

Unit VIII

COURSE TITLE	Building Design for Homeland Security	TIME	75 minutes
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UNIT TITLE	Chemical, Biological, and Radiological (CBR) Measures
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OBJECTIVES	<ol style="list-style-type: none">1. Explain the five possible protective actions for a building and its occupants2. Compare filtration system efficacy relative to the particles present in CBR agents.3. Explain the key issues with CBR detection4. Identify the indications of CBR contamination
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SCOPE	The following topics will be covered in this unit:
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1. Five protective actions for a building and its occupants: evacuation; sheltering in place; personal protective equipment; air filtration and pressurization; and exhausting and purging
 2. Air filtration and cleaning principles and its application
 3. CBR detection technology currently available
 4. Indications of CBR contamination that do not use technology
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REFERENCES	<ol style="list-style-type: none">1. FEMA 426, <i>Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings</i>, Chapter 52. FEMA 426, Appendix C, Chemical, Biological, and Radiological Glossary3. Case Study – Appendix A: Suburban, Hazardville Information Company or Appendix B: Urban, HazardCorp Building as selected4. Student Manual, Unit VIII5. Unit VIII visuals
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REQUIREMENTS	<ol style="list-style-type: none">1. FEMA 426, <i>Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings</i> (one per student)2. Instructor Guide, Unit VIII3. Student Manual (one per student) for selected Case Study4. Overhead projector or computer display unit5. Unit VIII visuals6. Chart paper, easel, and markers
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UNIT VIII OUTLINE	<u>Time</u>	<u>Page</u>
VIII. CBR Measures (61 slides at 55 minutes = approx. 0.9 minutes/slide)	75 minutes	IG VIII-1
1. Introduction and Unit Overview	8 minutes	IG VIII-5
2. Chemical Agents	5.5 minutes	IG VIII-10
3. Biological Agents	6 minutes	IG VIII-13
4. Radiological Materials	4.5 minutes	IG VIII-18
5. CBR Detection and Technology	5.5 minutes	IG VIII-21
6. CBR Protection Strategies	15 minutes	IG VIII-25
7. Other Issues for Consideration	10 minutes	IG VIII-38
8. Activity: CBR Measures (15 minutes for the students, 5 minutes for instructor review)	20 minutes	IG VIII-46
WRITTEN EXAM	1 hour	
Exam	30 minutes	
Feedback	30 minutes	

PREPARING TO TEACH THIS UNIT

- **Tailoring Content to the Local Area:** This is a generic instruction unit that does not have any specific capability for linking to the Local Area. However, Units IX, Site and Layout Design Guidance, and X, Building Design Guidance are excellent opportunities to illustrate the concepts in this instruction unit as applied to the Local Area.
- **Optional Activity:** There are no optional activities in this unit, except Student Activity questions that are applicable to the selected Case Study.
- **Activity:** The students will answer questions in the Student Activity exercises using the Case Study to identify prevalent CBR threats (Design Basis Threat and others) and using FEMA 426 to answer selected filtration and mitigation measure questions.
- Refer students to their Student Manuals for worksheets and activities.
- Direct students to the appropriate page in the Student Manual.

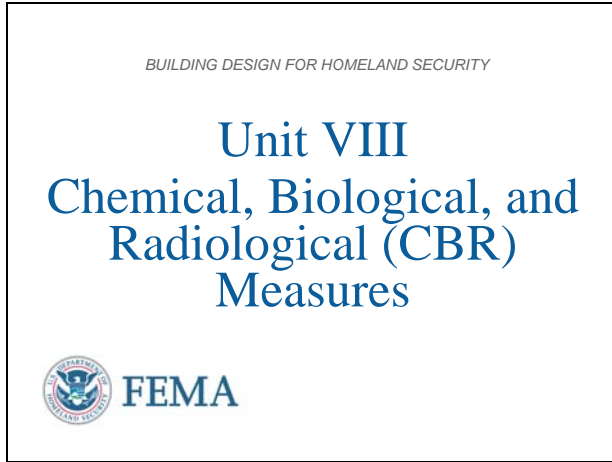
- Instruct the students to read the activity instructions found in the Student Manual.
- Tell students how long they have to work on the requirements.
- While students are working, all instructors should closely observe the groups' process and progress. If any groups are struggling, immediately assist them by clarifying the assignment and providing as much help as is necessary for the groups to complete the requirement in the allotted time.
- At the end of the working period, reconvene the class.
- After the students have completed the assignment, “walk through” the activity with the students during the plenary session. Call on different teams to provide the answer(s) for each question. Display the charts applicable to the respective question to illustrate the answer.
- If time is short, simply provide the “school solution” and ask for questions. Do not end the activity without ensuring that students know if their answers are correct or at least on the right track.
- Ask for and answer questions.

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INSTRUCTOR NOTES

CONTENT/ACTIVITY

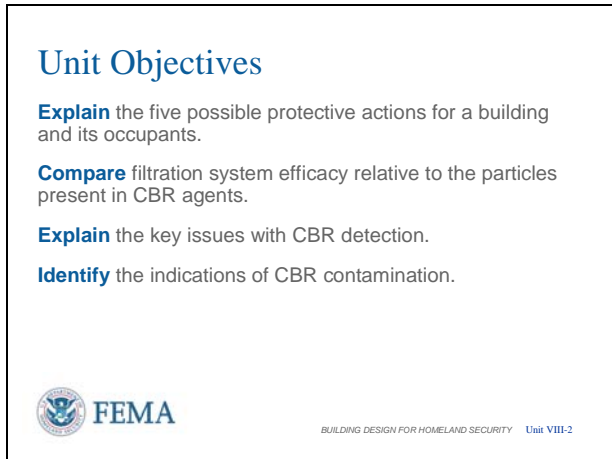
VISUAL VIII-1



Introduction and Unit Overview

This is Unit VIII CBR Measures. In this unit, CBR protective measures and actions to safeguard the occupants of a building from CBR threats are presented. The unit is based largely on CDC/NIOSH and DoD guidance.

VISUAL VIII-2



Unit Objectives

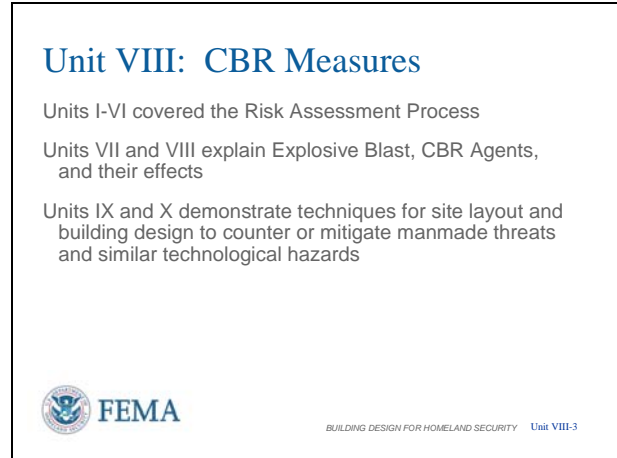
At the end of this unit, the students should be able to:

1. Explain the five possible protective actions for a building and its occupants.
2. Compare filtration system efficacy relative to the particles present in CBR agents.
3. Explain the key issues with CBR detection.
4. Identify the indications of CBR contamination.

INSTRUCTOR NOTES

CONTENT/ACTIVITY

VISUAL VIII-3



CBR Measures

This unit is based on guidance from the CDC/NIOSH and the DoD and presents protective measures and actions to safeguard the occupants of a building from CBR threats. The following will be discussed:

- Evacuation
- Sheltering in place
- Personal protective equipment
- Air filtration and pressurization
- Exhausting and purging
- CBR detection

Additionally, CBR design and mitigation measures are discussed in:

- **Chapter 3 of FEMA 426**
- **Appendix C of FEMA 426** contains a glossary of CBR terms and a summary of CBR agent characteristics

Recent terrorist events have increased interest in the vulnerability of buildings to CBR threats. Of particular concern are building HVAC systems, because they can become an entry point and distribution system for airborne hazardous contaminants. Even without special protective systems, buildings can provide protection in varying degrees against airborne hazards that originate outdoors.

VISUAL VIII-4

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 Current Technology
- Non-Technology CBR Contamination Indications



SOURCE: SENSIR TECHNOLOGIES
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-4



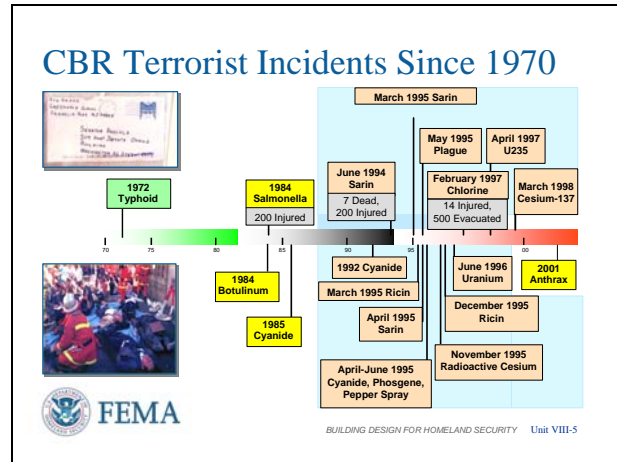
CBR Measures: FEMA 426 Chapter 5 Overview

This Unit draws on the latest research from CDC/NIOSH to present the best practices for detecting CBR agents, and safeguarding building occupants from the effects of CBR contamination.

Chapter 5 of FEMA 426 provides an overview on CBR Detection and Current Technology; and Indications of CBR Contamination, Evacuation, Sheltering in Place, Air Filtration and Pressurization, and Exhausting and Purging.

VISUAL VIII-5

CBR Terrorist Incidents Since 1970



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-5

CBR Terrorist Incidents Since 1970

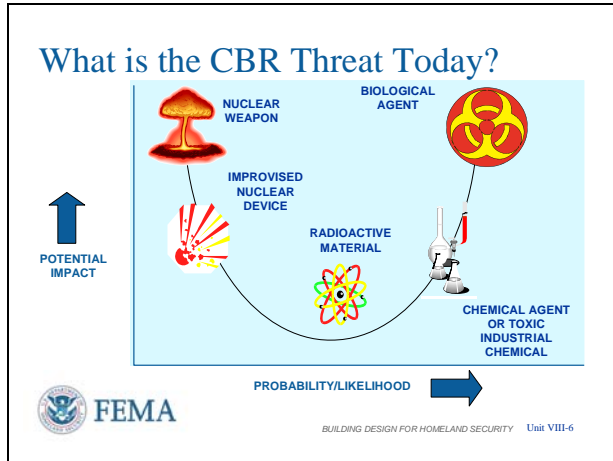
CBR attacks have been used since ancient times and, in the past 20 years, over 50 attacks have occurred.

