GBRMC

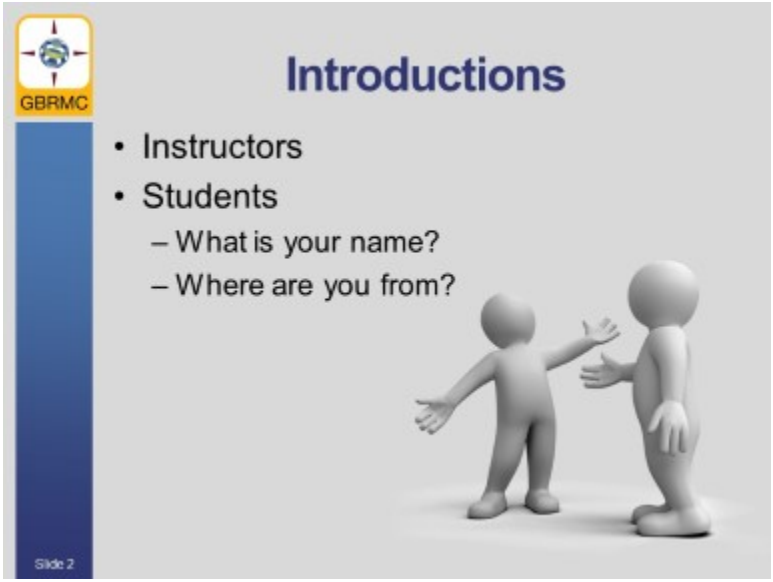
Engineering Controls and Laboratory Equipment

Student Guide

2012

GLOBAL BIORISK MANAGEMENT CURRICULUM

Welcome to Engineering Controls and Laboratory Equipment!


GBRMC
Introductions
• Instructors
• Students
– What is your name?
– Where are you from?
Slide 2

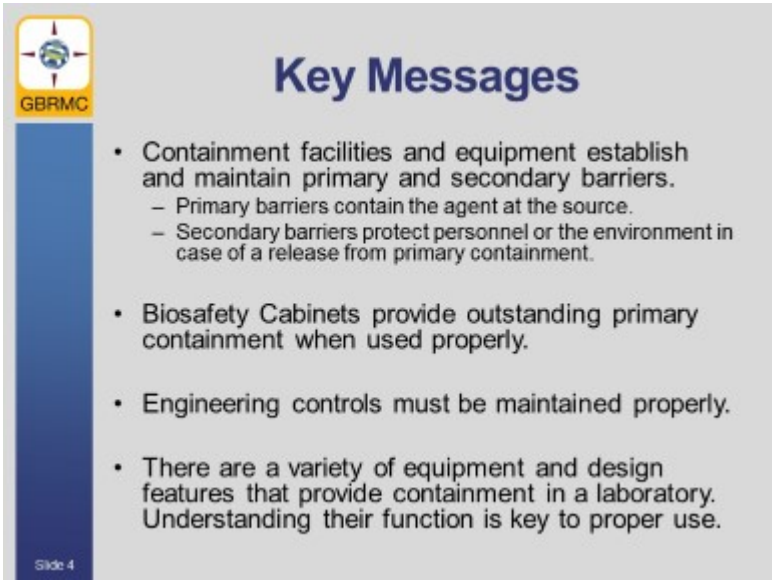
Action Plan

By the end of this lesson, I would like to:					
KNOW		FEEL		BE ABLE TO DO	

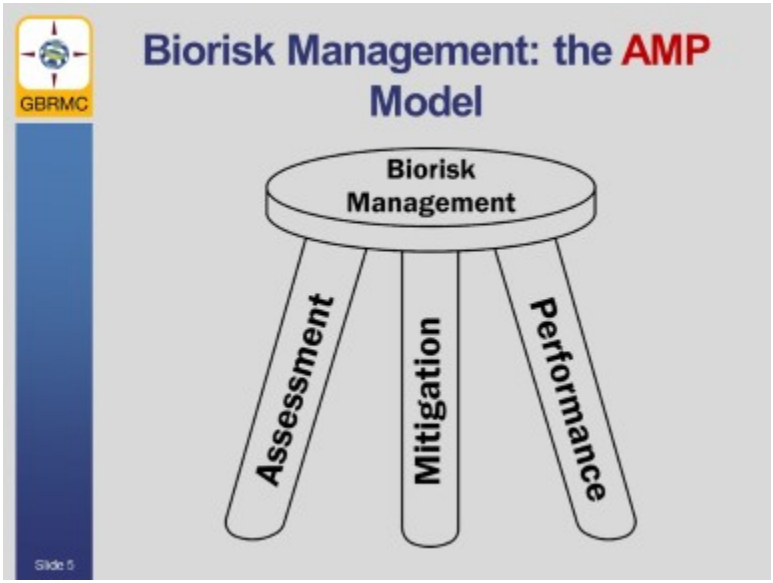
Your learning doesn't stop with this lesson. Use this space to think about what else you need to do or learn to put the information from this lesson into practice.

What more do I need to know or do?	How will I acquire the knowledge or skills?	How will I know that I've succeeded?	How will I use this new learning in my job?

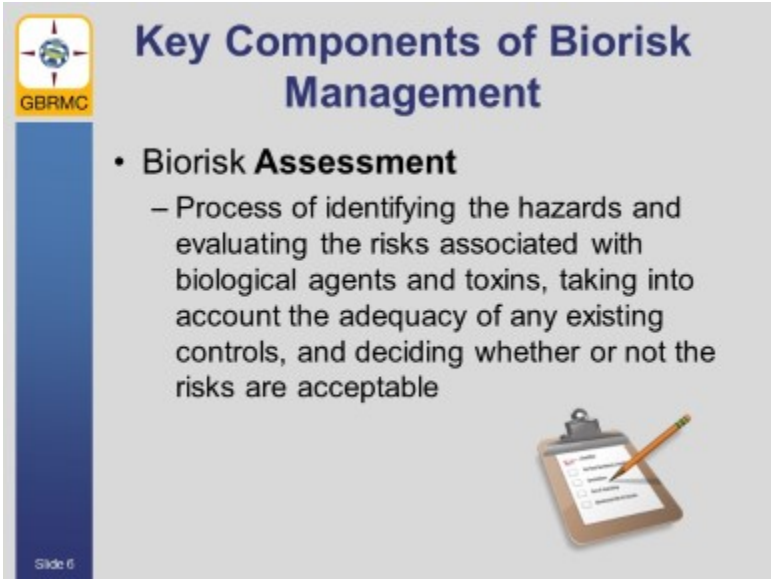
Use space on back, if needed


GBRMC
Key Messages
• Containment facilities and equipment establish and maintain primary and secondary barriers.
– Primary barriers contain the agent at the source.
– Secondary barriers protect personnel or the environment in case of a release from primary containment.
• Biosafety Cabinets provide outstanding primary containment when used properly.
• Engineering controls must be maintained properly.
• There are a variety of equipment and design features that provide containment in a laboratory. Understanding their function is key to proper use.
Slide 4

