HVAC SYSTEMS
DUCT DESIGN

SHEET METAL AND AIR CONDITIONING CONTRACTORS'
NATIONAL ASSOCIATION, INC.
www.smacna.org

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FOURTH EDITION – DECEMBER 2006

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FOREWORD

In keeping with its policy of disseminating information and providing standards of design and construction, the Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA), offers this comprehensive fundamental *HVAC Systems-Duct Design* manual as part of our continuing effort to upgrade the quality of work produced by the heating, ventilating and air conditioning (HVAC) industry. This manual presents the basic methods and procedures required to design HVAC air distribution systems. It does not deal with the calculation of air conditioning loads or room air ventilation quantities.

This manual is part one of a three set HVAC Systems Library. The second manual is the SMACNA *HVAC Systems-Applications* manual that contains information and data needed by designers and installers of more specialized air and hydronic HVAC systems. The third manual is the *HVAC Systems-Testing, Adjusting and Balancing* manual, a recently-updated publication on air and hydronic system testing and balancing.

The HVAC duct system designer is faced with many considerations after the load calculations are completed and the type of distribution system is determined. This manual provides not only the basic engineering guidelines for the sizing of HVAC ductwork systems, but also related information in the areas of:

a. Materials
b. Methods of Construction
c. Economics of Duct Systems
d. Duct System Layout
e. Pressure Losses
f. Fan Selection
g. Duct Leakage
h. Acoustic Considerations
i. Duct Heat Transfer
j. Testing, Adjusting and Balancing

With emphasis on energy conservation, the designer must balance duct size with the space allocated and duct system pressure loss. Duct pressure loss increases fan power and associated operating costs. Materials, equipment, and construction methods must be carefully chosen to achieve the most advantageous balance between both initial and life cycle costing considerations. This manual is designed to offer both the HVAC system designer and installer detailed information on duct design, materials and construction methods. Both U. S. and metric units have been provided in examples, calculations, and tables.

The SMACNA *HVAC Systems-Duct Design* manual is intended to be used in conjunction with the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE) *Fundamentals* Handbook. The basic fluid flow equations are not included here, but may be found in the ASHRAE handbook. Practical applications of these equations are included through use of reference tables and examples. Some sections of this manual have been reprinted with permission from various ASHRAE publications. Another important source of HVAC systems information is the Air Movement and Control Association International, Inc. (AMCA). SMACNA and the entire HVAC industry owe these two organizations a debt of gratitude for continued investments testing and development of HVAC standards.

Although most HVAC systems are constructed to pressure classifications between minus 3 inches water gage (wg) to 10 inches wg, (-750 to 2,500 Pascals (Pa), the design methods, tables, charts, and equations provided in this text may be used to design other duct systems operating at higher pressures and temperatures. Air density correction factors for both higher altitudes and temperatures are included.

SMACNA recognizes that this manual will be expanded and updated as new material becomes available. We will continue to provide the HVAC industry with the latest construction methods and engineering data from recognized sources including SMACNA research programs and the services of local SMACNA Chapters and SMACNA Contractors.

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CHAPTER 1

INTRODUCTION

1.1 SCOPE

This manual provides the duct system designer with the technical information required to design a complete air distribution system. This text has been extensively revised and updated, and now includes key portions of the previously separate Duct Design Home Course Study material.

1.2 HOW TO USE THIS MANUAL

This manual is divided into chapters that address each step of duct system design, layout, and sizing.

CHAPTER 1 INTRODUCTION
Brief introduction to the history, related building codes, smoke control, and system types for duct installations in commercial facilities.

CHAPTER 2 ECONOMICS OF DUCT SYSTEMS
How duct sizing and system layout impacts the economics for a project.

CHAPTER 3 ROOM AIR DISTRIBUTION
All of the design considerations related to room air distribution and indoor air quality.

CHAPTER 4 GENERAL APPROACH TO DUCT DESIGN
Basics of duct system design, including pressure losses, duct and diffuser noise, and basic system balancing issues.

CHAPTER 5 DUCT DESIGN FUNDAMENTALS
Fundamental elements of fan curves, pressure loss calculations, duct leakage, and duct heat gains and losses.

CHAPTER 6: FAN–DUCT CONNECTION PRESSURE LOSSES
Issues related to the transition from supply and return fans to the ductwork.

CHAPTER 7 DUCT SIZING PROCEDURES
Pressure loss design information for duct components including fittings, diffusers, registers, and duct transitions.

CHAPTER 8 PRESSURE LOSS OF SYSTEM COMPONENTS
Tables and graphs to estimate pressure drop for each component in a duct system.

CHAPTER 9 PROVISIONS FOR TESTING, ADJUSTING, AND BALANCING
How a new air distribution system should be balanced. Common duct system testing and balancing procedures.

CHAPTER 10 DESIGNING FOR SOUND AND VIBRATION
Noise generation and methods to reduce system noise.

CHAPTER 11 DUCT SYSTEM CONSTRUCTION
Construction and how duct material selection can improve indoor air quality.

CHAPTER 12 SPECIAL DUCT SYSTEMS
Kitchen and dishwasher exhaust ducts, and duct systems for corrosive and noxious gases.

APPENDIX
Tables and charts of duct design information in an easy to use format.

1.3 PURPOSE

The purpose of any heating, ventilating, and air conditioning (HVAC) duct system is to provide:

a. Thermal comfort

b. Humidity control

c. Ventilation air

d. Air filtration

However, a poorly designed or constructed HVAC duct system may result in a system that is costly to operate, noisy, and does not meet occupant comfort requirements.

This manual and associated SMACNA publications will assist both the system designer and the installer to provide an HVAC system that meets all these basic requirements.

1.4 HISTORY OF AIR DUCT SYSTEMS

Over 2,000 years ago, both the Greeks and Romans used masonry and terra cotta pipe to distribute flue gases from a central heating source to indirectly heat interior rooms and baths. The use of flues and ducts eventually disappeared until the twelfth century when heating fireplaces were moved from the center of a great-room to a sidewall, and chimneys or flues were used again.