CBR attacks require the right weather, population, and dispersion to be effective.

Recent attacks have had limited effectiveness or have been conducted on a relatively small scale.

Future attacks with Weapons of Mass Destruction could occur on a regional or global scale.

VISUAL VIII-6



What is the CBR Threat?

A fundamental question, *What is the CBR threat today?* This slide shows the relationship between the probability or likelihood of threats, and their potential impacts.

VISUAL VIII-7



Why Would Terrorists Use CBR?

- Available and relatively easy to manufacture
- Large amounts not needed in an enclosed space
- Easily spread over large areas
- Potential for mass casualties
 - Strong psychological impact
 - Overwhelms resources
 - Difficult to recognize (contagious or spread by victims)

Recent events have shown that people not directly affected by the attack, but nearby, will seek medical confirmation of health / non-contamination and quickly overwhelm medical resources.




INSTRUCTOR NOTES

CONTENT/ACTIVITY

VISUAL VIII-8

CBR Sources

- Laboratory/commercial
- Industrial facilities
- Foreign military sources
 - At least 26 countries possess chemical agents or weapons
 - 10 countries are suspected to possess biological agents or weapons
- Medical/university research facilities
- Nuclear facilities
- Home production



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-8

CBR Sources

There are many potential sources of chemical and biological agents, including laboratory and commercial production; and home production in those cases involving low concentrations of impure and inexpensive materials. Other sources include:



- Industrial facilities
- Foreign military sources
- Medical/university research facilities
- Nuclear facilities

The next series of slides will examine in more detail the properties of chemical and biological agents, **with implications for building design.**

VISUAL VIII-9

Limitations of CBR Materials

- Targeted dissemination is difficult
- Delayed effects can detract from impact
- Counterproductive to terrorists' support
- Potentially hazardous to the terrorist
- Development and use require time and expertise



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-9

Limitations of CBR Materials


- Targeted dissemination is difficult. While agents can be spread over a wide area with relative ease, targeting with sufficient concentration is much more difficult.
- Delayed effects can detract from impact. Terrorist seek immediate media impact, but many agents take time to result in impact
- Counterproductive to terrorists' support. Indiscriminate use of any WMD (Weapon of Mass Destruction), especially ones difficult to target with success, can attack innocents and those in the support base, thus reducing support of the populace for the terrorists' objectives.
- Potentially hazardous to the terrorist. Lack of expertise among terrorists can result in deadly contact with the CBR agents being produced, or premature explosion of bombs during the bomb

The slide shows the cover of Ben Laden's Terrorism Bible and The Mujahideen Poisons Handbook by Abdel Aziz. "Majahideen" - Arabic word meaning "holy warriors." This book is part of the Encyclopedia Jihad. The aim of this book is to further the military/political preparations, skills and knowledge of Mujahideen the world over.

VISUAL VIII-10

**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

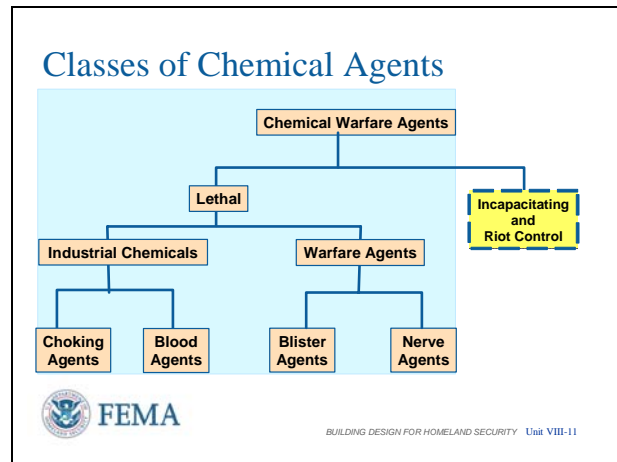


Subway riders injured in Aum Shinrikyo sarin gas attack, Tokyo, March 20, 1995. (AP Photo/Chris Clark)

FEMA
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-10

Subway riders injured in Aum Shinrikyo Sarin gas attack, in Tokyo, March 20, 1995.

VISUAL VIII-11



making process with deadly consequences

- Development and use require skill. More than one terrorist has produced bombs that will not explode and CBR agents that will not impact upon human beings to the level desired.

Chemical Agents: Characteristics and Behavior

These are the general characteristics of chemical agents

- Liquids that are spread as aerosols or gases
- Impact breathing and attack exposed skin
- May have a distinct odor that allow detection
- Greatly influenced by the weather – rain, wind, sunlight, including its own physical characteristics – heavier or lighter than air

Classes of Chemical Agents


Chemical agents are classified as either lethal or incapacitating and “riot control,” according to their intended use. For the purposes of this presentation, the emphasis has been placed on lethal agents as a consequence of their greater capacity for terrorist mischief.

- **Lethal:** These have been subdivided into two categories: industrial materials used or considered as chemical warfare agents, and chemical warfare agents, which have little or no other purpose beyond their intended use as weapons of mass destruction on the battlefield.

VISUAL VIII-12

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	Gasping for air Red eyes, lips, skin
Protection	Respiratory	Respiratory
Treatment	Aeration	Aeration, cyanide kit

Four industrial chemicals previously used as chemical warfare agents



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-12

- **Incapacitating and Riot Control:** Not considered as primary terrorist threats, due primarily to their relatively short duration of effects and minimal toxicity. Therefore, they are not discussed in detail in this unit.

Industrial Chemicals

This chart lists four industrial chemicals that were previously used as chemical warfare agents. These chemicals are used in the:

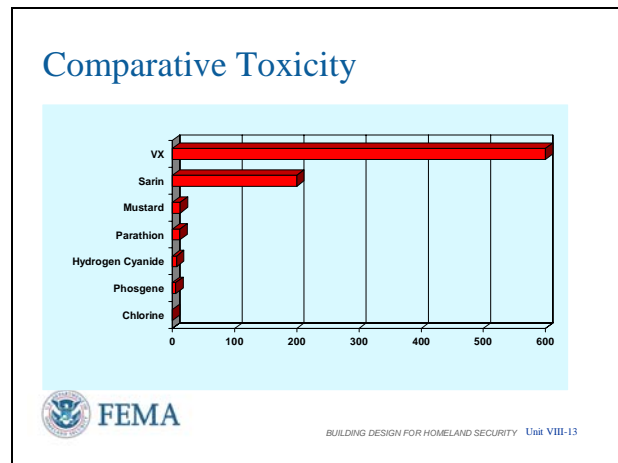
- Sanitation industry
- Plastics industry
- Pesticide industry.

All of these agents are generally respiratory agents and can be protected against by effective respiratory protection (i.e., self-contained breathing apparatus (SCBA)).

Skin contact with concentrated material may cause chemical burns and contact with eyes has similar effects as indicated by the MSDS (Material Safety Data Sheets) for these chemicals. However the main tactic for use of these chemicals does not seek this effect.

They are all exceedingly volatile and dissipate rapidly outdoors.

VISUAL VIII-13



Note: At this point, reinforce the following:
...as we collectively examine and identify opportunities to improve building safety from CBR, it is important to understand the characteristics of CBR, and their potential consequences for the public, and first responders.... detailed information on the properties of these agents can be found in Appendix C of FEMA 426.

VISUAL VIII-14

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 1 minute exposure to Sarin aerosol

Exam Questions #A15 and B15

Comparative Toxicity

This is a graphical comparison of the approximate lethalties of some chemical agents. They are based relative to Chlorine (CL or Cl) in terms of respiratory toxicity. If we use Chlorine as a baseline (1.0 on the graph):

- Phosgene (CG) is about 6 times more toxic.
- Hydrogen Cyanide (AC) is about 7 times more toxic.
- Parathion, an insecticide ingredient, is about 12 times more toxic.
- Mustard (H) is about 13 times more toxic.
- Sarin (GB) is about 200 times more toxic.
- VX (nerve agent) is about 600 times more toxic.

For skin toxicity, less than a pinhead of mustard agent is required to achieve a small blister. Less than a pinhead of VX can be lethal.

How Much Sarin Does it Take?


We have all heard of Sarin, which is among the most lethal of chemical agents. It is both odorless and colorless in pure form.

These numbers are the Lethal Doses 50 (LD₅₀) amounts for 1 minute of exposure to Sarin aerosolized liquid. This means that, in a 1-minute period, it would take approximately 26 gallons of Sarin to kill 50 percent of the people in a domed stadium, 5 cups of Sarin to kill 50 percent of the people in a movie theater, only about 1/4 cup of Sarin to kill 50 percent of the people in an auditorium, and the equivalent of a shot glass to kill 50 percent of the people in a 50-100 person conference room.

VISUAL VIII-15

Chemical Agents Key Points

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



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-15

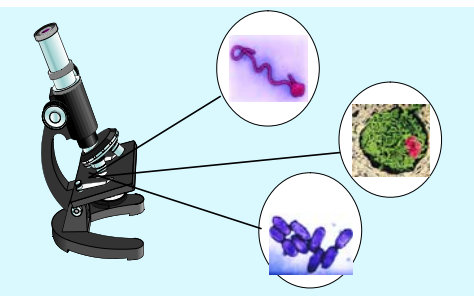
It is the aerosol that is most often fatal. For example, the Tokyo subway attack used Sarin liquid and the liquid caused very few deaths. Most casualties were from the closed subway environment where the Sarin aerosolized (evaporated) on its own in the confined space of the subway reaching toxic levels.

Chemical Agents Key Points

- Chemical agents are supertoxic. These agents were deliberately developed to cause injury or death to individuals.
- Relative toxicity: industrial chemicals < mustard < nerve. In terms of relative toxicity, the same amount of an industrial chemical is less toxic than a blister agent, and both are less toxic than a nerve agent.
- Normal states are as a liquid or a vapor. These agents are either a liquid or a vapor in their normal state. But the vapor is a more effective WMD.
- Inhalation hazard is of greatest concern. Nerve and blister agents pose both a skin and inhalation hazard. The inhalation hazard is of greater concern.

