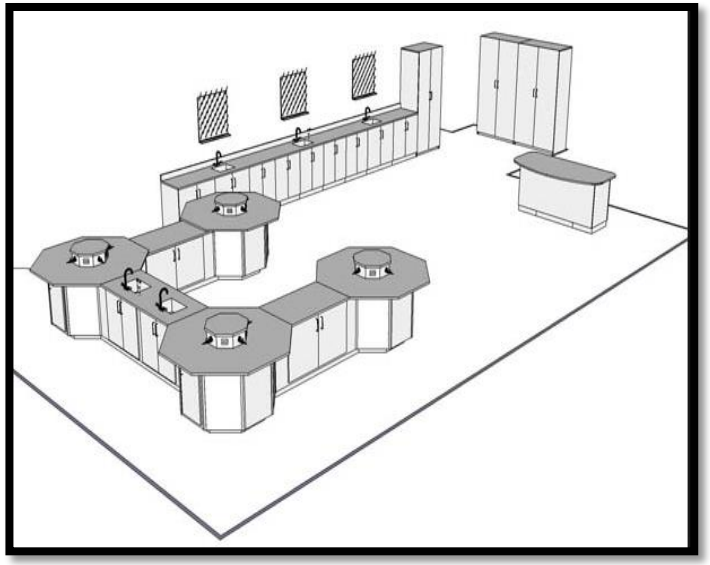
Laboratory Design, Accommodation & Environment



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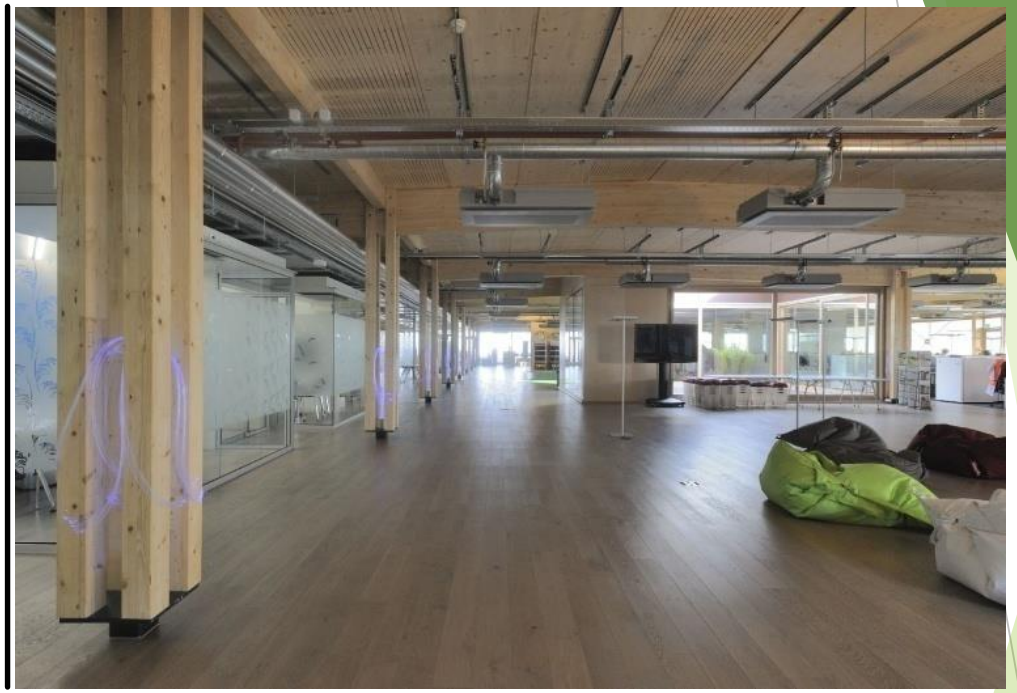


Key design drivers:

Technology & Equipment		Open & Flexible
Safety & Health	Team work	Environmental care

Lab Safety Remarks

In designing a laboratory and assigning certain types of work to it, special attention should be paid to conditions that are known to contain potential safety problems, such as:

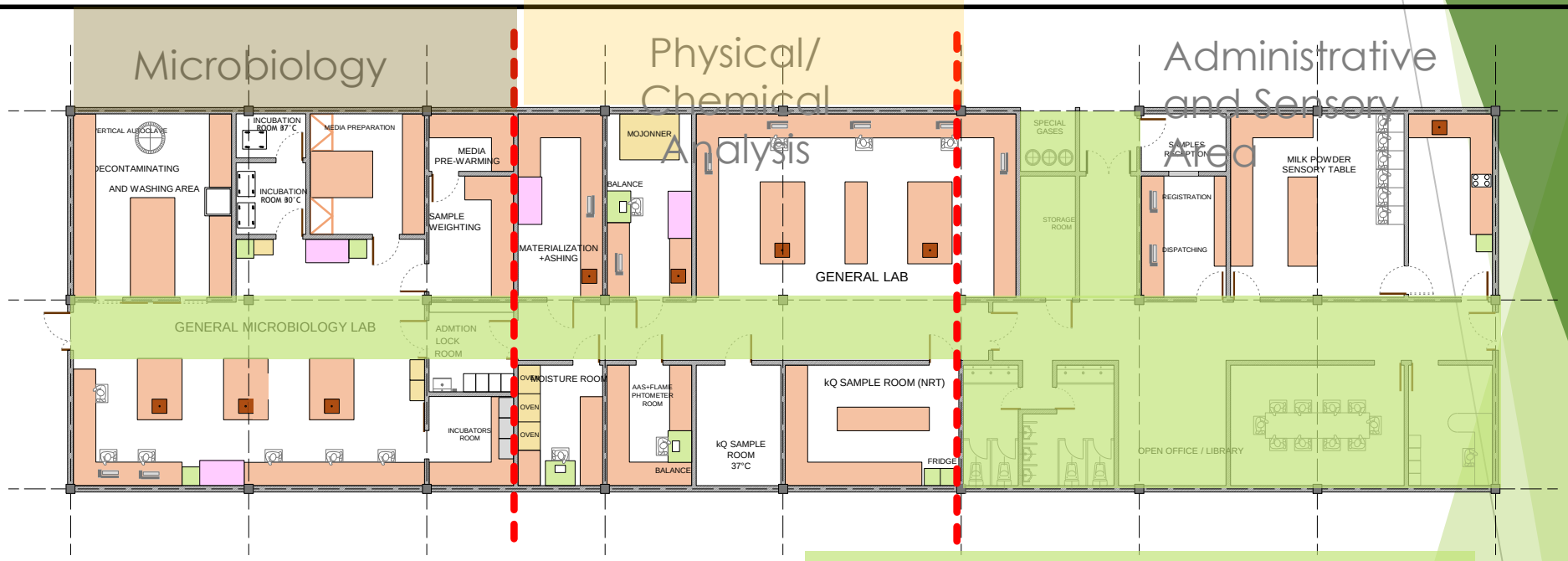
- *Unauthorised entrance* — Accessibility and Zoning
- *Workflow* — Flows analysis
- *Overcrowding and too much equipment* — Circulations design
- *Work with large volumes and/or high concentrations of microorganisms, and work with pathogens.* — Containment laboratory
- *Infestation with rodents and insects* — Internal partitions
- *Formation of aerosols* — Air handling specifications

