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BEST PRACTICES

Building automation systems in life science and laboratory environments

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Abstract

Considering the operation of building systems in a life science facility, if you need something to work, you need to make sure it works. Many aspects of lab operations are simply too important to ignore – from the safety and wellbeing of lab workers to the quality and integrity of the research. Thus, if a system is important to your organization, you must take the necessary steps to ensure the system works as designed and intended.

This paper explores the best practices to ensure that systems in life science and laboratory environments perform, and continue to perform, including monitoring for safety and performance, pressurization, and ventilation rates.

INTRODUCTION

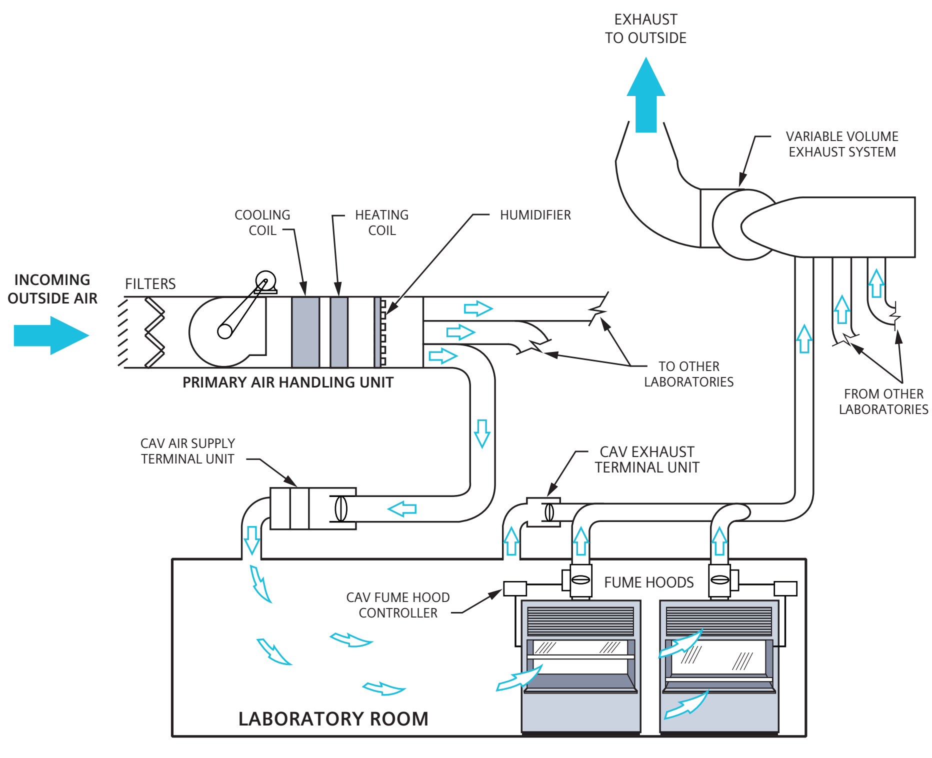
Three basic questions set the context to discuss building automation systems in life science and laboratory environments:

1. How do HVAC systems use energy in labs?
In **figure 1**, we can see the air handling unit (AHU) with fan and coils, which work together with the air terminal to deliver air into the laboratory / life science space. From there, the air is exhausted from the room either through the exhaust devices or the fume hoods.

Primarily, HVAC systems use energy at the coils in the process of heating or cooling air as it moves through the space. Secondly, the fans that move the air also consume energy, though to a lesser extent than at the coils. For both fans and coils, the energy consumed is a strong function of the quantity of air flowing. Thus, when energy conservation is an objective, the first priority should be to use less air, followed by improving the heating and cooling process. This can mean applying heat recovery or reducing simultaneous heating and cooling. The third priority is moving air more efficiently.

Figure 1:

How do HVAC systems use energy in lab environments?

