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At Biomedical-Research Laboratory, Pressure is on for Safety and Uptime

Controls help ensure negative-pressure environment

Located in San Antonio, the Southwest Foundation for Biomedical Research's 34,000-sq-ft Betty Slick & Lewis J. Moorman Jr. laboratory complex is one of the world's premier facilities for the study of emerging and deadly infectious diseases. Extremely flexible, it offers researchers the ability to traverse and work safely within 16 laboratories of different biosafety levels: BSL2, BSL3, and--the maximum in safety, for working with the most deadly viruses--BSL4.

The facility design team's primary objective was to design and build the most advanced laboratory and support facility on time and on budget. It succeeded on all fronts.

Assembling the Team

"One of the most challenging aspects of the design," Director of Environment, Health and Safety Jack Kelley said, "was to integrate 16 laboratories--the BSL4 suite, three BSL3 and 12 BSL2 labs--into a single building that would ensure maximum safety with maximum (24/7) facility uptime. It's essentially negative pressure, or vacuum, in a bottle: We must control everything--people, air, water, materials, etc.--going in or out of sealed environments at all times."

Kelley took his design team to the only operational BSL4 labs in the United States--the Centers for Disease Control and Prevention in Atlanta and the U.S. Army lab in Maryland--to learn ways to avoid creating a BSL4 lab that was overcontrolled and too expensive to maintain.

"We wanted off-the-shelf devices wherever possible," Kelley said.

Kelley sought help from Siemens Building Technologies.

"We were working with very discrete pressure differentials with equally discrete airflow-change ratios," Kelley said. "Siemens was absolutely critical. Their challenge was to control airflow to such an exacting degree that we could operate confidently with 0.05 in. of water- column pressure across all of the barriers and air-lock doors."

Siemens' solution involved the installation of an Apogee building automation system (BAS). Equally important, the company devised elaborate control strategies to integrate the control of laboratory ventilation systems; laboratory exhaust systems, including fume hoods and biological-safety cabinets; and all HVAC equipment with the decontamination and shower systems and air-lock-door controls. Kelley's control of the new laboratory is through a central server and three PC workstations located throughout the facility.

Controls Strategy Is Extensive

Strict guidelines on lab practice and technique, safety equipment, and facility design had to be followed to reduce or eliminate exposure to and transmission of potentially hazardous agents.

Complex, specialized ventilation- control and waste-management systems were installed to completely isolate the BSL4 lab to prevent the release of dangerous microorganisms into the environment or other labs. Essentially, the lab operates as a sealed area from which all materials, including exhausted air and wastewater, are filtered or heat- decontaminated prior to leaving. All work by personnel is conducted in full-body suits with respiratory support.

Room-pressurization and comfort-control functions are completely and seamlessly integrated into the BAS, a Siemens System 600 Apogee. All system points are controlled and/or alarmed from a common graphics-based software package running on the workstations. Software capabilities and functionality include full-featured graphical control and simultaneous multiple-display dynamic graphing. The modular technology comprises a mix of stand-alone modular building controllers, mechanical-equipment controllers, and terminal-equipment controllers (TECs), all of which are off-the-shelf equipment for simplified, relatively low-cost maintenance.

The BAS design permits expansion of both capacity and functionality through the addition of sensors, actuators, controllers, and operator workstations. The BAS allows adjustment of individual fume-hood face velocity, biosafety- cabinet exhausts, and room-cfm offsets from the BAS operator workstation. Real-time-measured airflow data is available at the BAS operator workstation to verify the safe operation of the direct-digital-control (DDC) strategies for proper laboratory pressurization.

The design of the BAS provides the network for the operator workstations and stand-alone DDC controllers. The BAS network architecture consists of three levels: an Ethernet (management level) network for the Apogee and security workstations; a high-speed, peer-to-peer (building level) network for the DDC controllers; and a local- area (floor level) network for the TECs controlling the BSL2 and BSL3 labs, fume hoods, and biosafety cabinets. The configuration of the BAS network is transparent when accessing data or operating the facility. All operator devices--network-resident and those connected via dial-up modems--have the ability to access all points and applications allowing multi-tasking report generation, control execution, and maintenance functions for all connected workstations. The network design provides high-speed data-transfer alarm reporting so that an alarm occurring at any controller is displayed at the designated workstation(s) and/or alarm printer(s) within five seconds. Constant pressure is critical Measures to maintain the tightly sealed environment are everywhere.

"There is a break tank that makes the initial air break between the water supply and the water pump that supplies the lab," Kelley explained. "Supply and exhaust air is HEPA-filtered--double- filtered on the exhaust--using parallel systems. We were not required to double-HEPA-filter the supply air, but chose to do that anyway. Both the intake- and exhaust-air systems are totally independent, and the parallel systems themselves are, of course, independent, too."

Siemens interconnected the supply- and exhaust-air systems to shut down the supply in the event of an exhaust failure. This was done to preclude the accidental pressurization of the lab.

An industrial programmable logic controller (PLC) controls the heat-decontamination system that heat-treats all of the fluids leaving the lab. The system uses an electric boiler with a 500-gal cook tank/holding tank. All fluids are "cooked" (sterilized) at 250 F for two hours, cooled, and then ejected into the sewer system. The BAS is integrated with the PLC through a Siemens Open Processor Driver, allowing monitoring of all critical processes and immediate alarming upon any malfunction.

To assure that the required "negative pressure in a bottle" is maintained to specifications, Kelley's department performs leak testing and pressure-decay testing, which requires a system shutdown, annually.

"We challenge all HEPA filters, ductwork, and the lab itself for leaks," Kelley said. "If a leak should ever occur, such as a crack or a failed seal, the negative operating pressure would force the air to flow in the proper direction."

Each lab area is a step down in pressure, with graduations across each barrier maintained at 0.05-in. water-column pressure. There are approximately six barriers that must be penetrated to reach the depth of the BSL4, which operates at a negative 0.3-in. water-column (WG) pressure. This is achieved through a finite balance between the supply and exhaust airflows. In the unlikely event of a leak or accident, such as a door failure or material being dropped, the ventilation controls would not allow any airborne material to escape because air is coming in constantly.

Siemens also installed the System 600 Apogee for control of a new 4,500-sq-ft central plant, which supplies all of the facility's heating, cooling, and emergency power. Siemens provides a full range of technical-support and compliance services.

Siemens installed and maintains two DSX card-access security systems: one to manage access to the virology and BSL4 labs, the other to control campus access. Both systems share the management-level network with the BAS. The fire-alarm system is a Siemens Cerberus Pyrotronics system, which is monitored by the BAS for alarm notification through strobe lights in the BSL4 lab and the designated alarm workstations.

Information courtesy of Siemens Building Technologies Inc.