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This second edition represents an update and revision of the manual. The request behind the revision effort was simply to make a successful resource more current. The updating process involved a thorough edit of all text in the manual, the addition of SI units throughout, the updating of references, and the editing of many illustrations. New material dealing with the design process, indoor air quality, and green design was added.
AIR-CONDITIONING SYSTEM DESIGN MANUAL
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SECOND EDITION

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PREFACE

This second edition represents a major update and revision of the ASHRAE Air-Conditioning System Design Manual. The request that drove this revision effort was simply to make a successful resource more current. The revision process involved a thorough editing of all text in the manual, the addition of SI units throughout, the updating of references, and the editing of many illustrations. New material dealing with design process, indoor air quality, desiccant dehumidification, and “green” HVAC&R systems was added.

The editor acknowledges the active assistance of a Project Monitoring Subcommittee (with Warren Hahn as Chairman) from ASHRAE Technical Committee 9.1, which supervised the revision of this manual. The editor and committees are grateful to several individuals who reviewed all or parts of the draft of this revision and made valuable suggestions for improvements and clarifications (see list of contributors). Andrew Scheidt, University of Oregon, provided graphic assistance for the editing of many illustrations.

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CHAPTER 1
INTRODUCTION

1.1 PURPOSE OF THIS MANUAL

This manual was prepared to assist entry-level engineers in the design of air-conditioning systems. It is also usable—in conjunction with fundamental HVAC&R resource materials—as a senior- or graduate-level text for a university course in HVAC system design. This manual was intended to fill the void between theory and practice, to bridge the gap between real-world design practices and the theoretical knowledge acquired in the typical college course or textbook. Courses and texts usually concentrate on theoretical calculations and analytical procedures or they focus upon the design of components. This manual focuses upon applications.

The manual has two main parts: (1) a narrative description of design procedures and criteria organized into ten chapters and (2) six appendices with illustrative examples presented in greater detail.

The user/reader should be familiar with the general concepts of HVAC&R equipment and possess or have access to the four-volume *ASHRAE Handbook* series and appropriate ASHRAE special publications to obtain grounding in the fundamentals of HVAC&R system design. Information contained in the *Handbooks* and in special publications is referenced—but not generally repeated—herein. In addition to specific references cited throughout the manual, a list of general references (essentially a bibliography) is presented at the end of this chapter.

The most difficult task in any design problem is how to begin. The entry-level professional does not have experience from similar projects to fall back on and is frequently at a loss as to where to start a design. To assist the reader in this task, a step-by-step sequence of design procedures is outlined for a number of systems.
INTRODUCTION

Simple rules are given, where applicable, to assist the new designer in making decisions regarding equipment types and size.

Chapter 2 addresses the difference between analysis and design. The chapter covers the basic issues that are addressed during the design phases of a building project and discusses a number of factors that influence building design, such as codes and economic considerations. Human comfort and indoor air quality, and their implications for HVAC&R systems design, are discussed in Chapter 3. Load calculations are reviewed in Chapter 4. The specifics of load calculation methodologies are not presented since they are thoroughly covered in numerous resources and are typically conducted via computer programs. HVAC&R system components and their influence on system design are discussed in Chapter 5.

Chapters 6 through 8 cover the design of all-air, air-and-water, and all-water systems, respectively. Here, again, a conscious effort was made not to duplicate material from the ASHRAE Handbook—HVAC Systems and Equipment, except in the interest of continuity. Chapter 6 is the largest and most detailed chapter. Its treatment of the air side of air-conditioning systems is equally applicable to the air side of air-and-water systems; thus, such information is not repeated in Chapter 7. Chapter 9 covers a variety of special HVAC&R systems. Controls are treated in Chapter 10.

