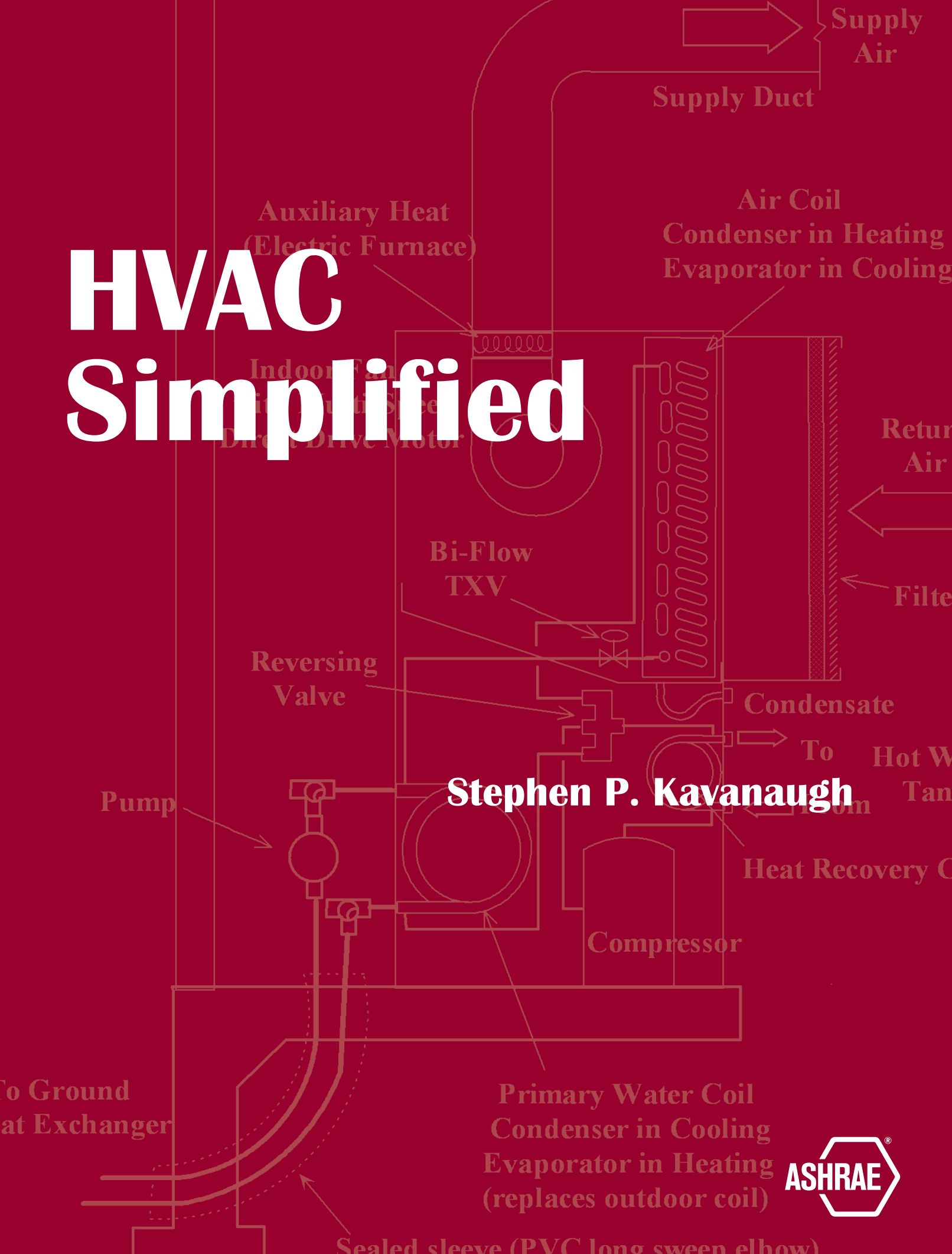
HVAC Simplified



Stephen P. Kavanaugh

Note to Purchasers

This book originally included a CD with supplemental files to accompany the text. This reprint of the book makes the files available via www.ashrae.org/HVACSimp24. Please note that for all references in the text to an accompanying CD, readers should now refer to this webpage to access these files.

HVAC Simplified

This publication was prepared in cooperation with TC 7.1, Integrated Building Design.

About the Author

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Kavanaugh is co-author of *Ground-Source Heat Pumps—Design of Geothermal Systems for Commercial and Institutional Buildings*, published by ASHRAE in 1997. He has presented over 100 engineering seminars for more than 2,500 designers on the topics of energy efficiency, ground-source heat pumps, and HVAC. He maintains the Web site www.geokiss.com, where there is more information about HVAC and ground-source heat pump design tools.

He is past chair and current program chair of ASHRAE Technical Committee 6.8, Geothermal Energy, as well as past chair of ASHRAE Technical Committee 9.4, Applied Heat Pumps and Heat Recovery.

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Preface

The text contains twelve chapters, including three short chapters that review the fundamentals of refrigeration, heat transfer, and psychrometrics. Information from the *ASHRAE Handbook—Fundamentals* is summarized and supplemented with items from industry sources. The remaining chapters assemble information from ASHRAE handbooks, standards, manufacturer data, and design procedures commonly used by professional engineers. Topics include equipment selection and specification, comfort and IAQ, building assemblies, heating and cooling loads, air distribution system design, water distribution system design, electrical and control systems, design for energy efficiency, and design for economic value.

A suite of complementary spreadsheet programs that incorporate design and computation procedures from the text are provided on the CD that accompanies this book. These programs include psychrometric analysis, equipment selection, heating and cooling load calculation, an electronic "ductulator," piping system design, a ductwork cost calculator, and programs to evaluate building system demand and energy efficiency. Future updates to these programs can be found at www.ashrae.org/publicationupdates.