VISUAL VIII-16

Biological Warfare Agents



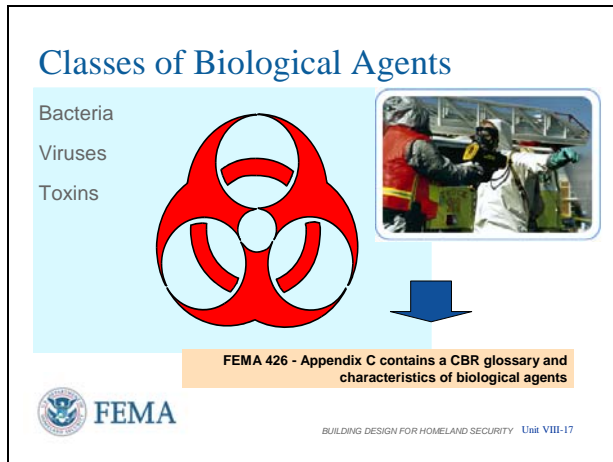
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-16

Biological Warfare Agents

Emphasize differences between chemical and biological agents:

- **Delayed effects:** The biggest difference is time. Unlike chemical agents, most of which have an immediate effect, most biological agents have a delayed effect ranging from several hours to days, and in some cases, weeks. In the event of a biological incident, there may be no casualties and nothing significant initially.
- **Toxicity:** By weight, biological agents

VISUAL VIII-17



Note: As we look at biological agents, you will see some similarities with what we discussed earlier with chemical agents, but you will also note some significant differences. Selected bacterial, viral, and toxin agents, their characteristics, and treatment are of particular concern when preparing for biological terrorism.

are generally more toxic than chemical agents. For example, Ricin is 6 to 9 times more toxic than Sarin, and Botulinum, another toxin, is 15,000 to 30,000 times more toxic than Sarin.


- **Human detection:** Biological agents are undetectable by the human senses.

Classes of Biological Agents

- Both **bacteria** and **viruses** are living organisms and, as such, require an environment in which to live and reproduce.
- They can enter the body through inhalation or ingestion, through a break in the skin, or through other body openings or orifices.
- Once the organisms invade the body, they begin to grow and reproduce. They can also produce toxins that may poison the body.
- **Toxins** are poisonous substances produced as a byproduct of pathogens or plants and even some animals.

VISUAL VIII-18

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

 BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-18

Bacteria


Anthrax and plague are two examples of diseases caused by bacteria. This chart highlights the important characteristics of each, including:

- Incubation period
- Whether they are contagious or not
- Signs and symptoms
- Protection
- Treatment

Again, a basic understanding of these characteristics will be valuable in developing an **appropriate and effective protective action strategy for your facility.**

VISUAL VIII-19

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 + Droplet + Airborne + Contact Precautions	Standard Precautions + Droplet + Airborne + Contact Precautions
Treatment	Vaccine, supportive therapy	Vaccines available for some

 BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-19

Viruses

Two viruses are highlighted: **Smallpox** and **Viral Hemorrhagic Fevers**. Both are contagious, and protective actions include the use of standard, airborne, and contact precautions.

For example, most contagion in smallpox is from people inhaling small droplets from the coughing of infected/contagious persons.

VISUAL VIII-20

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.

BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-20

Toxins

Finally, there are numerous naturally-occurring **toxins**. For our purposes, we will group them into two categories:

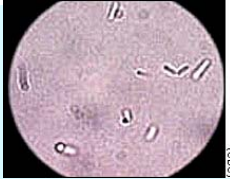
- **Neurotoxins:** Neurotoxins attack the nervous system. They are fairly fast-acting and can act in a manner opposite to that of the nerve agents because they prevent nerve-to-muscle stimulation.
- **Cytotoxins:** Cytotoxins are cell poisons. They are slower acting and can have a variety of symptoms, including vomiting, diarrhea, rashes, blisters, jaundice, bleeding, or general tissue deterioration.

There are numerous other modes of action of toxins, which are beyond our need to discuss here.

VISUAL VIII-21

Biological Agents Key Points

- Onset of symptoms
- Potentially contagious
- Signs and symptoms
- Protection
- Treatment



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-21

Biological Agents Key Points

NOTE: A very low dose of a biological agent can cause infection and spread disease, thus detection requires high sensitivity, but because there are many biologicals in the environment, detection requires selectivity, and since biological agents are very complex molecules making them difficult to identify/detect.

- **Onset of symptoms:** Most biological agents have an incubation period. Delayed effects will make identifying a biological attack more difficult.
- **Potentially Contagious:** Only a few biological agents are contagious: plague, smallpox, and viral hemorrhagic fevers (VHF), such as Ebola.
- **Signs and symptoms:** Signs and symptoms of many biological attacks initially manifest themselves as flu-like; therefore, it may be difficult to identify

Exam Questions #A14 and B13

Biological weapons are considered the emerging mass weapon of destruction of choice for terrorists because many agents can be made with standard commercial laboratory or brewing equipment.

VISUAL VIII-22

Biological Agent Categories

Some Biological agent(s)

- Variola major
- Bacillus anthracis
- Yersinia pestis
- Clostridium botulinum
- Ebola, Marburg
- Coxiella burnetii
- Brucella spp.
- Burkholderia mallei
- Burkholderia pseudomallei
- Toxins
- Food/Water safety threats
- Emerging threat agents

Disease

Category A

- Smallpox
- Anthrax
- Plague
- Botulism
- Tularemia
- Viral hemorrhagic fevers

Category B

- Q Fever
- Brucellosis
- Glanders
- Melioidosis
- Psittacosis
- Ricin toxin
- Typhus
- Cholera
- Shigellosis

FEMA

BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-22

that an attack has occurred.

- **Protection:** Standard precautions will be adequate protection against most biological agents.
- **Treatment:** Some biological agents can be treated with antibiotics, vaccines, and antitoxins; for agents for which there are none of the aforementioned treatments, supportive care should be administered, such as treating the symptoms.

The recent SARS and Avian Flu outbreaks demonstrate the relative ease by which naturally-occurring biological agents can quickly transmutate and spread across the globe. The flu strain that caused the Flu Pandemic of 1918 is still an active strain.

Biological Agent Categories

Agents are placed in one of three priority categories for initial public health Preparedness efforts based on the overall criteria and weighting of each agent.

Category A: Carry the highest priority because they:

- Can be easily disseminated or spread person-to-person
- Can be highly lethal
- Have the potential for serious public health impact
- Can potentially cause public panic and lead to social disruption

Category B: Carry the second-highest priority because they:

- Are moderately easy to disseminate
- Usually result in moderate morbidity
- Are generally less lethal

Category C: They include emerging pathogens that could potentially be engineered for future mass dissemination.

Course Title: Building Design for Homeland Security

Unit VIII: Chemical, Biological, and Radiological (CBR) Measures

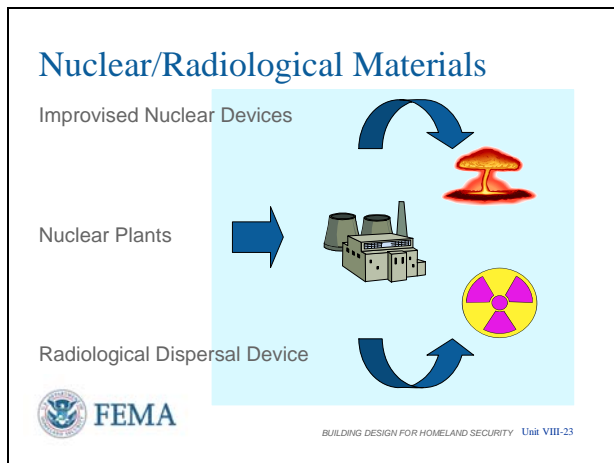
INSTRUCTOR NOTES

CONTENT/ACTIVITY

- Nipah virus
- Hantavirus

Not believed to present a high bio terrorism risk to the public health today, but could emerge as future threats.

VISUAL VIII-23



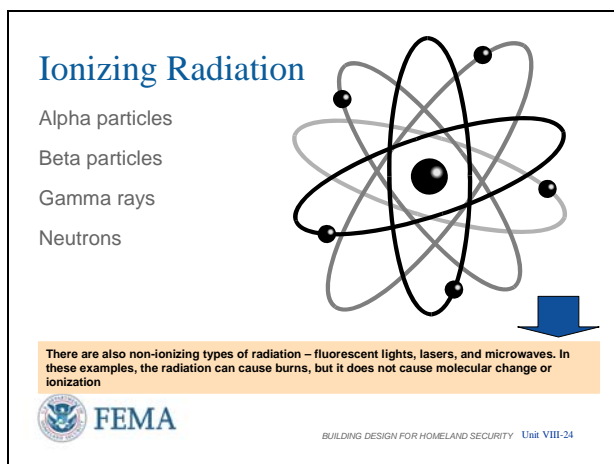
Nuclear/Radiological Materials

Of the three types of threats (chemical, biological, or nuclear/radiological), a **nuclear weapon explosion** is considered the least likely for terrorist use; however, the potential exists for it to happen and even more potential exists for the use of radiological materials.

Possible scenarios:

- Detonation of an **improvised nuclear device** (IND)
- Terrorist attack on a **nuclear plant**
- Use of a **radiological dispersal device** (RDD), or “dirty” bomb – the simple act of spreading the materials

VISUAL VIII-24



Ionizing Radiation

Ionizing radiation is either particle radiation or electromagnetic radiation in which an individual particle/photon carries enough energy to ionize an atom or molecule by completely removing an electron from its orbit. If the individual particles do not carry this amount of energy, it is essentially impossible for even a large flood of particles to cause ionization. These ionizations, if enough occur, can be very destructive to living tissue, and can cause DNA damage and mutations.

Exam Questions #A13 and B12

Note: In its simplest definition, radiation can be defined as either electromagnetic or particulate emissions of energy from the disintegration of the nucleus of an atom. This energy, when impacting on or passing through material, including humans, can cause some form of reaction.

For our purposes, ionizing radiation includes:

- **Alpha particles**
- **Beta particles**
- **Gamma rays**
- **Neutrons**

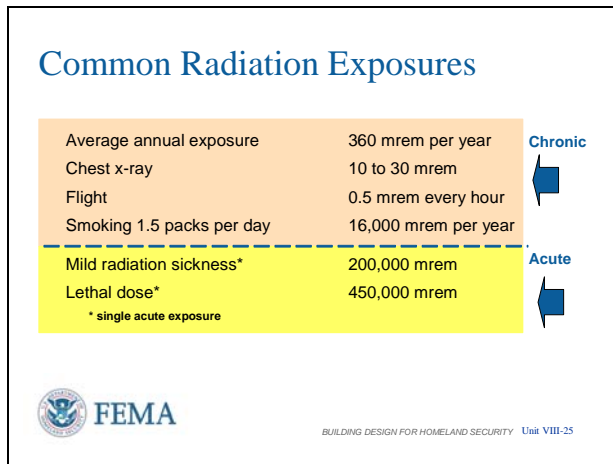
Again, for the purposes of this course, we are primarily concerned with the *hazard*, the *detection* of the hazard, and *protective*

INSTRUCTOR NOTES

CONTENT/ACTIVITY

Radioactive material: Any material that is giving off some form of ionizing radiation.