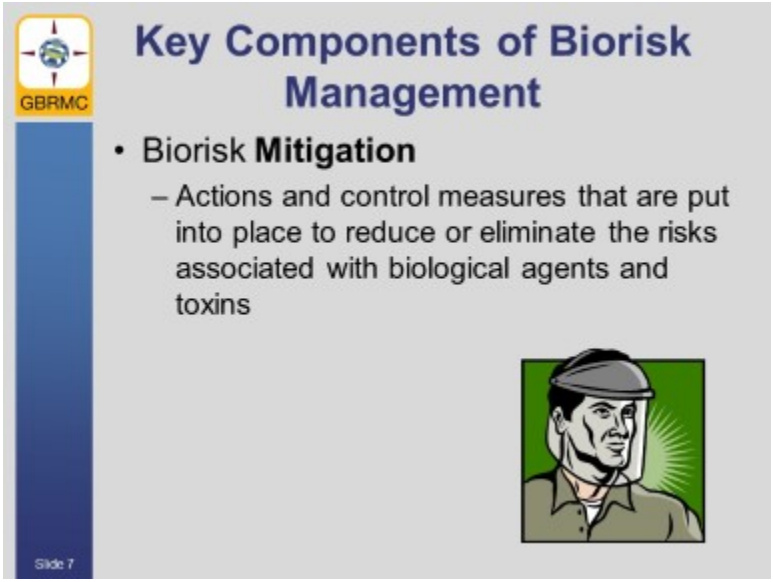
Biorisk Management



Review the AMP model for Biorisk Management



Define Assessment:

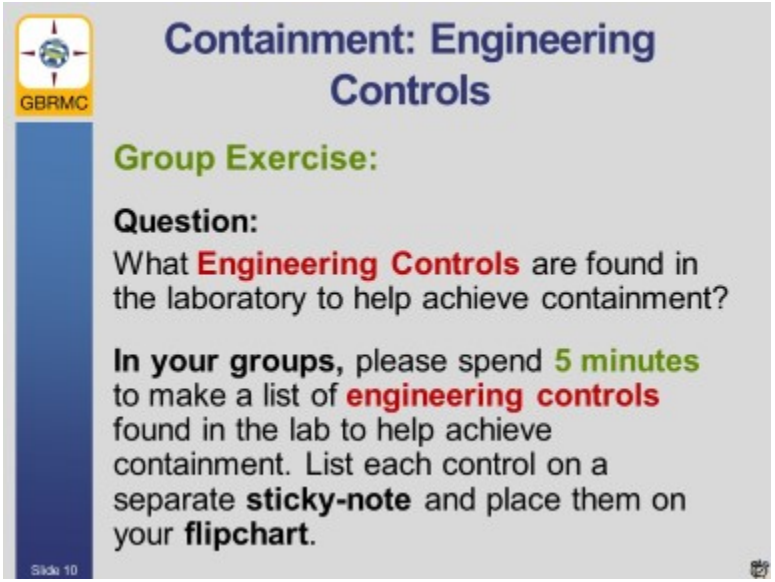


Define Mitigation:

Define Performance:

Containment

Define Containment: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Containment: Engineering Controls
Group Exercise:
Question:
What Engineering Controls are found in the laboratory to help achieve containment?
In your groups, please spend 5 minutes to make a list of engineering controls found in the lab to help achieve containment. List each control on a separate sticky-note and place them on your flipchart.
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Biosafety Levels and Containment

Biosafety guidelines provide **4 levels** of increasing and additive protections

- **BSL1** – Work with non-pathogens
- **BSL2** – Standard pathogen work
- **BSL3** – Containment Laboratory
- **BSL4** – Maximum containment laboratory

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What are "Biosafety Levels"?

- Biosafety Levels are **increasingly stringent combinations** of:
  - **Facility features**
  - **Safety Equipment**
  - **Work Practices**
  - **Administrative Controls**
  - **Personal Protective Equipment**
- **Designed to mitigate risk** from pathogens having similar consequences of exposure.

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Containment

How can we achieve containment?

- **Administrative controls**
- **Practices and Procedures**
- **Engineering controls**

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Engineering Controls

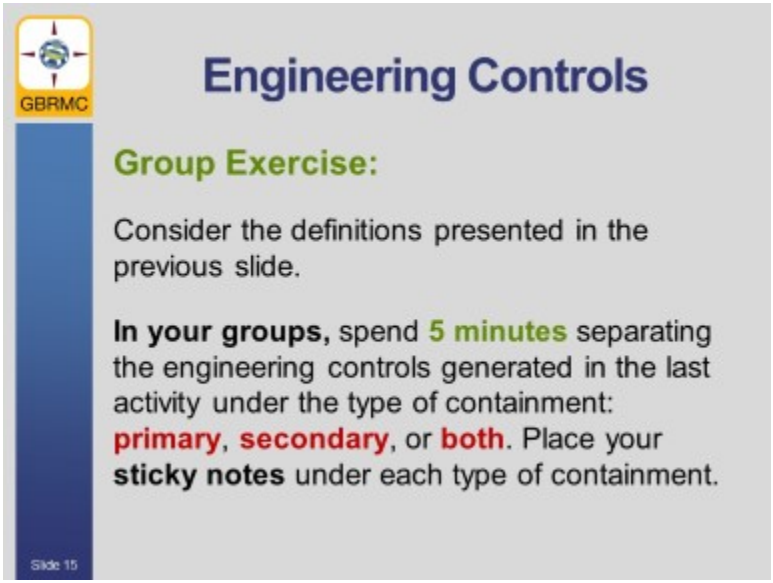
Primary Containment Barriers - contain the agent at the source

- BSCs & other ventilation equipment
- Animal isolation cages
- Specialized laboratory equipment

Secondary Containment Barriers – provide protection to personnel and the environment in case of a release from primary containment

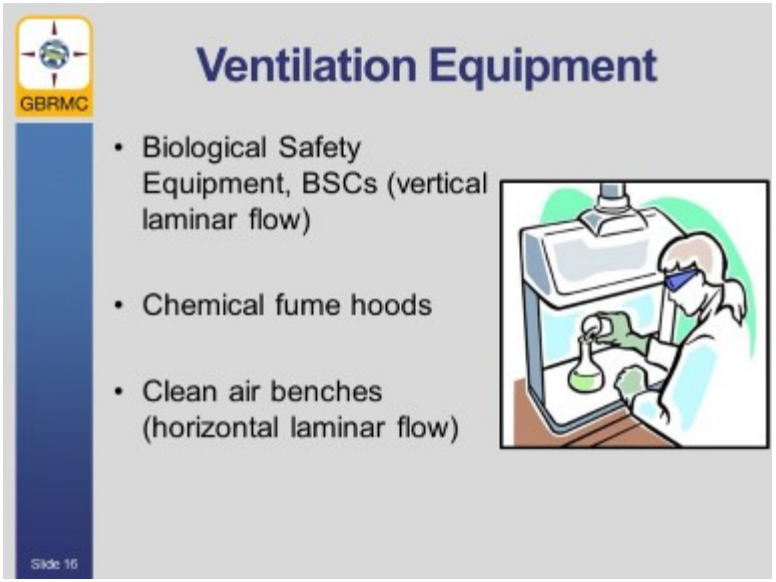
- Facility architectural features
- Facility mechanical systems

