

CONCLUSION

Moisture transport in building materials poses serious problems, both to human comfort and the structural integrity of building materials. It is essential to be able to determine the conditions and characteristics that cause moisture transfer across porous (building) materials. Nonisothermal moisture transport prediction is in its infancy. As pointed out earlier, several moisture diffusion theories have been developed but none universally accepted. Such models are based upon on the gradients of vapor pressure, chemical potential, moisture concentration and activated moisture content. Validity of these models has been difficult as a result of the lack of reliable experimental results. The prediction of moisture diffusion is complicated as a consequence of both the difficulty in designing accurate measuring techniques and the slow rate of movement of moisture through porous specimens.

The ASHRAE FDC measurement procedure was developed as an alternative method of measuring moisture transfer in porous materials under both isothermal and nonisothermal conditions. In addition to the shorter time in reaching steady-state, the apparatus has other added advantages over the traditional methods. The ASHRAE FDC method does not use saturated salt solutions. The mixing inside the chamber reduces uncertainties in convective resistance while promoting uniform conditions above the specimen. The apparatus consists of a system of two environmental chambers capable of controlling a wide range of temperatures and relative humidity within $\pm 0.05^{\circ}\text{C}$ and $\pm 0.10\% \text{R.H.}$ from the set points. The moisture transfer across the specimen is determined gravimetrically, the weight of the tubes (desiccant and bubble) responsible for the control of the relative humidity inside the chambers, is measured daily after the system has reached steady state. Typically, the apparatus requires only a day to reach steady-state in contrast to the one week required by the ASTM "cup method". The ASHARE FDC requires approximately between 4-10 days after reaching steady state to obtained moisture transport data, in contrast to the 5-9 weeks needed for the ASTM

method. The main objective of this research was to evaluate potential moisture diffusion models. Their applicability was assessed by how they satisfied the measured null flow condition. The results obtained from the apparatus tests agreed that moisture diffusion under nonisothermal conditions is governed by the gradient of the water-vapor pressure. The validity of the vapor pressure model was verified by a low temperature test, which yielded similar results from those obtained at room temperature.

The apparatus was validated by comparing permeance results obtained under isothermal conditions with previously published data (Burch and Thomas, 1992). This comparison showed a good agreement and that the permeance was constant under the range tested (25-50 per cent R.H.).

A small difference in static pressure across the specimen was observed during the ASHRAE FDC and ASTM cup measurement procedures. The pressure difference is believed to be caused by bulk air flow generated by the air diffusion process. The bulk flow of air governed by Darcy's Equation balances the diffusion of air in the opposite direction. Further analysis of this phenomenon and its significance in the moisture transport process is needed.

REFERENCES

ASHRAE, *ASHRAE Handbook, Fundamentals*, Inch-Pound Edition, Atlanta, 1997.

ASTM, 1990, "Standard Test Methods for Water Vapor Transmission of Materials," *Annual Book of ASTM Standards*, ASTM E96-90, pp 688-695.

Avramidis, S., Kuroda N., Siau J. F., 1987, "Experiments in Nonisothermal Diffusion of Moisture in Wood. Part II," *Wood and Fiber Science*, 19(4), pp 407-413.

Burch, D. M., Thomas, W. C., Fanney, A. H., 1992, "Water Vapor Permeability Measurements of Common Building Materials," *ASHRAE Transactions*, V98.

Burch, D. M., Thomas, W. C., 1993, *MOIST, A PC Program for Predicting Heat and Moisture Transfer in Building Envelopes*, Release 2.0, United States Department of Commerce Technology Administration, National Institute of Standards and Technology, pp 22, 63.

Chaddock, J. B., Todorovic, B., 1991, *Heat and Mass Transfer in Building Materials and Structures*, pp 3-19.

Chervier, V. F., 1996, "Moisture Transfer in Porous Materials Exposed to Combined Humidity and Temperature Gradients," M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Dahl, S. D., Kuehn, T. H., Ramsey, J. W., Yang, C., 1996, "Moisture Storage and Non-Isothermal Transport Properties of Common Building Materials," *HVAC&R Research*, 2(1), pp 42-56.

Galbraith, G. H., Mclean, R. C., Guo, J., 1998, "Moisture Permeability Data: Mathematical Presentation," *Building Services Engineering Research and Technology*, 19(1), pp 31-36.

Incropera, F. P., DeWitt, D. P., *Fundamentals of Heat and Mass Transfer*, Second Edition, John Wiley & Sons, New York, 1981.

Kreith, F., Bohn, M. S., *Principals of Heat Transfer*, Fourth Edition, Harper & Row, New York, 1986.

Lu, P. J., Leicester, R. H., 1997, "Effect of Cyclic Humidity Exposure on Moisture Diffusion in Wood," *Wood and Fiber Science*, 29(1), pp 68-74.

Moiser, R. C., 1994, "An Experimental Apparatus for the Measurement of Moisture Permeability of Building Materials," M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Peralta, P. N., Skaar, C., 1993, "Experiments on Steady-State Nonisothermal Moisture Movement in Wood," *Wood and Fiber Science*, 25(2) pp 124-135.

Peralta, P. N., 1990, "Nonisothermal Moisture Transport in Wood," Ph.D. dissertation, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Siau, J. F., Babiak, M., 1983, "Experiments on Nonisothermal Moisture Movement in Wood," *Wood and Fiber Science*, 15(1), pp 40-46.

Siau, J. F., 1983, "Chemical Potential as a Driving Force for Nonisothermal Moisture Movement in Wood," *Wood Science and Technology*, 17, pp 101-105.

Siau, J. F., 1983, *Transport Process in Wood*, Springer, Berlin, Heidelberg, pp 165-171.

Siau, J. F., 1985, "Nonisothermal Moisture Diffusion Experiments Analyzed by Four Alternative Equations," *Wood Science and Technology*, 19, pp 151-157.

Siau, J. F., 1992, "Nonisothermal Diffusion Model Based on Irreversible Thermodynamics," *Wood Science and Technology*, 26, pp 325-328.

Siau, J. F., Avramidis, S., 1993, "Application of a Thermodynamic Model to Experiments on Nonisothermal Diffusion of Moisture in Wood," *Wood Science and Technology*, 27, pp 131-136.

Siau, J. F., *Wood: Influence of Moisture on Physical Properties*, Department of Wood Science and Forest Products, Virginia polytechnic Institute and State University. pp 114-115, 179-184.

Skaar, C., 1981, "Thermal Diffusion of Bound Water in Wood," *Wood Science and Technology*, 15, pp 103-112.

Van Wylen, G. J., Sonntag, R. E., *Fundamentals of Classical Thermodynamics*, Third Edition, John Wiley & Sons, New York, 1985.

Wu, Q., Suchsland, O., 1997, "Effect of Moisture on the Flexural Properties of Commercial Oriented Strandboards," *Wood and Fiber Science*, 29(1), pp 47-57.