Laboratory Design and Review

International High Containment Biosafety Workshop

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Ken Ugwu, P. Eng.

Chief Biocontainment Engineer

Public Health Agency of Canada

Overviews

- Primary and Secondary Containment
- Architectural Design Issues
- Mechanical Design Issues
- Laboratory Equipment
- Electrical Design Issues
- Commissioning

Containment Cosiderations

- Primary and secondary barriers to **minimize the release** of infectious organisms
- Additional features to **prevent transmission** of organisms:
  - appropriate respiratory protection
  - HEPA filtration of exhausted laboratory air
  - strictly controlled laboratory access
  - Operational Practices

Containment Barriers

- Primary barriers achieved with proper use of safety equipment and good laboratory practices
  - BSCs (Class II or III) - all procedures
  - Isolators, Ventilated Racks, cages
- Secondary barriers protect the environment external to the laboratory and achieved with good facilities design and operational practices

Architectural Design Issues

- Planning, Design, Construction
- Layout Options
- Location and Access
- Walls/Floorings/Ceilings/Finishes
- Fixtures/Equipment
- Casework/Furnishing

Planning, Design, Construction Team

- Owner's representatives
  - Scientist(s)
  - Facility Manager
  - Biosafety Officer
  - Administrative/Financial Officer

Planning, Design, Construction Team

- Consultants
  - Architect
  - Mechanical/Electrical/Structural Engineers
  - Cost
  - Commissioning (Independent)
  - Project Manager

New Vs Renovation

- Considerations
  - Program
  - Equipment/space needs
  - Work with animals
  - Existing structure
  - Location
    - Urban Vs country side
    - Services availability

Laboratory Location and Access

- Isolated Zone/Separate Building
- Close to mechanical room/services
- Entry to laboratory via an anteroom
- Entry doors with controlled access system (e.g. card key)
- Office area located outside of containment laboratory

Entry and Access

- Controlled access
- Signage
- Antechamber with clean/dirty changes and shower
- Interlocking entry doors

Signage

Restricted area
Interdit au public
Authorized persons only
Personnes autorisées
NOTICE
MATERIAL SAFETY DATA SHEETS AVAILABLE UPON REQUEST
BIOHAZARD
CAUTION
BIOLOGICAL HAZARD
NOTICE
AUTHORIZED PERSONNEL ONLY

