

**Table 6 Duct Leakage Classification<sup>a</sup>**

Duct Type	Sealed <sup>b,c</sup>		Unsealed <sup>d</sup>	
	Predicted Leakage Class C <sub>L</sub>	Leakage Rate, L/(s·m <sup>2</sup> ) at 250 Pa	Predicted Leakage Class C <sub>L</sub>	Leakage Rate, L/(s·m <sup>2</sup> ) at 250 Pa
Metal (flexible excluded)	Round and flat oval	4	42 (8 to 99)	1.5 (0.1 to 3.6)
	Rectangular	17	68 (17 to 152)	2.5 (0.6 to 5.6)
Flexible	Metal, aluminum	11	42 (17 to 76)	1.5 (0.6 to 2.8)
	Nonmetal	17	30 (6 to 76)	1.5 (0.2 to 2.8)
Fibrous glass	Round	4	NA	NA
	Rectangular	8	NA	NA

<sup>a</sup>Leakage classes here are averages based on tests conducted by ASHRAE/NA (1977), ASHRAE/SMACNA/TMLA (1985), and Brown and Grigg (1995).

<sup>b</sup>“Sealed” leakage classes assume that, for metal ducts, all transverse joints, seams, and openings in duct wall are sealed.

<sup>c</sup>Leakage classes anticipate about 0.82 joints per meter of duct. For systems with a high fitting-to-straight-duct ratio, greater leakage occurs in both sealed and unsealed conditions.

**Table 7 Leakage as Percentage of Airflow<sup>a,b</sup>**

Leakage Class	System L/s per m <sup>2</sup> Duct Surface <sup>c</sup>	Static Pressure, Pa						
		125	150	500	750	1000	1500	
68	10	15	24	38	49	59	77	
	12.7	12	19	30	39	47	62	
	15	10	16	25	33	39	51	
	20	7.7	12	19	25	30	38	
	25	6.1	9.6	15	20	24	31	
	34	10	7.7	12	19	25	30	38
34	12.7	6.1	9.6	15	20	24	31	
	15	5.1	8.0	13	18	20	26	
	20	3.8	6.0	9.4	12	15	19	
	25	3.1	4.8	7.5	9.8	12	15	
	17	10	3.8	6	9.4	12	15	19
	12.7	3.1	4.8	7.5	9.8	12	15	
15	15	2.6	4.0	6.3	8.2	9.8	13	
	20	1.9	3.0	4.7	6.1	7.4	9.6	
	25	1.5	2.4	3.8	4.9	5.9	7.7	
	8	10	1.9	3	4.7	6.1	7.4	9.6
	12.7	1.5	2.4	3.8	4.9	5.9	7.7	
	15	1.3	2.0	3.1	4.1	4.9	6.4	
8	20	1.0	1.5	2.4	3.1	3.7	4.8	
	25	0.8	1.2	1.9	2.4	3.0	3.8	
	4	10	1.0	1.5	2.4	3.1	3.7	4.8
	12.7	0.8	1.2	1.9	2.4	3.0	3.8	
	15	0.6	1.0	1.6	2.0	2.5	3.2	
	20	0.5	0.8	1.3	1.6	2.0	2.6	
25	0.4	0.6	0.9	1.2	1.5	1.9		

<sup>a</sup>Adapted with permission from *HVAC Air Duct Leakage Test Manual* (SMACNA 1995, Appendix A).

<sup>b</sup>Percentage applies to airflow entering a section of duct operating at an assumed pressure equal to average of upstream and downstream pressures.

<sup>c</sup>Rates in this column are typical of the volumetric flow rate divided by total system surface. Portions of systems may vary from these averages.

*HVAC Duct Construction Standards* (2005). Fibrous glass ducts and their closure systems are covered by U.L. Standards 181 and 181A. For fibrous glass duct construction standards, consult NAIMA (2002) and SMACNA (2003). Flexible duct performance and installation

**Table 8 Typical Design Velocities for HVAC Components**

Duct Element	Face Velocity, m/s
<b>Louvers<sup>a</sup></b>	
Intake	
3300 L/s and greater	2
Less than 3300 L/s	See <a href="#">Figure 14</a>
Exhaust	
2400 L/s and greater	2.5
Less than 2400 L/s	See <a href="#">Figure 14</a>
<b>Filters<sup>b</sup></b>	
Panel filters	
Viscous impingement	1 to 4
Dry-type, extended-surface	
Flat (low efficiency)	Duct velocity
Pleated media (intermediate efficiency)	Up to 3.8
HEPA	1.3
Renewable media filters	
Moving-curtain viscous impingement	2.5
Moving-curtain dry media	1
Electronic air cleaners	
Ionizing type	0.8 to 1.8
<b>Heating Coils<sup>c</sup></b>	
Steam and hot water	2.5 to 5 1 min., 8 max.
Electric	
Open wire	Refer to mfg. data
Finned tubular	Refer to mfg. data
<b>Dehumidifying Coils<sup>d</sup></b>	2 to 3
<b>Air Washers<sup>e</sup></b>	
Spray type	Refer to mfg. data
Cell type	Refer to mfg. data
High-velocity spray type	6 to 9

