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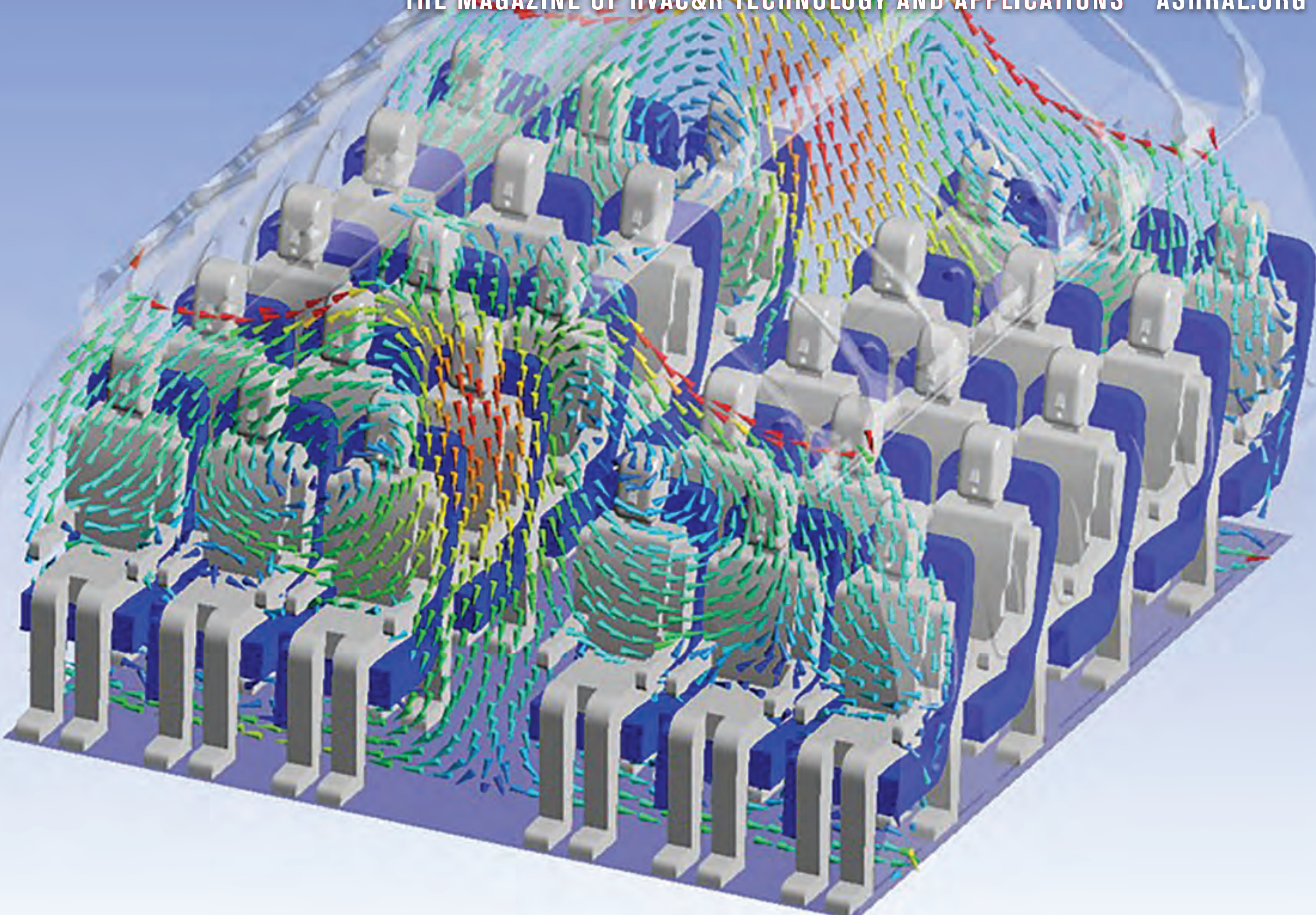