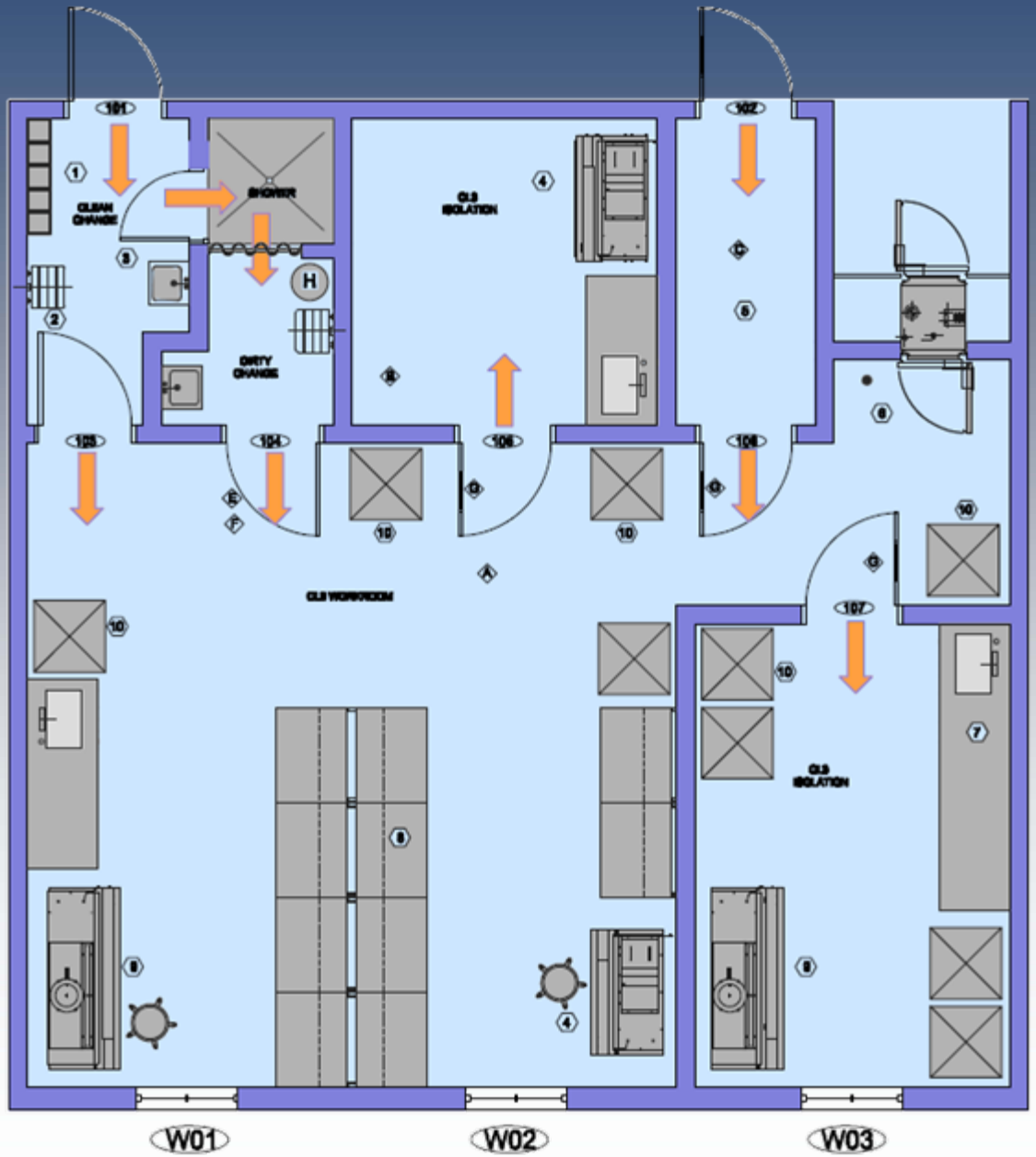
Model Options

- Factors that will influence Choice of Lab Type
  - Program intent
  - Nature of work
  - New/existing structure
  - Location of mechanical room/services
  - Cost (Initial/capital and Maintenance)
  - Experience and personal preferences

Model Options (cont'd)

- Common elements
  - Access limited
  - Air lock
  - Clean change
  - Shower
  - Chemical Shower (CL4)
  - Hands-free Sinks
  - Dirty change
  - Laboratory zones (main laboratory area)

BSL3 Laboratory Layout Option A



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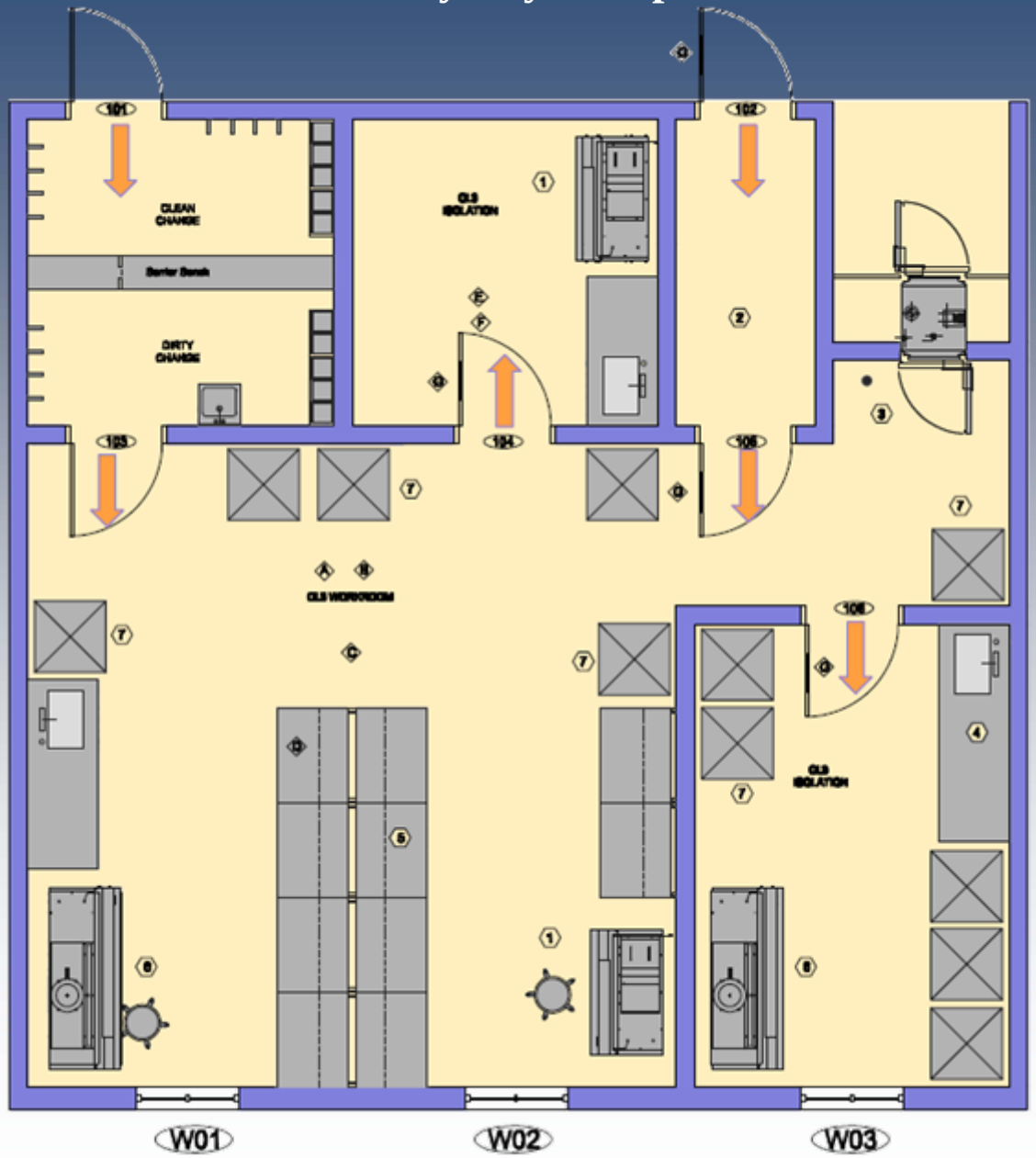
BSL3 Laboratory Layout Option B



