

Queen's University Scores High Marks with New Chemistry Lab

Fume Hood-Intensive Laboratory Design Emphasizes Flexibility

Queen's University in Kingston, Ontario, is scoring high marks with Chernoff Hall, its new fume hood-intensive, multi-use chemistry lab. The facility, which received a "Lab of the Year" high honors award from *R&D Magazine* for innovation and safety, is the first building in North America designed around the use of controlled air volume (CAV) fume hoods. The \$57-million (USD), five-story complex opened in summer 2002 and houses the University's chemistry department, providing laboratory space for more than 3,000 undergraduate students and 120 researchers.

"Our goal was to create a facility that would provide long term flexibility and adaptability, but also be inexpensive to build and operate," says Rick Boswell, manager of Queen's University department of chemistry.

Designed in collaboration with Toronto, Ontario-based Brisbin Brook Beynon Architects, the 151,000-sf, multi-disciplinary laboratory was built using redundant generic bench modules and flexible lab servicing plans. In addition to featuring 159 controlled air low-flow/low-volume fume hoods, the facility is a trend-setter in eliminating water aspiration as a means for separating chemical compounds. Designers developed an innovative system using a building-wide network of specialized miniature pumps made by vacuum technology specialists, Sweden-based PIAB (pronounced Pie A-B).

While most of the space in Chernoff Hall is dedicated to flexible research laboratories, the building also houses a 250-seat amphitheatre, several student lounges, and offices on the top floor with panoramic views of Lake Ontario. Now in its third year of operation, the building has proven to be highly adaptable, despite rapid growth and unexpected changes in the University's research emphasis.

Flexibility vs. Adaptability

One issue the design team had to confront was differentiating between the terms "flexibility" and "adaptability," as they were used in the project's mission statement.

"At first, those terms seemed interchangeable, but we realized that they are really different in relation to our program," says Boswell.

According to Boswell, flexibility is the ability for a researcher to relocate anywhere in the facility and have their needs met. Adaptability, on the other hand, refers to Queen's capacity to modify the facility over the long term in accordance with ongoing changes in personnel, research focus, and technology.

"We discovered that these issues were directly related to our churn rate. As far as adaptability goes, we had to determine how often we wanted to change our programs and therefore the facility. We settled on a cycle of about four years," says Boswell.

Intelligent Service Module

In order to maximize Chernoff Hall's flexibility, all lab space is designed around the idea of an "intelligent service module" (ISM). Functionally, ISM is a very compact generic workspace model that contains all the services necessary in a modern chemistry lab. This integrated modular design is used repeatedly throughout the building, which, in addition to making the facility more flexible over the long term, significantly expedited the installation process.

"With the intelligent service module it is much easier to change things around as we attract new researchers. Our goal was to install identical services at each location. You may not need nitrogen gas at that place today, but somebody is going to want it there tomorrow," says Boswell.

Instead of bringing services to the bench horizontally, through the floor or ceiling, the design team chose to create vertical service runs in order to make installing case work and moving benches easier.

"You also have to consider the vertical impact of changes because, when you alter one space, you also impact the spaces above and below it," says Boswell.

Though there is a slightly higher capital expense associated with the ISM model, Boswell explains that it is offset over the long term by the elimination of high renovation costs.

Educated Decisions

Chernoff Hall's ISM model is the result of extensive testing and researcher input. As part of the development process, designers created life-sized models using old casework and plywood in order to put the proposed modules through rigorous user-testing.

"We put the sinks, fume hoods, and turrets in the places they were indicated on the drawings, then had the researchers actually come in and kick the tires. We learned an enormous amount from this because people could get a feel for the space in a very tactile way," says Boswell.

Queen's worked with RWDI, an Ontario-based scientific consulting and engineering firm, to model airflow patterns of different designs using computer fluid dynamics.

"Computer fluid dynamic testing is a little more expensive up front, but it is an accurate predictor of how your building is going to work. If you are using a new concept, it's good to get it independently tested. The information pays off down the road," says Boswell.

As a result of these tests, Queen's changed the type and placement of diffusers in order to create cohesive laminar air flows within the labs.

One of the biggest issues the team had to resolve was whether to choose a constant air volume (CAV) or variable air volume (VAV) fume hood design.

“We serve both researchers and undergraduate students in the same facility, and it was important to be able to accommodate the undergraduates,” says Boswell.

The design team tested both styles of fume hood with the full array of standard chemistry equipment. Researchers were brought in and asked to perform basic tasks while designers measured the entrainment.