VISUAL VIII-25



Note: Mild radiation sickness (i.e., nausea, vomiting, and diarrhea) may onset after receiving a whole body dose of approximately 200,000 mrem in a short amount of time (generally less than 24 hours). The Lethal Dose (LD), known as the LD50/60, is a single, acute, whole body exposure of around 450,000 mrem. The LD50/60 is defined when 50 percent of all people present at an incident receive 450,000 mrem and die after 60 days after receiving no medical treatment.

actions that we can take.

Ionizing radiation is what causes injury or death, and is also a characteristic by which nuclear materials can be measured and identified.

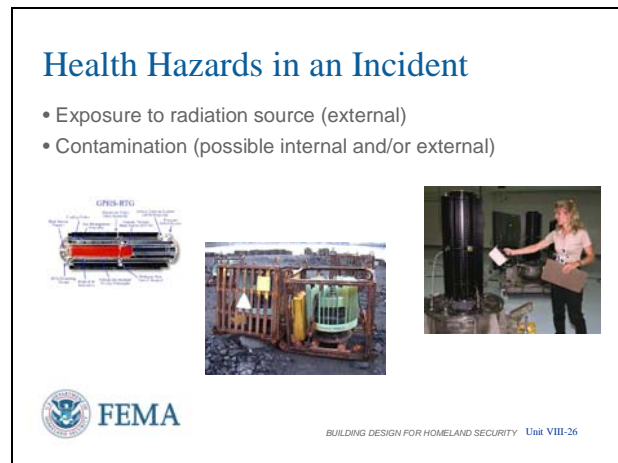
Common Radiation Exposures

This chart reflects naturally-occurring radiation doses (and doses received during normal activities) to provide a point of reference and for comparison. The threshold for any real consequences begins around 200,000 mrem.

The average annual radiation exposure has been calculated as:

Naturally occurring	295 mrem
Medical	52 mrem
Consumer products	10 mrem
Other	<u>3 mrem</u>
<i>Total</i>	<i>360 mrem</i>

VISUAL VIII-26



Exam Questions #A24 and B25

Note: Internal exposure through wounds or broken skin is also possible. Responders should take extra precautions when sharp objects, such as broken glass or jagged metal, are at the scene.

Left Photo - This image shows the cut-away of an actual Radioisotope Thermoelectric Generators (RTG) Unit which produces electricity via the thermoelectric effect.
Center Photo - RTG from the Cassini program.
Right Photo - RTG abandoned on the Kola Peninsula, Russia

Exam Questions #A24 and B25

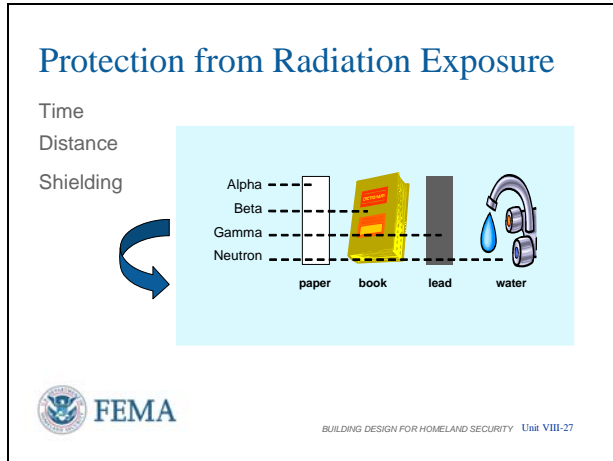
Health Hazards

The two radiation concerns at an incident are exposure and contamination by radioactive material. External irradiation occurs when all or part of the body is exposed to penetrating radiation from an external source. Contamination means that radioactive materials in the form of gases, liquids, or solids are released into the environment and get on people externally, get in them internally, or both.

Incidents involving either an explosion or fire will elevate the potential for internal or external contamination due to the spreading of the radioactive material in the form of small fragments (dust) or smoke. These materials can often be carried long distances downwind.

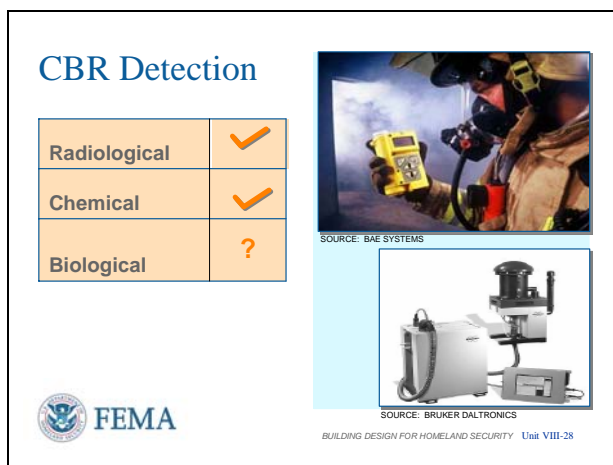
Radiological materials are both colorless and odorless.

VISUAL VIII-27



Note: Do not shield neutron-producing sources with lead or dense materials as the neutrons react with the material to produce gamma rays. Use wax, water, or plastic instead.

VISUAL VIII-28



Exam Questions #A14 and B13

Exam Questions #A19 and B20

Protection from Radiation Exposure

The radiation exposure received will depend on the type and strength of radiation source. This exposure can be reduced by effective use of:

- **Time:** The radiation dose is reduced in proportion to reduction in exposure time.
- **Distance:** Distance is also critical for reducing radiation exposure dose. Although alpha particles only travel a little over an inch in air, and beta particles will travel only a few yards in air, gamma rays can travel extensive distances.
- **Shielding:** Radiation can also be blocked or reduced by various materials. Alpha radiation is stopped by a sheet of paper, beta radiation is stopped by aluminum foil or clothing, gamma rays are only reduced by dense materials such as lead or earth, and neutrons are slowed or stopped by hydrogenous materials, such as wax or water.

CBR Detection

The underlying theme of this chapter is that effective protection against potential releases of CBR is a function of:

- 1) Effective and timely detection of the agent(s); and
- 2) A public that is knowledgeable of the most appropriate protective actions to take in the event of a CBR release.

The discussion on **CBR detection** includes:

- CBR detection technology currently available.
- Indications of CBR contamination.
- Mass spectrometry. (can positively identify a chemical agent at very low concentrations)

INSTRUCTOR NOTES

CONTENT/ACTIVITY

Sources of useful technical information:

- *NBC Products and Services Handbook* contains a catalogue of CBR detection equipment.
- *Guide for the Selection of Chemical Agent and Toxic Industrial Material Detection Equipment for Emergency First Responders*, published by the National Institute of Justice (NIJ) (Guide 100-00, Vols 1 & 2), June 2000.
- *An Introduction to Biological Agent Detection Equipment for Emergency First Responders*, published by the NIJ (Guide 101-00): December 2001.


Exam Questions #A14 and B13

Exam Questions #A19 and B20

VISUAL VIII-29

CBR Incident Indicators

Indicator	Chemical	Biological	Radiological
Dead Animals	✓		✓
Lack of Insect life	✓		
Physical Symptoms	✓	✓	✓
Mass Casualties	✓		✓
Unusual Liquids	✓		
Unexplained Odors	✓		
Unusual Metal Debris/Canisters	✓	✓	✓
Heat Emitting or Glowing			✓
Spray Mechanisms	✓	✓	

 FEMA

BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-29

Exam Questions #A16 and B16

- Most strategies for protecting people from airborne hazards require a means of detection (determining that a hazard exists).
- **Chemical detection** technology has improved vastly since Operation Desert Storm (when many military detection systems experienced high false-alarm rates). Current chemical detectors work in about 10 seconds.
- **Biological detection** technology has not matured as fast; generally require trained specialists to administer; biological signatures can take 30 minutes to detect. Biological detection requires sensitivity (very low effective dose must be detected), selectivity (there are many biologicals in the environment, thus must discern the contagious/deadly ones), and identification of very complex molecules (the complexity makes them difficult to identify).

A variety of **radiological detectors** have been developed for the nuclear industry and are commercially available.

CBR Incident Indicators

This is a summary table indicating warning properties of CBR agents in terms of dead animals, lack of insect life, physical symptoms, mass casualties, unusual liquids, unexplained odors, unusual metal debris, heat emitting or glowing, and spray mechanisms.

Details provided in visuals VIII-30, -31, -32, and -33.

INSTRUCTOR NOTES

CONTENT/ACTIVITY


In general, chemical agents will typically have a rapid onset of symptoms, while the response to biological or radiological agents can be delayed. Potential indicators of threats include suspicious packages or containers or unusual powders or liquids, droplets, mists, or clouds found near air-intake, in air-ventilation ductwork, and HVAC systems.

VISUAL VIII-30

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.
Loss 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.

Chemical agents have a rapid onset of symptoms



FEMA 426, Table 5-2: Indicators of a Possible Chemical Incident, p. 5-34
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-30

Chemical Incident Indicators


Most hazardous chemicals have warning properties that provide a practical means for detecting a hazard and initiating protective actions. Such warning properties make chemicals perceptible; for example, vapors or gases can be perceived by the human senses (i.e., smell, sight, taste, or irritation of the eyes, skin, or respiratory tract) before serious effects occur.

In the absence of a warning property, people can be alerted to some airborne hazards by observing symptoms or effects in others. This provides a practical means for initiating protective actions, because the susceptibility to hazardous materials varies from person to person.

VISUAL VIII-31

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. (Not current drought.)
Unexplained odors	Smells may range from fruity to flowery to sharp/pungent to garlic/horseradish like to bitter almond/peach kernels to new mown hay. It is important to note that the particular odor is completely out of character with its surroundings.
Low-flying clouds	Low-flying clouds/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.)



FEMA 426, Table 5-2: Indicators of a Possible Chemical Incident, p. 5-34
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-31


Chart 2 depicts the following chemical indicators: definite pattern of casualties; illness associated with a confined geographic area; unused liquid droplets; areas that look different in appearance; unexplained odors; low-flying clouds; and unusual metal debris.

VISUAL VIII-32

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.

Biological agents will typically have a more delayed effect

 FEMA FEMA 426, Table 5-3: Indicators of Possible Biological Incident, p. 5-35
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-32

Exam Questions #A16 and B16

Biological Incident Indicators

In the case of a biological incident, the onset of symptoms takes days to weeks and, typically, there will be no characteristic indicators. Because of the delayed onset of symptoms in a biological incident, the area affected may be greater due to the migration of infected individuals.

The indicators of biological attack easiest to identify are unscheduled and unusual spraying and abandoned spray devices.

Let's make a distinction between bioterrorism against people and against animals:

People: Farmers might see cows/livestock get anthrax after an anthrax biological attack (but not cats and dogs). No other commonly discussed biological agents used for people will affect animals. Alternately, rats carry fleas that spread plague, but the rats don't get plague.