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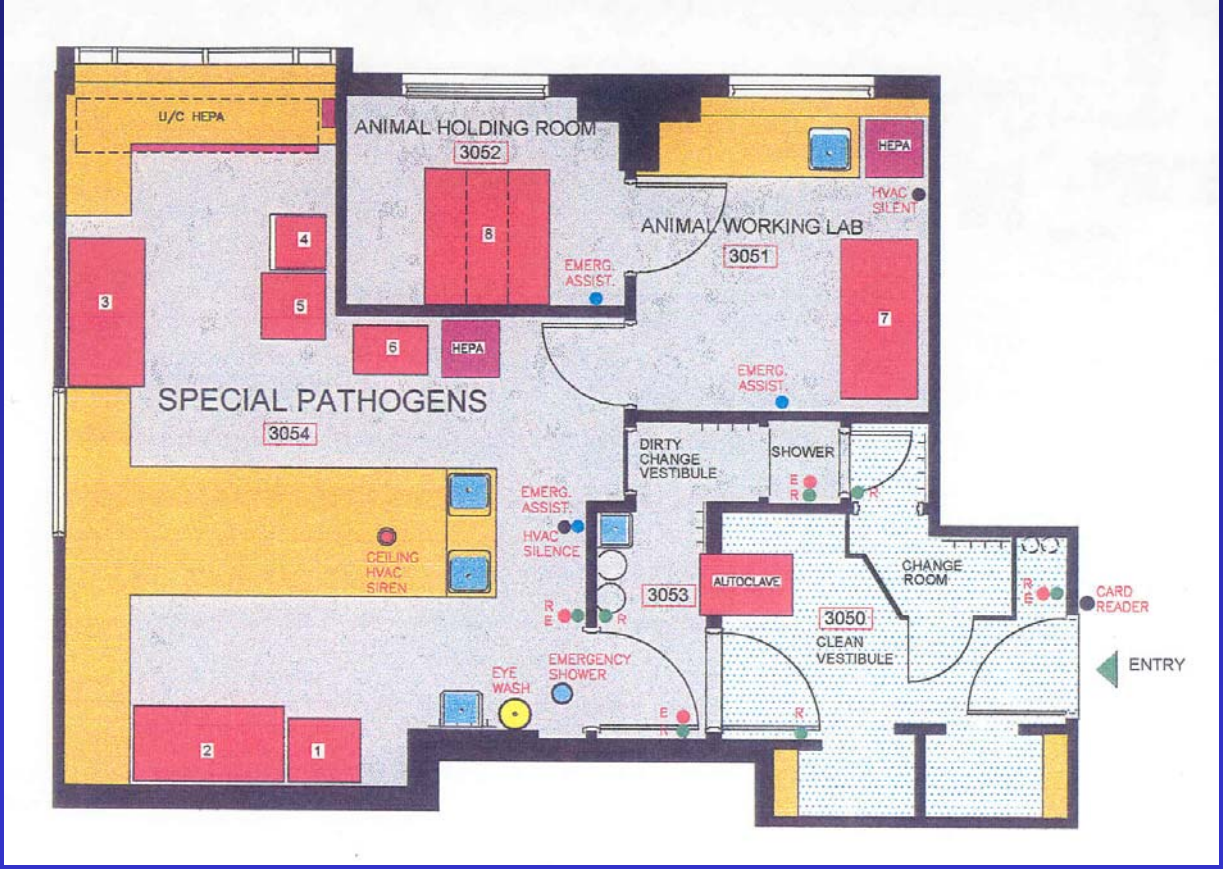
