Decontamination and Waste Management

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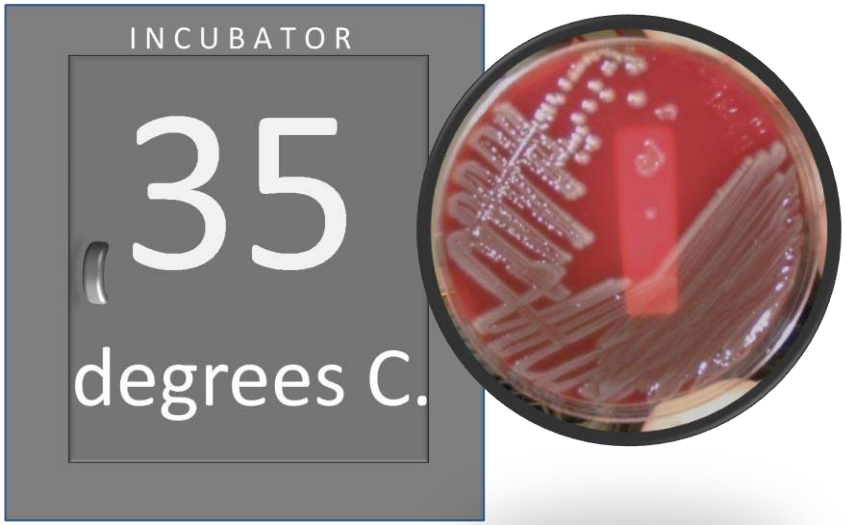
April 12, 2016

The risk from fomites



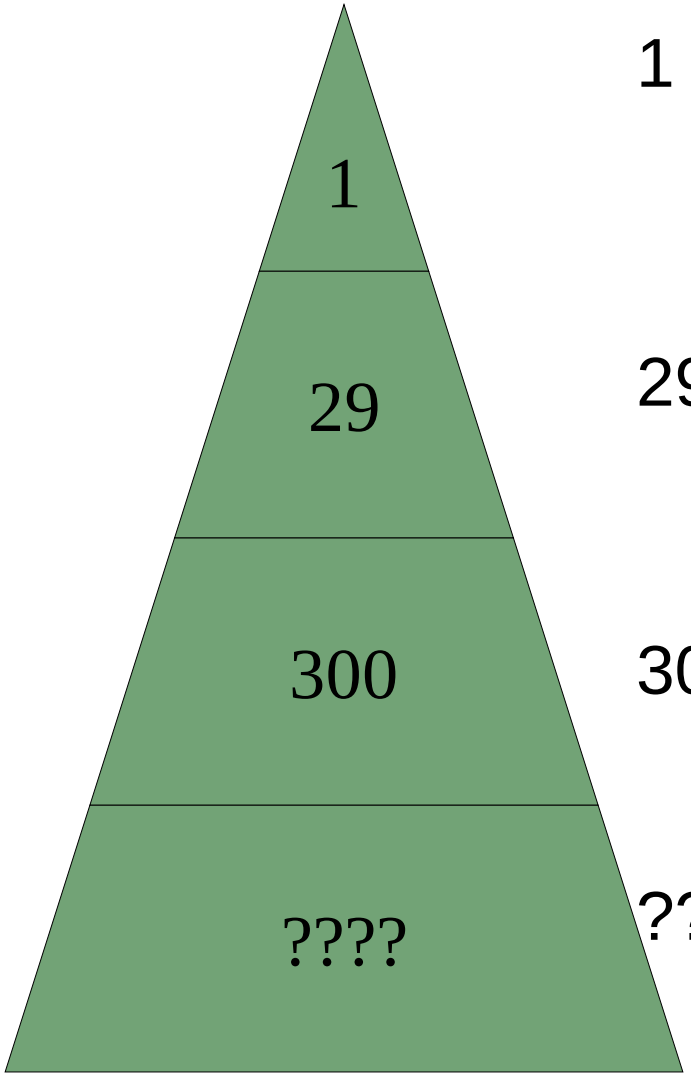
Stability:

Minutes to hours on surfaces (Measles virus)

Days to weeks on surfaces (Hepatitis B virus)

Weeks to months in hostile environment (Coxiella burnetii)

The Heinrich Pyramid (1931)



1 serious accident
is preceded by

29 minor incidents
which are preceded by

300 near misses
which are preceded by

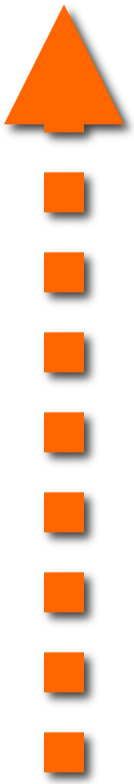
??? unsafe practices or
unsafe conditions.

Disinfection & Sterilization

- Decontamination – cleansing to remove pathogens to an acceptable level. Sterilization and disinfection are methods of decontamination
- Sterilization – complete kill of all microbial agents
- Disinfection – destruction of pathogenic microorganisms or their toxins by direct exposure to chemical or physical agents

Generalized Order of Resistance

- Prions (MOST DIFFICULT)
- Protozoan cysts
- Bacterial spores
- Non-enveloped viruses
- Mycobacterium
- Fungal spores, fungi
- Vegetative bacteria
- Enveloped viruses (READILY KILLED)



Levels of Disinfection/Sterilization

Process	Level of Microbial Inactivation	Method
Sterilization	Destroys all microorganisms including spores	High temperature Low Temperature Liquid immersion
High Level	Destroys all microorganisms except spores	Heat – automated Liquid immersion
Intermediate Level	Destroys vegetative bacteria, mycobacteria, most viruses, most fungi, NOT bacterial spores	Liquid contact
Low Level	Destroys vegetative bacteria, some fungi and viruses but no mycobacteria or spores	Liquid contact

Examples of Disinfection/Sterilization

Process	Examples
Sterilization	High temperature – Steam 40 min, Dry Heat (1-6 hr) Low Temperature – Ethylene oxide gas (15hr); hydrogen peroxide gas plasma (50 min) Liquid immersion – Chemical: 2% glutaraldehyde (20-45 min); 1.93% phenol (12 hr); 7.35% hydrogen peroxide (3 hr)
High Level	Heat – automated: Pasteurization (50 min) Liquid immersion: – Chemical: 2% glutaraldehyde (20-45 min); 1.93% phenol (12 hr); 7.35% hydrogen peroxide (3 hr); 650-675 ppm chlorine (10 min)
Intermediate Level	Liquid contact: Chlorine-based products; phenolics
Low Level	Liquid contact: quaternary ammonium compounds or 70-90% alcohol.

Sterilization

- Autoclave – The pressure chamber

  Steam/Pressure/Time

  121C(249F)/15 psi/15-20 min

  Trapped air is removed from chamber (gravity displacement or pre-vac)

  Packaging and placement
- Chemical – High Level Disinfectant

Autoclave Check to Verify

- Chemical indicators or autoclave tape change color when conditions met
  - The marker does not = sterility
- Bowie-Dick device to verify full cycle
- Biological Indicators/Spore Checks proof of sterility

Standard Practice:

Maintain a clean workspace and decontaminate daily with a disinfectant that is effective against the target organism

Sodium hypochlorite

70% Alcohol

Liquid Chemical Disinfectants

- The effectiveness of the disinfectants can be influenced by a number of factors:
  - presence of organic material (e.g., blood, serum, sputum)
  - temperature;
  - relative humidity;
  - concentration;
  - contact time

http://www.phac-aspc.gc.ca/publicat/lbg-ldmbl-04/ch8-eng.php

Peracetic Acid

Acetic Acid + Hydrogen Peroxide  Peracetic Acid + Water

- Clear, colorless liquid
- Broad kill spectrum
- No Activation required
- Odor or irritation not significant (vinegar)
- Material compatibility concerns
- Long shelf life
- No residual
- Decomposes rapidly