2: Zoning & Flows Analysis

- *Analytical & Service Areas*
- *Accessibility & Zoning*
- *Flows Analysis*
- *Storage*
- *Flexibility*
- *Circulations Design*
- *Escape Routes*
- *Emergency Doors and Passages*
- *Containment Lab*
- *Microbiology Lab Zoning*
- *Trolley Air Lock*

Accessibility & Zoning

Laboratories must have separate zones depending on types of analysis and rooms functionality.



Example of a factory laboratory zoning

Service Areas: Horizontal, simple, direct workflow

Factory laboratories, especially microbiology areas must never have a direct access to the production area.

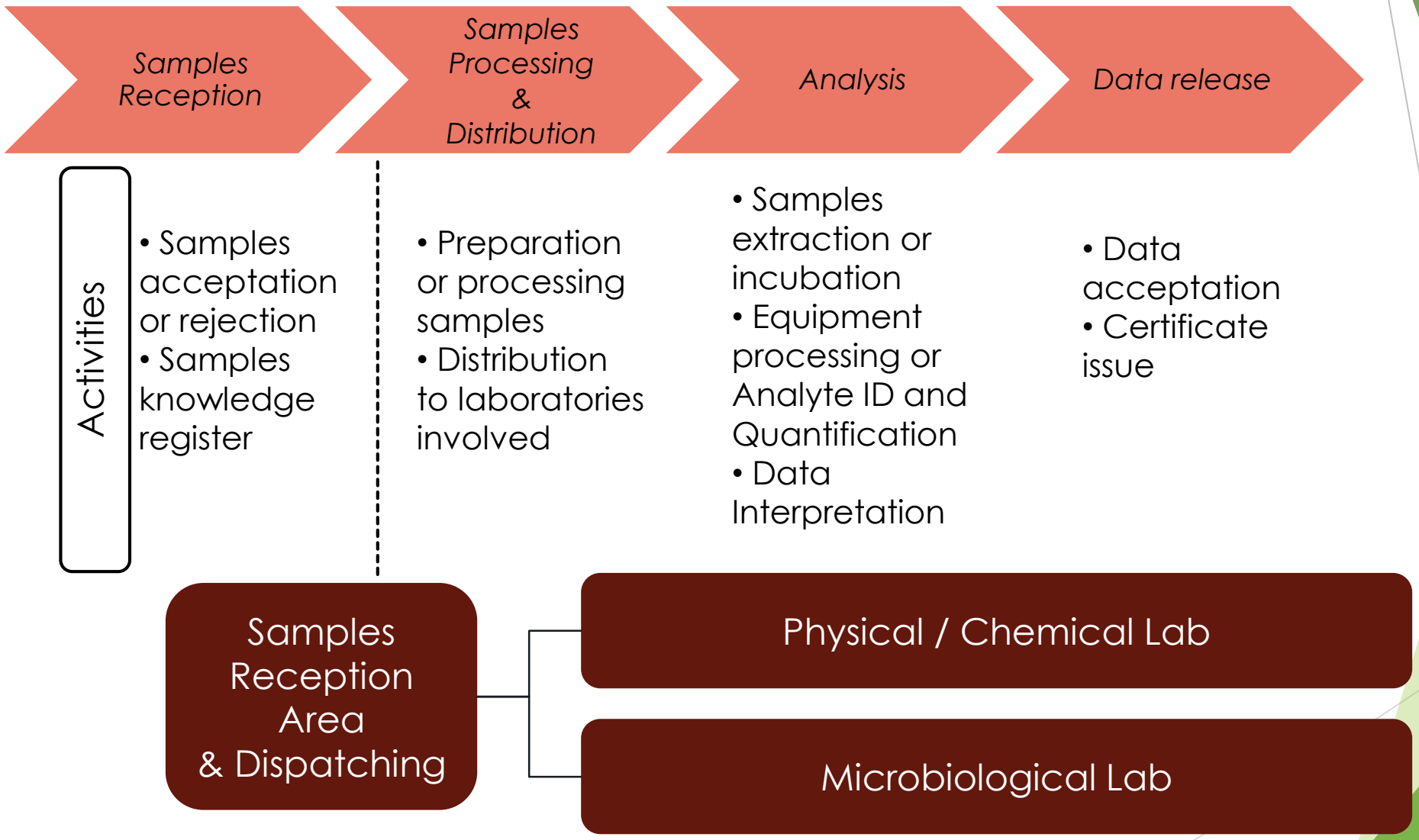
Flow Analysis

Close to lab entry, locate sample reception areas, equipped with computers for data registration.

Access to analytical areas with correct signalisation and limited to authorised people (badge controlled if required)

The biohazard warning sign and restricted access/authorised personnel sign must be displayed at the entrance to all mircobiology laboratories.