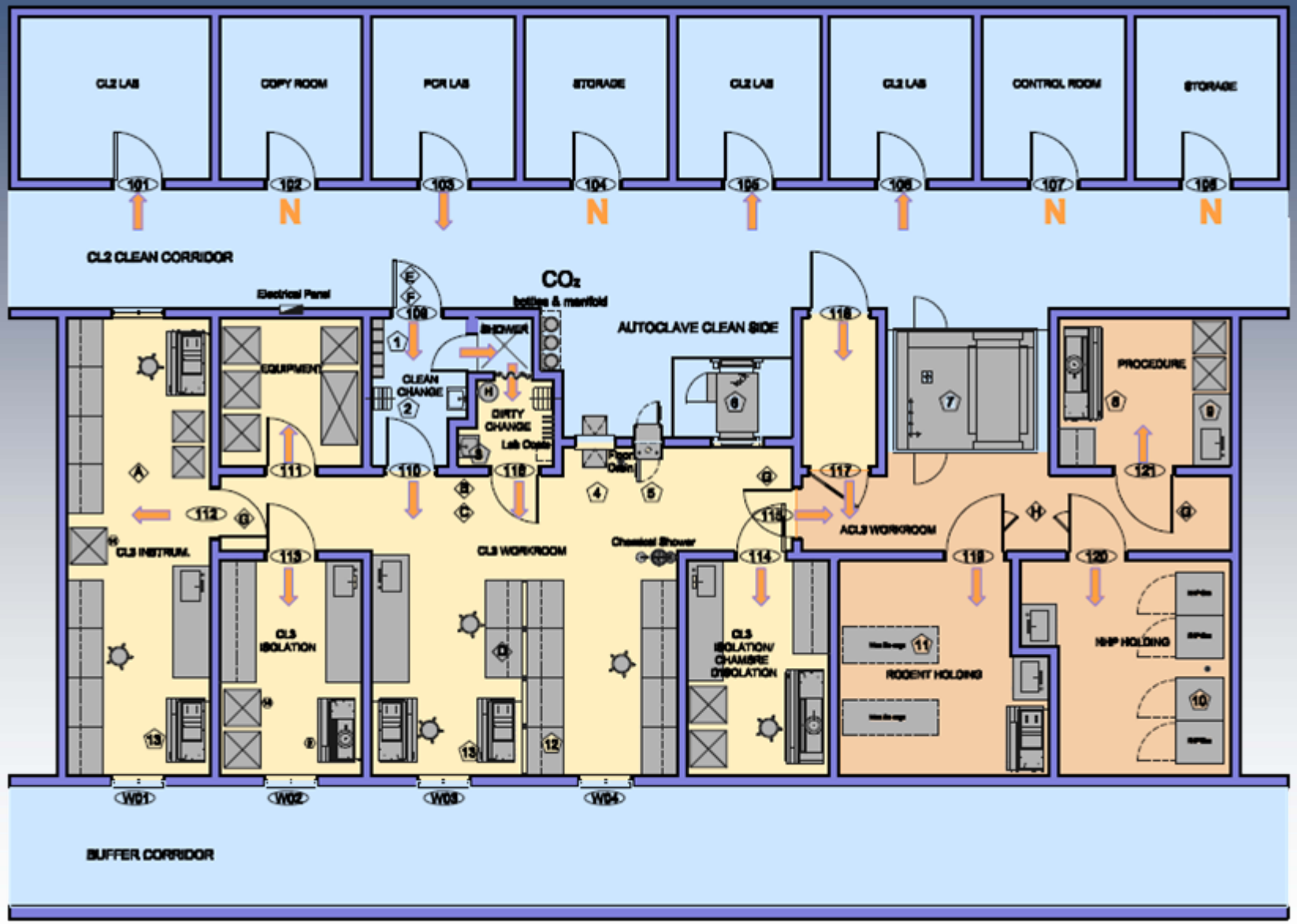
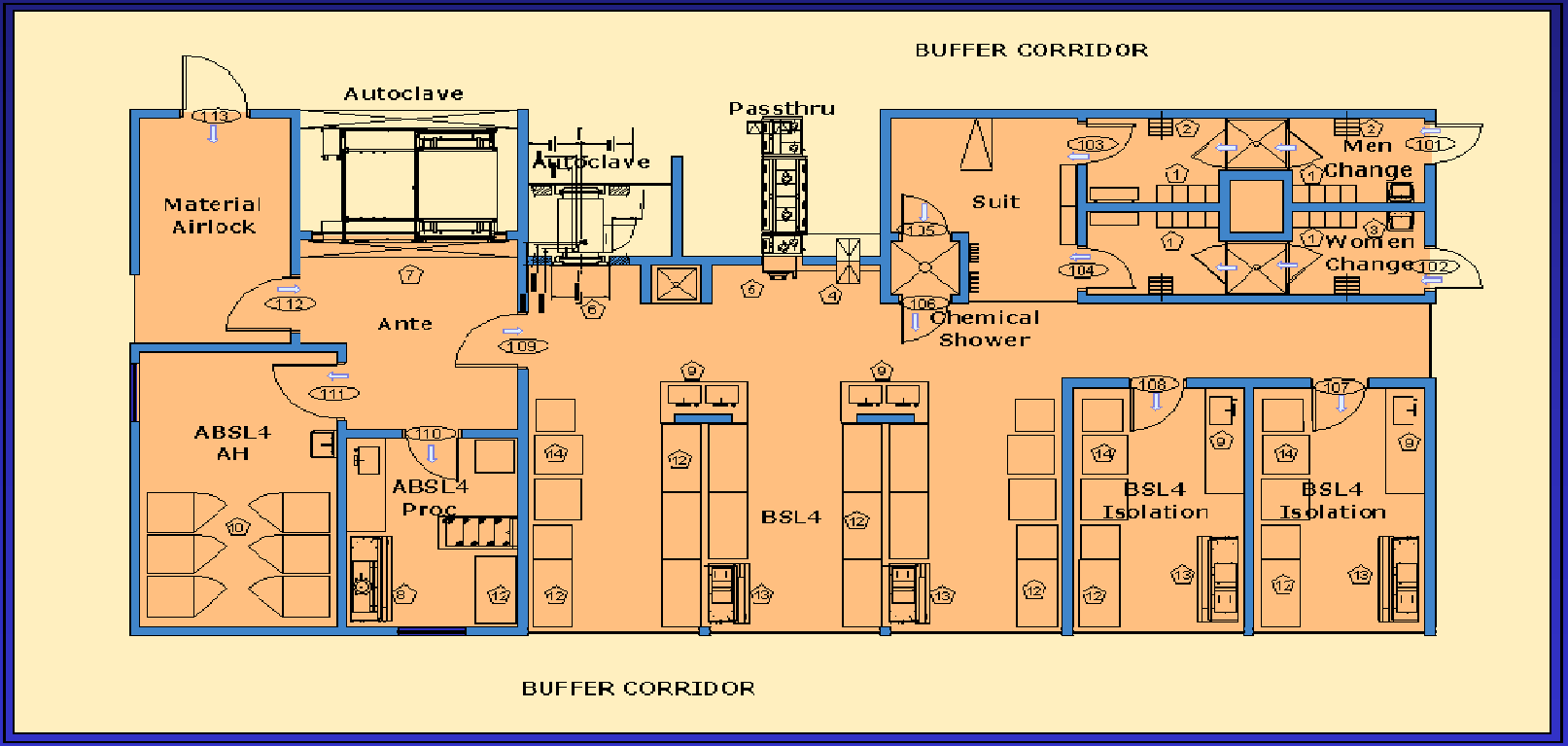
Laboratory Layout