Glutaraldehyde

- Well studied
- Relatively inexpensive
- Excellent material compatibility

- Respiratory irritation from vapor
- Pungent and irritating odor
- Slow mycobactericidal activity
- Allergic contact dermatitis
- Vapor monitoring needed

Hydrogen Peroxide

- No activation required
- No disposal issues
- No odor or irritation issues
- Many studies
- Material compatibility concerns
- Serious eye damage with contact

Intermediate and Low Level Disinfection

- Intermediate
  - EPA-registered hospital disinfectant with label claim regarding tuberculocidal activity
    - Chlorine-based products, phenolics
    - Exposure times at least 60 sec
- Low
  - EPA-registered hospital disinfectant with NO tuberculocidal activity
    - Chlorine-based products, phenolics, quatenary ammonium compounds, 70-90% alcohol
    - Exposure times at least 60 sec

EPA-registered Disinfectants

- http://www.epa.gov/oppad001/chemregindex.htm

- List A: EPA's Registered Antimicrobial Products as Sterilizers (PDF) (5 pp, 127k, About PDF)
- List B: EPA Registered Tuberculocide Products Effective Against *Mycobacterium tuberculosis* (PDF) (12 pp, 218k, About PDF)
- List C: EPA's Registered Antimicrobial Products Effective Against Human HIV-1 Virus (PDF) (66 pp, 483k, About PDF)
- List D: EPA's Registered Antimicrobial Products Effective Against Human HIV-1 and Hepatitis B Virus (PDF) (30 pp, 128k, About PDF)
- List E: EPA's Registered Antimicrobial Products Effective Against *Mycobacterium tuberculosis* Human HIV-1 and Hepatitis B Virus (PDF) (8 pp, 53k, About PDF)
- List F: EPA's Registered Antimicrobial Products Effective Against Hepatitis C Virus (PDF) (22 pp, 94k, About PDF)
- List G: EPA's Registered Antimicrobial Products Effective Against *Norovirus* (PDF) (3 pp, 51k, About PDF)
- List H: EPA's Registered Antimicrobial Products Effective Against Methicillin Resistant *Staphylococcus aureus (MRSA)* and Vancomycin Resistant *Enterococcus faecalis* or *faecium* (VRE) (PDF) (40 pp, 566k, About PDF)
- List J: EPA's Registered Antimicrobial Products for Medical Waste Treatment (PDF) (5 pp, 70k, About PDF)
- List K: EPA's Registered Antimicrobial Products Effective Against Clostridium difficile Spores (PDF) (1 pp, 56k, About PDF)
- List L: EPA's Registered Antimicrobial Products that Meet the CDC Criteria for Use Against the Ebola Virus
- List M: Registered Antimicrobial Products with Label Claims for Avian (Bird) Flu Disinfectants

Do you read the labels of the disinfectants you purchase?

Small Space Decontamination

- Disinfect with Liquid Disinfectant
- Routine surface disinfection of production equipment and rooms by wiping
- Spill Clean Up

Large Space Decontamination

- Plan for decontamination during design phase
- Reduce human exposure to disinfecting agents
- Schedule/coordinate for decontamination process. Determine impact of decontamination time
- Select appropriate agent
- Determine location of equipment
- Prepare the site
- Monitor concentration of disinfectant
- Post decontamination clean up and testing