Mass and Particle Removal Dynamics

Validating BIM Load Calculations | What to Know About Strainers

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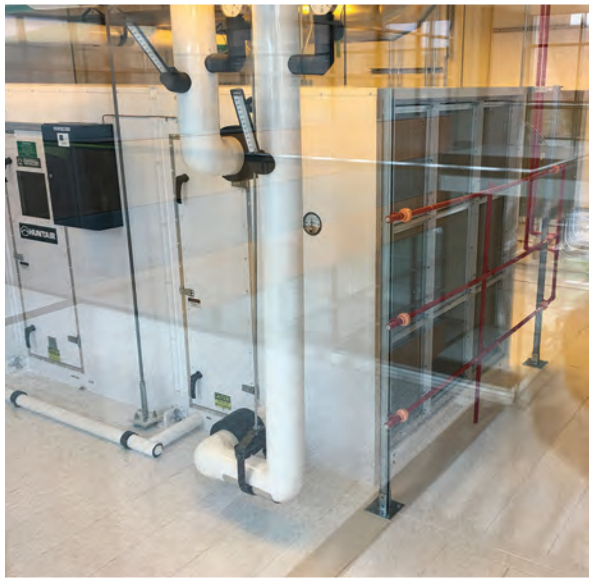
Cleanroom Renovation Reduces Energy, Water Consumption

BY CHAD LUNING, P.E., MEMBER ASHRAE; TIM JENDRYCKI, P.E., MEMBER ASHRAE; MICHAEL MCDERMOTT, MEMBER ASHRAE; KITTY KNAUZ, P.E., MEMBER ASHRAE; MARIO ZOTTA, P.E., MEMBER ASHRAE

Holonyak Micro & Nanotechnology Lab (HMNTL) in Urbana, Ill., is one of the country's largest and most sophisticated university facilities for conducting photonics, microelectronics, biotechnology and nanotechnology research. HMNTL faculty and students are conducting research that advances a broad range of applications, including high-speed data communications, high-efficiency lighting, solar power, flexible electronics, biosensors for drug discovery, biomedical imaging, disease diagnostics, vaccine delivery strategies, environmental monitoring and novel microelectronics/photonics concepts for next-generation computing architectures. The facility has 16 Class 100 and 1,000 cleanrooms (eight of each), 46 general purpose labs and a 2,500 ft^2 (232 m^2) Biosafety Level 2 bionanotechnology complex.

A cleanroom is defined by ISO14644-1 as a room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room and in which other relevant parameters—e.g., temperature, humidity and pressure—are controlled as necessary.

The HMNTL project included a new 4,000 ft^2 (372 m^2) renovation in the existing atrium to create new ISO Class 7 laboratory space for student development and manufacturing of silicon wafer integrated circuit boards. Mechanical design included new air-handling equipment, HEPA and ULPA filtration, toxic and solvent exhaust, high-purity gas distribution and a particulate monitoring system with demand-controlled ventilation. Cleanroom equipment installed included wet etching benches, a thermal evaporator, a high-temperature furnace and photolithography equipment.



Holonyak Micro & Nanotechnology Lab

The project also included installation of particle demand controlled filtration for eight Class 100 (ISO Class 5) and eight Class 1,000 (ISO Class 6) cleanrooms. Pairs of cleanrooms are served by a single recirculation air-handling unit. Cleanrooms in each pair were separately zoned by ductwork modification. This zoning enabled individual airflow control based on dynamic particle counts and occupancy. The Class 1,000 recirculating air handlers are each sized at 32,000 cfm (15 102 L/s) with two 16,000 cfm (7551 L/s) variable air volume dampers with an airflow measuring station. The Class 100 recirculating air handlers are sized at 40,000 cfm (18 878 L/s) each with two 20,000 cfm (9439 L/s) variable air volume dampers with an airflow measuring station.

The project also included a storm water reclamation system to provide makeup water from exhaust scrubbers.