Animals: Unlikely to happen and if it does few people are going to see it for what it is. It makes another distinction between biological and chemical indicators. However, if the attack is against animals, then animal effects are indications. For example foot and mouth disease or pseudo rabies or swine flu or bird flu would cause huge animal losses but no human deaths (unless you count the recent bird flu deaths by people handling infected poultry and this in contact). But these latter instances are not bioterrorism yet.

VISUAL VIII-33

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.

Radiological agents will typically have a more delayed effect

 FEMA FEMA 426, Table 5-4: Indicators of a Possible Radiological Incident, p. 5-36
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-33

Radiological Incident Indicators

In the case of a radiological incident, the onset of symptoms also takes days to weeks to occur and typically there will be no characteristic indicators. Radiological materials are not recognizable by the senses because they are colorless and odorless.


It is fortunate the radiological detectors are so mature to detect radiation sources and residual radiation.

VISUAL VIII-34

CBR Protection Strategies

Protective Actions:

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

 FEMA FEMA 426, Table 5-4: Indicators of a Possible Radiological Incident, p. 5-36
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-34

CBR Protection Strategies

Once the presence of an airborne hazard is detected, there are five possible **protective actions** for a building and its occupants. In increasing order of complexity and cost, these actions are:

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

To ensure the protective actions are effective you must have:


- A protective action plan specific to each building
- Training and familiarization for occupants

Protective actions are discussed in more detail in the following sections.

VISUAL VIII-35

Evacuation

- Determine airborne hazard source -- internal or external
- Determine if evacuation will make things better or worse
- Assembly should be upwind, at least 1,000 feet away, and three different locations (A, B, C plan)
- In most cases, existing plans for fire evacuation apply – follow through - exercise



FEMA
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-35

This map displays 1,000 foot radius to determine minimum evacuation distance, 2,000 feet would be better.

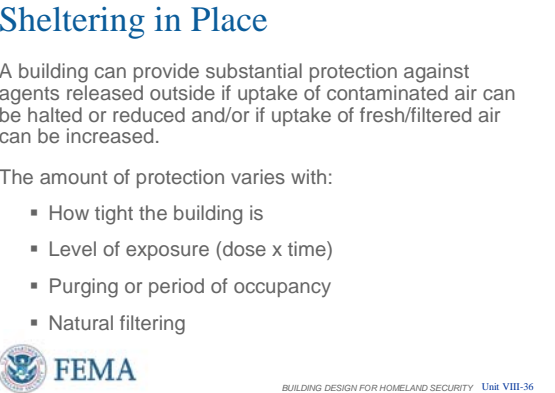
VISUAL VIII-36

Sheltering in Place

A building can provide substantial protection against agents released outside if uptake of contaminated air can be halted or reduced and/or if uptake of fresh/filtered air can be increased.

The amount of protection varies with:

- How tight the building is
- Level of exposure (dose x time)
- Purging or period of occupancy
- Natural filtering



FEMA
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-36

Exam Questions #A12 and B14

Evacuation

- Evacuation is the most common protective action taken when an airborne hazard, such as smoke or an unusual odor, is perceived in a building.
- There must be some detection method or knowledgeable personnel in place to make the determination of what to do – evacuate or some other action. This may be trained first responders, but even their response time can be too long depending upon the situation.
- Orderly evacuation is the simplest and most reliable action for an internal airborne hazard, but may not be the best action in all situations, especially in the case of an external CBR release, particularly one that is widespread.
- If some agent has infiltrated the building and evacuation is deemed not to be safe, the use of protective hoods may be appropriate.
- The evacuation plan should list each contingency and the decision process.

Sheltering in Place

Interrupting the flow of fresh air is the principal applied in the protective action known as sheltering in place.

Advantage: It can be implemented rapidly.

Disadvantage: Protection is variable and diminishes with the duration of the hazard.

The level of protection that can be attained by sheltering in place is substantial, but it is less than can be provided by high-efficiency filtration of the fresh air introduced into the building.

INSTRUCTOR NOTES

CONTENT/ACTIVITY

In most cases, air conditioners and combustion heaters cannot be operated while sheltering in place because operating them increases the outdoor-indoor exchange of air.

Sheltering in place is, therefore, suitable *only for exposures of short duration*, roughly 2 hours or less, depending on conditions.

Because the building slowly releases contaminants that have entered, at some point during cloud passage the concentration inside exceeds the concentration outside. Maximum protection is attained by increasing the air exchange rate after cloud passage or by exiting the building into clean air. The tighter the building, the greater the effect of this natural filtering.

Exam Questions #A12 and B14

The amount of protection varies with:

The building's air exchange rate. The tighter the building (i.e., the lower the air exchange rate), the greater the protection it provides.

- Sealing dampers on air intakes
- Previously sealed all identifiable air leakage in building envelope (smoke test or infrared survey on very hot or very cold day)
- This presupposes that all HVAC and other mechanical means that move air, including bathroom exhausts and elevators, are shutdown to not draw outside air into the building

The level of exposure. Protection varies with agent concentration and time, diminishing as the time of exposure increases or as concentration of agent increases. Thus a high-concentration plume passing quickly over a building would indicate sheltering in place to be the best option.

Purging or period of occupancy. How long occupants remain in the building after the hazardous cloud has passed also affects the level of protection. However, after the high-concentration plume passes, there will be some inleakage of agent that does occur and the longer one stays in the building the higher the exposure, unless the building is purged or aired out.

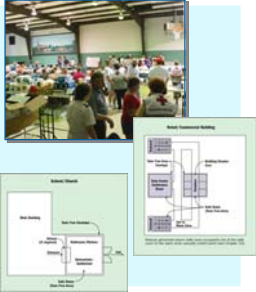
Natural filtering. Some filtering occurs when the agent is deposited in the building shell or upon interior surfaces as air passes into and out of the building.

VISUAL VIII-37


Sheltering in Place

Sheltering Plan should:

- Identify all air handling equipment to deactivate
- Identify cracks, seams, joints, and doors to seal (with method)
- Preposition needed supplies
- Identify safe rooms/safe havens
- Identify procedures for purging or airing out building
- Identify procedures for voluntary occupant participation
- Maintain comms - TV or radio



FEMA 453, Multihazard Shelter (Safe Havens) Design
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-37



Exam Questions #A20 and B19

Floor plans of gym area.

Note: Although sheltering is for protection against an external release, it is possible, but more complex, to shelter in place in one or more floors of a multi-story building after an internal release has occurred. In these circumstances, it is critical to turn off all air handling equipment, isolate stairwells, and not use elevators.

Sheltering in Place

If the office environment is complex, planning and exercises are important. The sheltering plan should include:

- Identifying all air handling units, fans, bathroom exhausts, and the switches needed to deactivate them
- Identifying cracks, seams, and joints in the building shell to be permanently sealed or temporarily sealed, along with sealing doors with duct tape
- Prepositioning supplies that are needed to initiate and sustain sheltering in place
- Identifying safe rooms or safe havens
- Identifying procedures for purging or airing out after an internal release
 - This must be done on a case-by-case basis for the agent involved and the agent concentration to be spread during the purging.
 - Competent first responder authority may best make this determination.
 - Sealing the release area and evacuating the building may be a better option and do not touch those purge fans!
- Identifying procedures for voluntary occupant participation
- Maintaining communications to understand what is occurring by monitoring TV or radio

During an event, the decision to shelter in place is voluntary, but people should enter the designated shelter area within 3-5 minutes. Depending upon plume speed and distance to travel, even this may be too long.

VISUAL VIII-38



Note: This slide depicts individuals wearing universal-fit escape hoods (upper left-hand corner picture and middle picture on the slide) that have been developed for short-duration "escape-only" wear to protect against chemical agents, aerosols (including biological agents), and some toxic industrial chemicals. The hoods are compact enough to be stored in desks (see picture in upper left-hand corner of the slide) or to be carried on the belt.

Exam Questions #A21 and B23

Personal Protective Equipment

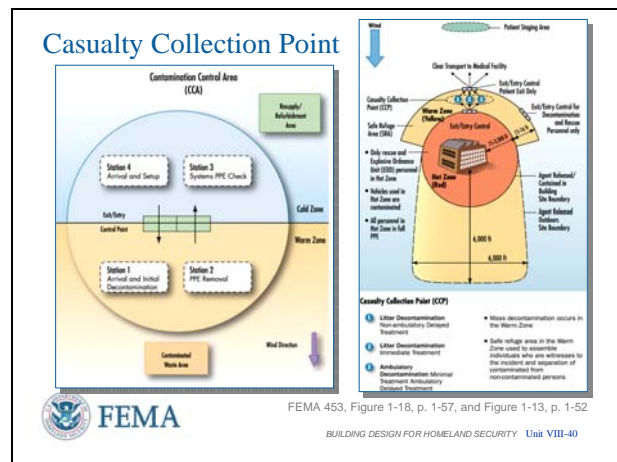
- A wide range of **individual protection equipment** is available, including respirators, protective hoods, protective suits, CBR detectors, decontamination equipment, etc.
- If masks have been issued, ensure that training is conducted on how to put on and wear the masks.
- No selection of personal protective equipment is effective against every possible threat. Selection must be tied to specific threat/hazard characteristics.
- Universal hoods designed for short duration escape wear only protect against chemical agents by using both HEPA and carbon filters.
 - Carbon filters are designed to filter a broad range of toxic chemicals, but not all chemicals.
 - The EVAC-U8 hood was recalled in April 2006 due to a problem with removing carbon monoxide, which was a stated claim, applicable to its use as a fire escape hood, but it is NOT a CBR hood.

VISUAL VIII-39



Shows pictures of aftermath of the tragic 9-11 events.

VISUAL VIII-40



9-11 Dramatic Events

Assembly should be to the upwind side of the building and at least 1,000 feet away, since any airborne hazard escaping the building will be carried downwind.

Starting from top left:

- Photo 1 - Remains Recovery
 - Photo 2 - Evacuation by Helicopter
 - Photo 3 - Arlington County EMS unit
 - Photo 4 - NMRT decontamination corridor
- Bottom left:

- Photo 5 - Evidence Collector
- Photo 6 - Man covered in debris from the Twin Towers collapse
- Photo 7 - FEMA Urban Search and Rescue Team from Montgomery County, MD is briefed before beginning work at Pentagon following 9-11 attacks.
- Photo 8 - FBI and US&R

Casualty Collection Point

Emergency operations need to be designed to allow law, fire, and medical vehicles and personnel access for mass decontamination operations.