BSL3 & ABSL3 Layout Option C1



BSL4 Laboratory Layout



Walls, Floorings, Ceilings, Finishes

- Coatings easy to clean
- Surfaces resistant to:
  - Scratches
  - Stains
  - Moisture
  - Chemicals and gases
  - Impact
  - Fumigation and chemical disinfecting agents

Walls, Floorings, Ceilings, Finishes (cont'd)

- Surfaces to be Continuous
- Surfaces/penetrations sealable to permit fumigation/ decontamination
- Windows sealed and not openable

Ceiling Finishes

Ceiling Finishing

Wall Finishing (Animal Rm)

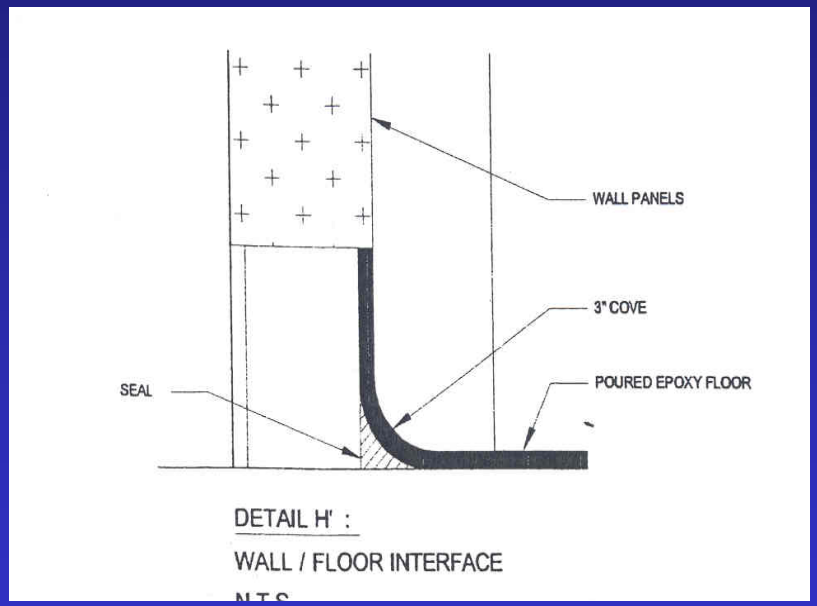
Finishes

Finishes

Floorings/ Finishes

- Floors
  - Slip resistant
  - Cove finish up the wall
  - Continuous surfaces
  - Seams welded
  - Crack resistant

Floor Cove


WALL PANELS
3" COVE
POURED EPOXY FLOOR
SEAL
DETAIL H' :
WALL / FLOOR INTERFACE

Penetration Seals (BSL3)

Casework and Furnishings

- Working surfaces of bench tops:
  - Non-absorptive (avoid use of organic materials)
  - S. steel or epoxy top
  - No open seams
  - Resistant to heat, scratch, stain, moisture, chemicals and gases
- Metal bench frame movable or fixed

Lab Sink

- Hands-free
- Location
  - Exit From Lab
  - Near Procedure Area (Cabinet)
  - Dirty Change (BSL3)
  - Clean Change

Change/Shower/Finishes

Doors

- Door openings sized for passage of all anticipated equipment
- Entry door to containment laboratory lockable
- Doors with self-locking mechanisms
- Material non-absorptive (avoid use of organic materials)
- Sealable for laboratory decontamination

Mechanical Design Issues

- Containment strategies
- Heating, Ventilation and Air conditioning (HVAC) systems
- Plumbing systems (Supply &Effluent)
- Control systems

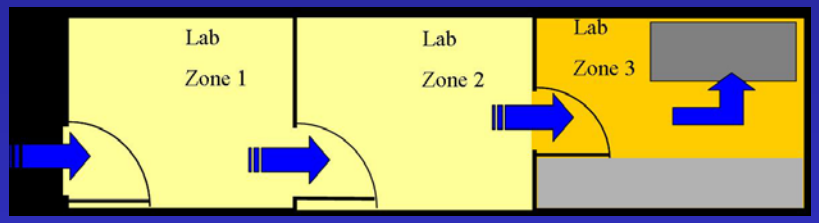
Achieving Containment

Strategies

- Inward directional airflow
- Isolation dampers
- Sealing service penetrations
- Backflow prevention
- Filtration
- Standard Operating Procedures

HVAC Systems – Supply Air

- 100% outside air (Can be re-circulated within same lab)
- System independent of other laboratory of lower containment and offices
- Directional airflow
  - Always towards areas of higher containment



HVAC Systems – Exhaust Air/ Air Filtration Systems

- HEPA filter assembly
  - HEPA filter
  - HEPA filter housing
  - Isolation damper
  - Magnehelic gauges
  - Scan section
  - Decontamination ports
  - Location