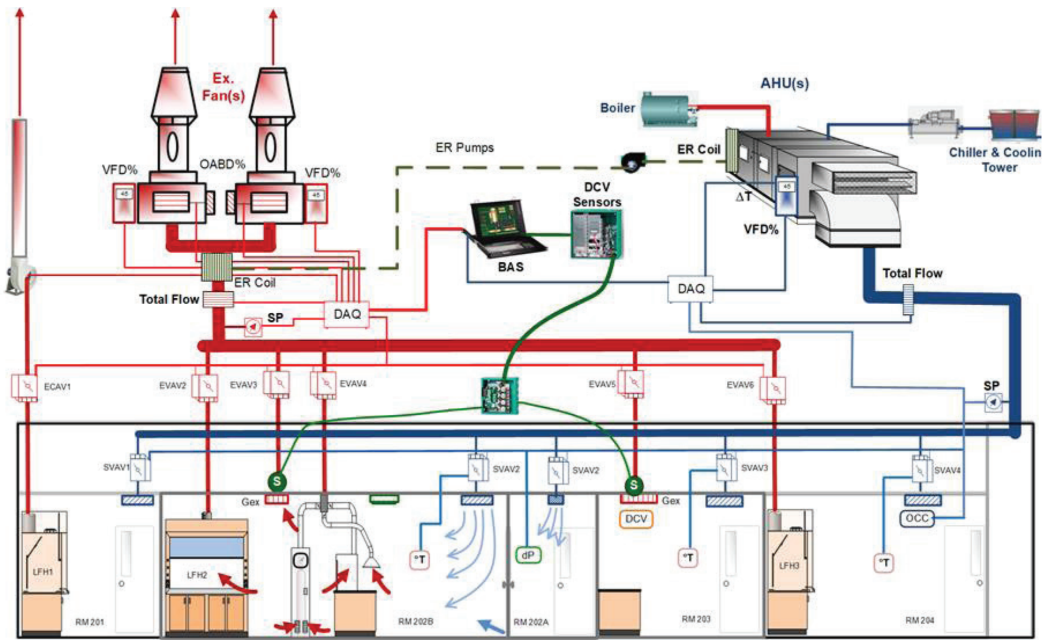


2. When do we accomplish sustainability? Or, when does sustainability occur?
Sustainability remains an important objective for organizations around the globe. Two aspects of sustainability particularly related to the building are energy usage and a safe indoor environment. Both of these happen as the building operates day after day and year after year. Design is important; commissioning is crucial. These are necessary enablers, but sustainability actually occurs (or doesn't) in long-term operation.

3. Where is the building automation system (BAS)?

The short answer is that the BAS is everywhere – from the sensors that measure air flow, space pressure, contaminants, temperature, and humidity to the fans on the roof of your building. **Figure 2** illustrates how complex this system is as it moves air through your life science space.

Figure 2: BAS in the lab space – illustration courtesy of Tom Smith, 3Flow



The BAS has four core jobs:

- Operating the equipment in ways that control for the ventilation, temperature, humidity, lighting, containment, and pressurization parameters that are required for safe and healthy operation and work
- Setting alarms and alerts for the people who use the building – from the lab workers performing research to the building operators who keep everything functioning as designed
- Logging data to confirm operations and functionality (in addition to real-time alerts and alarms)
- Connecting building operators with the mechanical systems so they can see what's going on in every area of the system and in every area of the building

All of the above begins with the sensors and the information infrastructure to enable key stakeholders to operate the building and – more importantly – monitor its operation for safety and performance.

With this context in mind, let's move into our best practices for BASs in life science and laboratory environments.

MONITORING FOR SAFETY AND PERFORMANCE

This best practice is central to our theme of making sure your systems work as they should. The BAS provides transparency into the data you need to monitor for both safety and performance, with three stakeholders' needs being met:

1

LAB WORKERS

This group interacts with the BAS at the room level, for example, at the fume hood display panel, at the room unit or lab monitor, via room pressure monitors, and / or through the sensors.

2

FACILITIES STAFF

This group relies on the BAS's interactive graphics, reports, alarms, and other data to support decisions about operating and managing the system.