The appendices contain detailed descriptions and design calculations for a number of actual HVAC&R-related building projects. They serve to illustrate the procedures discussed in the main body of the manual. The projects in the appendices were chosen to cover a variety of building applications and HVAC system types. They help to give the entering professional a “feel” for the size of HVAC&R equipment, and they indicate how a designer tackles particular design problems. Since these examples come from actual projects, they include values (such as thermal properties, utility costs, owner preferences) that are particular to the specific contexts from which they were drawn. The purpose of the examples is to show process, not to suggest recommended or preferred outcomes.

A few words of advice: do not hesitate to make initial design assumptions. No matter how far off the specific values of a final solution they might prove to be, assumptions enable the designer to start on a project and to gradually iterate and improve a proposed design until a satisfactory solution has been obtained. Frequently, more experienced colleagues may be able to assist by giving counsel and the benefit of their experience, but do not hesitate to plunge ahead on your own. Good luck!
1.2 HOW BEST TO USE THIS MANUAL

The following suggestions are made to obtain maximum benefit from this manual:

1. Consider the general category of the building being designed and read the appropriate chapters in the *ASHRAE Handbook—HVAC Applications* and the *ASHRAE Handbook—HVAC Systems and Equipment* to determine likely systems to consider for application to the project.

2. Familiarize yourself with the theory and basic functions of common HVAC&R equipment. The best sources for this information are HVAC&R textbooks and the *ASHRAE Handbook* series.

3. Read the chapters in this manual that address the systems of interest.

4. Review the example problems in the appropriate appendices of this manual.

5. Become familiar with state and local building codes, ASHRAE standards and guidelines, and applicable National Fire Protection Association (NFPA) resources.

Remember that this manual, in general, does not repeat information contained in *ASHRAE Handbooks* and special publications. You cannot, therefore, rely on this manual as the only reference for design work. As you gain experience, make notes of important concepts and ideas (what worked and what did not work) and keep these notes in a readily accessible location. This manual is intended to point the way toward building such a design database.

The best design reference available is the experience of your colleagues and peers. While an attempt has been made in this manual to incorporate the experience of design professionals, no static written material can replace dynamic face-to-face interaction with your colleagues. Use every opportunity to pick their brains, and let them tell you what did not work. Often, more is learned from failures than from successes.

1.3 UNITS

The first edition of this manual was written using I-P (inch-pound) units as the primary measurement system. In this edition SI (System International) units are shown in brackets following the I-P units. Conversions to SI units are “soft approximations” with, for example, 4 in. being converted as 100 mm (versus the more accu-
rate conversion to 101.6 mm or use of a true SI commercial size increment for a given product). See the ASHRAE guide “SI for HVAC&R” (available at no cost from the ASHRAE Web site, www.ashrae.org) for detailed information on preferred measurement units and conversion factors for HVAC&R design work.

1.4 GENERAL BIBLIOGRAPHY

In addition to specific references listed in each of the chapters of this manual, the following publications are generally useful to HVAC&R system designers. They should be available in every design office. ASHRAE publications are available from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. ASHRAE publications are updated on a regular basis (every four years for handbooks, often more frequently for standards and guidelines). The publication dates shown below are current as of the updating of this manual but will change over time. Consult the ASHRAE Web site (www.ashrae.org) for information on current publication dates.

ASHRAE Handbooks
(available on CD or as printed volumes, in I-P or SI units)


ASHRAE Standards and Guidelines


Other ASHRAE Publications


INTRODUCTION


**NFPA Publications**

(updated on a regular basis)


**Other Resources**

**Climatic Data:**


**Estimating Guides:**


**General Resources:**


A number of equipment manufacturers have developed HVAC design manuals and/or equipment application notes. These are not specifically listed here, in accordance with ASHRAE’s commercialism policy, but are recommended as sources of practical design and application advice. A search of manufacturers’ Web sites (for manuals or education) will usually show what is currently available (for free or for a fee).

An extensive list of applicable codes and standards, including contact addresses for promulgating organizations, is provided in a concluding chapter in each of the *ASHRAE Handbooks*. 