HVAC Systems – Exhaust Air/ Air Filtration Systems

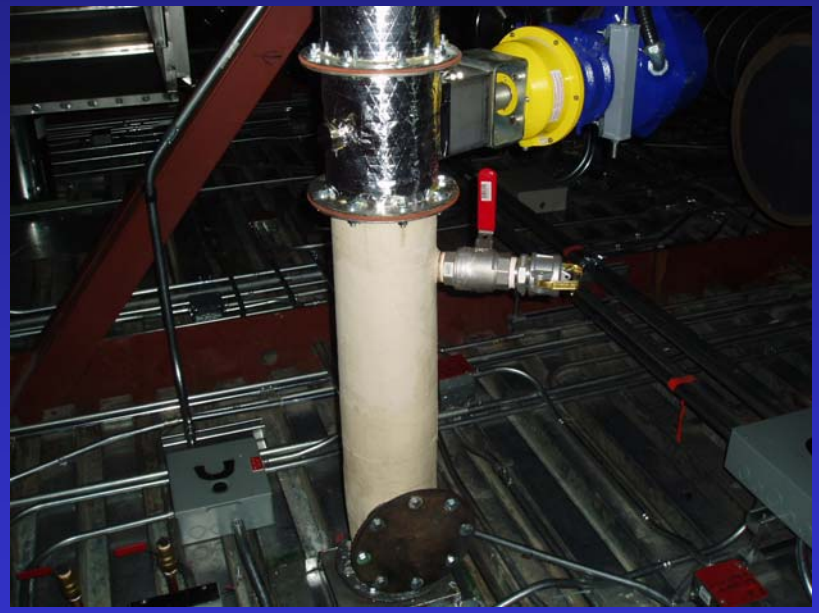
- HEPA filter assembly
  - HEPA filter
  - HEPA filter housing
  - Isolation damper
  - Magnehelic gauges
  - Scan section
  - Decontamination ports

