Overview

Air infiltration has been a subject of active research in many countries since the energy crisis of the mid-1970s with early work dating back to early in the century. Air infiltration touches on many topics in buildings research, not the least of which include energy, indoor air quality, and human comfort. Most residential buildings are ventilated primarily by air infiltration, and over a third of the space conditioning energy requirements can be typically attributed to it. The desire to provide adequate ventilation at minimum energy cost, combined with the complex nature of the physical processes involved in air infiltration, has effected the continuing interest in the topic.

While the theoretical scientist may be interested in the subject of air infiltration for its intriguing nonlinearities and other subtleties, those of a more practical bent have specific needs. Questions such as "How tight can buildings be and still supply adequate ventilation?" can only be answered if test methods exist that allow the appropriate quantities to be measured. Similarly, to answer other of the big questions such as "What is the distribution of air leakage in North American housing?" or "How much of an impact will weatherization have?" requires that these test methods get used and the necessary data collected for analysis. Finally, questions regarding how well one can know the values measured by the test methods require that the precision and bias of the measurements be determined.

ASTM has responded to these needs by developing consensus test methods that allow one to measure and study the important properties relating to air infiltration. In November 1975 ASTM subcommittee E06.41 on Infiltration Performances decided to develop standard practices relating to air infiltration: one on measurement of infiltration using tracer gasses and one on the measurement of airtightness using fan pressurization. At the time of this writing the current versions of these standards are E 741-83: Test Method for Determining Air Leakage by Tracer Dilution, and E 779-87: Method for Determining Air Leakage Rate by Fan Pressurization, respectively. Since those two fundamental standards were completed, ancillary ones have been written: E 1186-87: Practice for Air Leakage Site Detection in Building Envelopes, and E 1258-88: Test Method for Airflow Calibration of Fan Pressurization Devices. The consensus process in this area is continuing, and a revision of E 741 is currently underway.

ASTM has actively supported technical efforts surrounding its standards by sponsoring symposia (of which this book documents the third) on air infiltration. In March 1978 the first two standards were presented together with papers dealing with related topics in a symposium entitled Air Change Rate and Infiltration Measurements; the proceedings were published as a special technical publication, *Building Air Change Rate and Infiltration Measurements, ASTM STP 719.* This symposium focussed on measurement techniques and included limited data taken by researchers. In April 1984 a symposium entitled Measured Air Leakage of Buildings brought forth a wide variety of data that had been taken with the two standards; the proceedings were published as a special technical publication, *Measured Air Leakage of Buildings, ASTM STP 904.* This symposium focussed on (relatively) large sets of field data, which could then be used to learn something about the buildings—of various types—from which they came.

Like the 1978 symposium, the current symposium contains information on state-of-the-art techniques for measuring air change rates. In the intervening decade novel techniques for measuring more complex phenomena have been developed. The Axley and Persily papers describe some simplified methods for making single-zone air change rate estimates from tracer gas measurements; the Fortmann and Harrje papers deal with the more complex multizone tracer techniques.

Similarly, airtightness measurement techniques have also developed since 1978. Hayakawa and Shaw describe techniques for measuring the airtightness of large single-zone buildings. Brennan and Modera discuss various techniques for making these leakage measurements in a multizone environment. Because of the relative ease and invariability of making airtightness measurements compared to tracer gas testing, far more tightness tests are done. Ek, Love, and Perera use pressurization techniques to make airtightness measurements in buildings from manufactured housing to row housing to offices.

Like the 1984 symposium, many of the papers in this symposium contained measured data on either airtightness or air change rates, some from large datasets. All of the datasets serve to shed light on various aspects of air infiltration, but the Hadley and Parker papers, which refer to the large database of data being accrued in the Pacific Northwest, may be the most notable. The NOrthwest Residential Infiltration Survey (NORIS) may represent the first statistically justifiable dataset on both airtightness and ventilation.

A major thrust of this symposium, which was lacking in the other two, was to consider the error associated with making field measurements using various techniques. Harrje and Shaw use multiple techniques to measure the same quantity and compare the results. In this field, for which primary standards are lacking, such intercomparisons are the best—perhaps the only—way to estimate the absolute accuracy of some techniques. Charlesworth, Nankta, Tanribilir, and Yoshino all discuss the comparison of different, but related, measured quantities.

Many factors can cause error in a measurement of either airtightness or air change rate. These errors can arise because of instrument error, inappropriate choice of analysis technique, or poor measurement technique. Flanders and Kvisgaard found that occupancy can have very significant effects on the results of air change rate measurements—both on the tracer gas measurement itself and on the interpretation of the result. Due to the nonlinear nature of both the physical processes and some of the analysis techniques, there can be a strong coupling between the precision (normally associated with random errors) and accuracy (normally associated with systematic errors). Lagus and Modera use simulation tools to estimate errors in tracer gas and pressurization tests, respectively, due to factors not taken into account in normal analyses.

An ASTM symposium such as this is intended to elicit information relevant to the development and revision of consensus standards. Accordingly, this symposium focussed its attention on those issues and did not attempt to answer the larger questions such as those associated with air quality, stock characterization, etc. Indeed, the answer to many of these big questions are still beyond the reach of current research. This symposium did, however, hone the tools that those wishing to answer these questions must use.

This book would not have been possible without the work of a large number of dedicated individuals who made my job easy. First and foremost, of course, are the authors who wrote (and in large measure reviewed) the papers that make up this volume. My personal thanks must be given to the ASTM editorial staff for accomplishing the arduous tasks associated with the organization of the symposium, the coordination of review, and the general editioral support. Special thanks must also be given to the session chairmen for their efforts.

When exploring any field of research, understanding the potential of the results leads to enlightenment, but understanding the limitations of the results leads to wisdom. In the field of air infiltration the first two volumes have helped to enlighten us. It is my fervent hope that this volume will help to make us wise.

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