The Contamination Control Area is located on the boundary of the Cold Zone and Warm Zone and used by the rescue and decontamination personnel to enter and exit the Warm Zone. There are several processing stations, a resupply and refurbishment area, and a contaminated waste storage area. Runoff from decontamination operations must be controlled or contained to prevent further site contamination.

Casualty Collection Point is a critical element to save lives. The following operations may take place during an

INSTRUCTOR NOTES

CONTENT/ACTIVITY

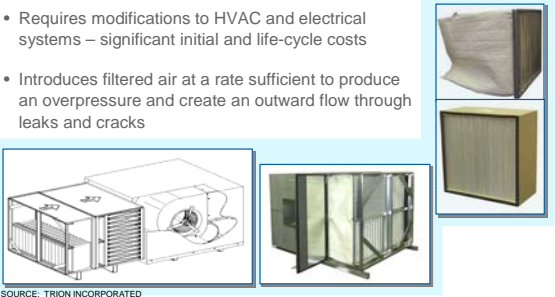
emergency operation.

- The Patient Staging Area (PSA) is located in the Cold Zone and is the transfer point for victims that have been stabilized for transport to higher care medical facilities or for fatalities to be transported to morgue facilities. The PSA area must be large enough to accommodate helicopter operations and a large number of ambulances.
- The Casualty Collection Point is located in the Warm Zone and will have typically have three processing stations:
 - Station 1 – Litter decontamination and non-ambulatory delayed treatment patients
 - Station 2 – Litter decontamination and immediate treatment patients
 - Station 3 – Ambulatory decontamination, minimal treatment patients, and ambulatory delayed treatment patients
- Mass casualty decontamination occurs in the Warm Zone. The Safe Refuge Area is located in the Warm Zone and is used to assemble individuals who were witness to the incident and separation of contaminated from non-contaminated persons.

VISUAL VIII-41

Air 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



SOURCE: TRION INCORPORATED

FEMA FEMA 426, Figures 5-5 and 5-12: Bag Filter and HEPA Filter; Commercial Air Filtration Unit, p. 5-12 and 5-22

BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-41

Exam Questions #A22 and B22

Note: Applying external filtration to a building requires modification to the building's heating, ventilation, and air conditioning (HVAC) system and electrical system. These changes are necessary to ensure that, when the protective system is in operation, all outside air enters the building through filters. The air exchange that normally occurs due to wind pressure, chimney effect, and operation of fans must be reduced to zero.

Exam Questions #A22 and B22

Air Filtration and Pressurization


- Two basic methods of applying air filtration to a building are external filtration and internal filtration. External filtration involves filtering and/or cleaning of the air drawn from the **outside**, while internal filtration involves filtering and/or cleaning of the air drawn from **inside** the building. Both methods require HVAC modifications that can be costly.
- Among the various protective measures for buildings, high efficiency air filtration/cleaning provides the highest level of protection against an outdoor release of hazardous materials.

VISUAL VIII-42

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



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-42

Exam Questions #A23 and B21

See CDC/NIOSH *Guidance for Filtration and Air-Cleaning Systems to Protect Building Environments from Airborne Chemical, Biological, or Radiological Attacks*.

Publication No. 2003-136, April 2003 for good explanations of these two types of filtration.

Air Filtration and Cleaning

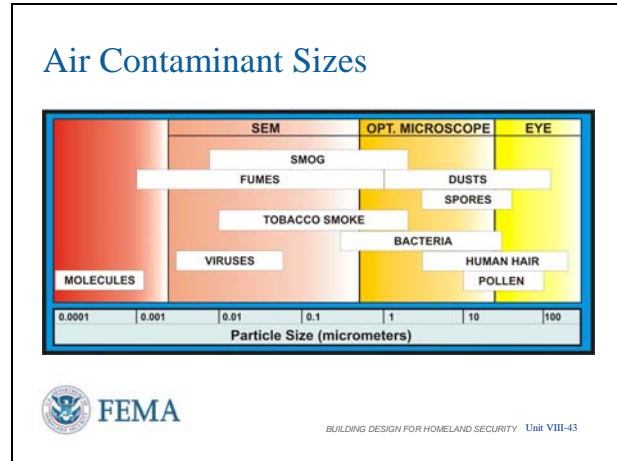
Air filtration is the removal of particulate contaminants from the air. Air cleaning is the removal of gases or vapors from the air. The collection mechanisms for these two types of systems are very different.

Particulate air filtration consists of fibrous materials, which capture aerosols. Their efficiency will depend on the size of the aerosol, the type of filter, the velocity of the air, and the type of microbe. The basic principle of particulate air filtration is not to restrict the passage of particles by the gap between fibers, but by altering the airflow streamlines. The airflow will slip around the fiber, but higher density aerosols and particulates will not change direction as rapidly. Particulate filters are not intended to remove gases and vapors.

Gas-phase air filtration sorbent filters use one of two mechanisms for capturing and controlling gas-phase air contaminants: physical adsorption and chemisorption. Both mechanisms remove specific types of gas-phase contaminants in indoor air. Unlike particulate filters, sorbents cover a wide range of highly porous materials, ranging from simple clays and carbons to complex engineered polymers. Activated carbon is the most common sorbent, but does not capture all chemicals.

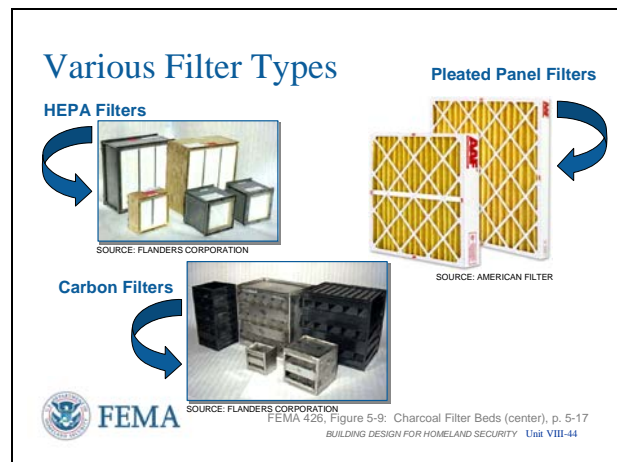
Sorbent filtration needs adequate residence time to ensure adsorption of the gas or vapors; that is adequate contact time for the flow rate of the air passing through the filters. In some cases, two sorbent filters may be needed in series to achieve needed residence time.

VISUAL VIII-43



Exam Questions #A22 and B22

VISUAL VIII-44



Air Contaminant Sizes

This chart illustrates the particle size for a number of the chemical, biological, and radiological agents of concern. Viruses are the smallest and most difficult to protect against.

In **FEMA 426, Table 5-1, page 5-12**, lists the new ASHRAE 52.2 Standards for particulate filter ratings to remove a given particle size. In most cases, new generation Minimum Efficiency Reporting Value (MERV) 11 to MERV 13 filters can be used in commercial buildings and effectively remove most particulates of CBR concern.

Various Filter Types

A wide variety of filters are available to meet many specialized needs:

HEPA (high efficiency particulate air) Filters - high performance filters that are typically rated as 99.97 percent effective in removing dust and particulate matter greater than 0.3 micron in size.

Carbon Filters - sorbent filters (gas-phase) that remove gas and vapors using the thousands of bonding sites on the huge surface area of activated carbon.

Pleated Panel Filters - particulate air filters consisting of fibrous materials that capture aerosols.

VISUAL VIII-45

ASHRAE Standards

MERV	ASHRAE 52.2			ASHRAE 52.1		Particle Size Range, μm	Applications
	Particle Size Range			Test			
	3 to 10 μm	1 to 3 μm	3 to 1 μm	Arrestance	Dust Spot		
1	< 20%	-	-	< 65%	< 20%	> 10	Residential, light, pollen, dust mites
2	< 20%	-	-	65 - 70%	< 20%		
3	< 20%	-	-	70 - 75%	< 20%		
4	< 20%	-	-	> 75%	< 20%		
5	20 - 35%	-	-	80 - 85%	< 20%	3.0 - 10	Industrial, Dust, Molds, Spores
6	35 - 50%	-	-	> 90%	< 20%		
7	50 - 70%	-	-	> 90%	20 - 25%		
8	> 70%	-	-	> 95%	25 - 30%		



FEMA 426, Table 5-1: Comparison of ASHRAE Standards 52.1 and 52.2, p. 5-12
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-45

ASHRAE Standards

The new ASHRAE Standard 52.2 is a more descriptive test than ASHRAE Standard 52.1. Standard 52.2 quantifies filtration efficiency in different particle size ranges and is more applicable in determining a filter's effectiveness to capture a specific agent. Standard 52.2 reports the particle size efficiency results as a MERV rating between 1 and 20. A higher MERV rating indicates a more efficient filter.

VISUAL VIII-46

ASHRAE Standards

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%	0.3 - 1.0	Hospitals, Smoke removal, Bacteria
13	> 90%	> 90%	< 75%	> 98%	80 - 90%		
14	> 90%	> 90%	75 - 85%	> 98%	90 - 95%		
15	> 90%	> 90%	85 - 95%	> 98%	> 95%		
16	> 95%	> 95%	> 95%	> 98%	> 95%	< 0.3	Clean rooms, Surgery, Chembio, Viruses
17	-	-	= 99.97%	-	-		
18	-	-	= 99.99%	-	-		
19	-	-	= 99.999%	-	-		
20	-	-	= 99.9999%	-	-		

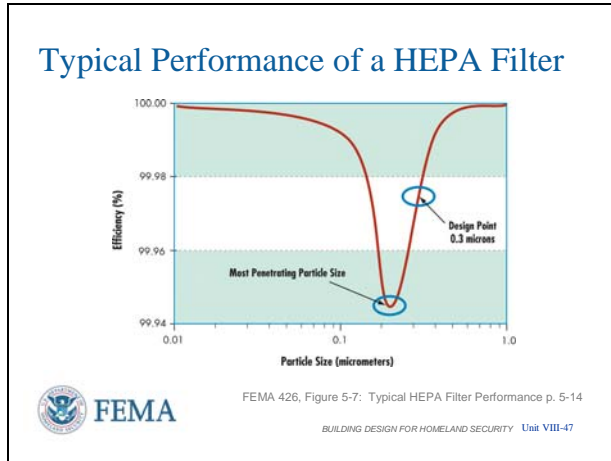


FEMA 426, Table 5-1: Comparison of ASHRAE Standards 52.1 and 52.2, p. 5-12
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-46

ASHRAE Standards

The standard provides a table (depicted on the slide) that shows minimum Particle Size Efficiency (PSE) for three size ranges for each of the MERV numbers 1 through 16. Thus, if the size of a contaminant is known, an appropriate filter with the desired PSE for that particular particle size can be identified.