Flow Analysis



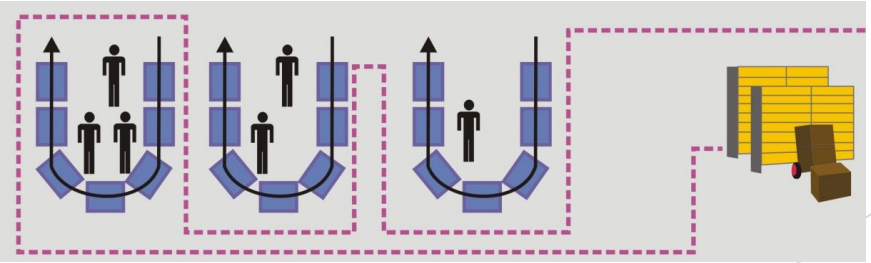
Flow Analysis

Driving criteria /Restrictions

- Zoning concept
- Samples isolation
- Samples contamination
- Safety & Health
  - Explosion
  - Air contamination

Targetting a « Lean Concept »

- Obtaining ***smooth flow***
- Minimising handling ***distances/costs***
- Reducing:
  - ▶ - ***Walking distances*** and
  - ▶ - ***Work in progress***: In the laboratory setting, this translates to « *samples in process »,* i.e. samples placed in racks waiting for processing and analysis, or test results waiting for review and release.
- Improving:
  - ▶ - ***Visibility*** for effective management of operations
  - ▶ - The ***work environment***
  - ▶ - ***Inventory*** management
- ***U-cell concept:*** To be analysed considering space constraints.



Microbiology Lab

Working with microorganisms can pose a risk to both the laboratory staff and the outside environment, including production. Microbiology laboratories must be designed to prevent the release of microorganisms into the environment and provide protection to the laboratory worker.

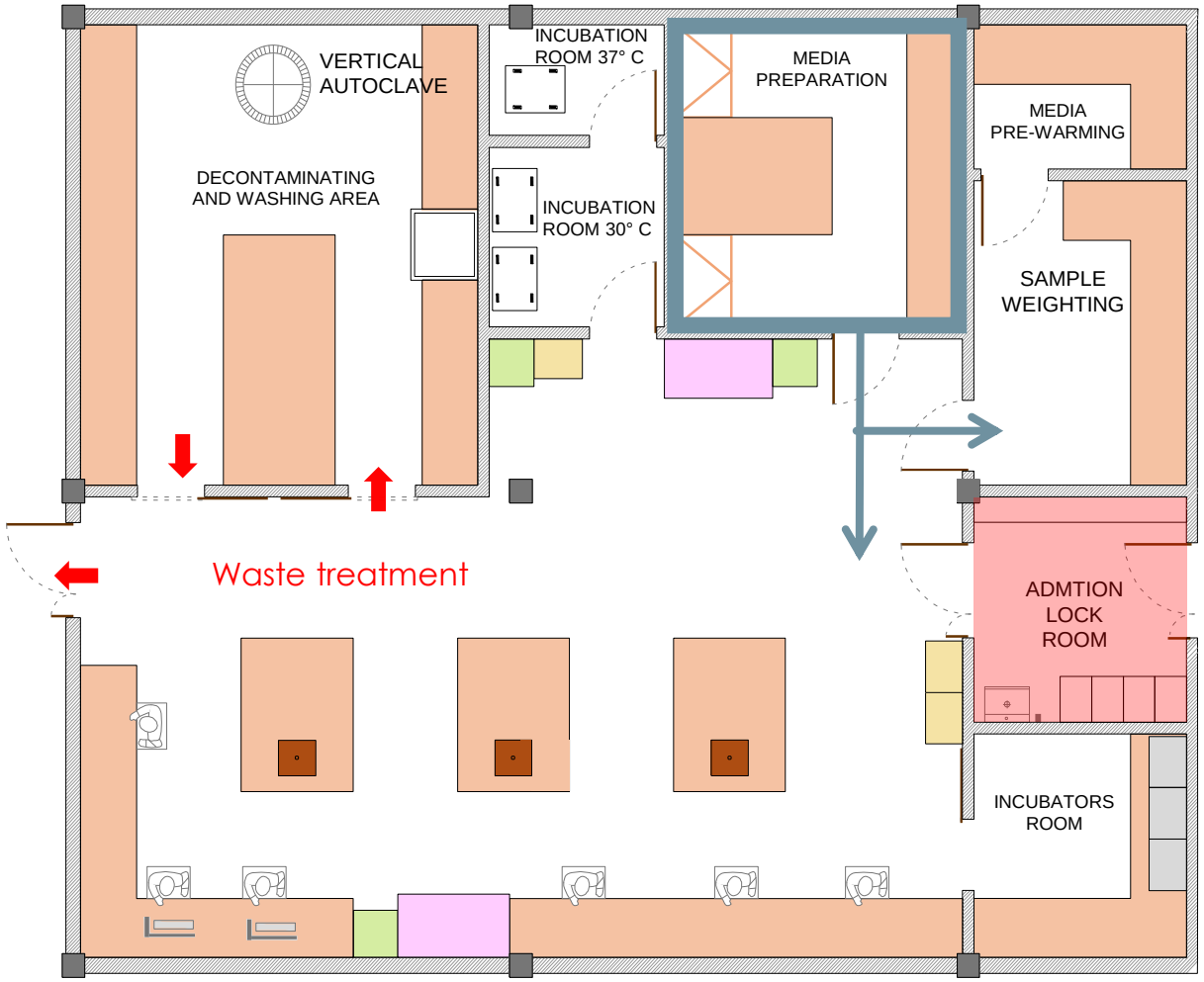
The Microbiology Laboratory is designed to:

- Mitigate the risk when a high risk to production is identified
- Work with large volumes and high concentrations of risk group 2 organisms
- Working when there is a high risk of aerosol spread.

The microbiology lab must be separated from the areas that are open to unrestricted traffic flow within the building.

Microbiology Lab Zoning Example

Traffic patterns and Separation of activities - Layout example for a factory microbiological laboratory



Microbiology Lab Zoning

Laboratories must have separate zones for activities that may result in cross-contamination between samples.

