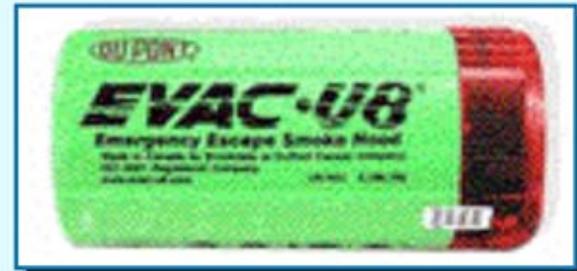
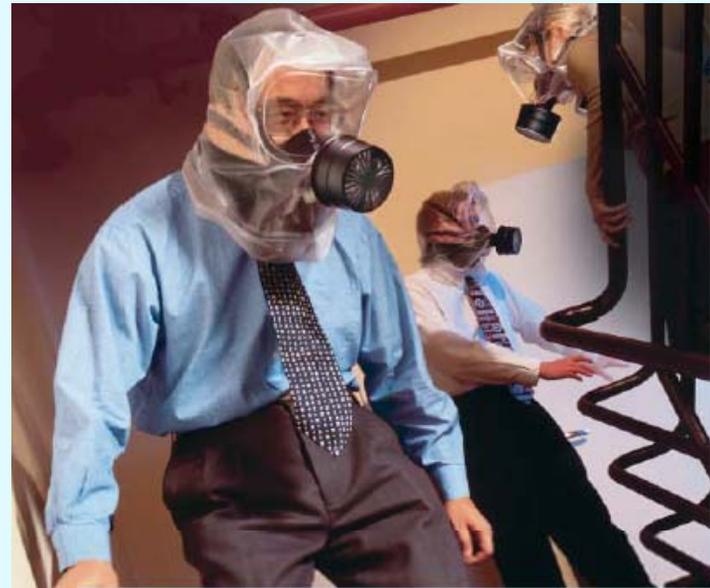


Sheltering in Place (2)

- Sheltering Plan should include:
- Identifying all HVAC equipment to be deactivated
- Identify cracks, seams, and joints to be temporarily sealed
- Prepositioning supplies
- Identify safe rooms
- Identify procedures for purging
- Identify procedures for voluntary occupant participation



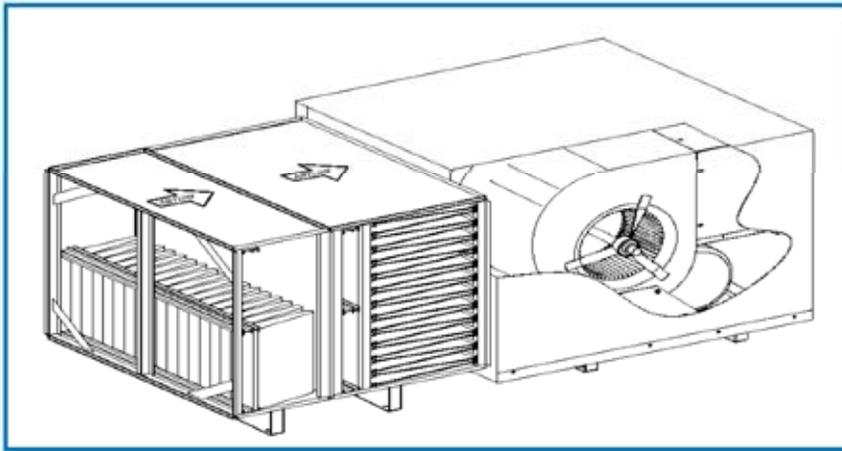
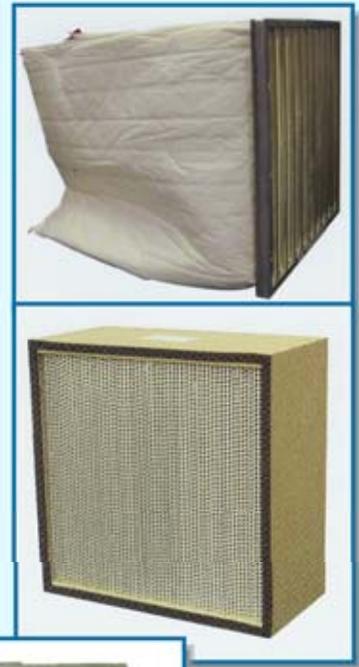
Personal Protective Equipment



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Filtration and Pressurization

