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Commissioning labs for safety

By Michael Click

The mission of a Commissioning Authority (CxA) is to assist the project team in achieving a fully functional building that ensures the client's vision and goals have been met. In laboratory construction, however, it is imperative for commissioning to not only optimize equipment performance, improve the functionality of systems and minimize energy usage, but also to bring safety to the forefront of the project's goals.

As laboratory buildings grow more complex and more highly tailored, the controls necessary to protect the health and safety of the occupants also become increasingly complicated. This is particularly true in an academic setting where labs are highly customized. With a CxA on board early in the design process, owners have the opportunity to evaluate appropriate exhaust system controls, ensure the systems are accessible and well-maintained, and ensure that occupants can exit the labs in case of power failure or other emergencies requiring evacuation.

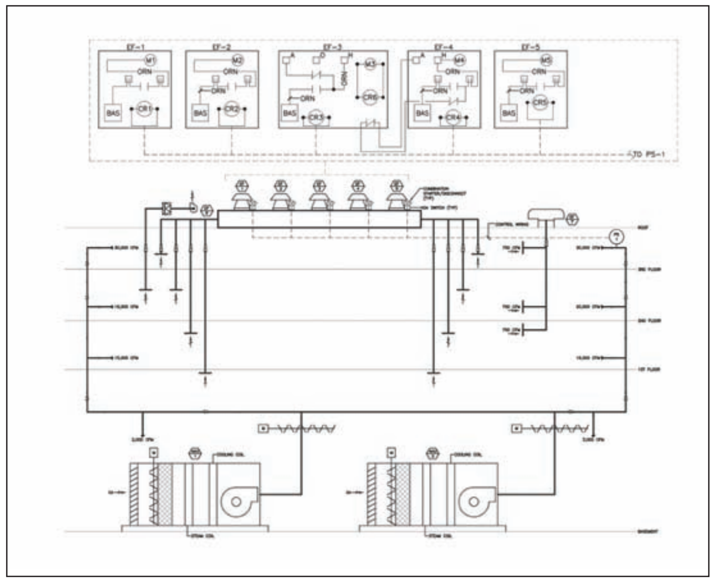
Commissioning has become an increasingly common process for laboratory exhaust systems in heavily ventilated laboratories. While recognizing the increased complexity and interdependency of systems, at the end of the day, the relationship between the laboratory controls and the building automation system is what helps to maintain containment and user safety within these laboratories.

Design The CxA should initially work alongside the design team and the Environmental Health and Safety (EH&S) group to discuss the standard operating procedures (SOP) for the use and maintenance of the laboratory. At Affiliated Engineers Inc. (AEI), we recognize that the project architect, engineer and contractor hold final responsibility and provide the expertise for how the systems function within the whole of the project. However, we also understand the role of the CxA in collaborating and effectively communicating with all involved parties helps to create a win-win scenario.

During the design phase of laboratory buildings, the design team is so focused on meeting programming goals and complying with building codes that it is easy to overlook the importance of fine-tuning the controls. Items such as the freeze state trip, smoke alarms, air handler failures, maintenance shutdown (coordinating the replacement of components) and unexpected power outages can often impact the operation of the lab in unforeseen ways.

It is vital for control sequences to be set up for maintenance, but even more importantly in case of an emergency, such as loss of power, chemical exposure or fire. The CxA should make specific recommendations for the coordination of certain systems to sustain operations during an emergency power outage. Key components for consideration include: exhaust plenum pressure transmitters, pressure switch in the supply duct, fume hoods and corresponding exhaust fans and bypass dampers. Of course, to make these parts and pieces work harmoniously, the building automation system (BAS) and the laboratory control system (LCS) must also be heavily considered.

When any of the above components lose power, without the stand-by power in the other controls, the static pressure of the building shell is immediately affected. For example, if a laboratory loses power and the air handling unit (AHU) was not backed up by a generator, the exhaust fans will continue to remove air from the hoods and related lab space. In most VAV control systems, the exhaust fans are merely looking at a differential pressure located in the exhaust air plenum and trying to maintain some setpoint. When the AHU shuts down and the exhaust air fans continue to operate, there is far more exhaust than supply air. In just a matter of minutes, the building is likely to become negatively pressurized, making it extremely difficult for people to leave the building. In fact, on some heavily ventilated laboratories, we have measured as much as 20 pounds of force is required at egress doors.