Microbiology laboratories must have an admission lock to provide a space where seperation between « high » and « low » risk areas can be applied.
This can be a physical barrier or a visual demarcation of the area.
Separate storage areas must be provided for laboratory coats/shoes and non laboratory clothing.

The admission lock must be equipped with a hand wash area and disinfectant distributor.

3: Design Concepts & Layout

- ***Flexibility***
- ***Circulations Design***
- ***Escape Routes***
- ***Emergency Doors and Passages***

Flexibility

Laboratories require flexible spaces and areas open for team work, interaction and creativity.

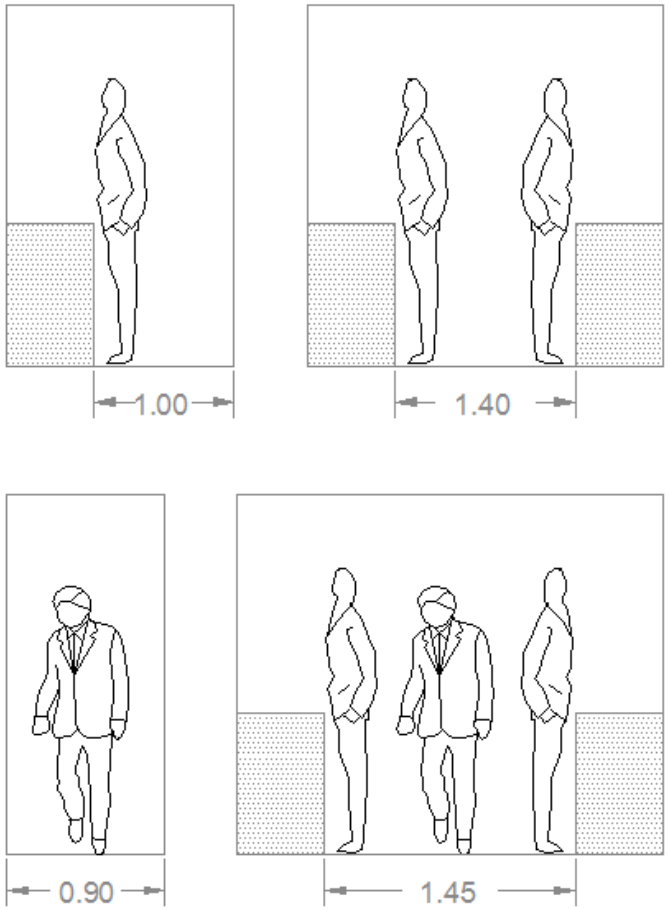
Traffic areas, break rooms, atrium spaces promote informal interaction and creativity.

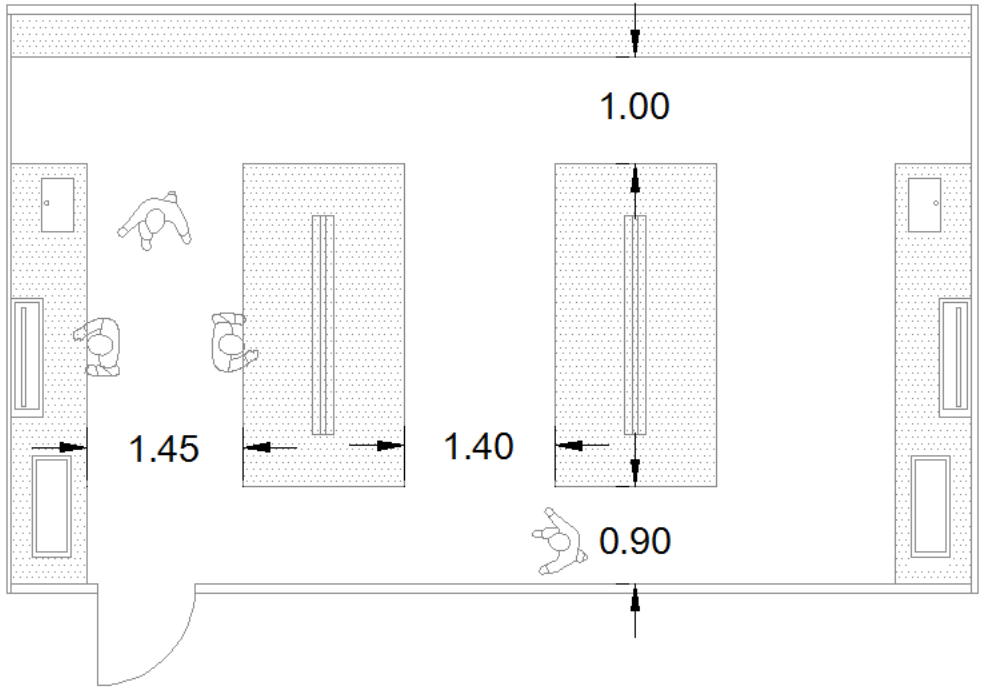
Open spaces/offices promote communication and layout flexibility to make changes without dismantling partitions.

Prefer interdisciplinary research units, minimise spaces identified with a particular department

Circulations Design

Recommended dimensions (minimums)





