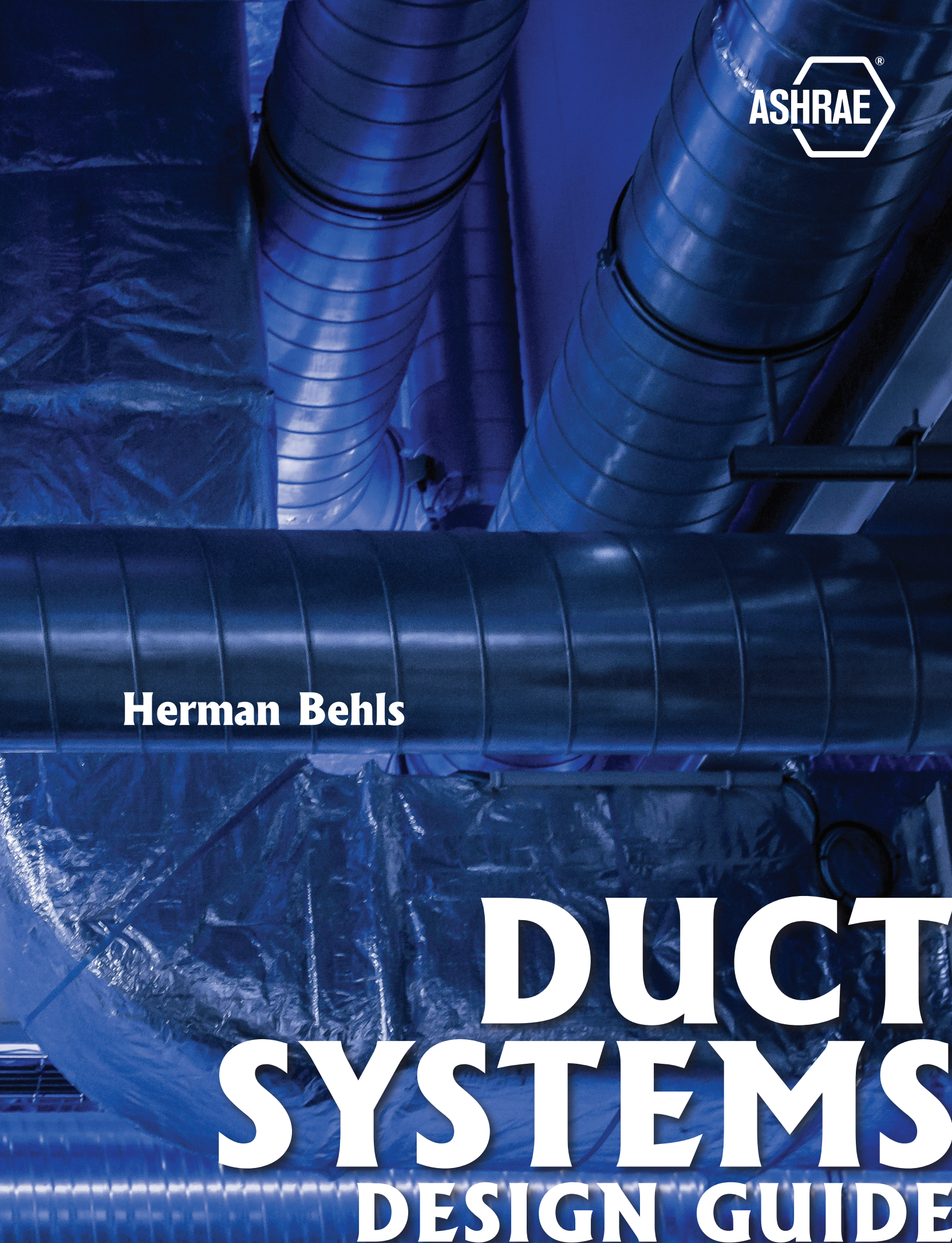


Herman Behls

DUCT SYSTEMS DESIGN GUIDE

DUCT SYSTEMS
DESIGN GUIDE

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✧ Dedication ✧

Duct Systems Design Guide is dedicated to the lasting legacy of Herman Behls.

When ASHRAE RP-1180 could not fulfill the vision for this guide, Herman volunteered to take on this responsibility. Sadly, Herman passed away on July 12, 2017, after a brief illness, and never got to witness the book's completion. To the very end Herman was working every day to finish its writing, and he is given full credit for the contents of this book.