Example: Relay logic excessive exhaust controls solution. All diagrams: Affiliated Engineers.

To make matters more complicated, even when the controls are backed up by an emergency generator, there is a lag as the building transitions from normal power to generator power. This lag can result in loss of control while the BAS or LCS restarts and assumes control. This is why providing an uninterruptible power system should also be considered to bridge the gap from normal power to emergency power. Consider an analogous comparison to a home computer: a thunderstorm may cause a home computer to lose power. It takes time to re-boot and function again when power is restored. Sometimes it even comes up garbled and the system needs to re-boot again. A laboratory control system is a computer that will have to reboot again if it loses power, and there is no guarantee that the system will operate correctly after it restarts.

In the building pressurization example above, building egress is immediately impacted. Failure of the control system to assume control of the HVAC system can result in a prolonged problem with building pressurization and building egress.

Commissioning can also play a significant role in helping the mechanical engineers and designers focus attention on such items as:

- Pressure transmitter setpoints during the loss of power.
- AHU shut down.

- Building performance during the transition from normal power to emergency power, etc.

In the event of a power outage, pressure switches can be electrically interlocked/hard wired to the exhaust fan starters, dropping back on exhaust capacity. Pressure transmitters can be set with differential pressure gauges to adjust to direct fan speeds. Through field observations and rigorously testing the laboratory exhaust system, fine tuning of the failure positions, setpoints, and actual conditions to allow sustainable egress can be accomplished. Frankly, this refinement can only be determined during a rigorous test program. There are too many unknowns and elements outside the design engineer's control for this level of detail to be addressed in the design phase.

Testing and checklists: Catching what designers may miss A CxA can help avoid emergency situations, such as inability to exit a laboratory, by taking the time to coordinate and complete the proper functional testing. While it is important to do individual component testing, it is also equally important to view the laboratory facility on a system level. Many times it is evident or proven that the equipment components are operating properly; however, the dynamics of the interaction between the components on a system level requires detailed functional performance testing to achieve optimal safety.

To ensure proper egress and safety in the building, it is critical to test many different failure scenarios while validating and functional testing the building as a whole. In many ways, different buildings have different characteristics. Identifying the potentially vulnerable points in the building along with rigorous testing against various failure scenarios is a suitable way to ensure building safety during a component failure.

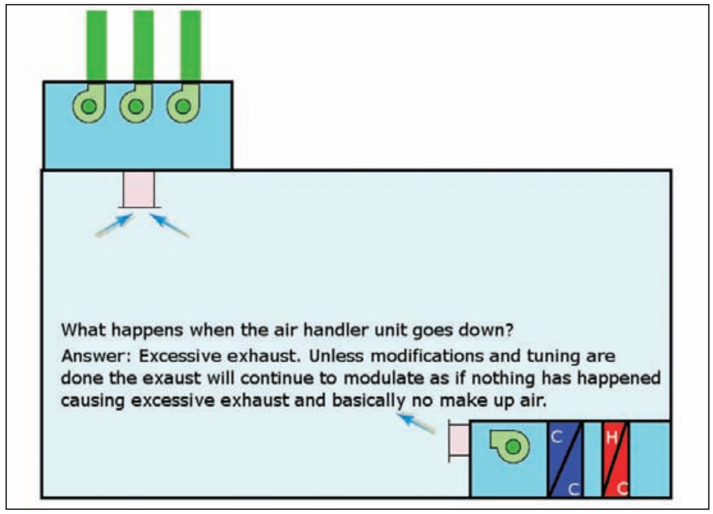
Testing laboratory exhaust systems is a fairly extensive process, requiring careful timing and coordination with the construction manager. The overall construction schedule can be shortened by scheduling functional testing concurrently with the completion of construction. Testing should occur as soon as a system is ready even if other construction is ongoing, allowing early issue identification and thoughtful resolution.