VISUAL VIII-47



Typical Performance of a HEPA Filter

HEPA filters are typically rated as 99.97 percent effective in removing dust and particulate matter greater than 0.3 micron in size.

A typical HEPA performance curve is depicted on this slide. The dip between 0.1 and 0.3 micron represents the most penetrating particle size. Many bacteria and viruses fall into this size range. Fortunately, microbes in this range are also vulnerable to ultraviolet radiation. For this reason, many facilities couple particulate air filters with ultraviolet germicidal irradiation (UVGI). UVGI will be discussed on slide VIII-55.

VISUAL VIII-48

Inside Versus Outside Releases

Outside Release

- Keep people inside building
- Reduce indoor/outdoor air exchange – close dampers
- Shut off air handling systems and equipment that moves air – HVAC, exhausts, combustion, computers, elevators
- Close all windows and doors
- Once the outdoor hazard has dissipated
 - Open all doors and windows
 - Turn on all fans, including purging systems

FEMA logo and text: 'FEMA BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-48'

Outside Versus Inside Releases

Outside Release

The intent is to limit exposure (dose x time) of individuals by keeping the agent and people separated to greatest extent possible. Use natural wind, sunlight, and agent material properties to allow the high-concentration plume to pass the building and minimize the agent that gets into the building.

- Keep individuals inside the building – use the building envelope as a protective enclosure
- Reduce the indoor/outdoor air exchange (seal dampers – low leakage, fast acting (much less than 30 seconds to close) dampers) to prevent contaminated air from passing through the HVAC system by normal chimney and wind effects
- Immediately shut off the air handling systems and any other system that has a fan that moves air – bathroom exhausts,


INSTRUCTOR NOTES

CONTENT/ACTIVITY

VISUAL VIII-49

Inside Versus Outside Releases
Inside Release

- Turn off all air handling equipment if no special stand-alone systems installed
- If special systems installed, i.e. mailroom
 - Place air handling system on full (or 100% outside air) to pressurize the space around release room
 - Turn off all air handling supplying release room
- Consider activating fire sprinklers in release room if toxic chemicals involved
- Evaluate evacuation routes for contamination
- Evacuate building in accordance with emergency plan



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-49

combustion burners, computer cabinet cooling fans, etc. Note that elevator operation acts as a big air pump that changes air pressure throughout the building. Do not want to set up a pressure differential that pulls outside air into the building when this outside air is contaminated.

- Close all windows and doors – Should have sealed all other leakage points throughout the building envelope as part of mitigation plan
- Once the outdoor hazard has dissipated, open all doors and windows and turn on all fans to ventilate the building. While the amount of agent entering the building should be low (low dose) if you do not ventilate the building the exposure time becomes great and the overall level of exposure can become dangerous.

Outside Versus Inside Releases

Inside Release

The intent here is to keep the release contained to the greatest extent possible and prevent it from getting to the other parts of the building or outside the building.

- This process must be well thought out, coordinated, and tested to ensure the building will function as desired.
- If the building cannot be operated this way, then follow outside release procedures, but with evacuation.

- If no special stand-alone systems, then shut down all air movement equipment
- If release is in a room with a special stand-alone system, then shut down that system and place the rest of the building's air handling system on "full (or 100%) outside air to keep the agent inside the release room.

INSTRUCTOR NOTES

CONTENT/ACTIVITY

- If advised of an in-building release of hydrogen cyanide gas, chlorine gases, or other toxic industrial chemicals, consider activating the fire sprinklers (water) to help wash the contaminant from the air stream. This would probably help for particulate aerosols like anthrax but will probably not work for vapors such as hydrogen cyanide gas or chlorine gas.
 - The negative to this process is that the water is now contaminated and can spread throughout the building.
 - The runoff water will also contaminate building components to a greater extent than if the sprinklers were not used, necessitating a greater clean-up effort.
 - Note that this type of operation is not standard on fire sprinkler systems and would be very difficult to implement.

- Evacuate the building in accordance with the building's emergency evacuation plan. Evacuation routes may be hazardous because they may take people through contaminated areas. It is necessary to evaluate the scenario prior to evacuating the building to prevent additional injuries from occurring.

VISUAL VIII-50

Exhausting and Purging

Basic Principles:

- Use ventilation and smoke/purge fans to remove airborne hazards
 - Use primarily after an external release plume has passed
 - Selectively use for internal release – may spread contamination further
- Purging should be carefully applied
 - Primarily when agent has spread throughout building



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-50

Exam Questions #A25 and B24

Note: Mention that a ventilation system and smoke purge fans can be used to purge the building after an external release after the hazard outdoors has dissipated, and it has been confirmed that the agent is no longer present near the building.

Exam Questions #A25 and B24

Exhausting and Purging

The fifth protective measure for CBR covered in **FEMA 426** is **Exhausting and Purging**. Turning on a building's ventilation fans and smoke-purge fans is a protective action for purging airborne hazards from the building and reducing the hazard to which building occupants are exposed.

- Purging must be carefully applied with regard to the location of the source and the time of the release. The main action is final clean-out of the building to allow a return to occupancy.
- If the hazardous material has been identified before release or immediately upon release, purging should not be employed, because it may spread the hazardous material throughout the building, the adjacent area, and to nearby buildings. In this case, all air handling units should be turned off to isolate the hazard while evacuating or temporarily sheltering in place.
- When purging, the indoor-outdoor air exchange rate can be increased by opening all windows and energizing all other fans.

VISUAL VIII-51

HVAC System Upgrade Issues

- 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?



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-51

HVAC System Upgrade Issues

- What is the threat?
- 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 filtration into the building envelope?
- Will improved indoor air quality offset upgrade costs?
- Is system maintenance addressed?

VISUAL VIII-52

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.)



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-52

Economic Issues to Consider


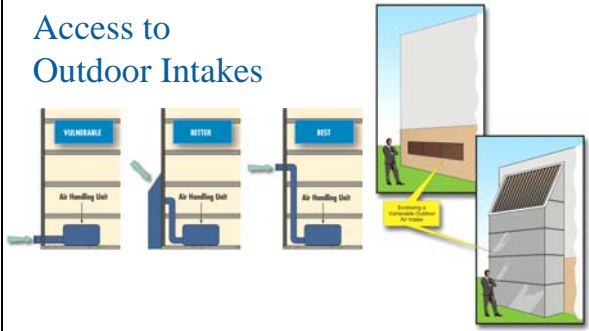
In developing, implementing, and sustaining a program to reduce vulnerability to terrorist threats, there are economic issues to consider, including three categories of costs:

- Initial costs
- Operating costs
- Replacement costs

These need to be factored into protection strategies.

VISUAL VIII-53

Access to Outdoor Intakes



FEMA 426, Figure 3-8, Example of Protecting Outdoor Air Intakes, p. 3-36 and Figure 3-11, Example of Enclosing Existing Vulnerable Air Intake, p.3-38
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-53

Access to Outdoor Intakes

- Several physical security measures can be applied to reduce the potential for hazardous materials entering a building through the HVAC system.
- One of the most important steps in protecting a building's indoor environment is the security of the outdoor air intakes. Outdoor air enters the building through these intakes and is distributed throughout the building by the HVAC system.
- If relocation of outdoor air intakes is not feasible, intake extensions can be constructed without creating adverse effects on HVAC performance.

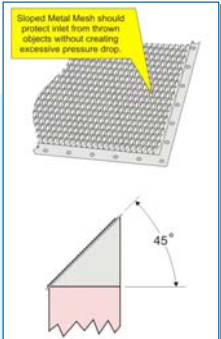
Note: The goal of this protective measure is to minimize public accessibility. In general, this means ***the higher the extensions, the better***—as long as other design constraints (excessive pressure loss, dynamic and static loads on structure) are appropriately considered.

This is a good idea for other reasons, such as keeping grass clippings, lawnmower fumes, and/or traffic fumes from being pulled into the building because of a low intake.

VISUAL VIII-54

Extension Design Recommendations

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



Sloped Metal Mesh should protect inlet from thrown objects without creating excessive pressure drop.

From CDC/NIOSH 2002-139, Guidelines for Protecting Building Environments from Airborne Chemical, Biological, or Radiological Attacks, p. 21
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-54


Extension Design Recommendations

An extension height of 12 feet will place the intake out of reach of individuals without some assistance. Also, the entrance to the intake should be covered with a sloped metal mesh to reduce the threat of objects being tossed into the intake. A minimum slope of 45° is generally adequate. Extension height should be increased where existing platforms or building features (i.e., loading docks, retaining walls) might provide access to the outdoor air intakes.

VISUAL VIII-55

Ultraviolet Germicidal Irradiation

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



UV lamps resemble ordinary fluorescent lamps, but are designed to emit germicidal UV

FEMA 426, Figure 5-10: UVGI Array with Reflective Surfaces, p. 5-19
BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-55

Ultraviolet Germicidal Irradiation (UVGI)

A design utilizing a combination of filtration and UVGI can be very effective against biological agents.

- Smaller microbes are difficult to filter out, but tend to be more susceptible to UVGI
- Larger microbes, such as spores, which are more resistant to UVGI, tend to be easier to filter out.

Note: UVGI has long been used in laboratories and health care facilities. Ultraviolet radiation in the range of 2,250-3,020 Angstroms is lethal to microorganisms. All viruses and almost all bacteria (excluding spores) are vulnerable to moderate levels of UVGI exposure. Spores, which are larger and more resistant to UVGI than most bacteria, can be effectively removed through high efficiency air filtration.

Consequently, most UGVI systems are installed in conjunction with high efficiency filtration systems.

A UVGI system is being tested under the sponsorship of the Defense Advanced Research Projects Agency (DARPA). For additional information consult:

<http://www.novatroninc.com/technology/>.

VISUAL VIII-56

URV AND UVGI INFORMATION

URV Average Intensities and Doses			
URV (UVGI Rating Value)	Average Intensity $\mu\text{W}/\text{cm}^2$	Dose at 1 (ft/min) = 0.5 sec $\mu\text{W}\cdot\text{s}/\text{cm}^2$	TB (Tuberculosis) Kill Rate %
9	250	125	23.4
10	500	250	41.3
11	1,000	500	65.5
12	1,500	750	79.8
13	2,000	1,000	88.1
14	3,000	1,500	95.9

URV = UVGI Rating Value
 UVGI = Ultraviolet Germicidal Irradiation

Simulation Results for Air Intake Release			
Predicted Performance	Anthrax	Smallpox	TB Bacilli
URV 11 - UVGI Removal Rate%	8.0	53.4	65.6
MERV 11 Filter Removal %	56.7	32.3	14.1
Combined Removal Rate %	60.2	68.5	70.4
Baseline Casualties (release over 8 hour period) %	99.0	99.0	99.0
Casualties with Filters and UVGI %	1.0	1.5	1.5

From "Immune Building Systems Technology", Kowalski 2003
 BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-56

URV and UVGI Information

This table displays UVGI Rating Value (URV) for air disinfections systems that parallel the ASHRAE 52.2-1999 method for testing and rating filters known as MERV (minimum efficiency reporting value). The proposed URV rating system consists of 20 separate levels of average UVGI intensity.