TARGET AUDIENCES

- Novice HVAC engineers that did not complete an HVAC course during their undergraduate program
- Engineers moving into the HVAC field from other areas
- Undergraduate engineering students in design-oriented curriculums
- Non-engineering professionals with strong building-related experience

DISTINGUISHING FEATURES

The text places an emphasis on design and the energy and economic evaluation of results.

A large amount of information is provided so that instructors and students do not have to frequently consult supplemental documents in order to complete HVAC system design. For example, one section provides an overview of the revised 2004 ASHRAE Standards 62.1 and 62.2 ventilation air system design mandates, a feature not even included in the ASHRAE Handbooks. Also, a large amount of manufacturer performance data is provided with correction methods when conditions vary from rated values. Performance data are provided for packaged ACs, RTUs, air and water heat pumps, furnaces, chillers (six product lines), compressors, cooling towers, hydronic coils, pumps, fans, electric motors, lighting products, and other equipment.

The text concludes with a chapter on design evaluation methods. Sections in this chapter include HVAC system demand computations, a discussion of simplified energy analysis, operating costs (including tables of maintenance, repair, and replacement costs), a presentation of methods to compute system installation costs (with references to more detailed sources), and economic analysis methods.

Author's Note

This text is an attempt to provide an understanding of fundamental HVAC concepts and to extend these principles to the explanation of simple design tools used to create building systems that are efficient and provide comfortable and healthy environments. My decision to include the term "Simplified" in the title is rooted in my own preference for simple and creative systems. However, this philosophy was perhaps better expressed by ASHRAE Presidential member Bill Coad when he quoted Albert Einstein: "Everything should be as simple as possible, but no simpler."[1]

Certainly, there are procedures and tools that provide higher levels of accuracy and detail than those I have included in this text. There are also some that are more straightforward and less complicated. However, I have attempted to provide a middle ground with regard to the level of difficulty by avoiding oversimplifications that are not suited to design and more complex methods that are more suited to analytical research.

More importantly, I encourage readers to extend this philosophy of simplification to building designs and HVAC systems. In some applications, complexity cannot be avoided. However, options also exist to extend complex technologies to modest buildings in which the added benefit is not economically justifiable for a client with limited financial and staffing resources. The engineer must apply the pearl of wisdom of Einstein to best meet the needs of 21st Century.

Steve Kavanaugh
December 2005

1. Coad, W.J. 1996. Indoor Air Quality: A Design Parameter. *ASHRAE Journal* 38(6):39–47.

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1 Introduction to HVAC

The challenges presented to engineers in the heating, ventilating, and air-conditioning (HVAC) industry have much in common with those in other technical fields. HVAC engineers face constraints imposed by rapidly changing technologies, increased liability, a heightened emphasis on short-term profitability, complexity in codes and standards, and an overabundance of information and misinformation. However, the public nature of the HVAC industry also presents many opportunities for the engineer to be creative and influential.

The successful HVAC engineer must be technically competent and conscientiously diligent in pursuit of optimum designs. However, in the 21st century, engineers must also be persuasive, to ensure their expertise is respected, passionate in their concern for the public health and environment, and open to all perspectives in pursuit of high quality and economically viable solutions. HVAC engineers encounter a wide variety of individuals ranging from owners of modest homes to employees of large industrial complexes. They must communicate and appreciate the needs of the broadest range of people because their clients include everyone who inhabits buildings.

In the real world there are many ethical conflicts, and although ethical lapses in legal, political, medical, and other professions are often more publicized, the HVAC industry is not without the potential for malpractice, conflict of interest, and dishonesty. Examples of inferior workmanship and unnecessarily inflated costs are evident in the industry. Rules, codes, standards, and guidelines evolve with input from those having self-serving agendas as well as those seeking the common good. Organizations such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the National Society of Professional Engineers (NSPE) offer guidance to members for ethical behavior. A summary is offered here as a starting point for HVAC design.

ENGINEERS' CREED AND ASHRAE CODE OF ETHICS

An excerpt from the Engineers' Creed of the National Society of Professional Engineers (NSPE) calls on the engineer to:

> … give the utmost performance;
>
> … participate in none but honest enterprise;
>
> … live and work according to the laws of man and the highest standards of professional conduct;
>
> …place service before profit, the honor and standing of the profession before professional advantage, and the public welfare above all other considerations....

The ASHRAE Code of Ethics (ASHRAE 2004a) states:

> As members of a Society,
>
> "organized and operated for the exclusive purpose of advancing the arts and sciences of heating, refrigeration, air conditioning, and ventilation, the allied arts and sciences, and related human factors for the benefit of the general public" [ASHRAE 2004b],
>
> We recognize that honesty, fairness, courtesy, competence and integrity must characterize our conduct. With the foregoing in mind
>
> - Our efforts shall be directed at all times to the enhancement of the public health, safety and welfare.
> - Our services shall be offered only in areas of our competence.
> - Our products shall be offered only in areas of their suitability.
> - Our public statements shall be issued only in an objective and truthful manner.
> - Our endeavors shall carefully avoid conflicts of interest and the appearance of conflicts of interest.
> - The confidentiality of clients' and employers' business affairs, proprietary information, and procedures shall be respected.
>
> Approved by the Board of Directors
> June 22, 1986

THE BUILDING INDUSTRY ENVIRONMENT

The HVAC engineer operates in a world in which technology is rapidly changing and conventional roles, social behavior, working relationships, and partnerships are being challenged and reinvented. Figure 1.1 is an organizational chart of conventional working relationships for a large building project. The building owner's