- Requires modifications to HVAC and electrical systems – significant initial and life-cycle costs
- Introduces filtered air at a rate sufficient to produce an overpressure and create an outward flow through leaks and cracks



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Figure 5-5: Bag Filter and HEPA Filter, page 5-12

Air Filtration and Cleaning

Two Types of Collection Systems:

Particulate air filtration

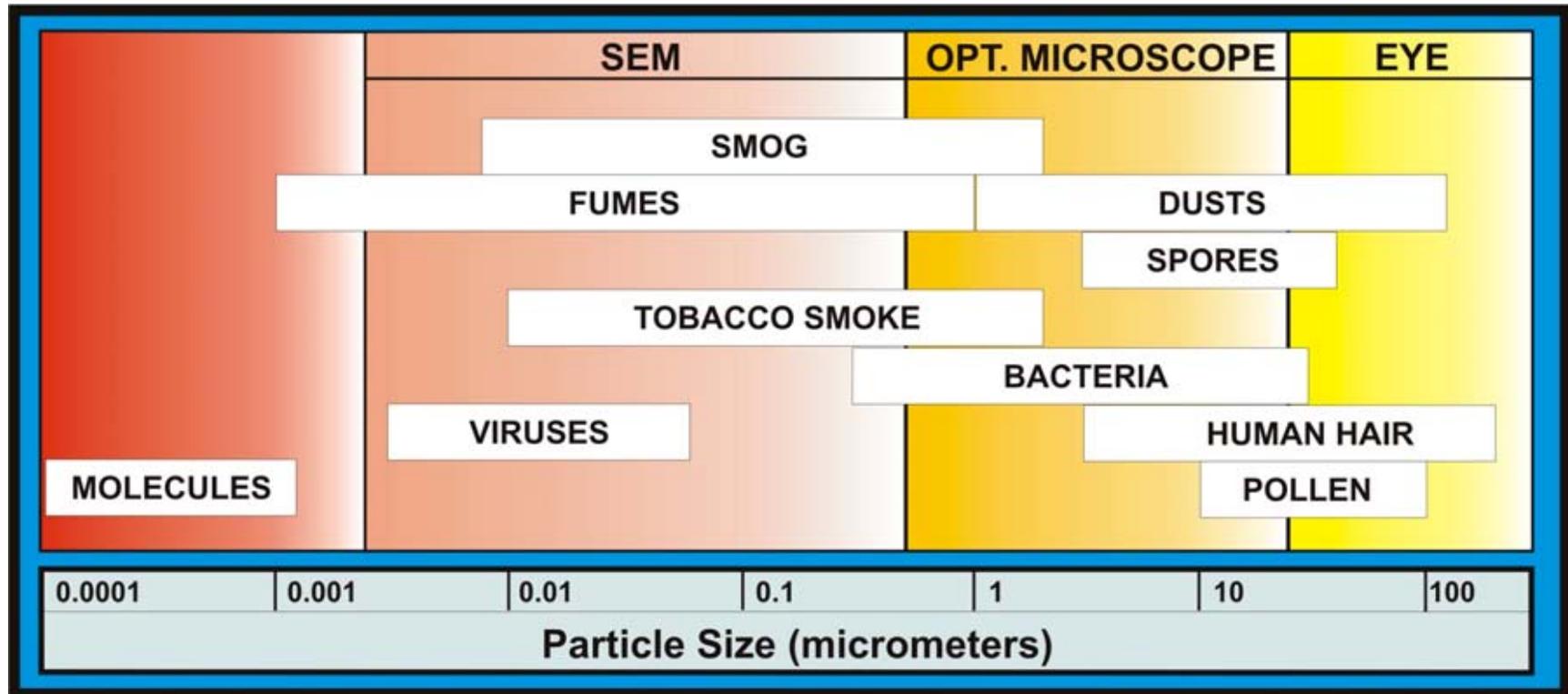
- Principles of collection
- Types of particulate filters
- Filter testing and efficiency ratings

Gas-phase air filtration

- Principles of collection
- Types of gas-phase filters



Air Contaminant Sizes



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Various Filter Types

HEPA Filters



CREDIT: FLANDERS CORPORATION

Pleated Panel Filters



CREDIT: AMERICAN FILTER

Carbon Filters



CREDIT: FLANDERS CORPORATION



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Figure 5-9 Charcoal Filter Beds (center), page 5-17

ASHRAE Standards (1)