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Energy Efficiency

Existing makeup air units were balanced to maintain proper positive cleanroom pressurization. Cooling and dehumidification in these units were adjusted to provide 68°F (20°C) and 50% relative humidity return air (48°F [8.9°C] dew point) from respective cleanrooms. Once the makeup air unit provided proper humidity control, the Class 100 and 1,000 recirculating air-handling unit cooling coils and heating coils could be controlled in sequence to maintain space temperature. The submitting engineers discovered that the Class 100 and 1,000 recirculating air-handling units had been cooling and reheating simultaneously to provide humidity control before the makeup air units were properly set up.

Cleanrooms are designed to maintain extremely low levels of particulates, such as dust, airborne organisms, or vaporized particles. Cleanrooms typically have a cleanliness level quantified by the number of particles per cubic meter at a predetermined molecule measure. Particle counters integrated with the BAS can adjust airflow based on ppm at a given particle size of 0.5 microns. The submitting engineers' initial concept was to have a permanent particle counter that regularly passes data to the new control system.

Airflow dampers modulate to maintain the following setpoints:

- The Class 100 cleanroom setpoint is 10 particles/ft^3 at 0.5-micron size (classification limit is 100 particles/ft^3 at 0.5 micron size). Using ISO 5 metric system parameters, the cleanroom setpoint is 352 particles/m^3 at 0.5-micron size (classification limit is 3,520 particles/m^3 at 0.5 micron size).
- The Class 1,000 cleanroom setpoint is 100 particles/ft^3 at 0.5-micron size (classification limit is 1,000 particles/ft^3 at 0.5 micron size). Using ISO 6 metric system parameters, the cleanroom setpoint is 3,520 particles/m^3 at 0.5-micron size (classification limit is 35,200 particles/m^3 at 0.5 micron size).
- The zone dampers were modulated to allow room airflow quantities to vary between 25 cfm/ft^2 and 35 cfm/ft^2 of floor area (127 L/s·m^2 and 178 L/s·m^2) when occupied.

Occupancy sensors were added to all cleanrooms to determine if the room is in use. Airflow dampers modulate to maintain the following setpoints:

- Occupied setpoint: Control zone dampers were modulated to allow room airflow quantities to be modulated between 25 cfm/ft^2 and 35 cfm/ft^2 of floor area (127 L/s·m^2 and 178 L/s·m^2). Particle count setpoints remained as noted above.
- Unoccupied setpoint: Control zone dampers were modulated to allow room airflow quantities to be modulated between 15 cfm/ft^2 and 35 cfm/ft^2 of floor area (76 L/s·m^2 and 178 L/s·m^2). Particle count setpoints remained as noted above.

Indoor Air Quality and Thermal Comfort

Particulate filtration is a key aspect of the air handler design, including a prefilter, secondary filter and ULPA filtration.

Cooling and dehumidification in the makeup air units were designed to provide constant discharge air control to provide space conditions of 68°F (20°C) and 50% relative humidity return air (48°F [8.9°C] dew point) from respective cleanrooms. The low space temperature was provided to accommodate the thermal comfort of cleanroom researchers in full protective clothing.

Innovation

The building has four Harrington scrubbers (toxic, toxic, acid, and solvent), only three of which run constantly, which were previously using varying volumes of city water to clean toxins from the air. Upon investigation with a flow meter, the engineers saw that each active scrubber was using more than 4.5 gpm (17 L/min). Water from an aquifer beneath the HTML building that is collected in a large pit is now used to feed the scrubbers rather than being sent directly to the sewer, reducing water and sewer use.

The engineers used a conservative combined average of 11 gpm (41 L/min) (total) for the calculated water savings. At 11 gpm (41 L/min), the city water use avoided is 15,840 gallons (59 961 L) per day, or almost 6 million gallons (22,710,000 L) a year, saving approximately $39,000 each year.

Cost Effectiveness

The total project budget was $5 million (funded through an energy savings performance contract). Baseline water and energy expenditure was $2,340,717 annually. The project saved $440,503 (19% reduction) in 2017; $720,315 (31% reduction) in 2018; $848,889 (36% reduction) in 2019; and $812,583 (35% reduction) in 2020. ■