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# MEP Engineering & Lab Design: Critical Factors

Designing a laboratory space is a highly intricate process that requires close collaboration between architects, engineers, and lab users. Determining the appropriate MEP systems for the project is vital for maintaining safety, environmental control, and efficiency, all while working to control operational costs.

Some major considerations that should be discussed early in the project planning include:

## 1. Ventilation Requirements

Determining the appropriate number of air changes per hour (ACH) is critical to maintaining a safe laboratory environment and has major implications for MEP design. Proper ventilation dilutes and removes hazardous fumes that have potential health risks.

- **ASHRAE Requirements:** The ASHRAE Classification of Laboratory Ventilation Design Levels (LVDL) recommends 4-10 ACH (in some cases more), depending on the lab's activities, with 8 ACH being a typical value. Laboratories dealing with hazardous chemicals may need the higher end of this range.
- **BioSafety Levels (BSL):** Labs that handle biological materials are classified under BioSafety Levels (BSL-1 to BSL-4), with higher levels requiring more stringent ventilation. HEPA filtration is used for BSL-3 and BSL-4 labs along with increased air changes for safety.
- **Operations Review:** Reviewing each laboratory operation with the owner and environmental health and safety (EH&S) officer is a crucial step to assigning a Laboratory Ventilation Design Level (LVDL). LVDL is a classification system that categorizes labs into five levels of increasing risk, from LVDL-0 to LVDL-4. Improper assignment at the beginning of design can quickly derail a lab design and lead to significant redesign or even construction costs.

## 2. Supply and Exhaust Air Systems

Space pressurization, whether positive or negative, is a critical element in laboratory design and operation. LVDL assignment will determine the pressurization but there are other factors that must be evaluated for a proper air balance:

- **Exhaust Air:** Most LVDLs require 100% exhaust, typically handled through general room exhaust. Other sources of exhaust – such as fume hoods which are a key safety feature in many labs – require high volumes of exhaust to maintain velocities across the sashes influencing the room air balance and quantity of makeup air. This must be considered early to avoid undersized systems.

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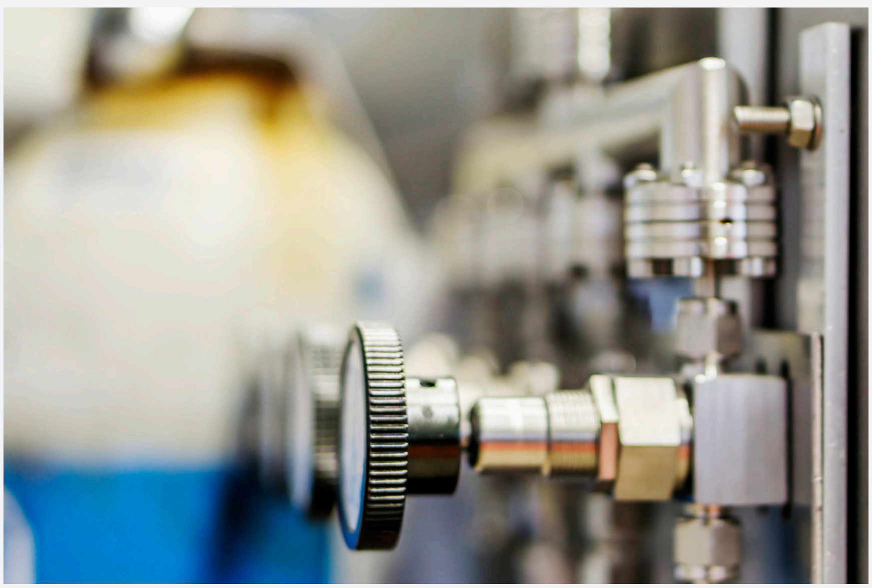
- **Supply/Makeup Air:** To prevent labs from becoming highly negative, supply/makeup air must be properly sized. Every exhaust source – whether it be general exhaust, fume hoods, snorkels, or lab equipment – plays into the makeup air quantity, but the supply air must also meet the heat gain of the lab equipment. In some instances, the makeup air will not be adequate to cover the heat gain forcing the supply air to increase and subsequently the exhaust to also increase in order to achieve space pressurization.
- **Hood Types:** Chemical fume hoods (CFH) are fully ducted with exhaust air to the outside, while laminar flow hoods (LFH) are ductless, drawing air through filters and recirculating within the lab. BSLs may also contain bio-safety cabinets (BSC), operating similar to CFHs with some containing HEPA filtration and recirculation capabilities. Chemical fume hoods require a minimum velocity across the sash to properly contain and exhaust chemicals. A typical velocity is 100 FPM, but consulting the EH&S may allow lower velocities down to 80 FPM or less. This reduction has significant cost savings in equipment and energy usage.
- **Energy Recovery:** Since hoods consume a significant amount of energy, incorporating energy recovery systems that capture and reuse energy from exhausted air can improve efficiency. Unfortunately, conventional energy recovery with wheels or plates have leakage rates between supply and exhaust airstreams so these cannot be used in labs. Run-around hydronic loops and heat pipes are alternative means for energy recovery but have lower efficiencies and sensible-only recovery.
- **Diversity:** Understanding how often hoods will be in use (simultaneous or intermittent) helps determine ventilation load and may reduce system size.



