HVAC systems are easy to design when all the rooms in the building have the same general requirements. When Calvin College, a 4,300-student college in Grand Rapids, Mich., USA renovated and expanded its fine arts center, it needed a design that would accommodate spaces from a control booth to a 1,200-seat auditorium with varying use schedules and criteria. In addition, the system had to accommodate the effect of adjacent spaces with shared walls where the HVAC might be operating in one area but not the next.

“One of the challenges we had was humidified areas adjacent to non-humidified with doors that opened and closed between them, and how to estimate the moisture loss,” says Jim Merlino, an engineer for GMB Architects + Engineers in Holland, Mich. who served as chief mechanical engineer for the redesign.

They were able to get the flexibility they needed by using a high-pressure fogging humidification system which allowed them to precisely control the moisture levels in each of the building’s air handlers.

Enhancing the fine arts experience
Calvin College opened the 72,000-square foot fine arts center in 1966. Through the years, the venue has hosted approximately 20,000 concerts, recitals, lectures and events. What once was a state-of-the-art theater had fallen behind the times, but it was in for more than a simple facelift.

“At the 35-year mark, any building is overdue for a major overhaul,” said Calvin’s vice president for administration, finance and information services Henry DeVries in the spring of 2009 when the theater was shut down for renovation. “We’re talking heating, plumbing, air conditioning and IT — all of that has to be upgraded.”

First, the building needed to be brought up to code. The asbestos insulation needed removal, and since the building was constructed prior to passage of the Americans with Disabilities Act, accessibility features needed improvement. In addition, the college wanted to create a beautiful space to train students and present visual, musical and theatrical productions.

As Director of Exhibitions Joel Zwart described it, “We’re making changes that will enhance the entire fine arts experience.”

The US$15 million renovation was overseen by architect Rob Den Besten, a 1996 graduate of Calvin College working at GMB Architects + Engineers in Holland, Mich. The existing auditorium was gutted and seats, lighting and wood paneling were removed. Several exterior wall sections were knocked down in preparation for the addition of 40,000 square feet of floor space. Keeping the main theater intact as the central focal point, the building was extended in three directions.

THE FINE ART OF CONTROLLING Humidity

By Drew Robb
At the northwest corner, the university added a 3,800-square-foot art gallery. The gallery is divided into two sections: a smaller gallery to display a rotating selection of the college’s 1,500-piece permanent collection and a larger gallery with 33-foot high walls capped by lightwells for temporary exhibitions.

On the southwest corner, the lobby was expanded and a new 240-seat recital hall was added. In the original layout of the fine arts center, the only recital space was the 1,100-seat main auditorium, however the new facility gives the option of a more intimate setting for performances.

Along the eastern side of the building the college added practice suites, classrooms, faculty offices and a student lounge for use by the music and English departments.

**Not too wet, not too dry**
Designing an HVAC system for such a facility presented a number of challenges. Calvin College has three boiler/chiller plants to heat and cool campus buildings, including the fine arts center, and these did not require an upgrade for this project. However, the project team had to take the building usage into account, as the occupancy variance would be far less predictable than, for example, an office building, which typically has fairly steady traffic within a regular timeframe.

“The building had very specific temperature and humidity requirements,” said Steve Schultz, an engineer at GMB. In addition to specific acoustic requirements, the building had to maintain comfortable temperature and humidity for occupants that would also fit the preservation needs of the art and instruments housed within.

The college owned a number of fine instruments which required precise environmental conditions. For example, the auditorium contained a mechanical action organ built by Schlicker Organ Company in 1966. When the area was gutted for the renovations, a temporary wall was built around the organ and a humidification system installed. Too dry an environment could cause materials to shrink and crack; too much moisture could lead to swelling and promote the growth of mold or mildew.

In addition, the heating and cooling system had to have the flexibility to accommodate a number of room sizes, which ranged from small offices and practice rooms to the vast...
main auditorium, as well as varying usage patterns in the classrooms, rehearsal rooms, recital hall, art galleries and lobbies. While an ideal air quality management scheme could be devised for each area in isolation, the interaction between the spaces complicated the heating and cooling strategy.