3

SAFETY OFFICER

Depends on the BAS records that indicate how the systems function and whether systems are over time or due to an event. Importantly, they will need immediate alerts for any unsafe conditions.

BASs are complex and because they contain so much data, it's not possible to do this work manually.

Consider establishing a monitoring program by first setting up a secure remote connection to your BAS, which can then be leveraged for fault detection and diagnostics as well as building analytics specifically for use in laboratory and life science environments.

Focus on performance

Figure 3: Laboratory performance report package

1. Identify and service areas that are underperforming: safety concerns, energy wasters
2. Identify airflow drivers in areas that are performing well
3. Leverage data from laboratory control system: airflow in CFM, occupancy points, alarm conditions from lab room controllers

These are powerful decision-making tools, which not only support your safety and performance monitoring program, but can also inform your decisions about operating for energy efficiency and sustainability. For example, an analysis of your data will reveal what's driving airflow, which you can use to help choose the correct improvement strategy. **Table 1** includes a few considerations for each main driver.[1]

Table 1
Considerations for improvement strategies from lab room driver report

Main driver	Improvement strategies to consider
Exhaust devices	• Decommission some exhaust devices if not all hoods are used regularly • Implement sash management programs or automatic closers if hoods are frequently left open • Re-evaluate minimum flow rate if hood drive air flow even when closed
Base ventilation	• Evaluate dilution flow in light of current industry trends; lower rates may be justifiable • Implement ventilation setback for unoccupied periods • Apply contaminant sensors to vary ventilation rate
Cooling	• Re-locate heat sources • Reduce electric lighting

Building analytics for labs provide a menu of relevant energy conservation measures based on the airflow drivers (i.e. ventilation, heating, cooling, and / or balancing fume hood flows) in a given space.

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[1]Coogan, Jim. "Information Tools to Manage and Improve Laboratory Ventilation Systems." From *ASHRAE IAQ 2013 Proceedings: Environmental Health in Low Energy Buildings.* www.ashrae.org. 2013.

