Improve Laboratory Buildings Energy Performance and Indoor Air Quality Using Laboratory Air Handling Unit System (LAHU)

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Modern research buildings often contain both laboratory and office sections. Conventionally, dedicated AHU systems serve the two sections respectively. The laboratory sections are designed to use 100% outside air, resulting in energy usage and construction costs that are often several times higher than commercial buildings. To reduce energy costs, a number of energy conservation measures have been developed and implemented in laboratory buildings. These measures include exhaust air heat recovery, supply air reheat, variable air volume (VAV) fume hoods, and usage-based control devices (UBC).

Heat recovery uses a heat exchanger to transfer heat between the exhaust and outside air streams. During winter, the outside air, warmed by the exhaust air, reduces pre-heating energy consumption. During summer, the hot outside air is pre-cooled by the exhaust air to reduce mechanical cooling. Air-to-air heat recovery is the most popular energy conservation measure for laboratory buildings. Several air-to-air heat recovery systems, including the “rotary wheel”, “fixed plate”, “heat pipe (thermosiphon)”, and “run-around coil”, have been considered in laboratory applications. The performance of heat recovery applications in laboratory buildings has demonstrated that heat recovery plays an important role in energy conservation.

In order to maintain suitable room humidity, the cooling coil discharge air temperature is controlled at 12.8°C (55ºF). Significant reheat occurs since the exhaust airflow is significantly higher than the airflow required by the laboratory section sensible load. The supply air reheat technique, which transfers heat from outside stream to supply air stream using heat pipes or run-around coils, provides a partial solution for efficient humidity control during the summer. The heat pipe is more feasible than the run-around coil, with this technology, due to its compact structure and no-power requirement. The cold end (one coil) of the heat pipe system is installed in the discharge duct after the normal cooling coil. The hot end (another coil) is installed before the cooling coil. These two coils are connected to form a heat pipe or run-around coil. The hot end absorbs heat from the outside air. The absorbed thermal energy is transferred to the cold end, where the cold discharge air is heated. The heat pipe/run-around coil reduces mechanical cooling energy due to the lower entering air temperature to the cooling coil. It also reduces reheat energy consumption due to the higher discharge air temperature, and maintains building humidity control due to the constant coil discharge air temperature. However, the supply air reheat technique is only suitable under hot summer conditions. During mild outside air temperature conditions, the supply air reheat technique provides little or no help in reducing reheat. The initial cost and the maintenance cost of the supply air reheat is also high.

VAV and Usage Based Control (UBC) systems have been used to reduce heating and cooling energy consumption through reduced outside airflow. After 10 years of

VAV applications in commercial buildings, the VAV fume hoods and control technologies were developed. The VAV fume hood maintains a constant face velocity. When the sash is partially closed, the exhaust air is proportionally reduced. The VAV fume hood reduces the exhaust airflow as much as 60% when the hood sash is closed. When compared with the constant air volume fume hood, the outside air requirement from the AHU is significantly decreased. Consequently, both heating and cooling energy are reduced. The potential energy savings have been investigated using both theoretical approach and field experiments. A case study showed that VAV fume hoods used an average of 40% less outside air in a chemistry building. UBC devices detect the presence of fume hood operators. When an operator is not present, the UBC reduces the fume hood face velocity to a lower value. When an operator is present, the UBC increases the face velocity to normal operation value. Although both the VAV fume hoods and the UBC technique substantially reduce airflow, a significant amount of reheat still exists.

To further improve energy performance in laboratory buildings, the conventional design concept, in which one AHU serves the office and another serves the laboratory, has been reevaluated. The result is an innovative AHU system, called a Laboratory AHU (LAHU), which has been specifically developed for laboratory buildings with increased energy performance and positive impacts to indoor air quality.