An efficient solution
To gain maximum control, GMB specified seven air handlers for the building. The smallest was a 450 CFM (cubic feet per minute) unit for the control booth. The largest was more than 100 times that size — a 46,200 CFM air handler for the auditorium. The air handlers drew heat and cooling from the larger campus system, but the humidity needed to be controlled locally, especially to bring outside air to a comfortable level during the winter months.

“We need to manage the humidity year round: in winter we add humidity, in the summer we dehumidify,” said Schulz. “The cooling systems provide the dehumidification in the summertime. In winter we add humidity by spraying water inside the air handlers and vaporizing it.”

Merlino says that they would have liked to design the system to maintain 50 percent relative humidity, but had to settle on 45 percent.

“Working with an existing building, we didn’t want to introduce too much moisture that might migrate from moist areas to dry, so we had to be careful to not to put too much humidity into the space.”

To add the moisture, they selected a high-pressure humidification system rather a steam generator or other type of humidifier.

“We didn’t have steam available so we would have had to use electric or gas steam generators,” Merlino said. “The high-pressure fogging system was the most energy efficient. The system cost more initially, but had lower overall lifecycle costs and paid for itself fairly quickly.”

The system uses a high-pressure pump to send water to a manifold system inside the air handlers. Specially designed nozzles in the manifold direct the water at impaction pins which split the water jet into billions of tiny droplets which quickly evaporate in the air stream, providing the required humidity. The pump uses a variable frequency drive to maintain the appropriate water pressure under varying loads, and solenoid valves control how many of the nozzles are operating at a particular time.

In this case, a single pump was used to provide humidification for all seven air handlers. The manifold inside each of the air handlers is sized with the appropriate number of fogging nozzles to meet the needs of the space that air handler serves. Each manifold has multiple solenoids to control how many of the nozzles are in use at a time. When the building management system calls for an increase in humidity in the auditorium, the recital hall, art gallery or any of the other rooms, the right number of solenoid valves open up to send water to the nozzles.

“There is a different quantity and arrangement of nozzles and control valves for each air handler, depending on the airflow, humidity and temperature requirements,” says Schulz.

A beautiful addition
Calvin College’s fine arts center closed at the end of the spring 2009 semester and had its grand reopening in October of the following year, rechristened as the Covenant Fine Arts Center. As with any new building, there was a breaking-in period. The physical plant department had a 1,000-item list of issues large and small to address.

Merlino says that some of the issues related to getting enough humidity in certain areas, but the fogging system was able to adapt to the additional load.

“We had the flexibility to add spray nozzles in a couple of systems where we had trouble maintaining high humidity levels,” he says.

Overall, the building has been a huge success, giving the school arts community a larger facility that is both functional and aesthetically pleasing. The project has earned several awards, including recognition as an Outstanding Design by American School & University magazine, Outstanding Project 2011 from Learning by Design and a Bronze Citation from School Designs.

“It is a beautiful auditorium and recital hall,” says Merlino.
About Mee Industries Inc.

Mee Industries Inc. is an innovative, high technology corporation that provides custom engineered, cost-effective fog solutions for a wide range of applications including gas turbine inlet-air cooling and reverse osmosis water treatment systems. Founded in 1969 by former Cornell University research scientist, Thomas Mee Jr., today the company also specializes in revolutionary fog solutions for industrial humidification, outdoor air conditioning greenhouse climate control, wine barrel humidification and unique special effects applications.

Renowned MeeFog™ turnkey solutions include meticulously designed and engineered, high quality, integrated systems that deliver an unequaled combination of price and performance. Mee Industries products are backed by an experienced staff of technical personnel including, engineers and project managers along with production and installation specialists. An active research and development effort ensures the position of technological excellence. Mee Industries is an ISO 9001:2008 certified corporation and manufactures components to meet exacting UL or CE requirements.

Mee Industries is a privately held company with corporate headquarters in Irwindale, California.

A typical fog system uses one horsepower for every 500lbs of water, which is 3% of the energy usage of compressed air-type systems and about 1% of the energy usage of steam systems.

**ENERGY COST COMPARISON CHART (ANNUAL)**

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<tr>
<th>System</th>
<th>Cost</th>
<th>Percentage</th>
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<tr>
<td>MeeFog™ System</td>
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<tr>
<td>Ultrasonic</td>
<td>$8,467</td>
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Assumptions: $.10 per kWh, $1.20 per therm, 3500 hours operation, 1000 lbs. per hour moisture output.