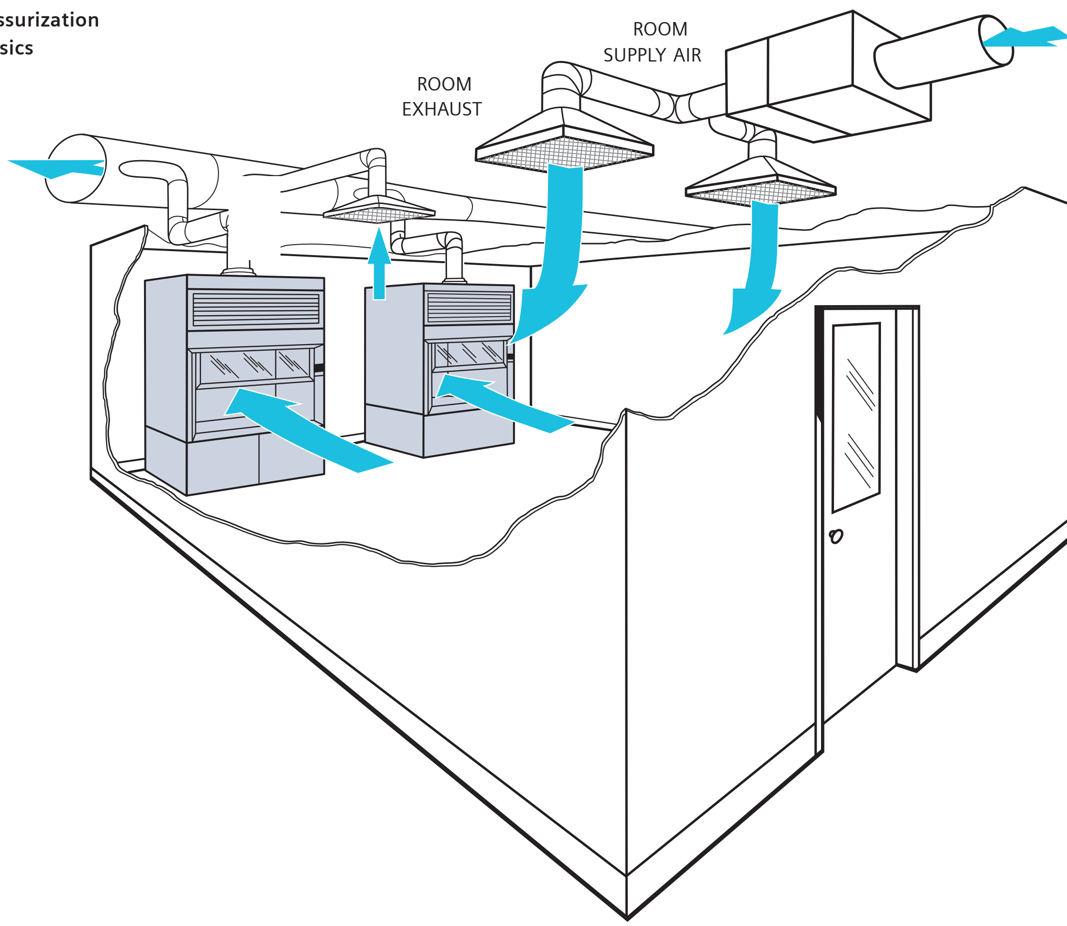
PRESSURIZATION

Room pressurization is a ventilation technology that controls the migration of air contaminants by inducing drafts between spaces. **Figure 4** illustrates the fume hoods, located at the back of this space, and the room exhaust and room supply air fans, located in the ceiling.

To create a space with negative pressure – one where the environment contains contaminants within it – the BAS will control the air flow to effectively supply less air than what's exhausted from the space. Infiltration makes up the rest, creating an inward airflow at the gaps that will contain the pollutants. Positive pressure spaces function in the opposite manner.

Laboratory testing can reveal discrepancies in terms of how laboratory environments should perform compared to how they actually perform. Ultimately, though, success in this context is measured not by air flows and pressure valves but by the control of contaminants.

Figure 4: Room pressurization physics



Three methods of controlling space pressurization are widely known:

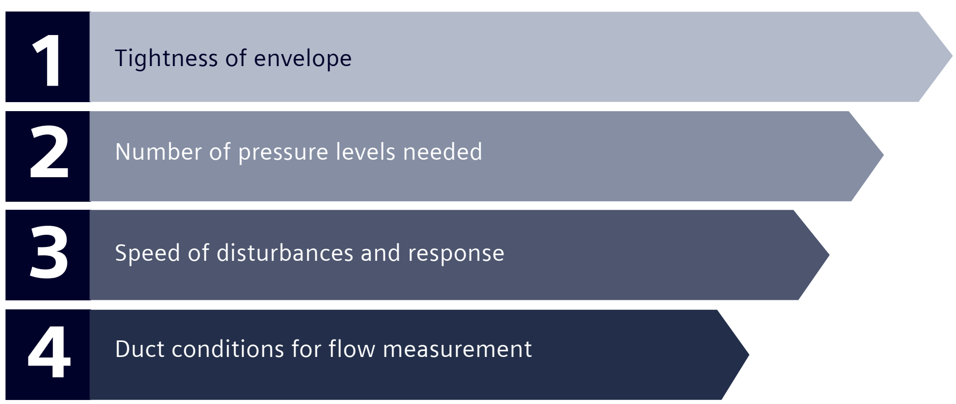
1. **Space pressure feedback:** Using sensors on your dampers and actuators, measure the pressure difference across the room boundary, compare to the selected setpoint, and adjust.
2. **Differential flow control (most common):** Refer to the two airflow control loops. There will be a slight difference between them; choose the difference to get to the relative amount of infiltration needed, then increase the difference between the control loops if the room is not reliably pressurized.
3. **Cascade control:** Combines the two methods above, but instead of manually selecting the flow difference, the room pressure control loop does this automatically.

The key to effectively implementing all of these methods is the envelope and its airflow leakage area. For a tighter, less "leaky" environment, room pressure feedback is most likely the right control method for more reliable pressurization. For spaces with looser construction, differential flow control is usually the better option.