ASHRAE 52.2				ASHRAE 52.1		Particle Size Range, μm	Applications
MERV	Particle Size Range			Test			
	3 to 10 μm	1 to 3 μm	.3 to 1 μm	Arrestance	Dust Spot		
1				< 65%		> 10	Residential, light, pollen, dust mites
2				65 - 70%			
3				70 - 75%			
4				> 75%			
5	20 - 35%			80 - 85%		3.0 - 10	Industrial, Dust, Molds, Spores
6	35 - 50%			> 90%			
7	50 - 70%			> 90%			
8	> 70%			> 95%			



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ASHRAE Standards (2)

9	> 85%	< 50%		> 95%	40 - 45%	1.0 – 3.0	Industrial, Legionella, dust
10	> 85%	50 - 65%		> 95%	50 - 55%		
11	> 85%	65 - 80%		> 98%	60 - 65%		
12	> 90%	> 80%		> 98%	70 - 75%		
13	> 90%	> 90%		> 98%	80 - 90%	0.3 – 1.0	Hospitals, Smoke removal, Bacteria
14	> 90%	> 90%	75 - 85%	> 98%	90 - 95%		
15	> 90%	> 90%	85 - 95%	> 98%	~95%		
16	> 95%	> 95%	> 95%	> 98%	> 95%		
17						< 0.3	Clean rooms, Surgery, Chembio, Viruses
18							
19							
20							



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Typical Performance of a HEPA Filter

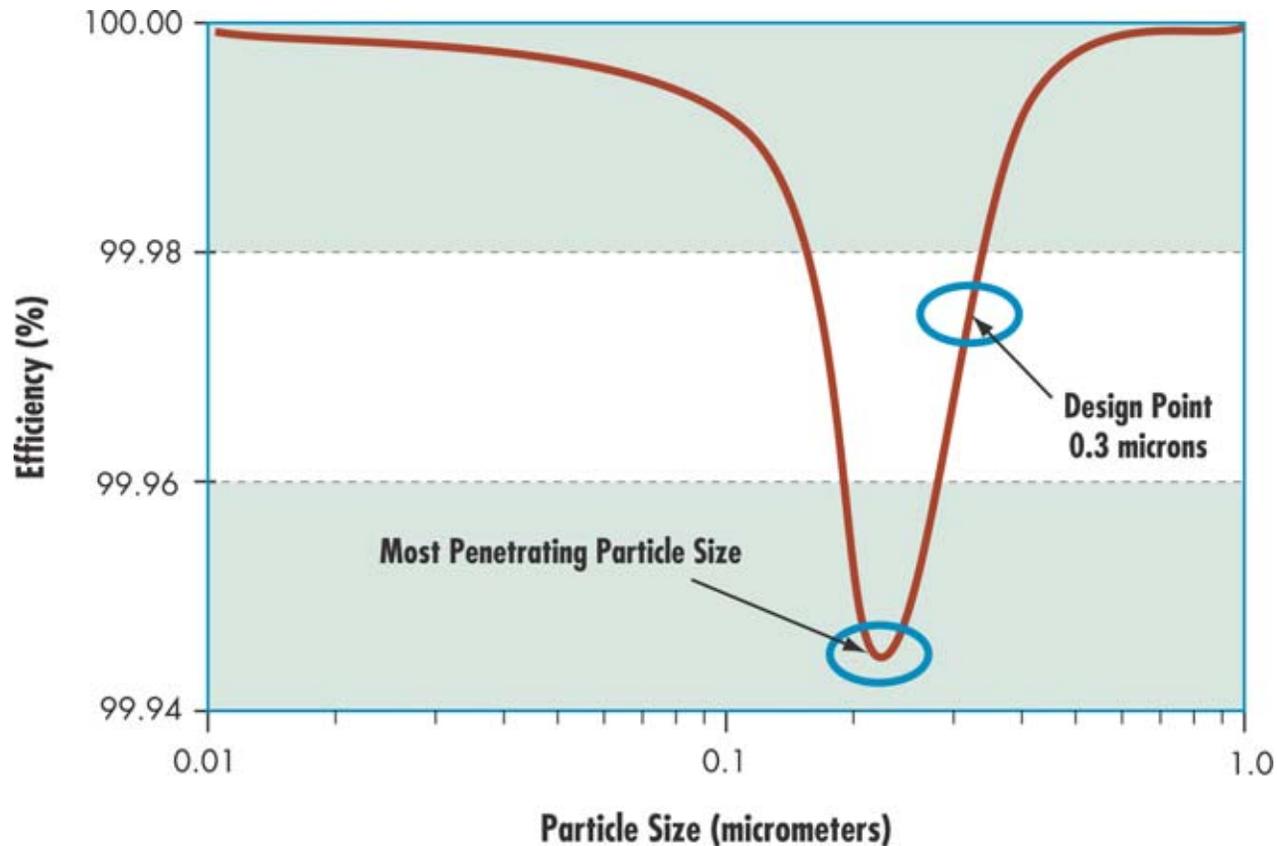


Figure 5-7 Typical HEPA Filter Performance page 5-14



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Exhausting and Purging

Basic Principles:

- Use ventilation and smoke/purge fans to remove airborne hazards.
- Use primarily for internal release or as a final action after an incident.
- Purging should be carefully applied.