Escape Routes

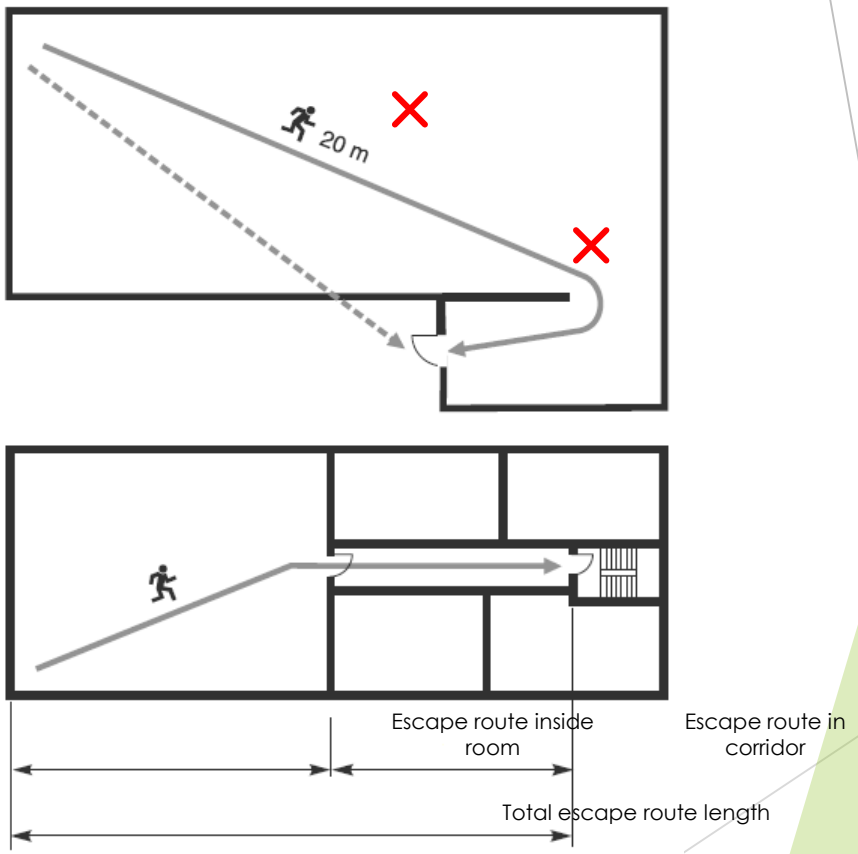
Escape routes must be continuous and unobstructed paths of exit, leading from any workplace point in a room to a place of safety.

The number of emergency exits depends on:

- Local legislation (consult a local expert)
- Number of people in a room
- Running distances (size of the building/room)
- Arrangement of the workplace

The total length of an escape route is measured in a straight line inside the room, and along the way in corridors.

The staircases to the exterior are not considered for this calculation.



Emergency Doors and Passages

Doors of escape routes must be recognised as such (signalisation), be ready to open at any time (no locking!) and open quickly in the escape direction without the use of aids.

The minimum dimensions of emergency doors must be:

- Single leaf : at least 0.90 m.
- Double leaf (one direction): at least 0.90 m operational width
- Double leaf (double action): each leaf at least 0.65 m.
- The clearance of doors must be at least 2.00 m to avoid bumping the head on the way
- Greater dimensions must be necessary e.g. when several people (>100) occupy the room

Escape route signalisation with symbols standardised internationally (white symbols on green background, illuminated or self-luminous)

Doors/windows connected to escape routes (corridors) must be fire resistant (min. 30 minutes) and be sealed against smoke.

Example fire door label

4: Internal Partitions & Finishes

- *Doors*
- *Windows*
- *Ceiling*
- *Flooring & Coving*

Doors

Doors list example, to be filled by project teams. KEY discussion with suppliers!

Accesses to laboratories should be built without door thresholds for safety reasons and to allow moving trolleys through

Windows

Internal Windows

Where possible, laboratories should have windows and views to corridors.

Windows should be built of laminated safety glass* and be sealed to smoke.

External Windows

In microbiology labs, windows must be fixed closed and sealed. All windows should be built of laminated safety glass*.

When windows can be opened (chemical, physical lab) they should be fitted with insects-proof fly-screens/mesh

* A protecting laminated foil (e.g. 3M Scotchshield window film) should furthermore be applied on the surface of the windows (face towards lab), to protect from splintering glass (contamination risk!):

Ceiling

The best solution is to have an exposed ceiling (roof / floor slab) with all services/installations visible.

The advantages of no false ceilings:

- Flexibility for adapting laboratory services is improved
- « Plug and play » quick fittings on pipe works services are readily accessible for equipment connections
- Cost advantage of no false ceiling
- No void above ceiling where microorganisms could accumulate
- Access for cleaning of exposed services
- Smoke detection in ceiling void avoided

The minimum clearance height of the laboratory rooms should be 2.70 m, plus additional space for installations

Ceiling

In some cases a false ceiling should be installed due to risk of cross-contamination, e.g. if there are too many penetrations for installations through a containment barrier.

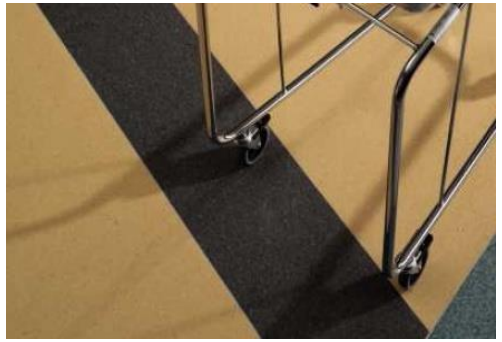
When a false ceiling is installed, it's recommended:

- To be of smooth metallic panel type (non-perforated), easily cleanable and with closed joints between the panels. Openings for inspection and cleaning purposes should be provided.
- To be of plasterboard, filled and painted, to provide a seamless, monolithic ceiling. Plasterboards fixed to galvanised steel suspension system (no wood) including perimeter sections fixed to the wall.

The void above ceiling should be accessible/ controllable (Look at recommendations for « Box-in-Box » rooms ceilings).

Flooring

All floor surfaces should be non-porous and smooth for easy cleaning



- Floors must be water-tight, easy to clean and resistant to chemicals.
- Floors must be resistant to disinfectants.
- Floors must be electrostatic conductive. Exceptions can be made in service areas without sensitive laboratory equipment.
- PVC or rubber floor covering is recommended in general.
- In wet rooms, textured or anti-slip epoxy flooring or anti-slip tiling is recommended.

Coving application

Coving finished

5: Building Services

- ***Air Handling Specifications***
- ***Lighting***
- ***Pipes & Cables Remarks***
- ***Waste Water Treatment***

Air Handling Specifications

- Temperature range of ***20 – 22°C***
  22 – 26°C (Tropical countries)
- Relative humidity ***50-60 %*** *(comfortable conditions)*
- For comfortable working conditions ***air velocity should not exceed 0.2 m/sec***
- Input air systems need dust filtered with ***coarse particles G4 pre-filter***
- ***F8 filter for air intake***
- ***HEPA filter H12 for air exhaust*** *(if required)*

Extracted air from the laboratory must not vent near factory doors, windows, intakes or into factory production areas.

