Introduction

The need for water vapor control in building walls has long been recognized in addition to the need for vapor retarders to prevent moisture movement by diffusion through building materials. During the 1948 Conference on Condensation Control in Dwelling Construction, held by the Housing and Finance Agency (a predecessor of the current U.S. Department of Housing and Urban Development), discussions were not primarily about the need for vapor barriers (as water vapor retarders were called at that time), but whether a "barrier" was necessary in all climates or only in some. The level of permeance that will constitute a vapor barrier and how to measure that permeance was also discussed.[1]

Much more recently, it became generally accepted that the movement of moist air is a major mechanism of moisture transport into wall cavities and attic spaces. Moreover, moisture movement due to diffusion becomes more significant when building envelopes are tighter against air leakages.

A consensus seems to have been reached, in general, that in cavity walls and cavity ceilings under roofs, vapor retarders are needed at the indoor side of cavities in moderate and cold climates; that vapor retarders are needed at the outdoor side of cavities in warm climates that do not have a significant heating season, especially in warm humid climates; and that vapor retarders with relatively high permeances are needed on both the indoor and outdoor sides of cavities in some warm climates, even though significant heating seasons occur at times. However, there has been little or no consensus on the definitions of types of climates, nor on the geographical borders of climate zones, because elevations and valleys in rugged terrain affect the thermal/moisture/wind exposures of a particular building.

The level of permeance required to reduce water vapor flow to acceptable levels also has undergone some change. In 1947, Rowley et al. suggested "representative vapor permeability rates" for materials used in frame construction, and classified them as low, below 0.5 perm; medium-low, 1.0 to 1.25 perms (grains per square foot per hour per inch of mercury) (72 ng/Pa · s · m^2); medium, 3.0 to 5.0; and high, above 30 perm.[2] The text makes it quite clear that the lower two classes meet the definition of a vapor retarder. Currently, the more restrictive definition of a vapor retarder is 1 perm (75.5 ng/Pa · s · m^2). That is the definition used in ASTM Recommended Practice for Selection of Vapor Barriers for Thermal Insulations (C 755-85) and is the definition used by most in the building industry as of this date. However, there is a movement under way to substantially lower the allowable permeance of vapor retarders. For example, the Minnesota Energy Code Rules[3] require vapor retarders with a permeance of no more than 0.1 perm (5.75 ng/(Pa · s · m^2) and the same rating is

[1] *Proceedings,* Conference on Condensation Control in Dwelling Construction, Housing and Home Finance Agency, Washington, DC, 17 May 1948.

[2] Rowley, F. B., LaJoy, M. H., and Erickson, E. T., "Moisture and Temperature Control in Buildings Utilizing Structural Insulating Board," Bulletin No. 26, University of Minnesota, Institute of Technology, Engineering Experiment Station, 1947.

[3] *Model Energy Code Amendments,* Minnesota Department of Energy and Economic Development, Amendments to Section 201: Vapor Barrier, Chapter 4215, Paragraph 4215.1400.

currently being considered by the task group in ASTM Committee C-16 converting Federal Standard TT-B-100 B to an ASTM standard.

Finally, during that meeting in 1948, Professor Rowley cited the need for a test procedure. We indeed do have currently an ASTM standard covering this subject. It is ASTM Test Methods for Water Vapor Transmission of Materials (E 96-80), originally published as a Tentative standard in 1952, and last updated in 1980. As the title indicates, there are more than one method in this standard, actually two, the wet-cup and the dry-cup procedures.

There are several problems with these methods. It is not always clear which of the two methods should be used, and the difference in results can be significant. For example, the *ASHRAE Handbook of Fundamentals* lists asphalt-saturated but not coated sheathing paper as 3.3 perm (1190 ng/Pa · s · m^2) dry-cup and 20.2 perm (1162 ng/Pa · s · m^2) wet-cup, and duplex sheet, asphalt laminated, aluminum foil one side as 0.002 perm (00.115 ng/Pa · s · m^2) dry-cup and 0.176 perm (10.12 ng/Pa · s · m^2) wet-cup. In these two examples, the wet-cup method yields values greater than the dry-cup method by factors of 6.12 and 88.0, respectively!

Another problem exists with errors resulting from various tolerances. Although ASTM E 96-80 lists a total possible error of 30% for the dry-cup method and 26% for the wet-cup method, substantially greater discrepancies, by factors up to 80 (8000%), were found, as indicated in the papers by Hoffee and by Toas.

Since vapor retarders with permeances of 0.1 to 1.0 are required both by good practice and by mandatory code provisions, the uncertainties and errors in a range up to several hundred percent potentially associated with measurements of water vapor permeance of materials by ASTM E 96-80 render that method, and the results obtained, of questionable utility at best. Since Committee C-16 is supposed to revise ASTM methods E 96-80 and C 755-85 within the next few years, and since Committee C-16 also is in the process of converting Federal Standard TT-B-100 B, it was determined that a major effort should go toward developing not only an improved procedure, but also a whole new concept of characterizing the water vapor permeance of materials. As a first step in such an assessment, a symposium was held in Bal Harbour on 10 December 1987, to give guidance to Committee C-16 on Thermal Insulation, and to the co-sponsoring Committees D-1 on Paint and Related Coatings and Materials; D-8 on Roofing, Waterproofing, and Bituminous Materials; D-10 on Plastics; E-6 on Performance of Building Constructions; and F-2 on Flexible Barrier Materials.

To make these proceedings most useful in providing assistance to a broad public, we are including a paper by Dr. Hutcheon that discusses the rationale for vapor retarders in building envelopes in greater detail than can be included in this short introduction. We further include a technical summary by Dr. Bomberg that integrates the various presentations and draws some tentative conclusions regarding potential future developments.

The editors hope that this publication will prove useful to those who are engaged in research on moisture movement and to those concerned with material properties relating to water vapor transmission. The final beneficiaries should be the building community, in general, in its effort to develop high-energy efficiency without undesirable side effects from moisture.

A symposium, such as the one on Mechanisms and Measurement of Water Vapor Movement Through Materials, and the preparation of the proceedings as a permanent record, requires the efforts of many. Foremost, of course, are the authors. Their contributions are obvious. Although not recognized by name, the reviewers' contributions are essential for producing a technically first-class publication. Just as important are the contributions of the ASTM Staff: Theresa Smoot who handled the myriads of advance details, Wendy Dyer who assisted during the symposium, Rita Harhut and Kathleen Greene who interfaced so ably with the authors and reviewers, and Helen Hoersch, who was responsible for editing the

entire publication. To all of these people, our most sincere thanks, and a very special acknowledgment of our appreciation to Wayne Ellis for chairing the panel discussion. Without their untiring cooperation this symposium would never have taken place and these proceedings would never have been published.

Heinz R. Trechsel
H. R. Trechsel Associates, Germantown, MD 20874; symposium cochairman and coeditor.

Mark Bomberg
Institute for Research and Construction National Research Council of Canada, Ottawa, Ontario, K1A OR6 symposium cochairman and coeditor.