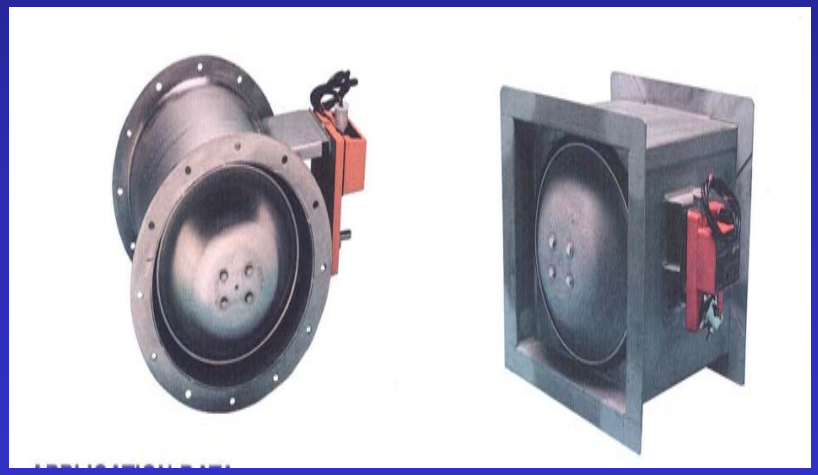
HEPA Filter Assembly/Location

Redundancy

- HEPA Exhaust
- Exhaust Fan

Isolation Dampers

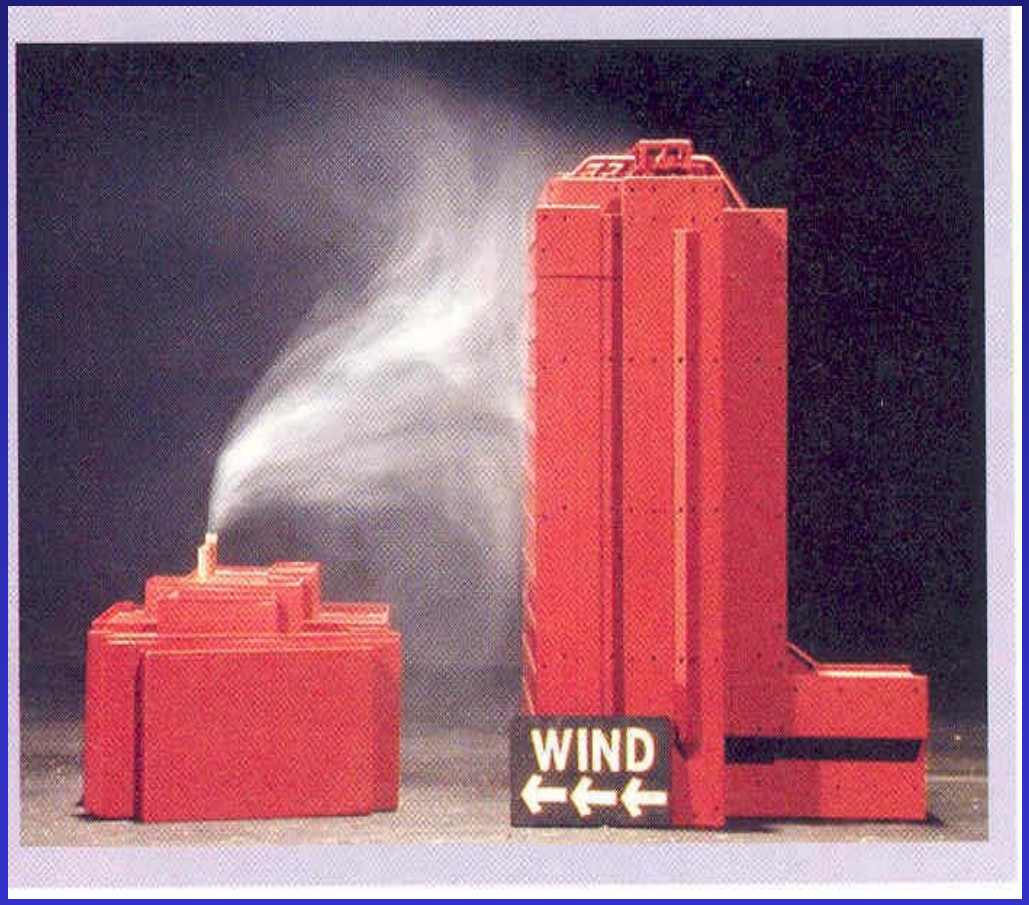




Duct Leak Test

Exhaust Re-entrenchment

- Stack location
- Prevailing wind direction
- Wind study



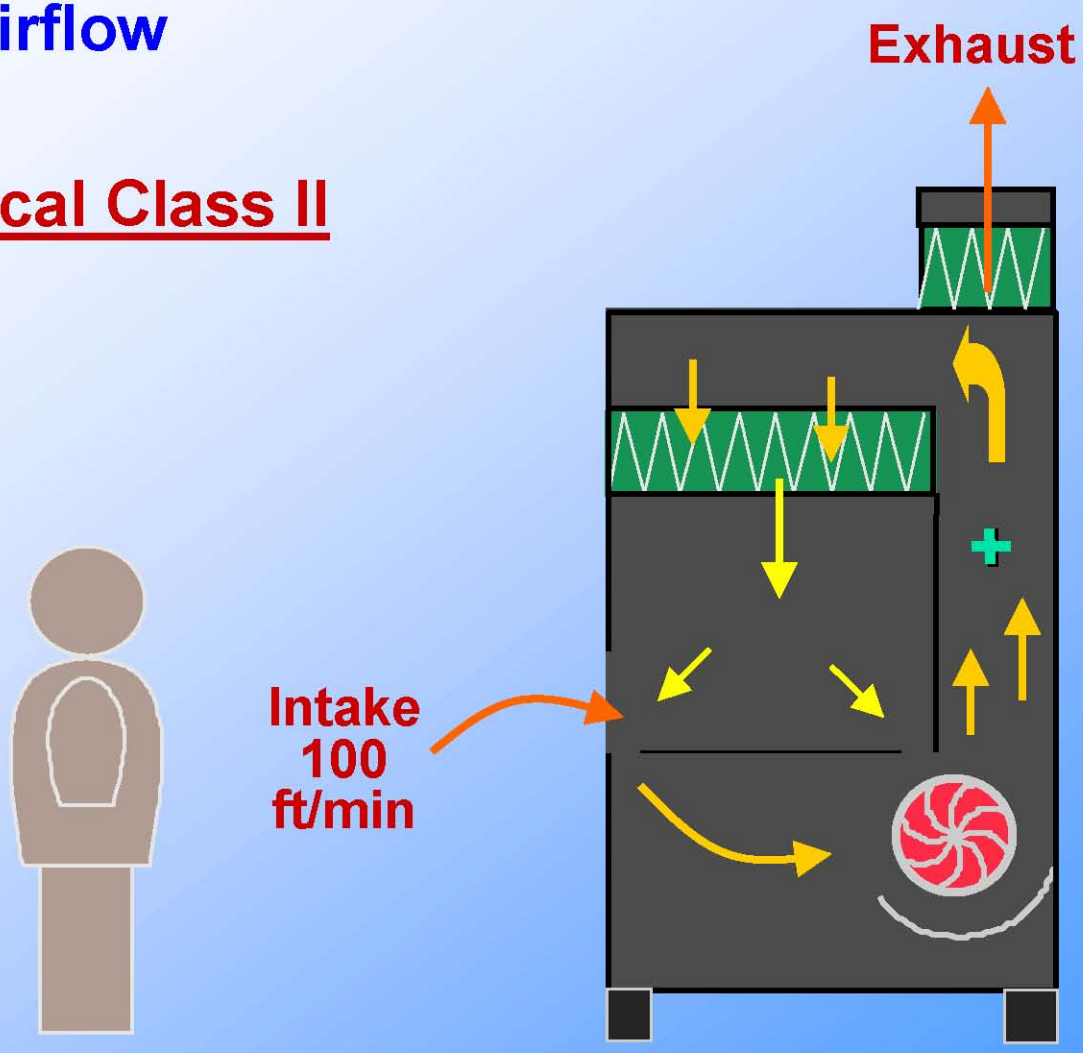
Laboratory Equipment

- Biological Safety Cabinet (BSC)
- Autoclaves
- Biowaste System
- Isolators
- Ventilated Cages
- Transfer Chambers
- Dunk Tanks
- Sinks

Biological Safety Cabinets

Airflow

Typical Class II



BSC

- Hard Connect
- Thimble/Exhaust Canopy
- 2A Exhaust Can be re-circulated into lab
- Service Clearance
- Location