Slide 14



Engineering Controls: Biosafety Cabinets

- Primary:
- Secondary:
- Both: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Ventilation Equipment
• Biological Safety Equipment, BSCs (vertical laminar flow)
• Chemical fume hoods
• Clean air benches (horizontal laminar flow)
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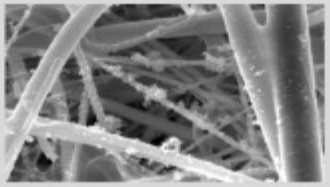
HEPA

Almost all engineering controls involving ventilation employ a HEPA filter for **primary** or **secondary** containment, or **both.**



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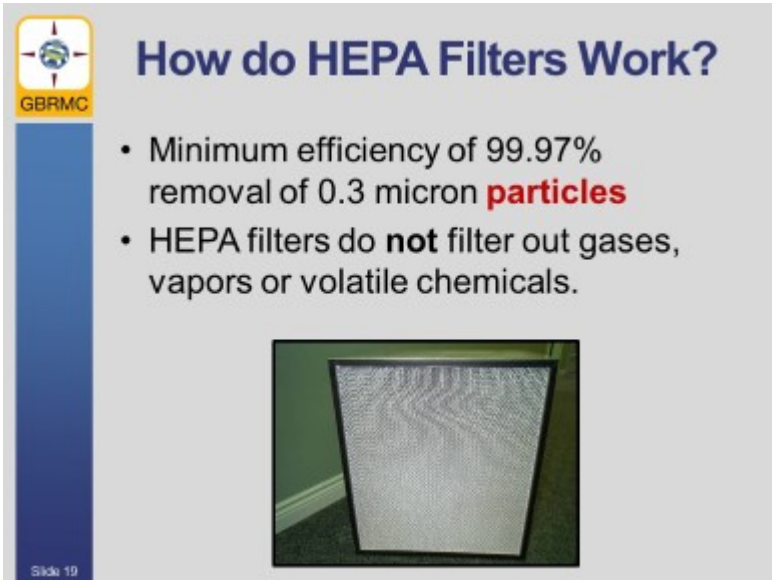
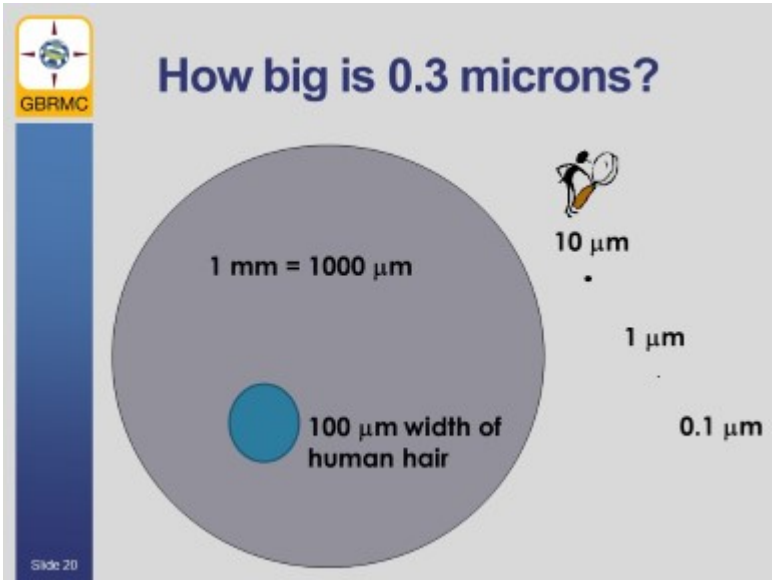
What is a HEPA filter?

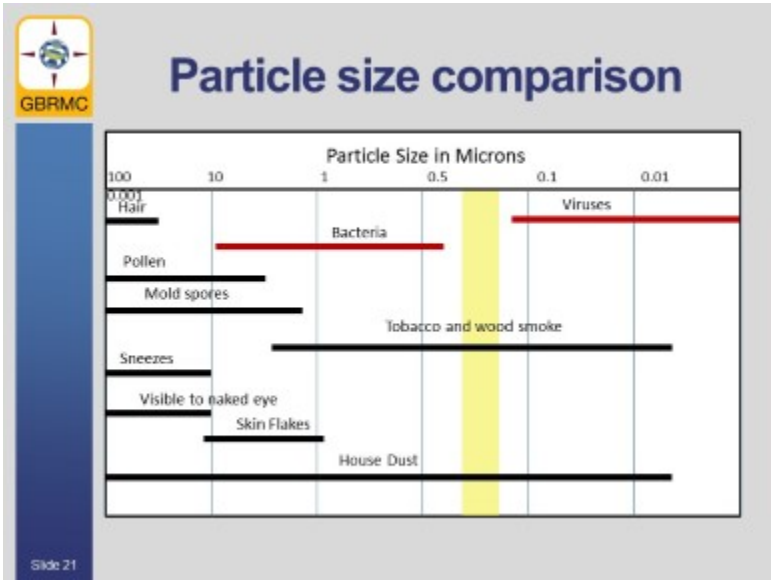
High
Efficiency
Particulate
Air
(**HEPA**) filter

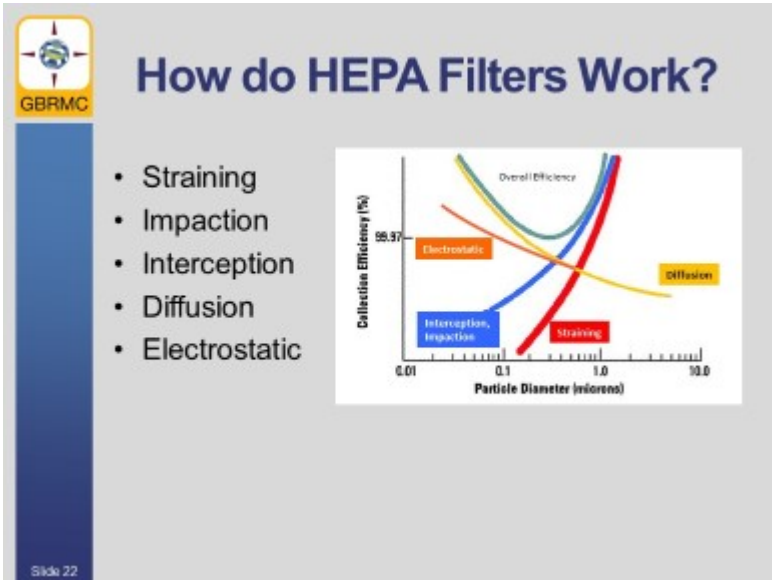
- Filters **0.3 micron** particles at 99.97% efficiency
- Filters **all other particles**, bigger AND smaller, at an efficiency GREATER than 99.97%