Generally, to make functional testing successful in a laboratory space, the air flow in the spaces should be balanced, the controls should be 100% completed; as-built drawings for the systems should be developed and provided to the CxA; ceiling tiles should be installed; and component systems serving the space should be operational.

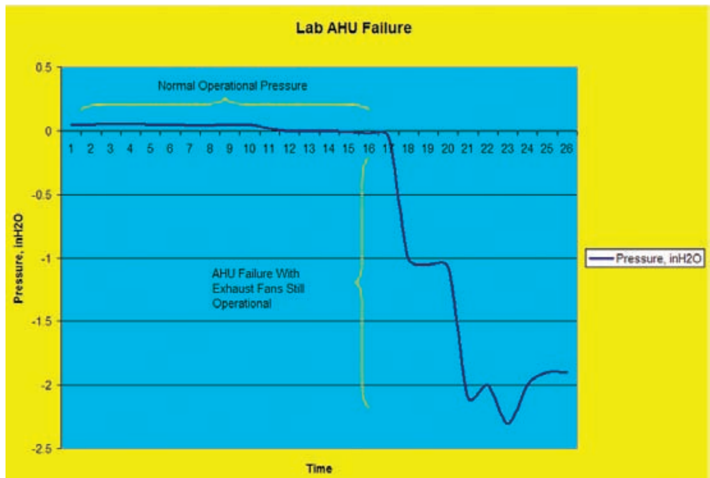
During the testing phase, all control functions, normal and emergency, should be assessed using objective and measurable criteria. The following should be considered when testing laboratory exhaust fans:

- Sequence of operation descriptions should be outlined in detail by the design professional for the project.
- Laboratory pressurization control checks should be conducted in the summer and winter to verify proper design pressure in the space.
- Using the list of current parameter values (Duct SP Setpoint), verify at the end of the test that all values returned to their original value.
- Check calibration of all critical sensors. Verify that sensor readings are within the specified design tolerances.
- Check calibration of all critical control devices (valves, dampers, actuators, pressure transmitters, etc.). Verify that device reading at BAS is the same as the actual condition observed at device. For items out of calibration or adjustment, fix immediately to ensure proper operation.
- Before starting functional testing, start trend log sampling of duct static pressure sensors, bypass dampers, runtime times and pressure switches on the system. Verify that the building is reporting that it is operating correctly. Functional testing can further verify and validate the building.
- Describe the failure modes for specific systems and for systems that work together. For example, if the air handler trips on a freezestat and shuts down, the exhaust fans should cut back to one half the current static pressure setpoint, allowing the building to not be pulled excessively negative and hinder egress.

Maintaining: Paying attention pre- and post-construction AEI integrates the owner's engineers and maintenance staff into the commissioning process through the course of the entire project. Obtaining their input during planning and design increases their buy-in of the criteria used to accept the project. Preparing the maintenance team for their post-occupancy responsibilities boosts the team's confidence that the commissioning was done properly. AEI recommends routine maintenance for laboratory facilities once a year, allowing for scheduled check-ins and testing without disrupting the functioning facility.



Example: Simplistic laboratory building overview.



Example: Sample trend data of excessive pressure during air handling unit failure in building.

Once the commissioning process is complete, a final report should be used to summarize the commissioning efforts within the project. It should minimally consist of:

- Completed pre-functional checklists.
- Completed functional performance tests.
- All identified issues and resolutions.
- Updated functional performance test to the as-built condition for future re-commissioning.
- Recommendations for system maintenance and re-commissioning.
- List of enhancements to improve the operation and maintenance of the facility. Ideally, this list would help with future repair and renovation budgeting.

Why not commission? Commissioning costs typically range from 1 to 2% of the cost of installing a system. An effective commissioning program typically has a payback period of two years or less and results in a 15 to 30 % savings in life-cycle costs. This front-end commissioning investment helps to ensure that the building and its supporting systems meet the needs and expectations of the building's occupants and, ultimately, keeps them safe.

Therefore the question is no longer "Why commission?" It's "Why not commission?"

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