Moisture Control in Buildings:

The Key Factor in Mold Prevention

2nd Edition

Heinz R. Trechsel
Mark T. Bomberg
Editors

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First of all, the Editors wish to thank the chapter Authors for their contributions and hard work. This book could not have been written by any one single author. The field of moisture control is too large and varied and includes too many disciplines for one single person to master and to condense it all into a single volume. Among the authors, Wayne Tobiasson was particularly helpful with his frequent and sorely needed encouragement and advice. Wayne, much more than he probably realizes, is responsible for keeping the editorial and review process moving. Your dedicated services are greatly appreciated.

The second large group of experts who performed an extremely valuable, essential, and unselfish service are the reviewers. It really falls on them to carefully review the chapters for technical accuracy and relevance. We are deeply indebted to all of them.

Also, without the dedicated and continuing support of Kathleen Dernoga and Monica Siperko of the Staff of ASTM International, the second edition of MNL18 would never have been possible. Many thanks to both of you.

Finally, in the original conception of the first edition of MNL18, three personalities must be mentioned here for their invaluable assistance and encouragement. Foremost Wayne Ellis, former chairman of ASTM, to whom the first edition was dedicated, Paul Reece Achenbach, former Director of the Building Environment Division of the National Bureau of Standards (now NIST), who provided his great technical understanding of the entire concept of moisture control in buildings, and E.C. Shuman, of Penn State University and former Chairman of ASTM Committee E06, whose long term association with the subject provided many historical insights. Our heartfelt thanks to all three of them. Unfortunately, they are no longer with us, but will be remembered for years to come.

Heinz R. Trechsel and Mark T. Bomberg
Editors

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Introduction

Well-designed buildings have many virtues, among them the ability to serve their intended purposes and to become a beautiful and essential shelter for human activities. Buildings also must resist various service loads, environmental stresses caused by temperature, humidity, wind and even those rare events of earthquakes or flooding. They must also provide a healthy indoor environment eliminating air pollutants; and they must maintain these functions over the full intended service life.

Most of these attributes can be affected by moisture. Uncontrolled moisture may reduce the structural soundness of buildings through dry rot in wood, corrosion in steel, freeze-thaw cycles in masonry, and other damage mechanisms. Moisture also can affect the health of occupants typically through the potential for breeding harmful organisms. With other words, uncontrolled moisture will negatively affect all the most vital attributes of buildings. On the other hand, moisture reduces the shrinking cracks of wood and furniture, and up to a point, is necessary to avoid respiratory discomfort. Thus, moisture is both a necessary constituency of our built environment and a potential liability. The issue, then, is not to eliminate moisture from our buildings, but to control it and its movements. Manual 18 addresses this general concept.

Over the 15 years since the publication of the first issue of MNL18, Moisture Control in Buildings, mold with its potential health effects have gained nationwide attention. When the first edition of this manual was exhausted, the sponsoring ASTM Committees C16 and E06 agreed with the consensus of the chapter authors that the need for the manual actually had increased and that an updated version was needed. All authors were given the option to do the update or rewrite their chapters. Those who were unable to do the revision were replaced by equally qualified authors.

As in the previous edition, the manual does not provide all details and requirements of the many technologies involved in controlling moisture in buildings, but it is focused on the major issues involved in the design, and selection of materials and the process of moisture resistive construction.

Since the manual is a collection of chapters prepared by individual authors, the reader may find instances of repetition or even conflicts between the chapters. To the extent that such conflicts reflect the current level of building science and of methods specific to moisture control in buildings, such conflicts were unavoidable. In such an instance we recommend that the reader review the references to the chapters to form his/her own opinion.

Although many chapters include specific recommendations, the editors caution the reader that each building is different, that conditions of building service and climate are different. Accordingly, no recommendations or details should be adopted without a careful analysis of the needs of the specific building. Where analytical means exist, these should be tried in lieu of cookbook solutions. Caution is advised as input data for material properties and weather data can be unreliable.

Many technical publications, research reports, and conference proceedings have been published on moisture control in buildings. However, to our knowledge, this manual is the only publication which provides under one cover the most important information relating to moisture problems in buildings and to serve as a desk-top reference manual for use by those who design, construct, sell, maintain, and own buildings and homes.

To increase the completeness of the Manual, three new chapters were added: Chapter 15 on *Details and Practice*, Chapter 25, on *Quality Management in Design and Construction of the Building Envelope*, and Chapter 28 *Towards Development of Methods for Assessment of Moisture-Originated Damage*. The details and practice should be helpful to design offices. Quality management responds to a concern that the details and material selections may be carefully developed during design, but are sometimes not exactly followed when the on-site construction

management organization does not understand the importance of a particular selection or design. The last chapter and updated Chapter 27 look to the future.

We also dropped the chapter on modeling because ASTM MNL 40 on *Moisture Analysis and Condensation Control in Building Envelopes*, published in 2001, provides an in-depth state of the art of modeling. But we did include a brief discussion of mathematical models in Chapter 10, *Design Tools*. All other chapters were revised or updated, in some cases, such as Chapter 6, *Exterior Climate Data for Hygrothermal Analysis*, the revision led to what essentially is a new chapter.

