EXECUTIVE SUMMARY

FINAL REPORT ARTI-21CR/605-20011-01
EVALUATING THE ABILLITY OF UNITARY EQIPMENT TO MAINTAIN ADEQUATE SPACE HUMIDITY LEVELS – PHASE II

The objectives of ASHRAE Research Project 1254-RP "Evaluating the Ability of Unitary Equipment to Maintain Adequate Space Humidity Levels, Phase II" were: a) to compare various unitary air conditioning system humidity control configurations in terms of humidity control performance and operating costs; and b) develop guidelines to help identify the important application characteristics and climate factors that determine which option is most appropriate. This research project builds on the Phase I project, ASHRAE 1121-RP, which was completed in June 2001 (Brandemuehl and Katejanekarn 2001). The Phase I final report describes the Evaluation Plan which guided this work.

The EnergyPlus whole-building energy simulation software (EnergyPlus 2005) was used to perform a parametric analysis of eighteen HVAC system types in seven commercial building types (Small Office, Large Retail, Classroom 9-month, Classroom 12-month, Restaurant Dining Area, Small Hotel/Motel Guest Room, and Theater) using two sets of ventilation rates (ASHRAE Standards 62-2001 and 62.12004) in 10 locations. To meet the needs of this project, new equipment models were developed and added to EnergyPlus to provide advanced modeling capabilities for multi-stage multi-mode DX cooling coils, and enhanced component configuration and control options. The systems types included single-path and dual-path DX with and without enhancements such as enthalpy wheel, demand controlled ventilation, desiccant dehumidifier, subcool reheat, hot gas reheat, and air-to-air heat exchangers around the cooling coil.

The relative performance of each system type was compared on the basis of humidity control (occupied hours >65% RH) and annual energy use, including heating energy. The systems were also compared on a life cycle cost basis using approximate installed equipment costs and HVAC annual energy costs. The following guidelines, issues, and conclusions resulted from this analysis.

Guidelines

- In nearly all cases, simple variations in the Base DX system (lower airflow, lower SHR) do little to improve humidity control but may be useful to save fan energy. The exception to this rule is Standard 2004 ventilation rates with the Retail application in the most humid climates.

- Demand controlled ventilation (DCV) saves energy, but does little to improve humidity control in most cases.

- Semi-active humidity control systems (Case 5 Subcool Reheat and Case 7 and Coil Bypass) can help but often fall short, especially in the most humid climates.

- Certain applications, such as the Theater, Restaurant and Motel, in very humid climates have high humidity issues primarily at times when there is no sensible load on the coil due to cool moist outside air. Only active humidity control systems (desiccants and reheat) can control humidity at such times. Depending on the control settings, enthalpy wheels may not operate at such times, and therefore provide less benefit for humidity control.

- For all of the systems without direct humidity control (all cases except desiccant Cases 8 and 14 and reheat Case 17), system capacity vs. load profile is crucial. The poor humidity control performance of many of these system options can be attributed primarily to a high percentage of hours operating at low part loads. 2-stage systems with a 60% stage 1 capacity help significantly, but do not overcome this issue. Case 6 Base DX w/o Latent Coil Degradation represents the ideal in capacity staging where the coil never evaporates condensed moisture back into the supply air stream.

- For the Office, humidity control is not an issue.

- For the Restaurant, Theater, and Schools, systems with direct humidity control (desiccant Cases 8 and 14 and reheat Case 17) are the only systems which can provide adequate humidity control in the most humid climates. In less humid climates, enthalpy wheel systems (Cases 9 and 12) can also provide adequate control.

- For the Motel, continuous operation and single-stage equipment result in excessive hours of high humidity. Only Case 14 Dual path w/Desiccant provides adequate (or near-adequate) humidity control in the most humid climates. Reheat and dual path systems can help significantly, and are sufficient in moderate climates.

- For the Retail Store, a wider range of options can be beneficial.

- The enthalpy wheel and DCV options generally provide equal or better humidity control compared to the base system, with significant energy cost and life cycle cost savings. Significantly better humidity control (but not necessarily adequate control) is found in the Restaurant with the 2004 Standard, Retail with both standards, and School with both standards. Worse humidity control is found in the Restaurant and Theater in certain locations.

Issues

The results of this analysis raise several issues for further investigation:

- Would adequate capacity staging solve humidity control problems in all but the most extreme cases? Case 6 Base DX w/o Latent Coil Degradation results show that better staging might help in cases with moderate humidity control issues, but it makes little difference in the Theater, Restaurant, School, and Motel in the most humid climates.

- Do the dual path systems in this analysis perform better because they are dual path, or simply because they have four stages of cooling available in the outside air stream? Would the same four-stage system in a single path unit provide similar results?

- For some applications in high humidity climates, there are times when a zero SHR is required, because humidity is high but there is no need for sensible cooling. This requires a system such as hot gas reheat, essentially a dehumidifier. How much of the total system cooling capacity is needed at these times? Would it be more cost effective to add a small dehumidifier in the outside air stream?

- Fan power issues are significant. Would generally lower fan cfm/ton be beneficial if combined with adequate capacity staging to improve humidity control and save energy? How can the year-round fan power penalty of some of these systems be minimized?

- The outdoor air preconditioning system was not the typical application. This should be examined in combination with subcool or hot gas reheat.

- Would alternative desiccant dehumidifier configurations, such as placing the desiccant wheel after the DX cooling coil, provide adequate humidity control at lower costs and energy use?

- Additional data mining may reveal trends related to design SHR, ventilation load index, or other defining characteristics of the loads.

Conclusions

This research project has provided the following benefits:

- Comprehensive analysis of humidity control performance of a wide range of DX system configurations.

- Significant advancement in whole building energy simulation capabilities for modeling DX equipment by adding new capabilities to EnergyPlus. This provides access to designers and analysts to study specific projects and extend the results of this analysis.

- Identification of key issues for further exploration to better understand some of the key drivers and possibly develop some simple new system configurations that can efficiently control humidity.