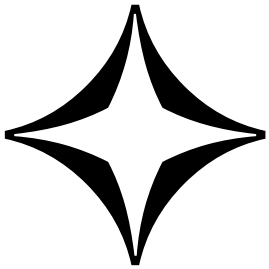
Herman was a former chair of ASHRAE Technical Committee (TC) 5.2 and served as the Research Subcommittee Chair for many years. Herman also served as a member of the Standards Committee and the Research Administration Committee. The contributions Herman made to the ASHRAE community are almost too numerous to count, but several honors he received deserve special mention. Herman became a member of the ASHRAE College of Fellows in 1995. This is reserved for ASHRAE members who have attained distinction in the fields of heating, refrigeration, air conditioning, ventilation, or the allied arts and sciences through invention, research, teaching, design, or original work or as an engineering executive on projects of unusual or important scope. Herman was also awarded the Service to ASHRAE Research Award in 2013 in recognition of his many years of contributions to the ASHRAE research program. At the time of this writing, Herman was one of only eleven recipients of this award since its inception.

Herman was the author of numerous work statements, acted as a PMS chair for many projects, reviewed papers, made seminar presentations, and always inspired thoughtful inquiry. In 2016 Herman was further honored with the Distinguished 50-Year Member Award, which recognizes persons who have been members of ASHRAE for 50 years and have performed outstanding service to the Society.

Among his other accomplishments, Herman was a principal author of ASHRAE Standards 120, 126, 130, and 215. He also was the primary author for the Duct Design chapter in *ASHRAE Handbook—Fundamentals* for several decades. Herman is also the father of the ASHRAE Duct Fitting Database and spent countless hours maintaining it. He was always willing to serve as a resource for anyone needing answers to their questions about the program.

Herman never stopped acquiring new knowledge from others and he was always willing to share his expertise with anyone who wanted to learn from a true teacher, friend, and mentor.





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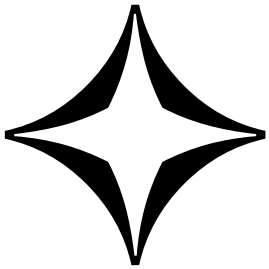
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Includes spreadsheets in Microsoft® Excel® format for designing commercial and industrial duct systems by the equal friction, static regain, and constant velocity methods online.





Preface

The goal of this design guide is to provide engineers and other design professionals with the tools and knowledge to design duct systems so that fans are properly sized, minimize the installed cost of the ductwork, minimize system-generated noise, and minimize fan energy. The original vision was that this guide would clearly describe procedures useful for entry-level engineers and designers who were first learning about duct design fundamentals. However, it was also desired that the guide be a valuable tool for more experienced engineers and design professionals wishing to refresh their design knowledge.

The guide was initially conceived as ASHRAE Research Project RP-1180. The Project Monitoring Subcommittee (PMS), under the auspices of ASHRAE Technical Committee (TC) 5.2, Duct Design, took control of the editorial process and accepted the task of authoring the guide after it became apparent that writing a duct design guide suitable for these disparate audiences was exceptionally challenging. Herman Behls, a former chair of TC 5.2, volunteered to complete the writing.

Introduction

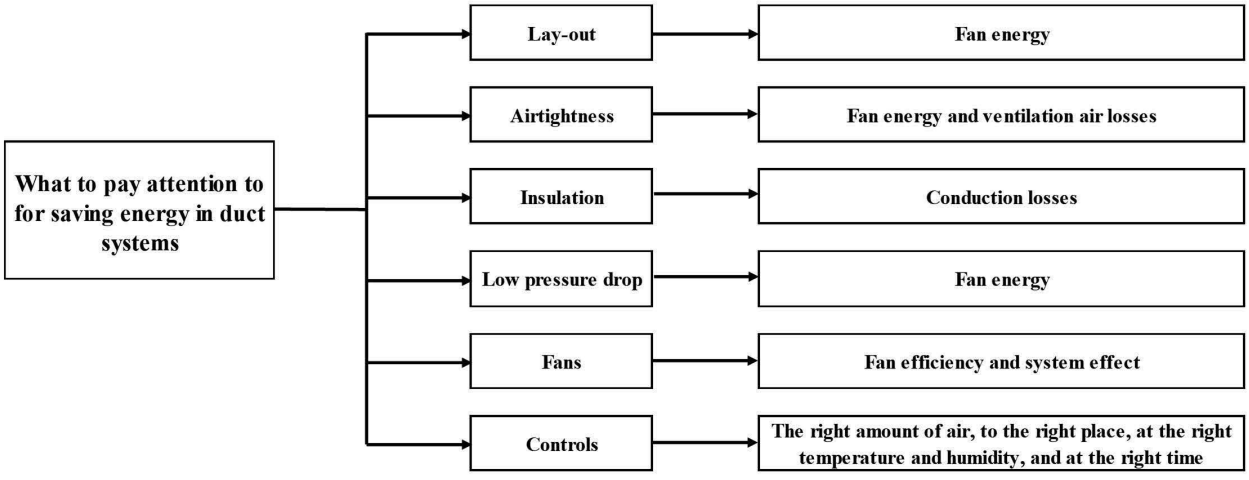
OVERVIEW

Ducts in air distribution systems are designed to transport a given volume of air as efficiently and quietly as possible to minimize energy consumption and eliminate excessive noise. Duct system layout, fitting selection, leakage, acoustics, and equipment selection are important aspects of duct design.