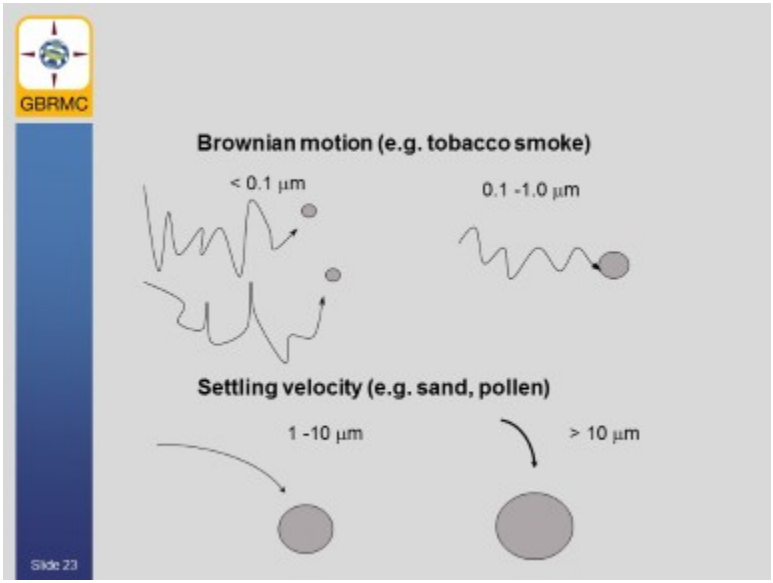
Slide 18

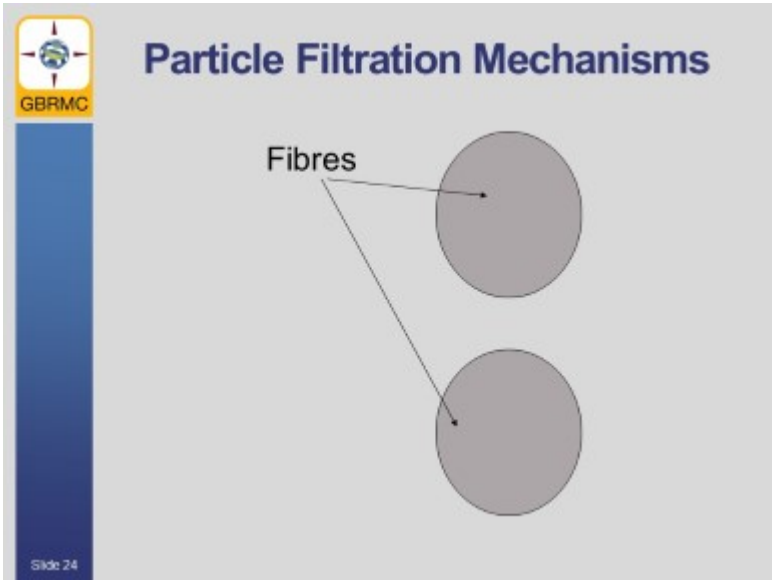

GBRMC
How do HEPA Filters Work?
• Minimum efficiency of 99.97% removal of 0.3 micron particles
• HEPA filters do not filter out gases, vapors or volatile chemicals.
Slide 19

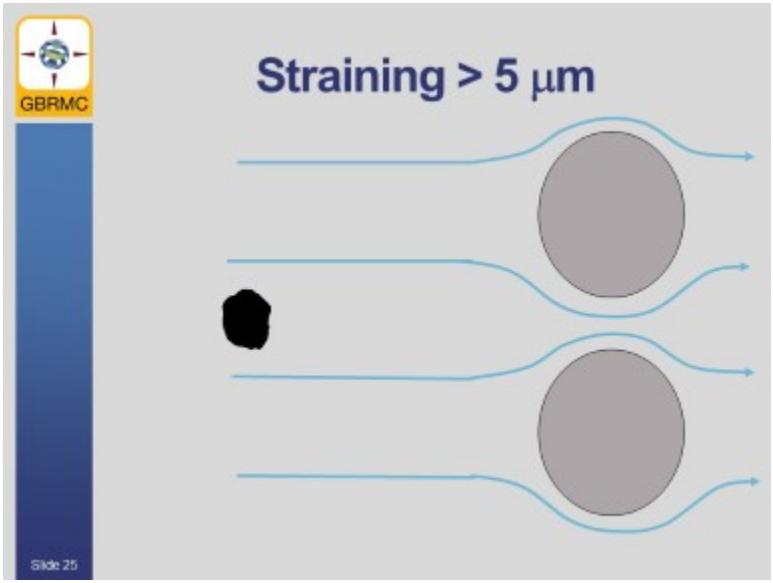

GBRMC
How big is 0.3 microns?
1 mm = 1000 µm
10 µm
1 µm
0.1 µm
100 µm width of human hair
Slide 20

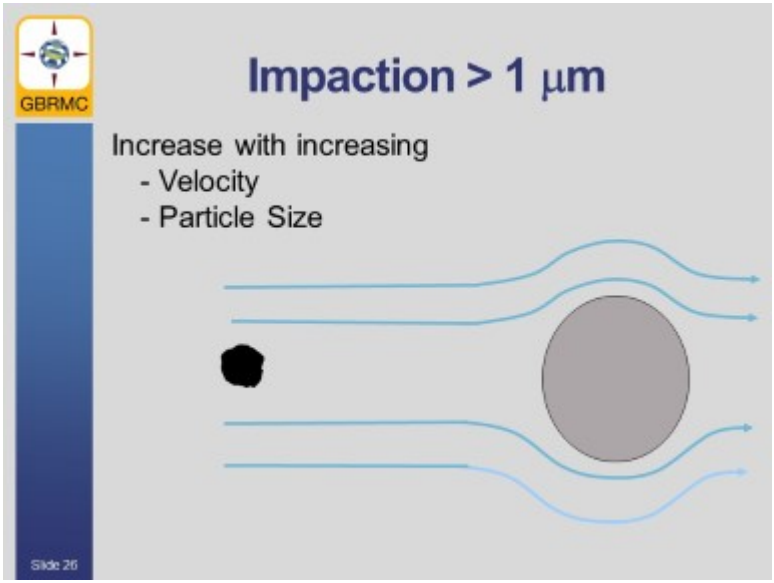

GBRMC
Particle size comparison
Particle Size in Microns
100
10
1
0.5
0.1
0.01
0.001
Hair
Viruses
Bacteria
Pollen
Mold spores
Tobacco and wood smoke
Sneezes
Visible to naked eye
Skin Flakes
House Dust
Slide 21

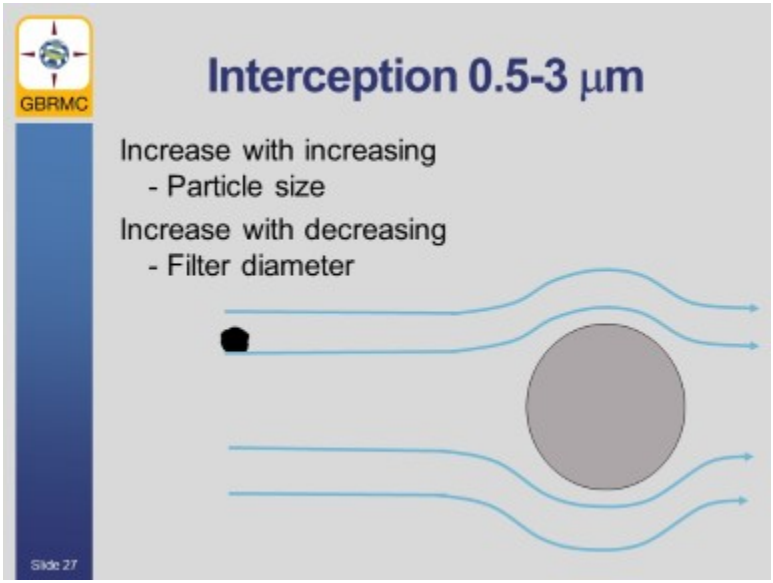

GBRMC
How do HEPA Filters Work?
• Straining
• Impaction
• Interception
• Diffusion
• Electrostatic
Overall Efficiency
99.97
Electrostatic
Diffusion
Interception, Impaction
Straining
Collection Efficiency (%)
0.01
0.1
1.0
10.0
Particle Diameter (microns)
Slide 22

