

Basics of Laboratory Biosafety

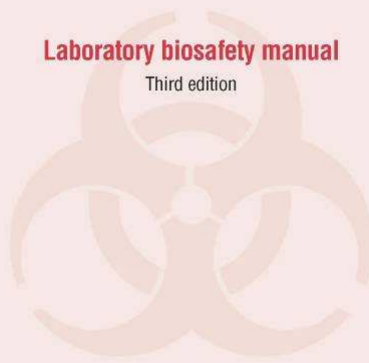
Paul A. Jensen, PhD, PE, CIH

Centers for Disease Control and Prevention
Coordinating Center for Infectious Diseases
National Center for HIV, Viral Hepatitis, STD, and TB Prevention
Division of Tuberculosis Elimination
Atlanta, Georgia USA



Laboratory biosafety manual

Third edition



World Health Organization
Geneva
2004

What is Biosafety?

- Discipline addressing the safe handling and containment of infectious microorganisms and hazardous biological materials

What is Biosafety?

Worker to:

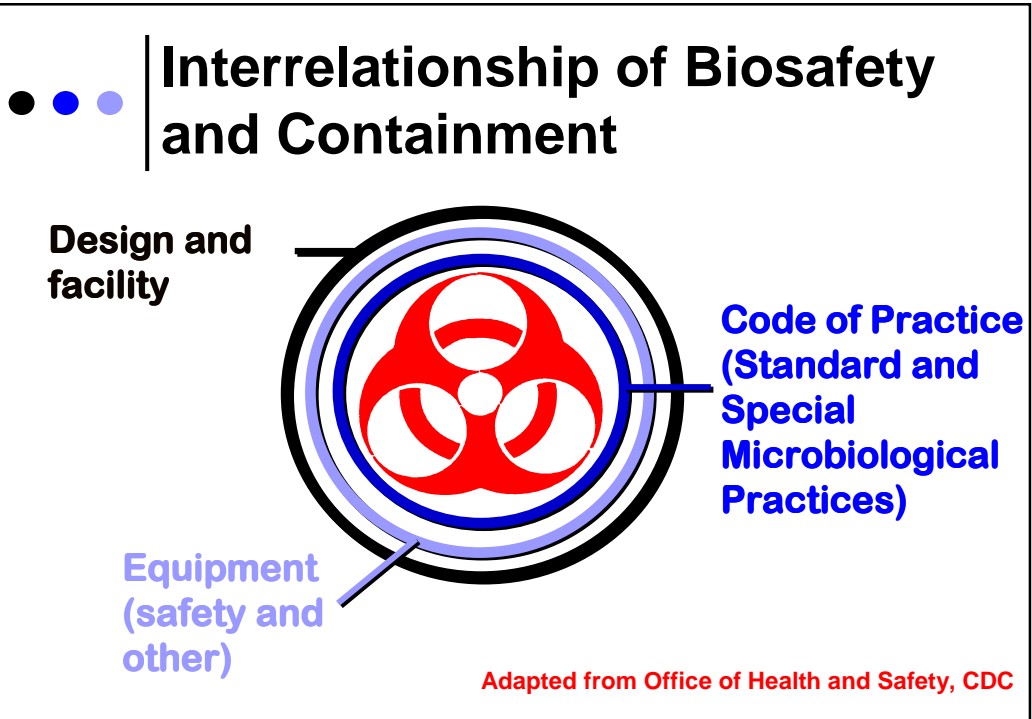
Worker
Specimen
Laboratory

Specimen to:

Worker
Specimen
Laboratory

Laboratory to:

Worker
Specimen
Laboratory



Laboratory Biosafety

- Code of practice
- Design and facilities
- Equipment
- Worker surveillance
- Training
- Waste
- Chemical, fire, electrical, radiation, and equipment safety

Excess Occupational Risk

Work Location	Incidence of TB (worker relative to general population)
Outpatient facilities	4.2 – 11.6
General medical wards	3.9 – 36.6
Inpatient facilities	14.6 – 99.0
Emergency rooms	26.6 – 31.9
Laboratories	42.5 – 135.3

Joshi R, Reingold AL, Menzies D, Pai M [2006]. Tuberculosis among health-care workers in low- and middle-income countries: a systematic review. *PLoS Med* 3(12): e494.
 Menzies D, Joshi R, Pai M [2007]. Risk of tuberculosis infection and disease associated with work in health care settings. *Int J Tuberc Lung Dis* 11(6): 593-605.

Excess Occupational Risk

Occupation	Incidence of TB (worker relative to general population)
Laboratory	
Microscopy technicians	0.2 – 10.0
Culture/DST technicians	1.7 – 34.9
DST technicians	4.5 – 102.5

Kim SJ, Lee SH, Kim IS, Kim HJ, Kim SK, Rieder HL [2007]. Risk of occupational tuberculosis in National Tuberculosis Programme laboratories in Korea. *Int J Tuberc Lung* 11(2):138–142.

Action Needed !!!