- ***Ventilation ducting should be cleanable (i.e. textile duct) and have easy access for maintenance and removal of filter.***
- ***Fans are preferably positioned at the outlets of exhaust ducts to maintain negative air-pressure in case of leaks.***
- ***Laboratory ventilation or air conditioning ductwork must not be connected to the factory system or other non-microbiological areas.***

Air Handling Specifications

Moisture room requires:
Relative humidity at 40-60 %
Constant temperature at
22°C +/- 2°C

Fat analysis («Mojoniier» method) room:
- Special explosion-proof (ATEX) ventilation that does not allow air to stay in the room.
- Room under slight overpressure.
- Supply of 100 % fresh air. Air entry from corridor.
- No air recirculation.
- Ventilation 5 air-changes/h outside of working period
- 20 air-changes/h when work is underway

Laboratories should renew air from 5 to 10 times/hour

Storage rooms for chemicals:

Air must never be re-circulated

Air should never be allowed to escape to the corridor.

Room pressure must always be negative

Air Handling Specifications

In Microbiology areas:

- No positive pressure
- Ideally no air recirculation, 100% fresh air
- If air is recirculated, it must be HEPA filtered before reintroduction into the laboratory

Sterilisation room with autoclave should have an extraction hood with an exhaust fan linked to the outside.

Microbiology laboratories

To reduce the area of the laboratory that can become exposed to bio-aerosols, air is usually introduced into the laboratory near the entry or desk working areas before being exhausted near the area of hazards.

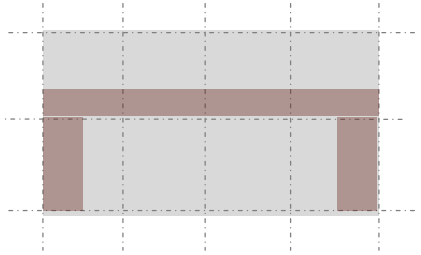
Analytical & Service Areas

Laboratory functionality depends on 2 types of areas: Analytical areas and Service areas.

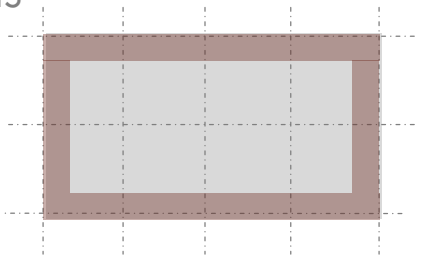
Bundling and locating Service areas with a structured logic inside a building optimises and facilitates its layout configuration.

Service areas

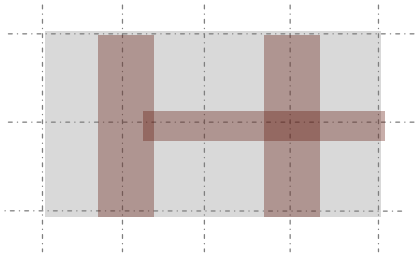
Analytical areas



Central circulation and alternate location of services: Optimising circulation



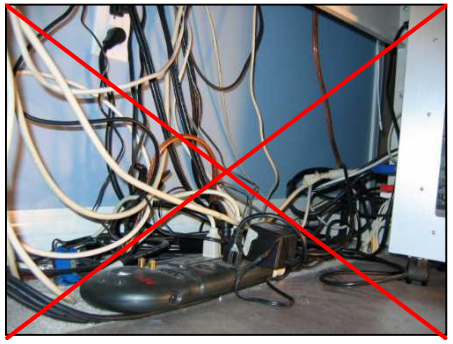
Peripheral circulation: Optimising central space and windows sharing

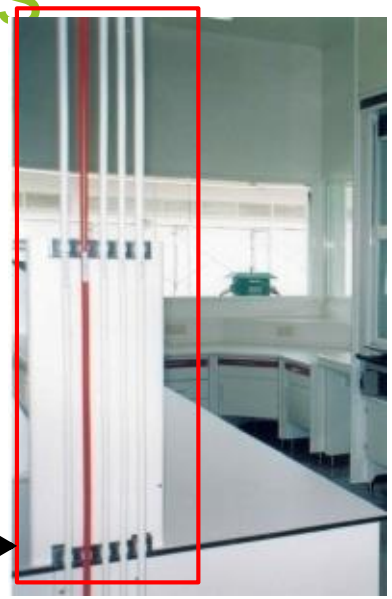


Other configurations

Service areas need to have a simple and modular approach to optimise functionality, room configurations, flexibility and extensions.