The goals of duct design are

- to design energy-efficient HVAC systems that deliver the proper quantity of air to specific areas of a building or zones while minimizing first costs and operating costs and
- to provide a comprehensive design and a high-quality project with adequate funding and minimum construction disputes to the owner.

Various aspects of the duct design process include minimizing fan energy use, as depicted in the figure below. All projects should document the Owner's Project Requirements (OPR)—the importance of this cannot be overemphasized. The OPR should be reviewed throughout the design but especially during the commissioning process. (A comprehensive discussion of commissioning is beyond the scope of this book, but there are numerous sources of information available, such as those listed at www.ashrae.org/commissioning-essentials.)



Energy-Saving Opportunities in Duct Systems

SCOPE

This design guide covers commercial and industrial duct systems. Residential duct system design is covered by Air Conditioning Contractors of America's (ACCA) *Manual D* (2016).

This guide does not cover thermal gravity effects (stack effect) or other similar applications where the duct system is vertical and density changes will impact the overall design. For stack effect examples and calculations, consult the System Analysis section of Chapter 21, "Duct Design," of *ASHRAE Handbook—Fundamentals* (2017c).

To determine system air quantities for commercial systems, consult Chapter 18, "Nonresidential Cooling and Heating Load Calculations," of *ASHRAE Handbook—Fundamentals* (2017a). To determine system air quantities for exhaust systems, use this design guide in conjunction with the American Conference of Governmental Industrial Hygienists (ACGIH®) *Industrial Ventilation: A Manual of Recommended Practice for Design*, 30th Edition (2019). Chapter 13 of this ACGIH manual includes the designs and air quantity requirements for numerous industrial applications.

To design room air distribution systems, consult the relevant ASHRAE Handbooks. For example, Chapter 20, "Space Air Diffusion," of *ASHRAE Handbook—Fundamentals* (2017b) presents the fundamental characteristics of space air diffusion, and Chapter 58, "Indoor Airflow Modeling," of *ASHRAE Handbook—HVAC Applications* (2019b) addresses air terminal units and their effects on occupant comfort along with tools for designing air distribution systems.

This design guide does not need to be read cover to cover. Readers with a fundamental understanding of duct design may only need to reference Chapters 3, 4, and 5 covering the equal friction, static regain, and constant velocity design methods. It is strongly suggested that readers also review the HVAC System Air Leakage section of Chapter 21, "Duct Design," of *ASHRAE Handbook—Fundamentals* (2017c), as it provides insight on system sealing requirements, scope of testing, acceptance criteria, recommended specifications, and the responsibilities of engineers and contractors.

Chapter 2 of this design guide includes a discussion on uncertainty and error considerations that readers should familiarize themselves with to appreciate the pressure drop calculation process.

Chapter 8 of this book offers a comprehensive overview of duct system acoustics; it is recommended that for additional guidance on acoustics readers see *Noise and Vibration Control* (Schaffer 2005) as well as Chapter 49, "Noise and Vibration Control," of *ASHRAE Handbook—HVAC Applications* (2019a). Schaeffer addresses general noise-control design guidelines during the various design phases and includes information on the architectural and structural aspects of HVAC system design. Sample specifications for acoustical materials and the acoustical performance of HVAC equipment are also provided. Schaffer also gives suggestions for troubleshooting HVAC noise and vibration complaints.

Each chapter of this design guide includes a nomenclature section at the end that defines the variables used in the chapter's equations, and example problems and solutions are included throughout the book to help readers understand the concepts of duct design with practical examples. Note that throughout this book all values and nomenclature are provided in Inch-Pound (I-P) units only.

This design guide is also accompanied by free spreadsheets in Microsoft® Excel® format that can be found online. These spreadsheets can be used for designing commer-cial, industrial, and local exhaust duct systems by the equal friction, static regain, and constant velocity methods. The spreadsheets are best used in conjunction with the web-based ASHRAE Duct Fitting Database (DFDB), available via subscription at www.ashrae.org/technical-resources/bookstore/duct-fitting-database (2016). This online database includes duct friction losses and fit-ting loss coefficients for more than 200 round, rectangular, and flat oval duct fittings and is useful to design engineers in the calculation of friction factors and loss coefficients for a wide variety of ducts and fittings.

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