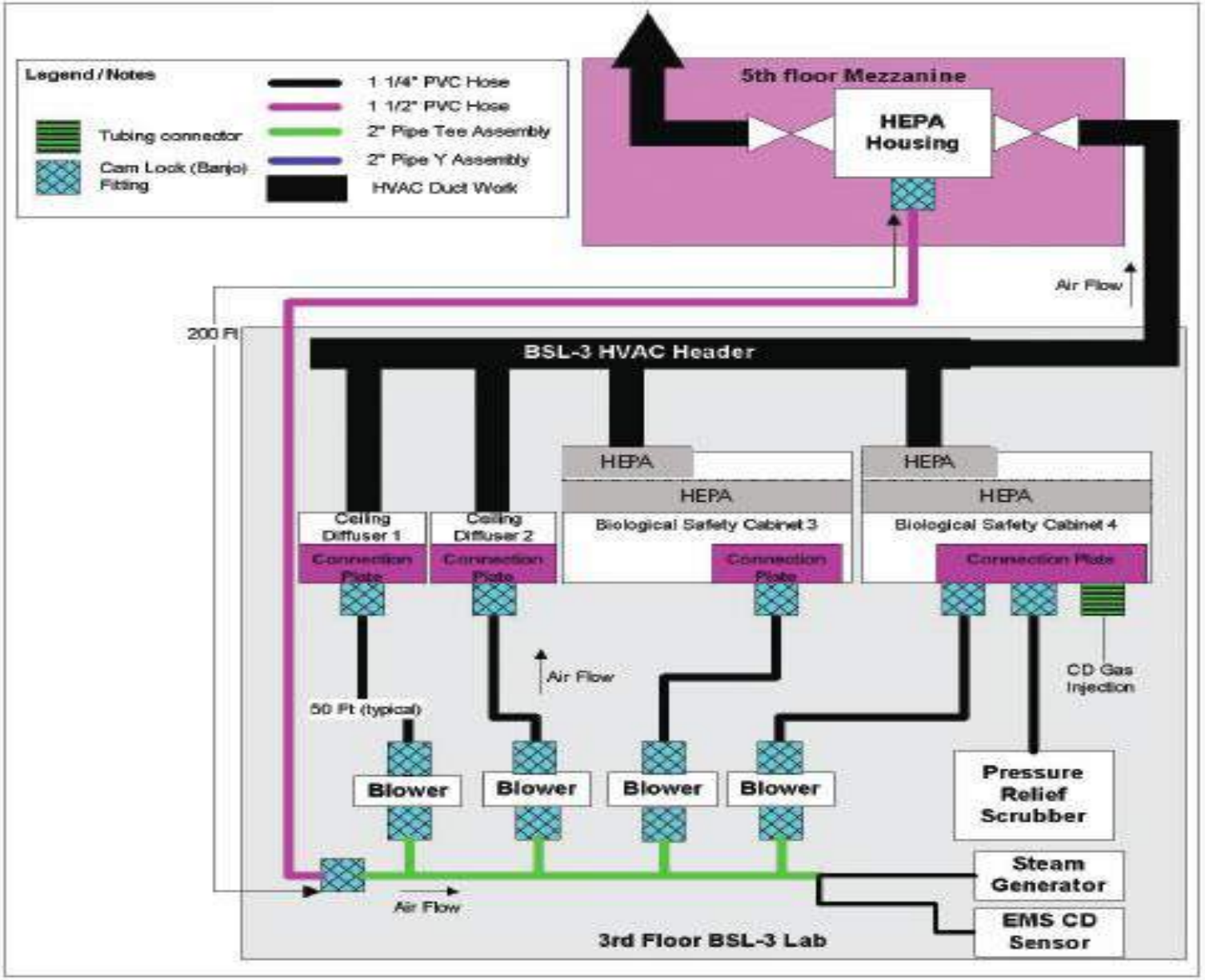


Figure 2: Decontamination Layout of a BSL-3 Area

http://www.cemag.us/articles/2009/07/case-study-exhaust-duct-decontamination-using-chlorine-dioxide-gas

Liquid Disinfection and Fumigation

- Surface decontamination
  - Any liquid disinfectant
  - Wipe, mop or spray
- Fumigation
  - Gas
    - Formaldehyde
    - Chlorine Dioxide
  - Vapor
    - Hydrogen Peroxide
  - Mist (Fogging)

Fumigation

- Planned exercise
- Appropriate controls in place
- Named, trained personnel
- Agreed plan
- Method that is known to be effective in the circumstances of use