Simulation Results for Air Intake Release
 Various simulations were run in the reference shown indicating the removal rates for three design basis pathogens for MERV 11 filters, URV 11 UVGI systems, and both working together. Note the almost 100 % casualties if the agent is released into the air intake over an 8-hour period without any protective systems installed, and that about 1 % casualties occur with MERV 11 and URV 11 systems working together for the same release.

VISUAL VIII-57


Infiltration and Bypass


Infiltration

- Building envelope tightness and ventilation control are critical

Bypass

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



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BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-57

Note: Building envelopes in residential and commercial buildings are, in general, quite leaky, and significant quantities of air can infiltrate the building envelope with minimal filtration. Field studies have shown that, unless specific measures are taken to reduce infiltration, as much air may enter a building through infiltration as through the mechanical ventilation system.

Infiltration and Bypass

Infiltration. Building managers *should not expect filtration alone to protect a building from outdoor releases*, particularly for systems in which no make-up air or inadequate overpressure is present. Filtration, in combination with other steps, such as building pressurization and tightening the building envelope, should be considered to increase the likelihood that the air entering the building actually passes through the filtration and air-cleaning systems.

Bypass. Filter bypass is a common problem found in many HVAC filtration systems. It occurs when air, rather than moving through the filter, goes around it, decreasing collection efficiency and defeating the intended purpose of the filtration system. Filter bypass is often caused by poorly fitting filters, poor sealing of filters in their framing systems, missing filter panels, or leaks and openings in the air handling unit downstream of the filter bank and upstream of the blower. Simply improving filter efficiency without addressing filter bypass provides little, if any, improvement to system efficiency. As a mechanical system loads with particulates over time, its collection efficiency increases, but so does the pressure drop.


INSTRUCTOR NOTES

CONTENT/ACTIVITY

VISUAL VIII-58

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.



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-58

Things Not to Do

More than anything else, building owners and managers should ensure that any actions they take do not have a detrimental effect on the building systems (HVAC, fire protection, life safety, etc.) or the building occupants under normal building operation.


Some efforts to protect the building from a CBR attack could have adverse effects on the building's indoor environmental quality. This can result in higher levels of illness among building occupants, much like “sick” building situations or long distance air travel.

Building owners and managers should understand how the building systems operate and assess the impact of security measures on those systems.

VISUAL VIII-59

Things to Do

- Have a current emergency plan that addresses CBR concerns
 - Exercise plan
 - Revise plan based upon lessons learned
- Understand your HVAC building vulnerabilities
- Conduct periodic walk-through of the system for evidence of irregularities or tampering
- Recognize that there are fundamental differences among various CBR events



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-59

Things to Do

Facilities managers should have a current emergency plan that addresses chemical, biological, and radiological (CBR) attacks, know their building HVAC system vulnerabilities, and conduct periodic walk-through inspections of the systems for evidence of irregularities or tampering.

Individuals developing emergency plans and procedures should recognize that there are fundamental differences among various CBR agents.


INSTRUCTOR NOTES

CONTENT/ACTIVITY

VISUAL VIII-60

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 and other reaction decisions.
- Develop an emergency plan and ensure it works.




BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-60

VISUAL VIII-61

Unit VIII 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 Case Study and FEMA 426
Answer worksheet questions



BUILDING DESIGN FOR HOMELAND SECURITY Unit VIII-61

Refer participants to **FEMA 426** and the Unit VIII Case Study activity in the Student Manual.

Members of the instructor staff should be available to answer questions and assist groups as needed.

At the end of 10 minutes, reconvene the class and facilitate group reporting.

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.

Bottomline: Develop an emergency plan for CBR attacks, knowing what actions will be taken, exercise the capability and ensure it works.

Student Activity

This activity provides a check on learning about the nature of chemical, biological, and radiological agents.

Activity Requirements

Working in small groups, refer to the HIC Case Study and **FEMA 426** to answer the worksheet questions.

Take 10 minutes to complete this activity. Solutions will be reviewed in the plenary group.

Transition

This completes the information Units I through VII. A written exam will cover these units.

Unit IX will cover Building Design Guidance. Units IX through XII will not have a written exam.

INSTRUCTOR NOTES

CONTENT/ACTIVITY

1. Distribute the exam (Version A or B) and answer sheet. Ask the students to record their name and the date on both the answer sheet and exam. Remind them that the test is an open book exam.
2. Allow 30 minutes for test completion and then collect the exams and answer sheets.
3. Review the test with the students by asking them to provide the correct answers any confirming if they are right. Encourage them to ask questions, and explain (as needed) why each answer is correct.
4. Score the tests prior to the end of the day and identify any questions where more than half of the class got the answers wrong. Include this information in the test database.
5. Identify any student who has not achieved a 70 % score. These individuals will require remedial instruction that night. Then take the other version of the exam the next day. This second exam will require a passing score of 70 % in order to pass the course.
6. Update the exams and instructor guides for all questions that were not answered correctly by 50 % or more of the students.

When the test is finished, **collect the exams and answer sheets.**

WRITTEN EXAM

There are two versions of the written exam:

- Version A
- Version B

Use the provided Scoring Sheet.

Correct answers and their sources are listed on the Answer Keys, which follow.

UNIT VIII CASE STUDY ACTIVITY: CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL (CBR) MEASURES

The requirements in this unit's activity are intended to provide a check on learning about the nature of chemical, biological, and radiological agents and associated mitigation measures.

Requirements

1. Identify the prevalent CBR threat(s) that exist and/or are identified as the Design Basis Threat in the selected Case Study.

Appendix A: Suburban, Hazardville Information Company

Design Basis Threat

Chemical: *Large quantity gasoline spill and toxic plume from the adjacent tank farm, small quantity (tanker truck and rail car size) spills of HazMat materials (chlorine).*

Biological: *Anthrax delivered by mail or in packages, smallpox distributed by spray mechanism mounted on truck or aircraft around metropolitan area.*

Radiological: *Small "dirty" bomb detonation within the 10-mile radius of the HIC building.*

Other:

- Chemical:**
- 1) *There are a significant number of hazardous waste sites in near proximity to the HIC building. The vast majority are small generators such as gas stations, dry cleaning, and other commercial businesses.*
 - 2) *HIC is surrounded by a number of commercial activities and key national critical infrastructure to include Hazardous Material (HazMat) facilities, HazMat being transported on the roads and rails, a nearby fuel tank farm, and an airport.*
 - 3) *There are two large manufacturing plants with large quantities of hazardous materials stored on site within 2 miles of the HIC Headquarters, one to the north and the other to the southwest. In addition, there are more than a dozen Tier II HazMat facilities within 3 miles of the building (in all directions)*
 - 4) *Approximately 5,000 trucks per day pass the HIC office on the nearby interstate highway. About 30 percent of these trucks (1,500 trucks/day) carry placards indicating that HazMat is aboard, but only about 5 percent (250 trucks/day) carry sufficient HazMat to warrant placarding.*
 - 5) *Approximately 50 percent of the HazMat passing the HIC office is Class 3 (flammable and combustible liquids). Class 2 (gases) and Class 8 (corrosives) each constitute about 15 percent.*

Approximately 10 percent of the trucks carry more than one class of HazMat.

- 6) It is estimated that approximately 10,000 railcars of HazMat move through this area each year. Hazardous materials range from liquid petroleum products to chlorine to anhydrous ammonia.*
- 7) A leg of the Piedmont Petroleum Pipeline (PPP) runs underneath the office park in the vicinity of HIC Headquarters. Part of Piedmont's regional network, this portion of the pipeline normally carries a variety of refined products, including commercial and military jet fuels, diesel and three grades of gasoline, home heating fuels, etc. Four buried pipes carry approximately 20 million gallons per day.*
- 8) Connected to the pipeline, less than 1 mile from HIC, is a 20-million gallon capacity fuel farm. Operated by the Shellexico Company, this tank farm stores a variety of petroleum products, primarily gasoline. Thirteen tank trucks were observed leaving the tank farm in a 1-hour period, indicating a calculated movement rate of approximately 300 trucks per day (about 3 million gallons of fuel).*

Appendix B: Urban, HazardCorp Building

Design Basis Threat

Chemical: Large quantity gasoline spill and toxic plume from the upwind petroleum tank farm or large quantity chlorine release from the upwind chemical storage tank farm. Small quantity (tanker truck and rail car size) spills of HazMat materials (chlorine).

Biological: Anthrax delivered by mail or in packages, smallpox distributed by spray mechanism mounted on truck or aircraft around metropolitan area

Radiological: Small "dirty" bomb detonation within the 10-mile radius of the HazardCorp Building.

Other:

- Chemical:*
- 1) More than 2,000 trucks loads of hazardous materials are transported each day within city limits.*
 - 2) Two large Hazardous Material (HazMat) Storage facilities are to the west of the building. One a large petroleum tank farm and the other a chemical storage tank farm with chlorine, liquid natural gas, and hydrofluoric acid. These tank farms receive and distribute product by truck, rail, and ship.*
 - 3) Shipping along the river to the west of the building carries petroleum products, fertilizer, and liquid natural gas among other items.*
 - 4) There are on average 100 hazardous materials spills and releases each year in the city.*

- 5) *There are a significant number of hazardous materials use and waste sites in near proximity to the HazardCorp Building. The vast majority are small generators such as gas stations, dry cleaning, and other commercial businesses.*
- 6) *Large generators are also in the area: HC Telecon has 3 facilities within 0.5 to 2.5 miles, two Shellexico Tank Farms within 3 miles, two HC Chemical Storage sites at 1.5 and 4 miles, HC Fuel Tank Cleaning at 1.5 miles, HC Hazardous Waste Storage at 3 miles, HC Chromium Plating at 1.3 miles, two HC Brass sites at 3 miles, and HC Electroplating at 3 miles.*
- 7) *In addition, rail and maritime transportation move significant hazardous materials through the area.*

Radiological: HC Radiological at 2.5 miles

Refer to **Table 5-1 on page 5-12 of FEMA 426** and answer the following questions:

2. What size filtration unit (MERV) is required to filter out 80 percent of Legionella and dust particulates (1 to 3 microns)? *12*
3. What range of MERV is required to remove 85 percent of smoke particles greater than 0.3 micron in size? *15 or higher*
4. What mitigation measure can be used in HVAC system to destroy bacteria and viruses?
UVGI lamps

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