

American Society of Heating,
Refrigerating and Air-Conditioning
Engineers, Inc.

Humidity Control Design Guide

for Commercial and Institutional Buildings

Lew Harriman
Geoff Brundrett
Reinhold Kittler

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ASHRAE

Humidity Control Design Guide

For Commercial and Institutional Buildings

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Project Guided & Funded by:

- ASHRAE Technical Committees
  TC 3.5 Desiccant & sorption technology
  TC 7.5 Mechanical dehumidifiers
  TC 8.7 Humidifying equipment
  TC 9.12 Tall buildings
- The Gas Technology Institute
- U.S. Department of Energy
  (Through Oak Ridge National Laboratory)

ISBN 1-883413-98-2

American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
1791 Tullie Circle, N.E., Atlanta, GA 30329
(404) 636-8400 www.ashrae.org

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Preface

This project resulted from an awakening of interest in humidity control among building owners, Architects and HVAC Engineers.

During the 1990's, it became apparent that many commercial buildings have problems related to moisture and humidity control. The causes of these problems are complex, and they touch all the disciplines involved in a building project. This particular book deals with only one aspect of preventing moisture problems—the HVAC system. The book was produced as a response to requests from ASHRAE members for more and better information about designing for humidity control. It appears to be the first time in the 101-year history of the Society that ASHRAE has focused a book on this topic.

We are very pleased to have had the opportunity to collect and present this information. All of the authors share the opinion that this attention to humidity control is long overdue, and that if designers have access to better information, the environment for building occupants all over the world will be better in many important ways. Human comfort, energy economics, equipment design and construction costs can all be improved by a better understanding of humidity and how it can be controlled.

At the same time, we are humbled by the magnitude of the project we have undertaken. Imagine how difficult it would be to produce a book titled: "Temperature Control Design Guide." The possibilities for books on that topic are endless, and the opinions of experienced professionals are often contradictory and strongly-held. We faced a similarly daunting task in writing this book.

With that in mind, we trust that the reader will consider this book simply a good beginning rather than the last word on humidity control. Much remains to be done. We sincerely hope that the reader will share his or her experiences, observations, questions, corrections and considered judgements in the form of additional written work, expanding the range and depth of information available to our profession and to the public at large.

Acknowledgments

We are especially grateful to the U.S. Department of Energy, its Offices of Distributed Energy Resources and Power Technologies, and also to the Gas Technology Institute for their technical and financial support of this project. We also appreciate the three years of effort by the dedicated professionals who gave their time to serve on the project monitoring committee and on the ASHRAE technical committees that guided our work. Further, the authors are indebted to the writer Cynthia Harriman, for her tireless weed-cutting of our dense prose and her hunting down of errors in usage, grammar and typography. Wherever the book is clear, accurate and complete, it is largely because of the oversight of these generous volunteers.

Finally, the information in this book is the product of our personal experiences and those we have collected from hundreds of other professionals through conversations, technical and trade papers and our day-to-day professional and commercial activities. Consequently, this work is dedicated to our families, teachers, clients and colleagues, without whom this book could not exist.



Lew Harriman
Portsmouth, New Hampshire
January 2008

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Humidity Control Design Guide

For Commercial and Institutional Buildings

Major Sections & Chapter Titles

Basics

1. Purpose, Assumptions & Terminology
2. Humidity Control Basics
3. Psychrometrics of Humidity Control

Humidity Effects

4. Human Comfort
5. Corrosion
6. Electrostatic Discharge
7. Mold & Mildew
8. Dust Mites & Insects
9. Bacteria & Viruses

System Design

10. Design Procedure
11. Estimating Dehumidification Loads
12. Estimating Humidification Loads

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14. Humidifiers
15. Load Reduction Equipment
16. Building Pressure Management
17. Humidity Sensors & Controls

Applications

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21. Hotels
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23. Museums, Libraries & Archives
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25. Eldercare Buildings
26. Dormitories
27. Swimming Pools
28. Ice Rinks
29. Dry Air Storage
30. Laboratories

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Introduction

Controlling humidity in commercial buildings is simple. Just add or subtract enough moisture to or from the air to compensate for any surplus or deficit of humidity inside the building.