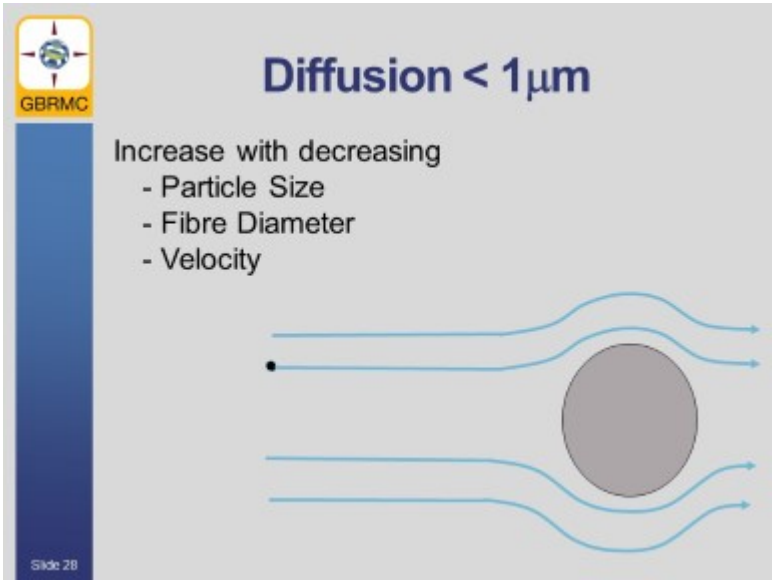

GBRMC
Brownian motion (e.g. tobacco smoke)
< 0.1 µm
0.1 -1.0 µm
Settling velocity (e.g. sand, pollen)
1 -10 µm
> 10 µm
Slide 23

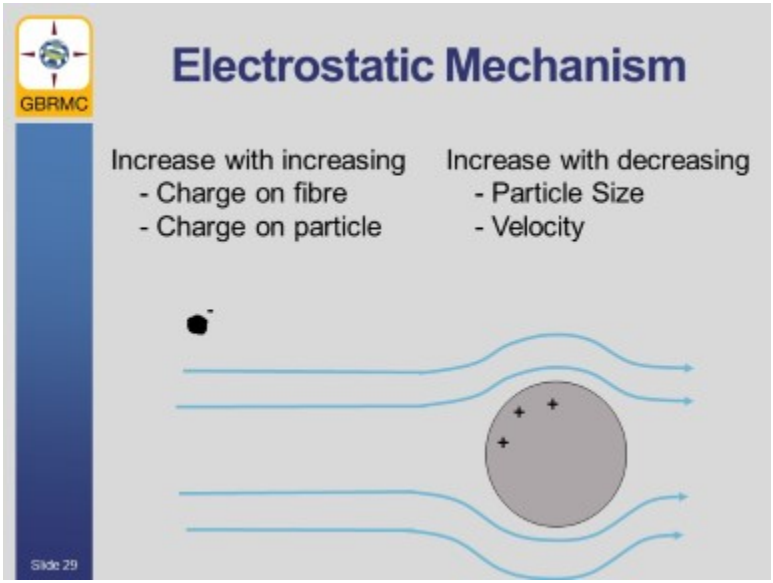

GBRMC
Particle Filtration Mechanisms
Fibres
Slide 24

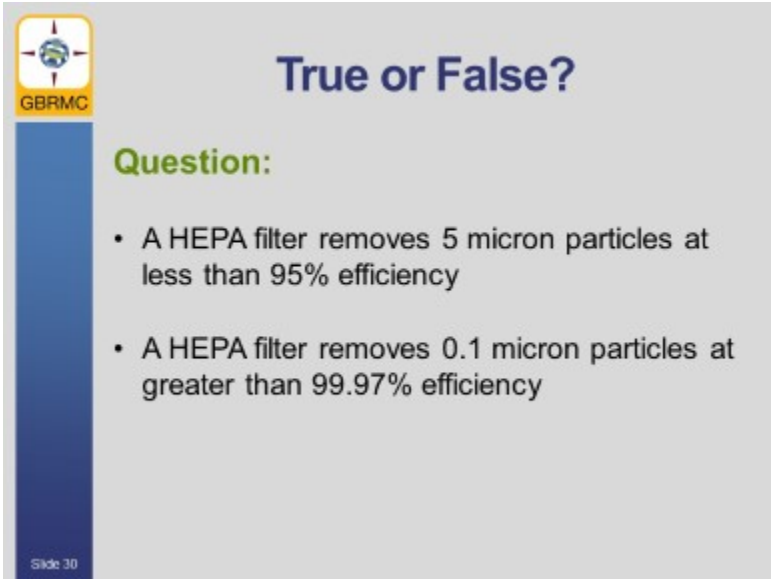

GBRMC
Straining > 5 μm
Slide 25


GBRMC
Impaction > 1 μm
Increase with increasing
- Velocity
- Particle Size
Slide 26


GBRMC
Interception 0.5-3 μm
Increase with increasing
- Particle size
Increase with decreasing
- Filter diameter
Slide 27


GBRMC
Diffusion < 1μm
Increase with decreasing
- Particle Size
- Fibre Diameter
- Velocity
Slide 28


GBRMC
Electrostatic Mechanism
Increase with increasing
- Charge on fibre
- Charge on particle
Increase with decreasing
- Particle Size
- Velocity
Slide 29


GBRMC
True or False?
Question:
• A HEPA filter removes 5 micron particles at less than 95% efficiency
• A HEPA filter removes 0.1 micron particles at greater than 99.97% efficiency
Slide 30

Biological Safety Cabinets (BSCs)

- Primary means of containment
- Three design types
  - **Class I, Class II, and Class III**
- Designed to provide protection for
  - **Personnel**
    - Directional flow of air into cabinet
  - **Environment**
    - HEPA filtered exhaust
  - **Product (except Class I)**
    - Laminar flow of HEPA filtered air

How is protection achieved?