Issues to Consider

- What is the threat? Toxic Industrial Chemicals, particulate, gaseous, chemical, biological?
- How clean does the air need to be and what is the associated cost?
- What is the current system capacity?
- Is there filter bypass and how significant is air infiltration into the building envelope?
- Will improved indoor air quality offset upgrade costs?
- Is system maintenance addressed?



Economic Issues to Consider

Initial Costs

- Filters, housing, blowers
- Factors including flow rate, contaminant concentration

Operating Costs

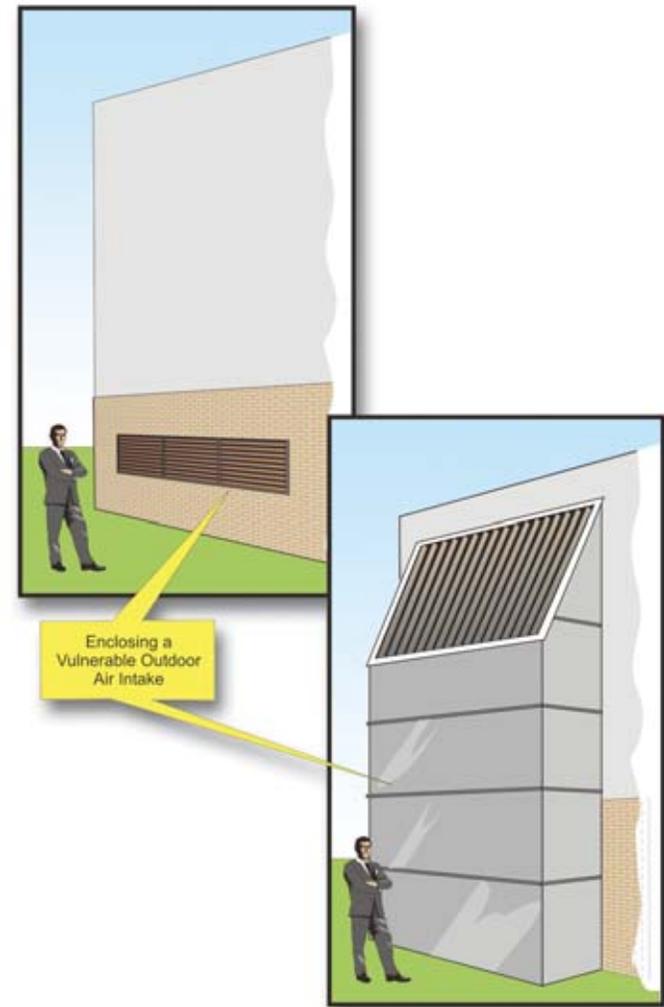
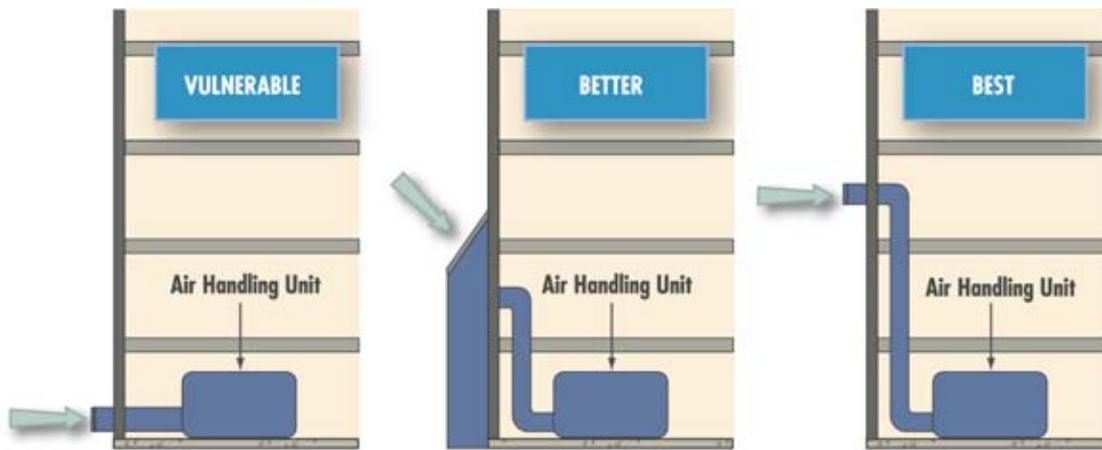
- Maintenance, replacement filters, utilities, waste disposal

