Variable Air Volume Systems for Environmental Quality

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To my wife Sue for her understanding, encouragement, and patience, and to my daughter Helen and my son Michael.

—Steve Y. S. Chen, P.E.

To Dr. David A. Pistenmaa, Ph.D., M.D., whose skill and talent helped save my life and give me the opportunity to live and work after my encounter with cancer.

—Stanley J. Demster, P.E.

Preface

The energy crisis of the 1970s stimulated the development of new technologies to reduce energy usage in buildings. Computer-aided energy management techniques as well as rigorous applications of the variable air volume (VAV) concept were all initiated during this period. Since then, many new VAV components, such as terminals, fans, air-regulating devices, and controls have been developed. These components have all contributed to the enormous advancement of VAV technology. The increasing application of direct digital control (DDC) since the early 1980s has also intensified this trend.

Today VAV technology is universally accepted as a means of achieving an energy-efficient and comfortable building environment. In fact, VAV systems are one of the most popular air-conditioning systems for commercial and institutional buildings in the United States. Yet not all VAV systems are successful. There are many nonworking VAV systems. Multiple factors contribute to this unfortunate situation. The most significant one is insufficient understanding of VAV concepts and the interaction of system components with control loops under the continuously changing flow conditions. More specifically, there is a lack of appreciation by building professionals of the dynamic interplay among system components and their controls in a given VAV environment. This interplay must be carefully analyzed, measured, and controlled throughout the entire life cycle of the VAV system. The design, construction, and operation phases must all be taken into account.

Traditionally, the design, construction, and operation of a VAV system are separate and independent processes handled by different groups of building professionals: typically, system designers, contractors, and operators. These processes are further complicated by the delegation of responsibilities among different engineering disciplines, including HVAC, electrical, control, acoustics, and facility management. This fragmentation of the building design and construction processes makes the total integration of the VAV system function very difficult.

This book addresses the issue of building and VAV system integration in four major sections: Introduction, VAV System Design, VAV System Construction, and VAV System Operation.

Part 1: Introduction. This section discusses the history, classifications, components, advantages, and disadvantages of VAV systems. The objective is to familiarize the reader with the VAV concept and the intricacy of VAV components and their interactions with controls.

Part 2: VAV System Design. This section emphasizes the importance of designing VAV systems for total environmental quality. Chapter 6 explores the impact of VAV design on five major environmental factors: namely, thermal comfort, indoor air quality (IAQ), variable volume air distribution, acoustics, and building pressurization. Total environmental quality is achieved through integrated design considerations, careful system and component selection, and a continuously interactive design process. These subjects are covered in detail in Chapters 7 through 10. Although seldom emphasized in conventional design, it is the interactive process of design and analysis that often determines the quality of VAV systems. Chapter 11 discusses this subject and shows 10 types of analyses with specific examples to illustrate their effectiveness in VAV design.

Part 3: Construction of VAV Systems. This section discusses realization of the original design intent through the proper construction and installation of system components.

Part 4: Operation of VAV Systems. This section is the final link to ensure the success of a VAV system in a given building environment. It covers a wide range of subjects, from the understanding of design intent to VAV routine maintenance. In particular, it emphasizes practical considerations for the proper operation of VAV systems, such as zoning, actual versus design, making modifications and corrections, and troubleshooting.

The glossary following Part 4 includes terms and concepts which are most frequently used in this book which require further explanation and clarification of their meanings.

In summary, this book provides a comprehensive overview of VAV technology based on the best currently available information, and on the authors' own experience in the design, construction, and operation of modern VAV systems. It is the sincere hope of the authors that this book will aid the reader in utilizing VAV technology to achieve a quality building environment.

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Part

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Introduction to VAV Systems