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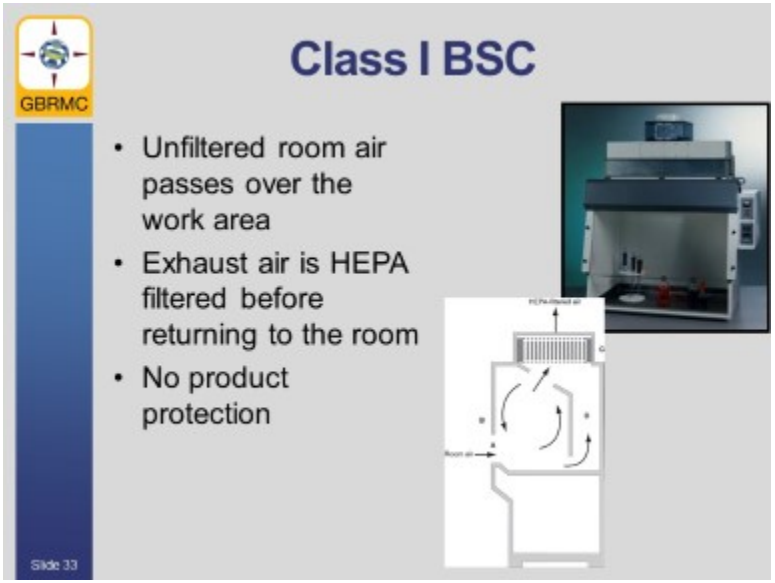
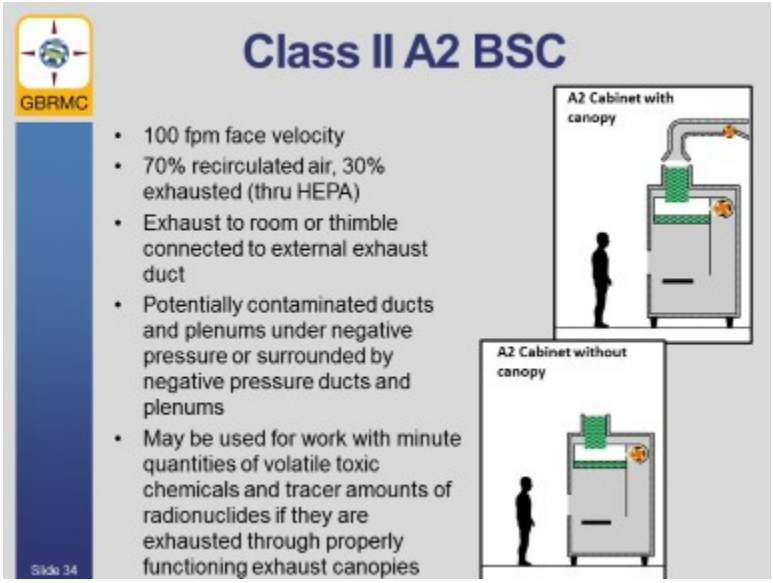
Directional Airflow in BSC

Page 32



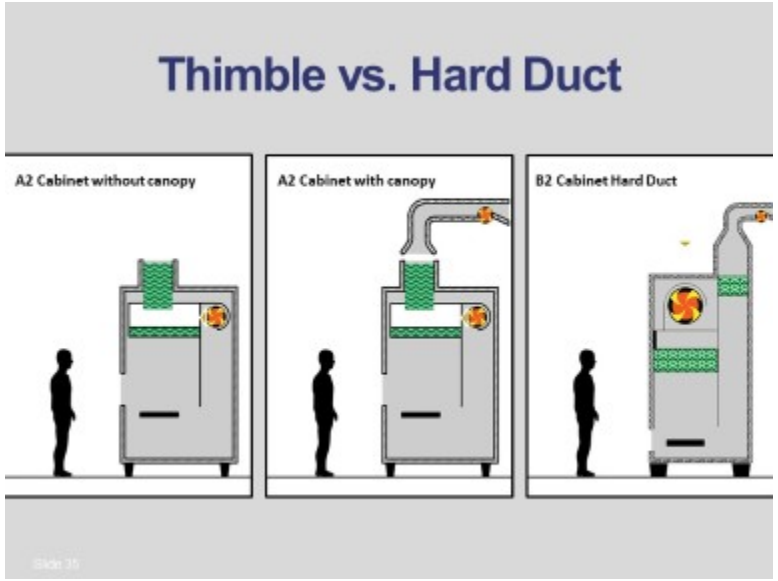
- Purpose:

- Function:



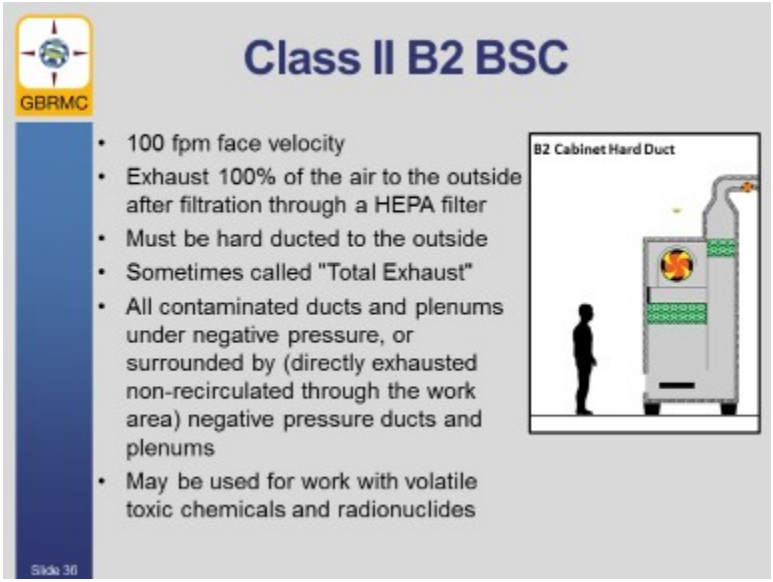
- Purpose:

- Function:



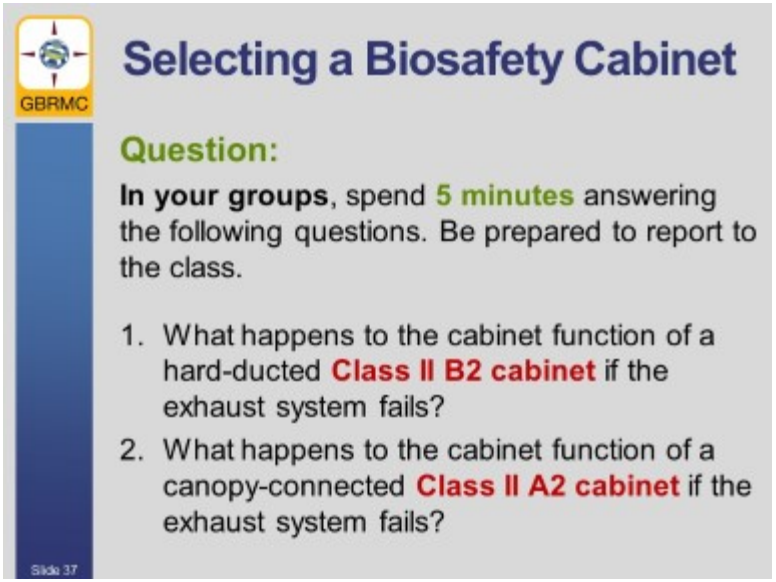
Thimble:

Hard Duct:



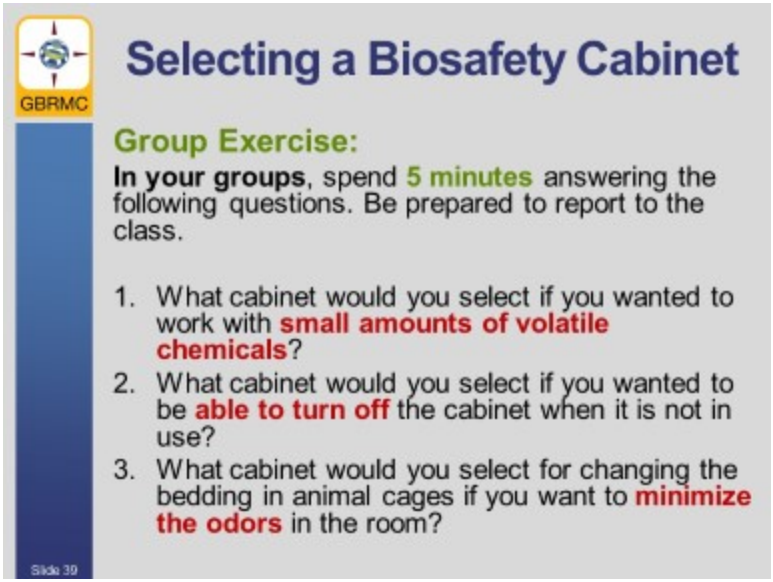
- Purpose:

- Function:


GBRMC
Selecting a Biosafety Cabinet
Question:
In your groups, spend 5 minutes answering the following questions. Be prepared to report to the class.
1. What happens to the cabinet function of a hard-ducted Class II B2 cabinet if the exhaust system fails?
2. What happens to the cabinet function of a canopy-connected Class II A2 cabinet if the exhaust system fails?
Slide 37

- Purpose:

- Function:


GBRMC
Selecting a Biosafety Cabinet
Group Exercise:
In your groups, spend 5 minutes answering the following questions. Be prepared to report to the class.
1. What cabinet would you select if you wanted to work with small amounts of volatile chemicals?
2. What cabinet would you select if you wanted to be able to turn off the cabinet when it is not in use?
3. What cabinet would you select for changing the bedding in animal cages if you want to minimize the odors in the room?
Slide 39

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Proper BSC Set-up

- Allow cabinet to run 5 minutes prior to use
- Disinfect work surfaces.
- Wipe off each item you place into the BSC to minimize potential contamination.
- Adjust Sash.
- Arrange materials in the BSC to segregate contaminated and clean items.

Slide 40

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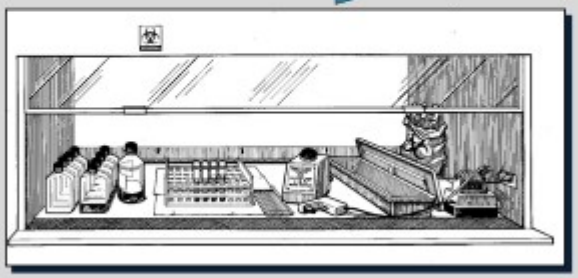
Class II Biosafety Cabinet Use

Layout of Equipment

Clean side → Dirty side



Neat, clean, organized, everything needed placed inside before beginning work

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Working in a BSC

- Perform work at least four inches behind the front air intake grille.
- Avoid unnecessary movement in and around the cabinet.
- Collect waste, pipettes, and contaminated materials in the cabinet.
- Wipe down cabinet work surfaces when work is completed.

Slide 42

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UV Lights in a BSC

- Not recommended and limited effectiveness
- Must be cleaned weekly
- Bulbs usually need to be replaced regularly (every 90 days of use)
- Must be turned off while the room is occupied

Slide 43

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Limitations of BSCs

Only **small quantities** of volatile chemicals may be used in **any** type of BSC

- Motors on standard BSCs are not spark-proof

Should **not** use **Bunsen burners** or **alcohol lamps** in BSCs

- Over time, heat can damage the HEPA filter
- Heat can create turbulent airflow, compromising protection
- And, potential for fire to destroy BSC
  - Buildup of flammable vapors with 70% recirculation

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GBRMC

Limitations of BSCs

BSCs need to be **tested** and **certified** regularly to assure they are providing the expected protection

- Prior to service
- After repairs or relocation
- Annually

Slide 45

Other Engineering Controls

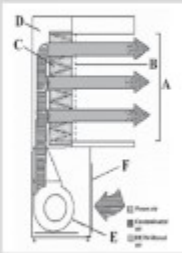
Chemical Fume Hoods

- Designed for use with chemicals
- Provides personnel protection through inward air flow
- Usually no HEPA filtration
- 100% exhaust through hard ducting to exterior of the building

Slide 46

Clean Bench or Laminar Flow Hood

- Outward air flow is directed toward the worker's breathing zone (no personnel protection)
- Provides a sterile environment
- Used primarily with non-hazardous material (media prep)



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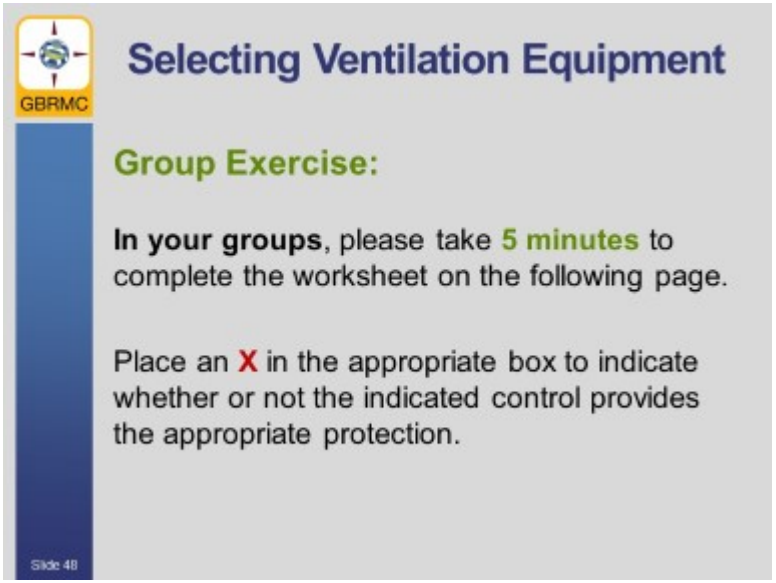
GBRMC
Selecting Ventilation Equipment
Group Exercise:
In your groups, please take 5 minutes to complete the worksheet on the following page.
Place an X in the appropriate box to indicate whether or not the indicated control provides the appropriate protection.
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Group Exercise

	Personal Protection	Product Protection	Environment Protection	Large Amounts of Chemical Use	Small Amounts of Chemical Use
Class I					
Class II A2					
Class II B2					
Class III					
Clean Bench					
Fume Hood					

Centrifuge Safety

- Follow recommended maintenance schedules.
- Balance rotors carefully.
- Never defeat safety interlocks.
- Wash rotors with mild detergent - never harsh or caustic cleaners.
- Never use abrasive or stiff brushes.
- Allow rotors to air dry (upside down) before placing in a cold room.

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Centrifuge Safety

- Routinely decontaminate rotors and centrifuge interiors appropriate disinfectant.

- Use secondary safety cups when spinning infectious materials.