Formaldehyde Method

- Evaporation of paraformaldehyde (0.3g/cubic ft)
- Separate humidification to 60-85% and heating to >21.1 degree C
- Neutralize with ammonium carbonate (1.1-1.3 g/g of paraformaldehyde)

Formaldehyde CH_2O

- Long experience of successful use for rooms & BSC
- Inexpensive and easy to handle
- Fumigation by vaporize formalin solution or depolymerization of solid paraformaldehyde
- Commonly used for BSC's and changing HEPA filters
- Simple to use and easy to detect
- Broad spectrum efficacy including TB

Formaldehyde

- Slow acting, poor penetration
- Vapor must be vented outside to reduce concentration
- Highly toxic, exposure limit of 2ppm must not be exceeded
- Can react with hypochlorite to form carcinogenic compound bis-(chloromethyl)-ether
- Can damage materials

Hydrogen Peroxide Vapor H_2O_2

- Clear, colorless liquid 35% solution vaporized via a generator
- Four phases for decontamination: conditioning, gassing, dwell, and aeration
- Fast action without environmentally harmful end products
- May not be compatible with all materials

Chlorine Dioxide Gas ClO_2

- Green-yellowish gas with a chlorine-like irritating odor
- Although chlorine dioxide (CD) has “chlorine” in its name, its chemistry is radically different from that of chlorine.
- CD oxygenates products rather than chlorinating them and thus trihalomethane (THM) formation does not occur. Therefore, unlike chlorine, CD does not produce environmentally undesirable organic compounds containing chlorine.

Chlorine Dioxide Gas ClO_2 cont.

- Gaseous CD has been shown to be more effective than liquid CD when applied in equal concentrations and times.
- Chlorine dioxide, in both gaseous and aqueous phase, is a strong oxidizing agent and has about 2.5 times the oxidation capacity of chlorine.
- Additionally, CD gas has been approved for use as a sterilant/decontaminate by the U.S. EPA.

Chlorine Dioxide Gas ClO_2 cont.

- humidification to soften the spore walls,
- the introduction of CD gas into the area to reach the desired concentration,
- dwell period (called exposure) where the gas just sits for a period of time to obtain the desired kill level,
- aeration to remove the gas by bringing in fresh air and exhausting up the stack.

Comparison of Fumigation Methods

	Chlorine Dioxide	Hydrogen Peroxide	Formaldehyde
TWA – 8 h	0.1 ppm	1.0 ppm	0.75 ppm
Odor detection	Yes	No	Yes
Carcinogenic	No	Questionable	Yes
Vent to outside	Yes	Yes	Yes
Cycle Time	3-4 h	6-12 h	>12 h

Comparison of Fumigation Methods

	Chlorine Dioxide	Hydrogen Peroxide	Formaldehyde
Concentration	360 ppm	750 ppm	8000pm
Good Penetration	Yes	No	Yes
Penetration of water	Yes	No	No
Equipment Location	Outside Room	Either	Inside Room
Aeration time	30-60 min	Overnight	1 h

Why fumigate a BSC

- To ensure safety to service personnel who need to access a contaminated BSC ex. motor replacement or HEPA filter change
- Help prevent contamination of samples being processed inside a BSC
- Prevent transmission of infectious agent that could harm lab staff
- Prior to move of BSC

BSL-3 Ventilation Systems

- To determine performance, review:
  - Supply
  - Exhaust
  - Directional airflow
  - Engineering controls such as BSC, downdraft tables, fume hood etc.
  - Building automation system
  - Air filtration Exhaust stacks
  - Redundancy
  - Canopy hoods