Pipes & Cables



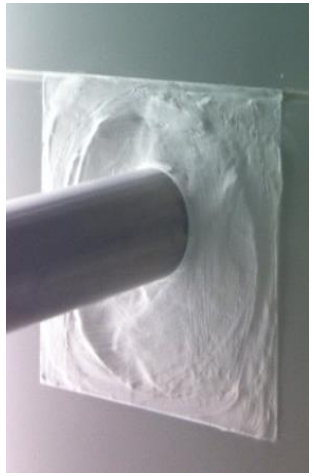


Services pipes from ceiling well attached to furniture

Cables safely organised

Electrical services at wall

Firewall sealant

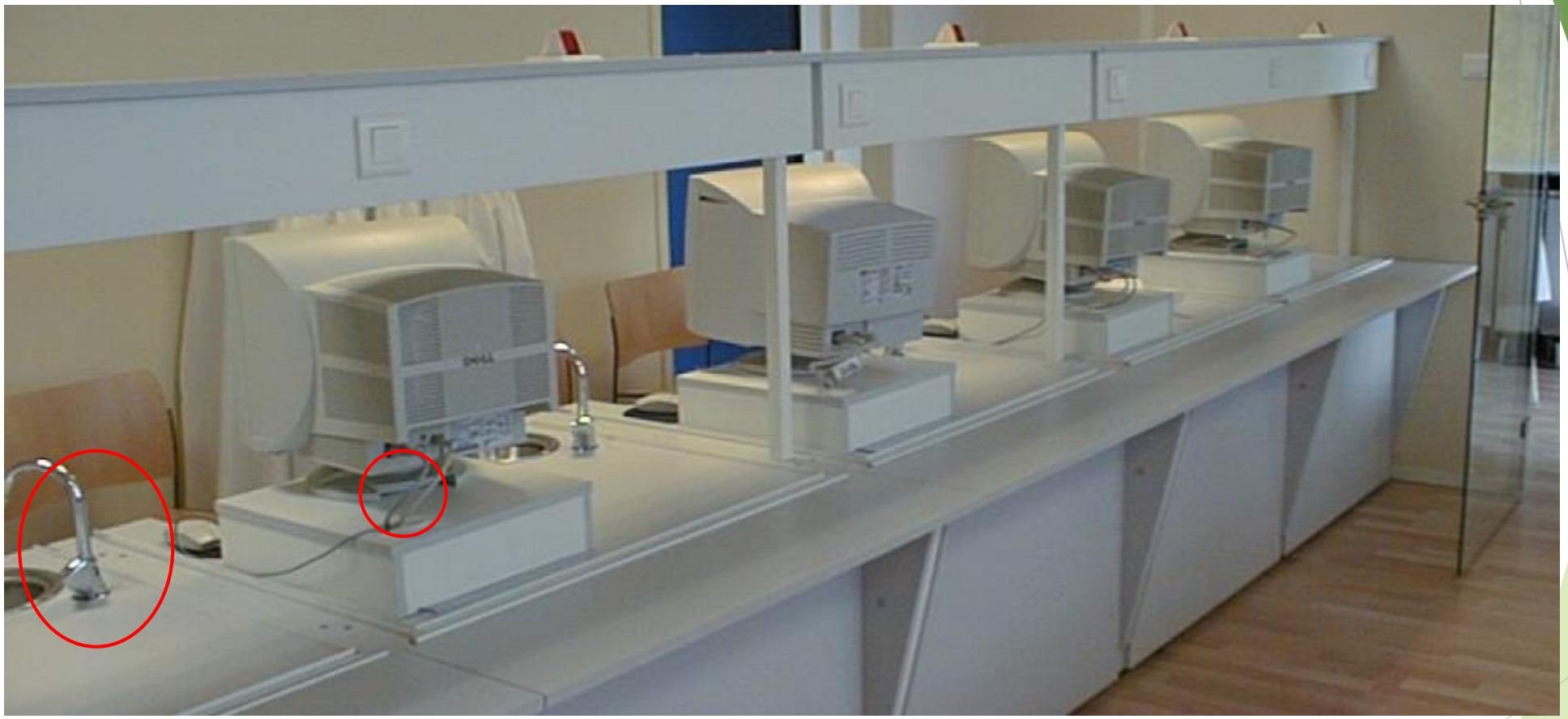


Openings in walls, floors and ceilings should be sealed considering fire rating and acoustics requirements.

Cable trays vertically oriented

Cable trays 10 cm away from wall to facilitate cleaning.

Pipes & Cables



6: Equipment

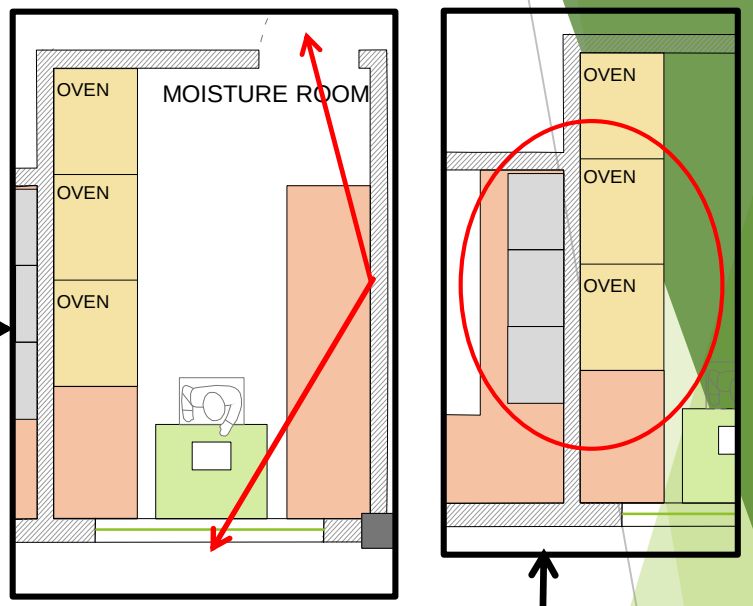
- ***Analytical Equipment Installation***
- ***Safety Equipment***

Analytical Equipment

Equipment must be located to facilitate directional workflow from « low » to « high » risk activities.

Microbiology laboratories must have a Class II Biosafety Cabinet (BSC). To minimise fluctuations that could cause the BSC to operate outside their containment parameters, these cabinets must be located as far as possible from doors/windows, high traffic areas, and potentially disruptive equipment. Air inlets from HVAC systems should be carefully assessed and adjusted to ensure they do not disrupt the airflow in the cabinet.

To avoid extra costs due to ventilation, it is important to locate laminar flow cabinets together or adjacent to a same wall, if possible.



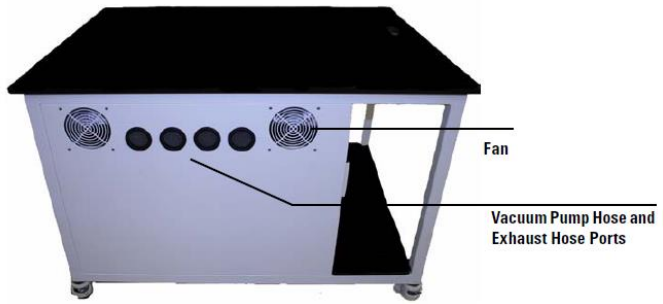
Analytical Equipment - Noise

In rooms with a significant noise level (presence of autoclaves, 4 similar equipments, etc), it is recommended:

- On-line data treatment to minimise time spent by analyst in the lab itself
- Acoustic separation/insulation of the instrument lab (glass sliding door, acoustic screens)from other area when possible
- Wear ear plugs when working in the room

Most high end equipments are now using strong vacuum pumps for mass spectrometry; this pump needs to be enclosed in a cabinet with noise insulation, but with fans to the room for heat exhaustion.

i.e. Agilent G3215A Mass Spec Bench



Mass Spec Bench (rear view).