The difficulty comes in changing the amount of that addition and subtraction in response to changing loads, so that humidity stays within an acceptable range. Also, the designer must achieve control within an acceptable budget for both construction and operation. To do this, the designer must understand the owner's purpose for the project. That understanding allows the HVAC designer to make more effective assumptions as the project proceeds.

The authors have taken the same approach to writing this book. We begin our work by explaining our understanding of the book's purpose. Based on that understanding, we proceed to make assumptions about our readership and its needs. These assumptions have governed our decisions about what information to include, and they influenced both the structure and the depth of that information. To help *you* decide whether this book will meet *your* needs, you may wish to consider our purpose and assumptions.

Purpose

The purpose of this book is to help technical professionals design humidity control systems for commercial buildings. If you are not a technical professional, or are interested mostly in residential or industrial buildings, this book is likely to meet fewer of your needs.

Assumptions

We assume the reader:

1. Is a technical professional, although not necessarily one with an HVAC engineering degree or professional engineer's registration.
2. Has a basic understanding of HVAC terminology, elementary algebra and the common variables of equations used in designing HVAC systems.

As an overall focus, we write primarily for the system designer who "has to get it done by Friday." We expect that the text may also be useful to others such as architectural designers, building developers and owners, maintenance professionals, students, teachers and researchers. However, where decisions have been made about technical depth and detail, we have tried to meet the needs of the HVAC designer before meeting the needs of others.

Strengths And Limitations Of This Book

We expect that this information will be most useful for designing humidity control systems for commercial and institutional buildings, rather than for industrial, agricultural or residential buildings.

Emphasis on low-rise construction

Our book is focused on the low-rise construction typical of 90% of the commercial space built each year in North America. The book contains less information that is specific to high-rise buildings alone.

Includes information to help establish the humidity control level

After the owner clearly defines the purpose of controlling humidity, the next step is to establish the humidity control level. The book includes information about the effects of different humidity levels on comfort, corrosion, electrostatic discharge, mold and mildew, dust mites and insects as well as bacteria and viruses. We hope this information will help the owner and designer establish a control level that will achieve the purpose of the project.

Most useful for controlling humidity between 30 and 60% rh

We assume the designer's system will be intended to control humidity within a defined range, and that its range will fall somewhere between 30 and 60% rh. There are other reference books that would be more helpful than this text for designing systems to maintain a control level above or below that mid-range humidity.

This book emphasizes dehumidification

This book was created by ASHRAE research project 1047-RP. That project was originally generated in response to a strong demand

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from the ASHRAE membership for better information concerning *dehumidification* systems for hot and humid climates.

After the project began, the Authors and the Project Monitoring Committee both agreed there is also a pressing need for information that helps the designer of *humidification* systems in dry climates. So we have included information on that topic as well. But the principal emphasis of this book is on dehumidification.

This book is frequently redundant

The Authors and the Project Monitoring Committee believe that most readers will first read the specific sections that are most related to their immediate projects. So, we have tried to make each chapter as complete as possible *by itself*. Consequently some of the text and graphics appear in more than one chapter. Repetition reduces the number of annoying references to other chapters, but it will be redundant for those intrepid souls who read the book cover-to-cover.

For specifics, you'll have to contact equipment suppliers

The worldwide range of equipment is far too broad to include here. Also, critical equipment details become obsolete as manufacturers change their designs. Finally, enough detail to be useful would violate the commercial impartiality required for ASHRAE publications. So this book only helps begin the design process.

This information should help you define the basic layout and general requirements of a humidity control system, including general types of dehumidifiers and humidifiers, their controls and the loads they must remove. After that, you will need to have more extensive discussions with equipment suppliers to complete a full set of plans and specifications.