Replacement Costs

- Filter life (factors include continued concentration and particle size distribution, flow rates, etc.)



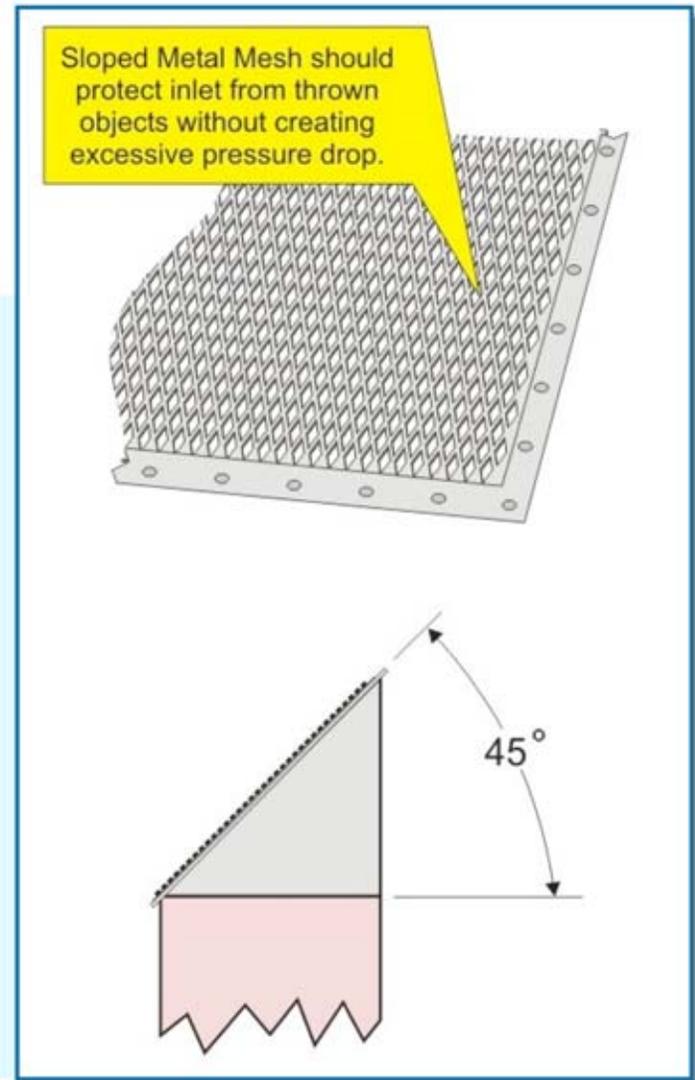
Access to Outdoor Intakes



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Extension Design Recommendations

- Lowest edge as high as possible (> 12ft)
- Sloped inlet (min. 45° recommended)
- Metal mesh protecting inlet



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Ultraviolet Germicidal Irradiation

All viruses and almost all bacteria (excluding spores) are vulnerable to moderate levels of UVGI exposure



UV lamps resemble ordinary fluoresc



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Infiltration and Bypass

Infiltration

- Building envelope tightness and ventilation control are critical

Bypass

- Filters should be airtight
- Check gaskets and seals
- Periodically check



Things Not to Do

- Outdoor air intakes should not be permanently sealed.
- HVAC systems (includes filter upgrades) should not be modified without understanding the effects on building systems or occupants.
- Fire protection and life safety systems should only be modified after careful analysis and review.



Summary

- CBR threats are real and growing.
- Industrial chemicals are readily available.
- Military chemicals require specialty expertise.
- Most buildings provide a reasonable level of protection.
- Inside versus outside building release determines evacuation decision.



Unit VII Case Study Activity

Chemical, Biological, and Radiological (CBR) Measures

Background

Purpose of activity: check on learning about the nature of chemical, biological, and radiological agents

Requirements

Refer to HIC case study and FEMA 426, and answer worksheet questions