Safety Equipment

Local fire regulations must be consulted and complied

Safety/Emergency Equipment *:

1. Portable CO_2 fire extinguishers & Fire hose
2. Safety showers (potable water)
3. Safety and escape route signalisation
4. Fire blankets
5. First-aid box
6. Emergency eye-wash fountain(potable water)
7. Safety acid, base and solvent storage cabinets
8. Emergency lighting
9. First-aid room (not mandatory for labs. Generally existing in factory sites)

1

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Storage

To reduce the risk of fire/explosion in laboratory areas, storage for corrosive chemicals, flammable solvents and gases should be placed away from the laboratory building (given land availability).

Storage of gas cylinders of flammable and/or toxic gases (e.g. acetylene, hydrogen, nitrous oxide etc.) must:

- Be located outside the lab building
- Be located out of pedestrian and vehicle traffic
- Be under shade (not exposed to direct sunlight)
- Be secured from tilting
- Be ventilated (either naturally or artificially*)
- Be labelled with warning signs
- Be equipped with fire safety equipment*

Correct labelling

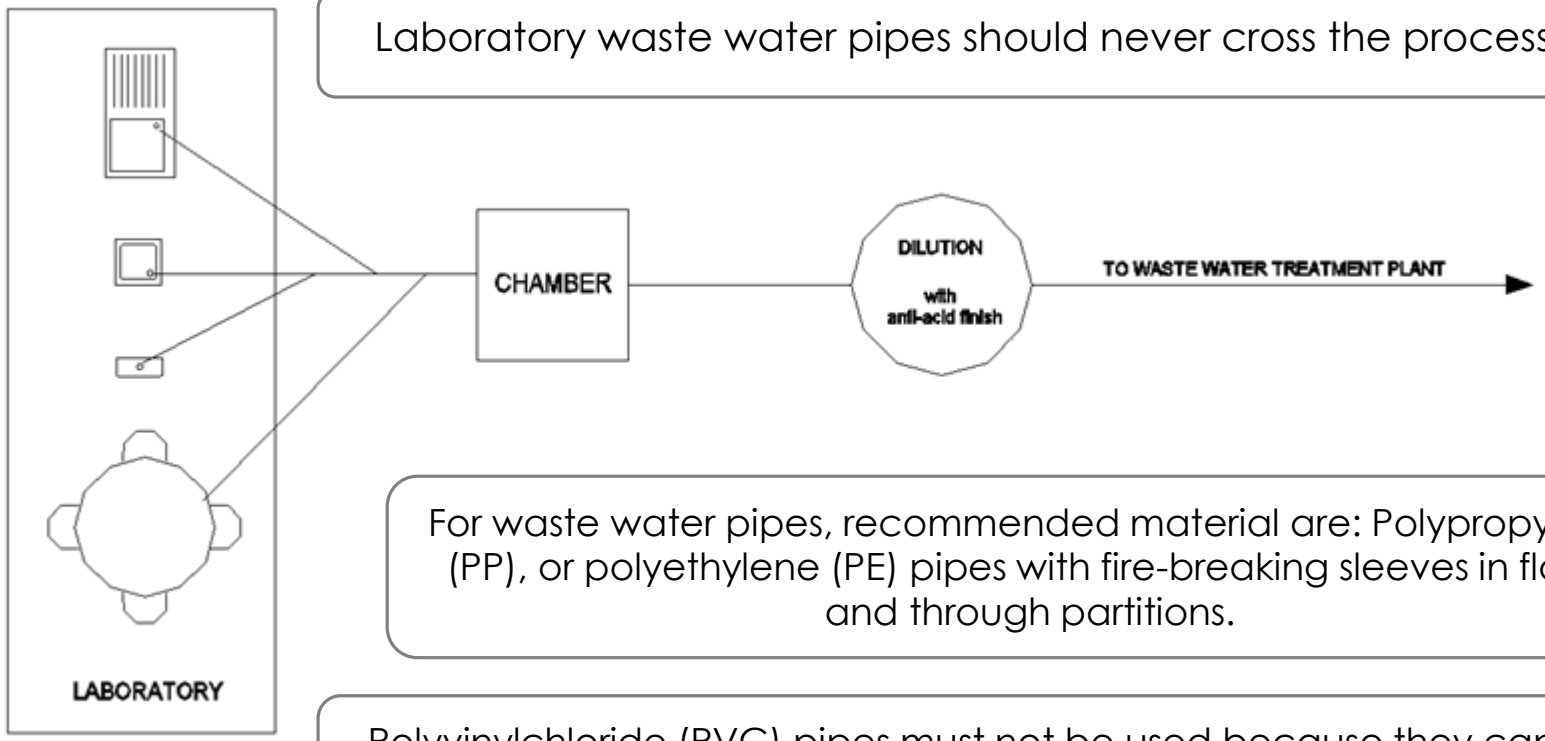
Locked metal cabinet

* For closed storage rooms of chemicals and flammable solvents and gases, oxygen reduction solutions could be implemented if fire risk and potential damage is very high:

Waste Water Treatment

Waste water should be conducted to a neutralisation tank, fitted with a solvent separation chamber before being directed to the waste treatment plant (in factory laboratories) or to the communal sewerage.

Laboratory waste water pipes should never cross the process area.



For waste water pipes, recommended material are: Polypropylene (PP), or polyethylene (PE) pipes with fire-breaking sleeves in floors and through partitions.

Polyvinylchloride (PVC) pipes must not be used because they can be affected by some solvents and are not suitable for use with autoclaves.


Thank You!