In other words, the best practice is to *design around the airflow leakage and account for it when selecting a control method.* If you're uncertain about the airflow leakage, *install room pressure sensors to enable consistent performance monitoring and specify in your design documentation that the system must be capable of switching control methodology after construction.*

Factors that affect pressurization control method

Figure 5:
Selecting a control method



VENTILATION

Ventilation engineers and safety officers work together to answer a range of questions about laboratory ventilation: How much do we need to remove contaminants not capture by exhaust devices? How do we set the right ventilation rate? Answering these questions – and others – may start with a hazard assessment, and often the conclusion is that a constant ventilation rate does not make sense for a given environment. That is, the best answer may be that you need vary the ventilation rate in response to changes in the space.

Occupancy is a well-established means for setting variable ventilation rates, or demand-controlled ventilation. In addition to the hazard assessment, ***consider deploying a comprehensive network of sensors to detect people, contaminant concentrations, and environmental conditions that align with your safety program and goals.*** Today's Internet of Things (IoT) sophisticated sensors can also reveal traffic patterns and space density in your lab, alerting managers when people are congregating in areas where they should not. In a post-COVID-19 era, this type of information can prove invaluable for a range of situations beyond setting ventilation rates.

Demand Controlled Ventilation
Any means by with the outdoor air flow can be varied based on changing number of occupants and/or ventilation requirements

Any approach to varying the ventilation rate in response to demand must include a careful evaluation of the benefits and limitations inherent in the technologies and methodology.

The lab design team will collaborate in a multidisciplinary, four-step process[2] to create an effective demand-controlled ventilation program:

1. **Identify** conditions (such as occupancy) that warrant differing air flow rates. If it's true that when people leave the space, ventilation is not required, it's a condition that can be applied to the BAS.
2. **Determine** safe, appropriate flow rates for the conditions. For example, set rates for when spaces are both occupied and unoccupied.
3. **Select** BAS controls inputs and occupancy sensors to trigger changes in air flow.
4. **Design** indicators for lab workers and others in the space. They need to know the moment conditions change to help keep them as safe as possible in the workspace.

As the lab operates, *rely on the BAS to confirm that all sensors work correctly,that they are indeed connected to the system and indicating the correct spaces, and that lab workers are alerted if and when conditions change. Carefully verify the dynamic effect on the ventilation rates;* in short, we return to our main point – if you need it to work, make sure it works.

A final note on ventilation: the safety process for contaminant sensing is not as straightforward as it would seem. Where and how to sense the contaminants of concern are important considerations and simply having sensors in the space is not enough to keep everyone automatically safe.

[2]This process aligns with the ASHRAE *Laboratory Design Guide,* 2nd ed.

CONCLUSION:
The BAS as a source of information and verification

In summary, this paper shared a range of best practices for the BAS in laboratory and life science environments:

Monitoring for safety and performance
Consider establishing a monitoring program by first setting up a secure remote connection to your BAS, which can then be leveraged for fault detection and diagnostics as well as building analytics specifically for use in laboratory and life science environments.

Pressurization
Design around the airflow leakage and account for it when selecting a control method. If you're uncertain about the airflow leakage, install room pressure sensors to enable consistent performance monitoring within the BAS.

Ventilation
Consider deploying a comprehensive network of sensors to detect people, contaminant concentrations, and environmental conditions that align with your safety program and goals. Rely on the BAS to confirm that all sensors work correctly, that they are indeed connected to the system and indicating the correct spaces. Carefully verify the dynamic effect on the ventilation rates.

At the end of the day, the BAS is more than just a system to control the physical events that happen within your life science environment. It's a valuable source of information and data you can rely on to operate your lab as safely, efficiently, and effectively as possible. By integrating and applying a network of sensors, remote analytics, fault detection and diagnostics, and a long-term commissioning strategy, your BAS is key to monitoring lab operations for safety and performance, pressurizing spaces, and establishing ventilation rates that maximize both efficiency and safety.

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