“Safety was ultimately what drove the fume hood decision. We went with CAV hoods because they are on all the time. In the undergrad situation, with classes that are three hours long, you have to assume that they will be in use for the entire time with a hundred percent diversity,” says Boswell.

New Ideas

In addition to being the first chemistry lab in North America specifically designed around multiple low-flow/low-volume fume hoods, Chernoff is also one of the first to eliminate the use of water aspiration as a means of separating chemical compounds.

Instead of using water to create a vacuum, which is expensive and water-intensive, Chernoff has a system of 250 miniature PIAB pumps that use compressed air to create a useable vacuum. Organic compound vapor is then extracted via air ducts instead of flushed out.

“The PIAB pumps helped us a great deal in terms of rationalizing the functions on the bench top. Now we could deliver compressed air, which we were going to deliver anyway, and use it in a different function,” says Boswell.

One problem designers encountered was that the PIAB pumps require larger than normal compressors and those compressors were originally put in too small a space.

“The original space got up to about 130 degrees and we couldn’t keep it cool. That is one of the errors that we made, but we have since moved them to a different location and have yet to run out of compressed air,” says Boswell.

Boswell emphasizes the importance of modeling, testing, and getting user input when developing new lab designs such as the ISM.

“It’s important to verify your assumptions as much as possible. Mock-ups are inexpensive to make and they effectively communicate concepts to the users, which minimizes change orders and saves money down the road,” he says.

Adapting to Change

Since the building opened, undergraduate lab enrollment at Queen’s has increased from 2,400 students to more than 3,000, three new principal investigators have moved in, and the number of researchers has increased from 85 to 120.

Chernoff Hall’s design has demonstrated a high degree of adaptability.

“We anticipated that our major growth area would be materials science and it turned out to be medicinal chemistry. We had to retool some things but, because of proper planning, we were able to reduce the impact of these changes,” says Boswell.

The Canada Foundation for Innovation (CFI) and the Canada Research Chair (CRC) also contributed research funds to Queen’s, which unexpectedly increased the building’s level of instrumentation.

“With one of the CFI grants we acquired four mass spectrometers and two NMRs when we had anticipated only half that many. The good news is that the power and infrastructure didn’t have to be upgraded because we already had it there,” says Boswell.

Since Chernoff Hall opened, the University has modified approximately 15 percent of the space without running into any major surprises.

“The ability to adapt to these changes and maintain flexibility in our daily operations speaks well of the ISM design. If I had to give the facility a grade for achieving the stated goals, it would be an A plus,” says Boswell.

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Biography: Rick Boswell is the manager for the department of chemistry at Queen’s University in Kingston, Ontario. He has been working in laboratories at the University for more than 18 years and been responsible for renovating many older research and teaching laboratories on campus, including the programming and planning for Chernoff Hall. In addition to managing chemistry in the building that he planned, Boswell also consults privately to other institutions and private firms on laboratory programming and planning.

This report is based upon a presentation by Boswell at Tradeline’s *Science Buildings Canada 2005* conference in May.

For more information:

Rick Boswell
Department Manager
Queen’s University,
Chernoff Hall
Kingston ON K7L 3N6
Canada
(613) 533-6662
rick@chem.queensu.ca

Project Team:

Architect: Brisbin Brook Beynon Architects, Toronto, Ontario
General Contractor: M. Sullivan and Son Ltd., Arnprior, Ontario
Mechanical Consulting: Keen Engineering, Toronto, Ontario
Scientific & Engineering Consulting: RWDI, Guelph, Ontario
Vacuum Technology: PIAB, Hingham, Mass.

Project Information:

Purpose: Multi-use educational chemistry research lab
Gross area: 151,000 sf
Construction Cost: \$57 million
Completed: Summer 2002
Queen's University Chemistry: www.chem.queensu.ca



Chernoff Hall, on the campus of Queen's University in Kingston, Ontario, is a five-story, 151,000-sf, multi-disciplinary chemistry laboratory and educational facility. Opened in summer 2002, the facility is designed around the use of redundant generic bench modules, flexible lab servicing plans, and controlled air volume fume hoods. The building also houses a 250-seat lecture theatre, student lounges, and faculty office space. *(Photo courtesy of Queen's University.)*

Chernoff Hall is designed around the "intelligent service module" (ISM): a flexible generic workspace model providing all the services necessary in a modern chemistry lab. The laser lab on the left is built in an identical space as the organic chemistry lab on the right. The same services are available in both places. The organic lab on the right is outfitted with fume hoods and casework, while the laser lab emphasizes wide open floor space with piping and electricity in overhead trays. *(Photo courtesy of Queen's University.)*