<sup>a</sup>Based on assumptions presented in text.  
<sup>b</sup>Abstracted from Ch. 26, 2008 *ASHRAE Handbook—HVAC Systems and Equipment*.  
<sup>c</sup>Abstracted from Ch. 26, 2008 *ASHRAE Handbook—HVAC Systems and Equipment*.  
<sup>d</sup>Abstracted from Ch. 22, 2008 *ASHRAE Handbook—HVAC Systems and Equipment*.  
<sup>e</sup>Abstracted from Ch. 40, 2008 *ASHRAE Handbook—HVAC Systems and Equipment*.

standards are covered by U.L. Standards 181 and 181B and AHC (2003). Soldered or welded duct construction is necessary where sealants are not suitable. Sealants used on exterior ducts must be resistant to weather, temperature cycles, sunlight, and ozone.

Shaft and compartment pressure changes affect duct leakage and are important to health and safety in the design and operation of containment and smoke control systems. Shafts should not be used for supply, return, and/or exhaust air without accounting for their leakage rates. Airflow around buildings, building component leakage, and the distribution of inside and outside pressures over the height of a building, including shafts, are discussed in [Chapters 16 and 24](#).

**System Component Design Velocities**

[Table 8](#) summarizes face velocities for HVAC components in built-up systems. In most cases, the values are abstracted from pertinent chapters in the 2008 *ASHRAE Handbook—HVAC Systems and Equipment*; final selection of components should be based on data in these chapters or, preferably, from manufacturers.

Use [Figure 14](#) for preliminary sizing of air intake and exhaust louvers. For air quantities greater than 3300 L/s per louver, the air intake gross louver openings are based on 2 m/s; for exhaust louvers, 2.5 m/s is used for air quantities of 2400 L/s per louver and greater. For smaller air quantities, refer to [Figure 14](#). These criteria are presented on a per-louver basis (i.e., each louver in a bank of louvers) to include each louver frame. Representative production-run louvers were used in establishing [Figure 14](#), and all data used were based on AMCA Standard 500-L tests. For louvers larger than

# Ashrae Handbook Chapter 49

**M Tight**



## **Ashrae Handbook Chapter 49:**

*ASHRAE Handbook*, 1999 *Air Conditioning and Ventilation: Fundamental to Practical* Nopparat Katkhaw, 2025-10-12 This book was written based on over 20 years of real world engineering and teaching experience It is carefully compiled from ASHRAE Handbooks SMACNA Standards and CARRIER reference documents along with other professional resources in the HVAC field The content is organized into two main units each supported with numerous comprehensive examples covering both SI and I P units to suit international practice Designed for students engineers and anyone interested in HVAC system design this book has been proven by more than 5 000 copies sold in print reflecting its practicality and reliability in both classroom and field applications CHAPTER 1 Psychrometrics and Thermal Comfort **Mechanical and Electrical Equipment for Buildings** Walter Grondzik, Daniel Overbey, Alison Kwok, 2026-05-11 UPDATED EDITION OF THE LEADING AWARD WINNING REFERENCE ON MECHANICAL AND ELECTRICAL SYSTEMS FOR BUILDINGS OF ALL SIZES Twice awarded the AIA s Citation for Excellence in International Architecture Book Publishing Mechanical and Electrical Equipment for Buildings comprehensively reviews mechanical and electrical systems for buildings of all sizes providing design guidelines and detailed design procedures for each topic covered To assist with learning this book contains in depth discussions of why and how to which help the reader better understand concepts and applications This 14th Edition features substantial revisions to core content reflecting the latest knowledge and advancements in the field with coverage of topics including green buildings zero energy zero carbon zero water zero waste healthy buildings resiliency electrification and decarbonization along with revised references to codes standards and rating systems from ASHRAE NFPA ICC IES USGBC LEED ILFI Living Building Challenge IWBI the WELL Building Standard and more With this new edition readers will also find an updated Learner s Guide new PowerPoint learning aids for each chapter updated case studies and an improved test bank of questions and answers New illustrations are also included throughout Mechanical and Electrical Equipment for Buildings explores topics including Design resources covering energy performance water efficiency decarbonization as well as a holistic overview of the impact of the built environment on environmental health and human wellbeing Passive environmental systems that support human thermal visual and acoustical comfort Factors for healthy buildings biophilic design and building system solutions that improve indoor environmental quality IEQ Considerations for efficient effective and durable building enclosures HVAC components including heating and cooling equipment air and water delivery air filters and HVAC system taxonomy anatomy and controls Basic design criteria pertaining to fire protection vertical transportation telecommunications and building automation systems Following in the footsteps of previous editions spanning the greater part of a century Mechanical and Electrical Equipment for Buildings continues to be the leading resource on the subject for professionals and students in architecture architectural engineering and construction [NEHRP Commentary on the Guidelines for the Seismic Rehabilitation of Buildings](#) Eugene Zeller, 2000-06 This document from the National Earthquake Hazards Reduction Program