Verify BSL-3 Related Systems

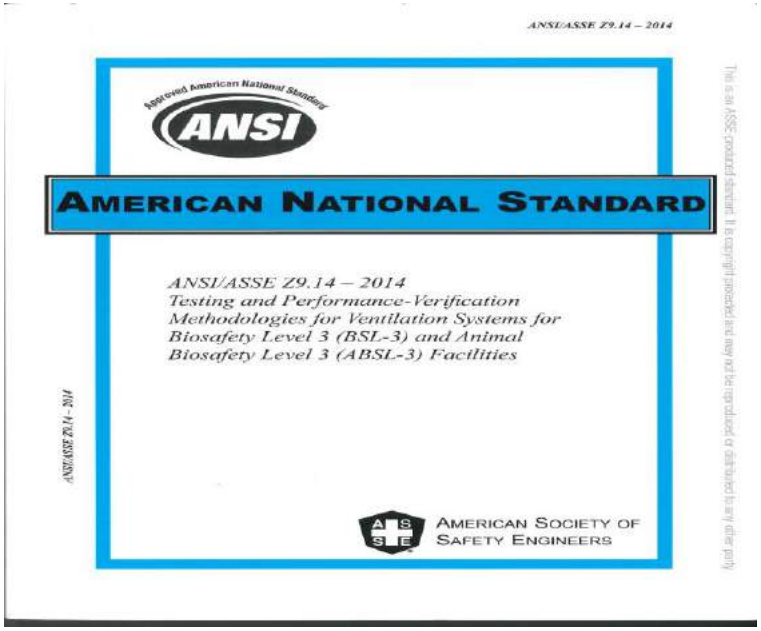
- Maintenance of pressure gradients, temperature and humidity
- Physical integrity
  - Sealing and leakage factors
  - Interlocking systems
  - Anterooms
  - Doors/windows
- Emergency and back up power systems
  - Alarms
  - Operating sequences

BSL-3 SOP Elements

- Written test procedure for test of system
- State acceptance criteria for each test
- Floor plan of the lab showing the directional airflow
- Simplified schematic of the ventilation system
- Schematic of normal and emergency power
- Safety precaution for testing
- Security issues and notifications
- Verification of alarms generated in case of failure

BSL-3 SOP Elements cont.

- List of test equipment
- Documentation of most recent calibration certificates of the test equipment