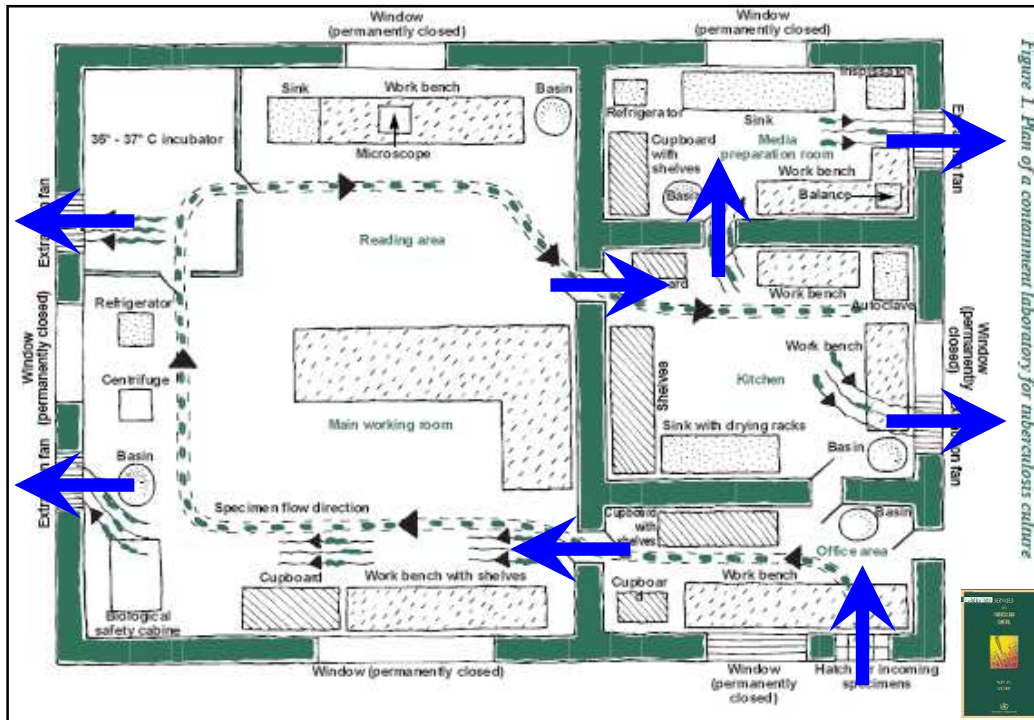


Figure 1. Plan of a containment laboratory for tuberculosis culture

Practical Solutions

- Who needs what, based on risk?
 - BSL 1 All
 - BSL 2 Most
 - BSL 3 Few
 - BSL 4 Very, very few!!!

Mycobacterium tuberculosis

Table 1. Classification of infective microorganisms by risk group

Risk Group 1 (*no or low individual and community risk*)

A microorganism that is unlikely to cause human or animal disease.

Risk Group 2 (*moderate individual risk, low community risk*)

A pathogen that can cause human or animal disease but is unlikely to be a serious hazard to laboratory workers, the community, livestock or the environment. Laboratory exposures may cause serious infection, but effective treatment and preventive measures are available and the risk of spread of infection is limited.

Risk Group 3 (*high individual risk, low community risk*)

A pathogen that usually causes serious human or animal disease but does not ordinarily spread from one infected individual to another. Effective treatment and preventive measures are available.

Risk Group 4 (*high individual and community risk*)

A pathogen that usually causes serious human or animal disease and that can be readily transmitted from one individual to another, directly or indirectly. Effective treatment and preventive measures are not usually available.

WHO 2004

Table 2. Relation of risk groups to biosafety levels, practices and equipment

RISK GROUP	BIOSAFETY LEVEL	LABORATORY TYPE	LABORATORY PRACTICES	SAFETY EQUIPMENT
1	Basic – Biosafety Level 1	Basic teaching, research	GMT	None; open bench work
2	Basic – Biosafety Level 2	Primary health services; diagnostic services, research	GMT plus protective clothing, biohazard sign	Open bench plus BSC for potential aerosols
3	Containment – Biosafety Level 3	Special diagnostic services, research	As Level 2 plus special clothing, controlled access, directional airflow	BSC and/or other primary devices for all activities
4	Maximum containment – Biosafety Level 4	Dangerous pathogen units	As Level 3 plus airlock entry, shower exit, special waste disposal	Class III BSC, or positive pressure suits in conjunction with Class II BSCs, double-ended autoclave (through the wall), filtered air

BSC, biological safety cabinet; GMT, good microbiological techniques (see Part IV of this manual) **WHO 2004**

Confusion

- Risk group
- Risk procedure

Table 3. Summary of biosafety level requirements

	BIOSAFETY LEVEL			
	1	2	3	4
Isolation ^a of laboratory	No	No	Yes	Yes
Room sealable for decontamination	No	No	Yes	Yes
Biological safety cabinets	No	Desirable	Yes	Yes
Personnel safety monitoring capability ^d	No	No	Desirable	Yes

- **Code of Practice should be added to table**
- **Administrative Controls must be highlighted first!!!**

^a Environmental and functional isolation from general traffic.

^b Dependent on location of exhaust (see Chapter 4).

^c Dependent on agent(s) used in the laboratory.

^d For example, window, closed-circuit television, two-way communication.