NEHRP was prepared for the Building Seismic Safety Council BSSC with funding from the Federal Emergency Management Agency FEMA It provides commentary on the NEHRP Guidelines for the Seismic Rehabilitation of Buildings It contains systematic guidance enabling design professionals to formulate effective reliable rehabilitation approaches that will limit the expected earthquake damage to a specified range for a specified level of ground shaking This kind of guidance applicable to all types of existing buildings in all parts of the country has never existed before Illustrated

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*ASHRAE Handbook & Product Directory* American Society of Heating, Refrigerating and Air-Conditioning Engineers,1979

**90.1 User's Manual** American Society of Heating, Refrigerating and Air-Conditioning Engineers,2004 This User s Manual provides detailed instruction for the design of commercial and high rise residential buildings to ensure their compliance with ANSI ASHRAE IESNA Standard 90 1 2004 In addition this Manual encourages the user to apply the principles of effective energy conserving design when designing buildings and building systems offers information on the intent and application of Standard 90 1 illuminates the Standard through the use of abundant sample calculations and examples streamlines the process of showing compliance provides Standard forms to demonstrate compliance provides useful reference material to assist designers in efficiently completing a successful and complying design This Manual also instructs the user in the application of several tools used for compliance with Standard 90 1 the EnvStd computer program used in conjunction with the Building Envelope Trade Off compliance method the selection and application of energy simulation programs used in conjunction with the energy cost budget method of compliance This Manual is intended to be useful to numerous types of building professionals including architects and engineers who must apply the Standard to the design of their buildings plan examiners and field inspectors who must enforce the Standard in areas where it is adopted as code general and specialty contractors who must construct buildings in compliance with the standard product manufacturers state and local energy offices policy groups utilities and others

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Handbook of Applied Thermal Design Eric C. Guyer,1989 Problems in thermal design are encountered in a vast array of fields from manufacturing equipment to energy systems and consumer products to scientific apparatuses The tools to achieve the solutions to these problems lie within this handbook Written for the non specialist this comprehensive resource addresses the use and control of thermal phenomena in both products and processes With contributions from leading experts in the field this book gives a foundation to the four principal facets of thermal design heat transfer analysis materials performance heating and cooling technology and instrumentation and control The focus is on providing practical thermal design and development guidance across the spectrum of problem analysis material applications equipment specification and sensor and control selection Professional in thermal design heat transfer and mechanical engineering will find this handbook invaluable

*ASHRAE Handbook, 1981 Fundamentals* American Society of Heating, Refrigerating and Air-Conditioning Engineers,1981 **2008 Building Energy Efficiency Standards** California Energy Commission,2009 2010 California Energy Code International Code Council,2010-05-15 This document is the 6th of 12 parts of the official triennial compilation and publication of the adoptions amendments and repeal of administrative regulations to California Code of Regulations Title 24 also referred to as the California Building Standards Code This part is known as the California Energy Code Preface

**2005 California Energy Code** California Building Standards Commission,2005 Managing Energy Resources in Times of Dynamic Change William H. Mashburn,1992 Whether your facility is large or small industrial or commercial institutional or governmental you ll find easy to implement solutions to your toughest energy management challenges in this fully updated reference The guidelines presented are based on actual experience of today s most successful energy managers You ll discover scores of practical methods for launching these cost cutting procedures in your own operations Tested and complete the guide s solutions are designed to help energy managers at every point during their planning tasks from starting up new programs to completely overhauling existing systems to patching up costly trouble spots along the way The second edition has been expanded to include the reviving of programs that for one reason or another have become inactive The text is packed with handy charts tables graphs and fully worked out examples to speed and simplify your workday tasks

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