The editors recognize that mechanical equipment has a significant impact on moisture control in buildings. However, a thorough discussion of the issue would require an entire book all by itself. Accordingly, we have included Chapter 9 on mechanical equipment to emphasize the importance of mechanical equipment and its design and to illustrate one engineer's thoughts on the issue.

The updated manual consists of four parts:

Part 1, "Fundamentals," discusses moisture transfer, condensation, and evaporation. Moisture related properties of building materials, organisms and health effects, climate and moisture sources.

Part 2, "Applications," discusses the technologies that affect the moisture balance in buildings and the techniques used to determine the suitability of materials, components, systems, and structures. There are chapters on air infiltration and ventilation, design tools, measurement techniques and instrumentation, troubleshooting, and a chapter on case studies.

Part 3, "Construction Principles and Recommendations" includes discussions of and recommendations to make both new and existing commercial and high buildings, new and existing residential buildings, as well as manufactured and historic buildings. One chapter is devoted to suggested construction details and one discusses roofing.

Part 4, "Implementation," discusses implementation mechanisms. This section is organized along a simple concept: First, the building should be designed, built, and repaired in accordance with the contract documents which contain the principles outlined in the earlier sections and chapters. Second, codes and standards provide a firm basis for selecting products, systems, and construction features. Third, in the design office and on the construction site, the principles of recognized quality management must be observed to assure that what is constructed complies fully with the contract documents. And finally, when all else fails, there are arbitration and court proceedings to resolve conflicts. Each of these mechanisms is discussed to give the reader a good understanding of the process beyond just a good design and adequate specifications. The Manual closes with a look to the future and a discussion of a Conceptual System of Moisture Performance Analysis.

The editors would appreciate receiving any comments or criticisms, but they also hope that the second edition of MNL18 be as well received as the first edition was.

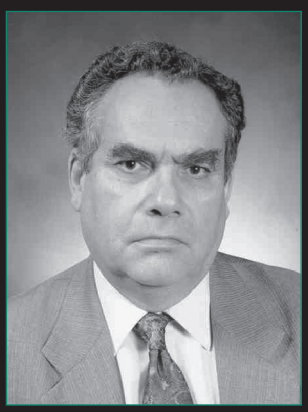
Heinz R. Trechsel and Mark T. Bomberg
Editors

Heinz R. Trechsel has been consulting on moisture problems in buildings for over 25 years, has managed design contracts for the Naval Facilities Engineering Command (USN), managed the Energy Conservation research program for NBS (now the National Institute for Standards and Technology), and developed innovative building products and systems for the steel industry.

Trechsel is a graduate architect of the Swiss Federal Institute of Technology in Zürich and a registered architect in the State of New York.

As a member of ASTM since 1961 he is currently active in Committees C16 on Thermal Insulation and E06 on Performance of Buildings and has been chairman of several subcommittees. He received the ASTM Award of Merit in 1986. Trechsel also is a member of the National Institute of Building Sciences (NIBS) and was chairman of its Building Enclosure Technology and Environment Council (BETEC).

Trechsel has published extensively on moisture control and on energy conservation in buildings. He was editor of the first edition of MNL18, *Moisture Control in Buildings*, published in 1994; Manual 40, *Moisture Analysis and Condensation Control in Building Envelopes;* Co-editor of ASTM STP 719, *Building Air Change Rate and Infiltration Measurements*; STP 779, *Moisture Migration in Buildings*; STP 904, *Measured Air Leakage of Buildings*; and STP 1039, *Water Vapor Transmission through Building Materials and Systems* (with Dr. Mark Bomberg).



Mark T. Bomberg obtained the title of Technology Doctor at the Lund University for research on moisture transport in building materials and has been involved in the field of building physics for over 35 years (25 years at the National Research Council of Canada and 10 years in academia). Bomberg also earned Doctor of Science (Engineering) from Warsaw Technical University, Poland where he previously graduated in civil engineering.

He currently leads the hygrothermal program at Syracuse University, Syracuse, New York. An ASTM member since 1976, he is active in Committees C16 on Thermal Insulation and E06 on Performance of Buildings, he is also the recipient of the 2009 C16 David L. McElroy Award. He is a co-leader in the field of heat, air and moisture in the Building Enclosure Technology and Environment Council (BETEC) at the National Institute of Building Science and one of the organizers of the BEST conferences (www.thebestconference.org) where he chairs the energy efficiency track.

Bomberg has more than 200 research papers and several book chapters in the area of building physics; he co-edited with Heinz Trechsel ASTM STP 1039, *Water Vapor Transmission through Building Materials and Systems*. Worth mentioning is M.T. Bomberg and J.W. Lstiburek, *Spray Foam in External Envelopes of Buildings*, published in 1998 by Technomic Publication Corporation; the third edition was reprinted by CRC Press in 2006.

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