Terminology

The heating and air conditioning industry is constantly changing, so its terminology is sometimes unclear and not always consistent. Beyond the psychrometric variables described in Chapter 3, we use a few other words and phrases which should be clear if you are to understand what we say in this book:

Humidity moderation

By moderation, we mean that the HVAC system helps the building avoid extremes of humidity, but that humidity can still swing, uncontrolled, throughout a broad range over 24 hours. Humidity *moderation* is easier and less expensive than humidity *control*.

Humidity control

By control, we mean that the indoor humidity is held within a defined range at all times. That range may be wide or narrow, and it may only have a high or low limit rather than both. But when a building is said to require humidity control, we assume the system must not allow the indoor humidity to rise or fall beyond the limits specified by the owner. *Control* is more difficult and costs more to achieve than *moderation*. This book is focused primarily on humidity control rather than just moderation.

Mechanical dehumidifier

A mechanical dehumidifier removes moisture by cooling the air so that its excess moisture condenses and is drained away as liquid water. The process uses mechanical means—compressors, condensers, pumps and motors—to achieve the cooling of air, and therefore its dehumidification. Such equipment is also called a "cool-reheat" dehumidifier, or a "cooling-based" dehumidifier.

Any cooling coil will condense water and dehumidify air if the airs dew point is high enough. But what we mean by a mechanical dehumidifier is a piece of equipment that has been designed specifically for removing moisture rather than for cooling, and one which operates independently of the building's cooling equipment.

Desiccant dehumidifier

A desiccant dehumidifier removes moisture by attracting water vapor out of the air to the surface of a desiccant. The desiccant adsorbs

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(or absorbs) water in its vapor phase. No condensation of liquid water is involved. Water vapor moves out of the humid air to the dry desiccant surface in response to the difference in vapor pressures. After a great deal of water has been adsorbed by the desiccant, hot air is used to dry out the saturated desiccant for reuse.

Desiccant dehumidifiers are sometimes called "active desiccant wheels", or "chemical dehumidifiers." Like mechanical dehumidifiers, they operate independently of cooling or heating equipment as they dry the air.

Load reducer

By "load reducer," we mean a passive desiccant wheel or other heat exchanger. These are also called enthalpy wheels, heat recovery wheels, total heat wheels, total enthalpy wheels or air-to-air heat exchangers or heat pipes.

Chapter 15 contains detailed information about these devices. They are placed between the exhaust air and the incoming ventilation air, so they can transfer energy between those two air streams. Some of them can recover the dehumidification effect from exhaust air during the summer, and others simply recover the heating or cooling effect of that exhaust air.

We call these heat exchangers "load reducers" to distinguish them from dehumidifiers and humidifiers, which by themselves, can remove or add moisture to the air. A load reducer cannot, by itself, control humidity. They only work when they have exhaust air flowing through them, and that exhaust air must be dry enough or humid enough to reduce the load from the incoming ventilation air. A system with a load reducer still requires a humidifier or dehumidifier if it is to control humidity.

Ventilation air

By ventilation air, we mean *outdoor* air. In other words, air that enters the system from outside the building, as opposed to air that has been recirculated from someplace inside the building. Ventilation air is also sometimes called either "fresh air" or "outdoor air."

Ventilation pretreatment system

By this we mean a separate system which dehumidifies or humidifies ventilation air *before* that incoming outdoor air mixes with the return air from the rest of the building.

We use this term to describe a system which is principally concerned with pretreating the moisture content of the incoming air. But beyond those functions, such a pretreatment system might also clean the air by removing particulate with filters, and adjust the temperature of the incoming air with heaters or coolers.

Corrections & Suggestions, Please

Finally, we assume that as the first ASHRAE book ever dedicated to the subject of humidity control, the material contained here is simply a good beginning. It can certainly be improved as readers use the information and learn from that experience. We encourage you to contribute to the ongoing improvement of this book. We welcome all constructive comments and suggestions on any aspect of this text. Please address your remarks to:

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