Class III BSC

- Requires:
  - Decon Chamber
  - Pass –through Dunk Tank
  - Under at least 120Pa Negative Pressure always
  - HEPA Supply
  - Double HEPA Exhaust (Dedicated)
  - Bubble Tight Isolation Dampers
  - Decon Ports
  - Interior Smooth edges
  - Custom Built

Class III BSC

Dunk Tank

- Dunk Tanks
  - Disinfectant
  - Seals

Decon Chamber

Observation/Vision Windows

- Essential on:
  - Walls
  - Doors
  - Pass Through Chamber/Box

Ventilated Racks/Cages

- Temperature
- Humidity
- HEPA/Prefilters
- Airflows
- Decontamination

Plumbing Systems – Drainage

- Cross contamination
  - Separate drain and vent lines from areas of lower containment
  - Direct to main building sanitary

Fixture

- Hands Free Sinks
- Location
  - Lab Exit
  - Dirty Change

Back Flow Preventer

- Protect portable water
- All service supply

Drainage

Waste/Effluent Treatment Systems

- Autoclave
- Chemical
- Heat

Autoclave

- Single Door
- Double Door
- Bioseal

Electrical Issues

- Power Supply
  - Emergency Power
    - Life safety equipment (fire alarm)
    - Lighting, security
    - Critical laboratory equipment
    - HVAC systems
    - Uninterrupted power supply (UPS)
  - Electronic Access Control
  - Communication Devices

Electrical Issues (cont'd)

- Door interlock
  - Magnetic locks
  - Emergency overrides
- Emergency alarms
  - Visual
  - Audible

Electrical Issues (cont'd)

- Communication Devices
  - Phone
  - fax
  - Radio
  - intercom
  - Closed-circuit television

Security/Entry Control

- Entry/Alarm centrally monitored
- Control Panels with visual press conditions
- HVAC Alarms
- Access Card Reader
- Emergency Pull Stations/Push Button

Elec Sealed Box

Lighting

Alarms

Notice
Alarms Sounding?
Respirator failed?
Air supply still failed?
Fire?

Pressure Monitors

Commissioning

- Verification of the physical construction and performance of critical containment components
- Process designed to ensure that the finished facility, equipment and system will operate in accordance with the design intent and construction documents
- Part of certification process

Commissioning (cont'd)

- Architectural Verifications
  - Room integrity
    - Finishes (floors, walls, ceilings)
    - Penetration and integrity of seals
- Casework surface
- Doors and windows

BSC Commissioning

Commissioning (Cont'd)

- Mechanical Verifications
  - Major HVAC components
    - Directional airflow/pressurization
    - Supply and exhaust ductwork leak test
    - Integrity of HEPA filter housing
    - Isolation dampers (operation, leak test)
    - Supply and exhaust fans
    - Operation of backflow preventers
    - Biological safety cabinets
    - Autoclaves

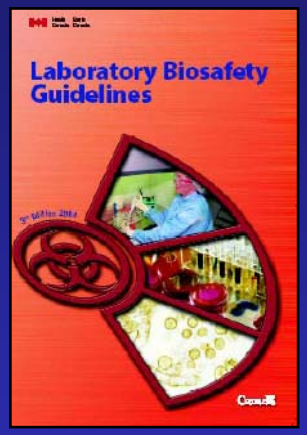
Commissioning (cont'd)

- Electrical Verifications
  - Supply and Exhaust fans failures
  - Failure alarms
  - Standby power and UPS
  - Interlocking doors
  - Security and access systems
  - Communication equipment

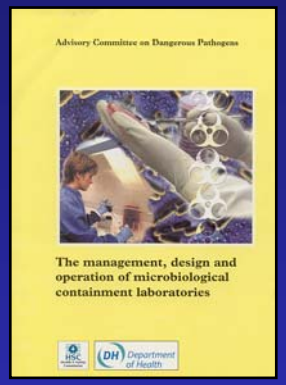
Guidelines, Standards & Codes

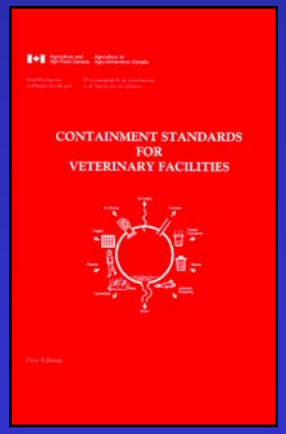
- Applicable Biosafety Guidelines and Standards
- Federal Government
- Provincial Government
  - Ministry of the Environments
- Municipal Governments
- Local and Federal Fire Authorities

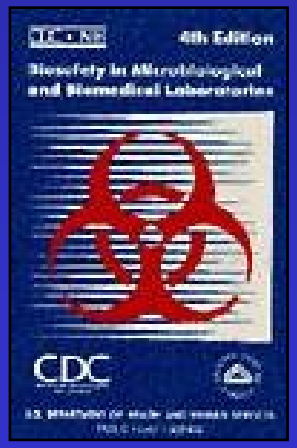
Standards


Laboratory Biosafety Guidelines

LABORATORY BIOSAFETY MANUAL
Third edition


Advisory Committee on Dangerous Pathogens
The management, design and operation of microbiological containment laboratories


CONTAINMENT STANDARDS FOR VETERINARY FACILITIES


4th Edition
Biosafety in Microbiological and Biomedical Laboratories
CDC

THANK YOU

Ken_ugwu@phac-aspc.gc.ca