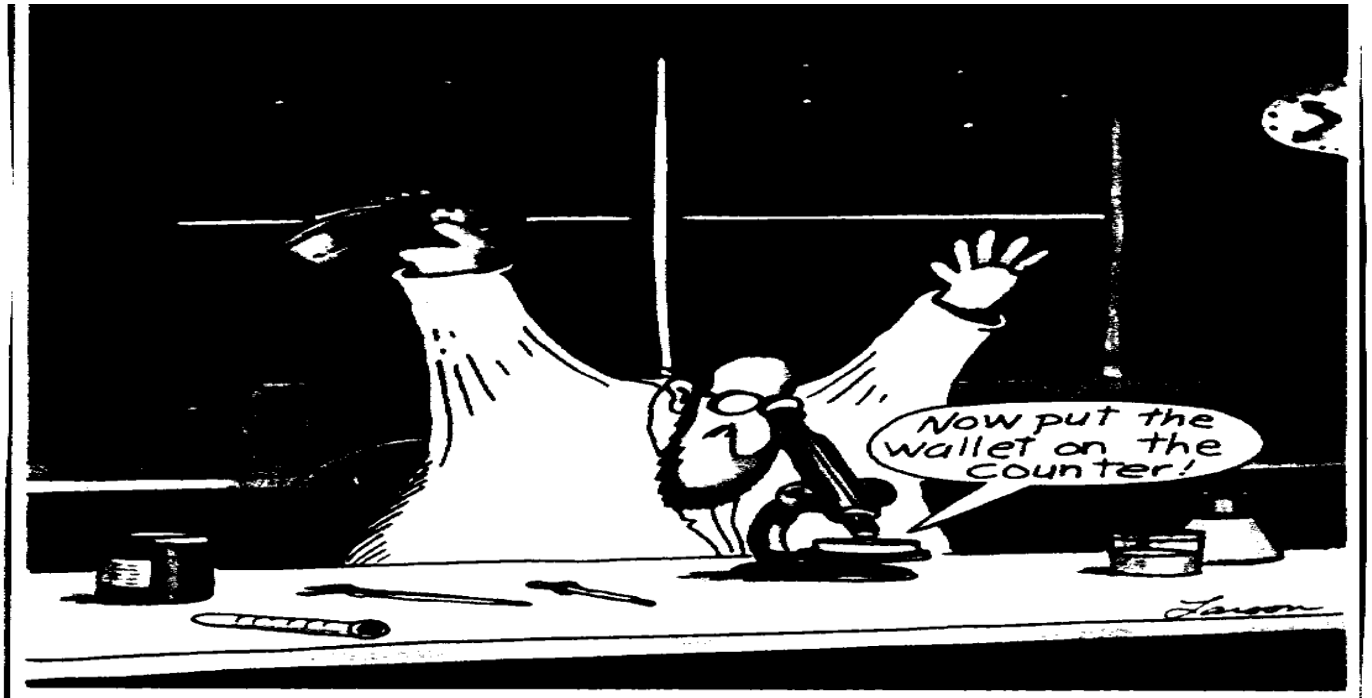


BSL-3 Engineering Controls

What must be verified?

- No recirculation of room or equipment air to areas outside containment area
- Air change rate
- Directional airflow
- Pressurization controls
- Filtration
- Equipment redundancy
- Standby power
- Power failure results
- Instrumentation accuracy and calibration of critical devices
- Interlocks

Questions?



Working alone, Professor Dawson stumbles into a bad section of the petri dish.

Medical Waste Definition

- “Infectious Waste”
- No indication that medical waste is any greater risk than residential waste
- No epidemiologic evidence of disease transmission in the community
- May include microbiological laboratory waste, hazardous waste, blood/body fluids, sharps, pathology waste etc.
- Careful handling, sorting and appropriate disposal successfully deals with risk

Waste-Related Regulations and Guidance

- Regulations
  - EPA
  - OSHA
  - DOT
  - State Agencies
  - Local rules
- Guidance
  - CDC
  - EPA

Medical Waste Categories

- Contaminated Sharps
- Microbiologic cultures and stock of infectious agents
- Animal wastes
- Blood and body fluids
- Human /animal specimens
- Isolation wastes: gowns, gloves, respirators etc.

Waste Management Plan

- Must address every step from acquiring material that become waste to generation of waste, discarding, collection and containment handling, accumulation and storage, transportation, treatment, and ultimate disposal
- Cradle to grave

Medical Waste Plan Objectives

- Rendering infectious waste safe for disposal
- Ensuring that there is minimal risk to patients, personnel, visitors and the community
- Meeting or exceeding all federal, state and local regulations
- Educating staff regarding the management plan and risk associated with “infectious waste”

Medical Waste Plan Components

- Designation – keep a list of medical waste generated in the facility
- Segregation – at the point of origin
- Packaging – package to protect staff, visitors, and patients
  - Ex. sharps containers are impervious, rigid, puncture resistant, leak-proof
- Storage – Treat and dispose waste as soon as possible

Biological Waste Disposal

Biological waste containers should always be labeled with a biohazard symbol

Safe Handling, Minimizing & Disposal of Sharps

- Always use a proper leak proof container to dispose of sharp materials
- Never fill sharps container to the top
- Use plastic vs. glass
- Use retractable/ shielded needles

Medical Waste Plan Components

- Transport – internal and external systems used for transport must maintain integrity of the packaging and protect handlers
- Treatment – several options, often contracted out, incineration most common, steam sterilization, chemical disinfection etc.
- Disposal – direct to a sanitary landfill
- Contingency Planning – unforeseen events
- Training – of all personnel involved

Special Considerations

- Add medical waste flow to the risk assessment process
- Consider waste generation when designing the laboratory
- Consider waste generation when looking at new instrument

Training and Drills

- Biohazards
- Risks of different types of exposures
- Available vaccinations and side effects
- Post-incident first aid and remediation
- Signs and symptoms of infection
- Emergency response procedures
- Incident reporting procedures

Any comments?