## 3. Control Systems and Redundancy

A critical aspect of MEP design is implementing robust control systems to manage air handling units, pressurization, and emergency systems. Planning for redundancy is essential to ensure continuous lab operation.

- **Pressurization:** Some laboratories require negative pressure relative to adjacent spaces to prevent contamination. This is especially crucial in labs handling hazardous or sensitive materials.
- **Redundancy:** Redundant air handling units, boilers, chillers, and exhaust fans with control systems ensure uninterrupted operations during maintenance or failure. Exhaust systems, such as high plume exhaust fans for lab exhaust,

must be fully redundant; however using N+1 (one is on and the other off) may cause a brief interruption to airflow upon fan failure, so N-1 (both operating at 50%) may be a better option.

- **Ventilation Setback:** Operating variable airflow systems that adjust based on lab usage and occupancy can reduce energy consumption when full ventilation is not required.
- **Emergency Power:** Many labs require backup power through generators or uninterruptible power supplies (UPS) to maintain critical systems like ventilation, cooling, and power to sensitive equipment. Proper sequencing for startup after power loss is critical to ensure labs are operational quickly and safely.
- **EH&S Considerations:** The systems must meet Environmental Health and Safety (EH&S) guidelines, including integrated alarms and emergency shutdowns to ensure lab safety.

## 4. Vibration and Sound Control

Laboratories often contain sensitive equipment that can be disrupted by vibration and sound. Managing vibration and noise levels is a key part of MEP design to ensure equipment functions properly.

- **Equipment Sensitivity:** Identifying sensitive equipment early allows for proper isolation strategies, such as using vibration dampening materials or mounts for mechanical equipment.
- **Fan and Duct Noise:** Noise from fans and ducts can interfere with lab operations, particularly in noise-sensitive environments. Controlling fan noise, ductborne noise, and transmission between spaces is crucial.
- **Noise Criteria (NC):** Maintaining noise levels at or below NC-35 is generally acceptable for laboratory environments. In spaces with highly sensitive equipment, even lower NC levels may be necessary.
- **Acoustical Design:** Understanding the acoustical needs of the lab space ensures proper isolation of noise-producing elements and protects lab operations from external disturbances. Acoustical consultants are good resources for identifying needs and solutions.

## 5. Planning for Specialty Gases and Water Systems

Many labs require specialized gases and water systems, and the early design phase must account for these needs to ensure smooth operations.

- **Specialty Gases:** Gases like argon, carbon dioxide, nitrogen, oxygen, compressed air and vacuum are common in labs and must be stored and distributed safely, with some being generated on site. This may involve local tanks or centralized tank farms with dedicated gas distribution systems.

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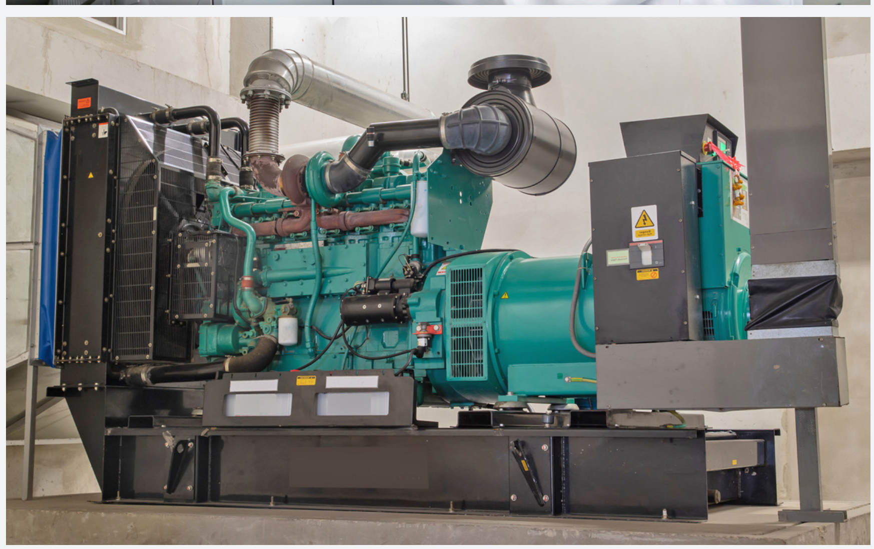

- **Safety Systems:** Gases require safety features such as leak detection, pressure monitoring, and proper ventilation in storage areas to comply with safety standards. Use of O2 sensors to exhaust gas cylinder storage rooms is common practice.
- **Water Systems:** High-purity water, such as deionized (DI) or reverse osmosis (RO) water, is essential for many laboratory processes. Planning for sufficient space and piping for these systems is critical.

## 6. Future Planning and Flexibility

Laboratory needs often evolve over time, and designing flexible MEP systems that can adapt to changing requirements is crucial.

- **LVDL Transition:** A lab's ventilation needs may shift as research focus changes, requiring a transition between **ASHRAE Laboratory Ventilation Design Levels** (LVDL). Planning for increased air changes, pressurization needs, or new equipment loads prevents costly retrofits later.
- **Modular Design:** Modular MEP systems allow for future expansion or reconfiguration as the laboratory's requirements grow or change, reducing downtime and saving on future construction costs.
- **Future Capacity:** Ensuring that the MEP infrastructure can support additional equipment, exhaust systems, or utilities will make future upgrades easier and less disruptive.

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