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Centrifuge Safety

- Load and unload rotors/safety cups containing infectious materials inside a BSC.
- Wipe off the outside of each secondary container with a suitable disinfectant.

Slide 53

Centrifuge SOP Exercise

Group Exercise:

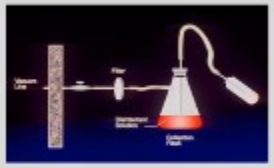
Question:
A high-speed centrifuge exploded in your lab, how would you respond?

In your groups, spend **5 minutes** to develop a step-by-step response place for an accident (explosion) involving a high speed centrifuge in the lab.

Slide 54

Vacuum Line Protection

- Protect all vacuum lines with traps and hydrophobic filters
- Change high use filters every six months
- Direct fluid side toward vacuum flask
- Be sure inflow tube extends below the flask arm.



Slide 55

Examples of Poor Engineering Controls

Transport Containers

- Robust, leak proof, unbreakable, autoclavable
- Used to transport infectious material within a lab facility
- Load and unload in a BSC
- Wipe of exterior with appropriate disinfectant
- Autoclave in between uses
- Sufficient absorbent should be present at the bottom

Slide 56

Engineering Controls – Identifying Problems

Question:

What is **wrong** with this picture?

Identify:

- The **Result**
- The **Assumed Risk**

Slide 57

Engineering Controls – Identifying Problems

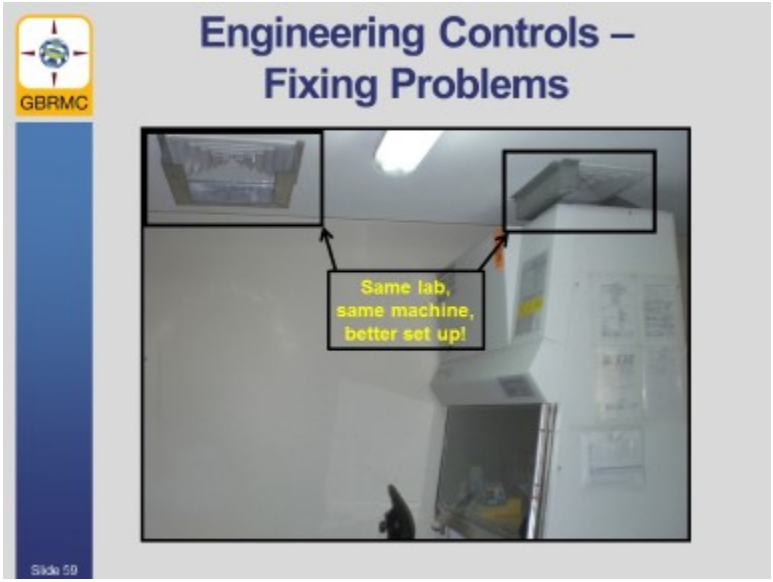
Question:

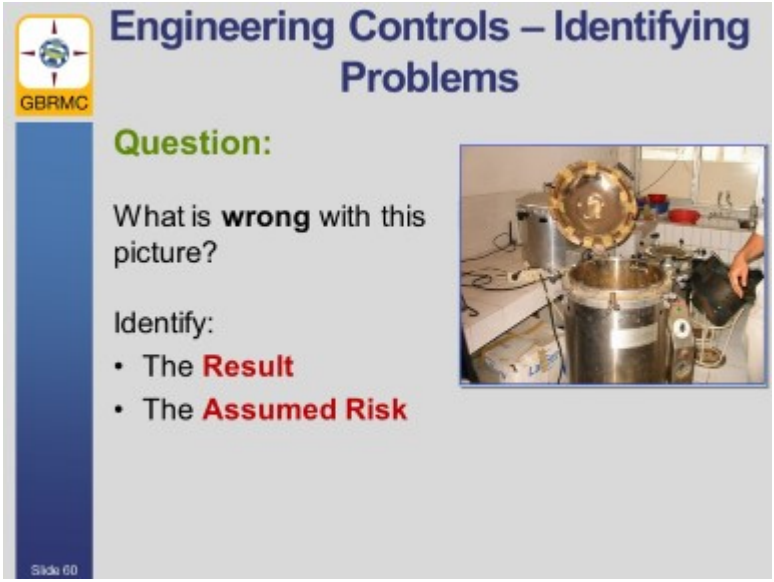
What is **wrong** with this picture?

Identify:

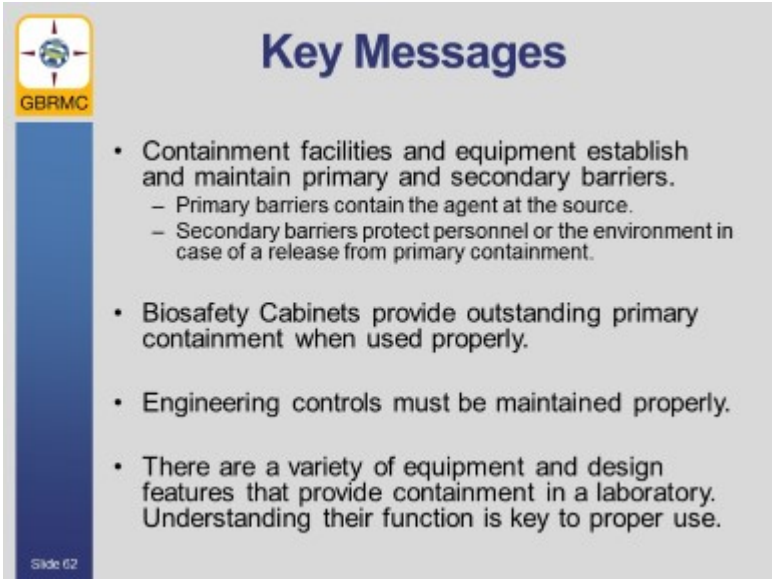
- The **Result**
- The **Assumed Risk**

Slide 58


GBRMC
Engineering Controls – Fixing Problems
Same lab, same machine, better set up!
Slide 59


GBRMC
Engineering Controls – Identifying Problems
Question:
What is wrong with this picture?
Identify:
• The Result
• The Assumed Risk
Slide 60

Review & Wrap-Up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– Secondary barriers protect personnel or the environment in case of a release from primary containment.
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• Engineering controls must be maintained properly.
• There are a variety of equipment and design features that provide containment in a laboratory. Understanding their function is key to proper use.
Slide 62

Action Plan

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KNOW		FEEL		BE ABLE TO DO	

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What more do I need to know or do?	How will I acquire the knowledge or skills?	How will I know that I've succeeded?	How will I use this new learning in my job?

Use space on back, if needed

Reference

BSC	Air Flow (%)		Exhaust System	Volatile Toxic Chemicals/Radionucleotides
	Recirculated	Exhausted		
Class I	0	100	Exhaust to room, hard duct or thimble connection	Yes if hard ducted to building exhaust
Class IIA1	70	30	Exhaust to room or thimble connection to building exhaust	No
Class IIA2 – vented outside	70	30	Exhaust to room or thimble connection to building exhaust	Yes (Minute amounts)
Class IIB1	30	70	Hard duct	Yes (Small amounts)
Class IIB2	0	100	Hard duct	Yes
Class III	0	100	Hard duct	Yes