WHO 2004

Table 3. Summary of biosafety level requirements

	BIOSAFETY LEVEL			
	1	2	3	4
Isolation ^a of laboratory	No	No	Yes	Yes
Room sealable for decontamination	No	No	Yes	Yes
Ventilation:				
— inward airflow	No	Desirable	Yes	Yes
— controlled ventilating system	No	Desirable	Yes	Yes
— HEPA-filtered air exhaust	No	No	Yes/No ^b	Yes
Double-door entry	No	No	Yes	Yes
Airlocks	No	No	Yes	Yes

- Inward airflow ≠ Negative Pressure**
- Controlled ventilation = Mechanical ventilation**
- Controlled ventilation = Natural ventilation???**
- Why HEPA-filtered exhaust?**
- What level of airflow rate or air exchange rate?**

WHO 2004

Table 3. Summary of biosafety level requirements (facility & equipment)

	BIOSAFETY LEVEL			
	1	2	3	4
Isolation ^a of laboratory	No	No	Yes	Yes
Room sealable for decontamination	No	No	Yes	Yes
Ventilation:				
— inward airflow	No	Desirable	Yes	Yes

“BSC and/or other primary containment devices for all activities”

— on site	No	Desirable	Yes	Yes
— in laboratory room	No	No	Desirable	Yes
— double-ended	No	No	Desirable	Yes
Biological safety cabinets	No	Desirable	Yes	Yes
Personnel safety monitoring capability ^d	No	No	Desirable	Yes

^a Environmental and functional isolation from general traffic.
^b Dependent on location of exhaust (see Chapter 4).
^c Dependent on agent(s) used in the laboratory.
^d For example, window, closed-circuit television, two-way communication.

WHO 2004

Table 3. Summary of biosafety level requirements (facility & equipment)

	BIOSAFETY LEVEL			
	1	2	3	4
Isolation ^a of laboratory	No	No	Yes	Yes
Room sealable for decontamination	No	No	Yes	Yes
Ventilation:				
— inward airflow	No	Desirable	Yes	Yes
— controlled ventilation	No	Desirable	Yes	Yes
— HEPA-filtered air exhaust	No	Desirable	Yes	Yes
Double-door entry	No	Desirable	Yes	Yes
Airlock	No	Desirable	Yes	Yes
Airlock with shower	No	Desirable	Yes	Yes
Anteroom	No	Desirable	Yes	Yes
Anteroom with shower	No	Desirable	Yes	Yes
Effluent treatment	No	Desirable	Yes	Yes
Autoclave:				
— on site	No	Desirable	Yes	Yes
— in laboratory room	No	Desirable	Yes	Yes
— double-ended	No	Desirable	Yes	Yes
Biological safety cabinets	No	Desirable	Yes	Yes
Personnel safety monitoring capability ^d	No	No	Desirable	Yes

What’s the difference between:

- Airlock
- Anteroom
- Double-door entry

^a Environmental and functional isolation from general traffic.
^b Dependent on location of exhaust (see Chapter 4).
^c Dependent on agent(s) used in the laboratory.
^d For example, window, closed-circuit television, two-way communication.

WHO 2004

Table 3. Proposed summary of biosafety requirements

	PROCEDURE			
	A	B	C	D
Isolation ^a of laboratory				
Room sealable for decontamination				
Ventilation:				
— inward airflow				
— controlled ventilating system				
— HEPA-filtered air exhaust				
Double-door entry				
Airlock				
Airlock with shower				
Anteroom				
Anteroom with shower				
Effluent treatment				
Autoclave:				
— on site				
— in laboratory room				
— double-ended				
Biological safety cabinets				
Personnel safety monitoring capability ^d				

PA Jensen

Comparing Levels of Protection of Selected PCDs

Primary Barrier	Personnel	Product	Environment
Chemical Fume Hood / Ventilated Workstation	x		
Clean Bench / Laminar Flow Cabinet		x	
BSC Class I	x		x
BSC Class II	x	x	x
BSC Class III	x	x	x

Adapted from Office of Health and Safety, CDC

BSCs

- What Class?
- What Type?
- How do we exhaust them?
 - Direct connect?
 - Thimble?
- Does exhaust satisfy ventilation requirement
 - Technically?
 - Practically?

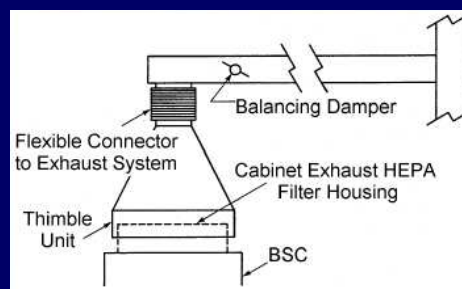




Class II Type A2

Advantages of using a canopy/thimble:

- May help with exhausting lab
- If exhaust filter fails, BSC exhaust air will not recirculate into lab







Take-Home Message

Need:

- Minimum, practical guidelines, norms, SOPs, and common sense
- Sustainability
- Affordability
- Pass the “laugh” and “cry” tests

Thank you!!!



PJensen@cdc.gov

www.cdc.gov