

CHAPTER 14

INDUSTRIAL AIR CONDITIONING

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THIS chapter addresses air-conditioning systems for industrial facilities such as manufacturing plants, laboratories, processing plants, and power plants. HVAC systems provide the process environment (including temperature, humidity, air motion, air quality, noise, and cleanliness) to facilitate industrial processes and provide for the health, safety, and comfort of personnel.

Many industrial buildings require large amounts of energy, in both manufacturing and maintaining building environmental conditions. This chapter provides system and building design guidance for energy conservation by using insulation, ventilation, and waste heat recovery.

1. GENERAL REQUIREMENTS

Typical temperatures, relative humidities, and specific filtration requirements for storage, manufacture, and processing of various commodities are listed in [Table 1](#). Requirements for a specific application may differ from those in the table.

Industrial processes or regulatory requirements may change over time; thus, systems should be able to provide for future requirements to the extent this is practical.

Outdoor design requirements and indoor temperature, humidity, cleanliness, noise, and allowable variations should be established by agreement with the owner. A compromise between requirements for product or process conditions and those for comfort may optimize quality and production costs.

An environment that allows a worker to safely perform assigned duties without fatigue from the effects of temperature and humidity may enhance performance.

Special Warning: Some industrial spaces may contain flammable, combustible, and/or toxic concentrations of vapors or dusts under either normal or abnormal conditions. In spaces such as these, there are safety issues that this chapter may not completely address. Special precautions must be taken in accordance with requirements of recognized authorities such as the National Fire Protection Association (NFPA), the Occupational Safety and Health Administration (OSHA), and the American National Standards Institute (ANSI). In all situations, engineers, designers, and installers who encounter conflicting codes and standards must defer to the code or standard that best addresses personnel safety.

2. PROCESS AND PRODUCT REQUIREMENTS

An industrial product or process may require control of the indoor environment if it affects one or more of the following factors.

The preparation of this chapter is assigned to TC 9.2, Industrial Air Conditioning.

Rate of Chemical Reaction

Some processes require temperature and humidity control to regulate chemical reactions. In rayon manufacturing, for example, pulp sheets are conditioned, cut to size, and mercerized. The temperature directly controls the rate of reaction, and the relative humidity maintains the solution at a constant strength and rate of evaporation.

In drying varnish, oxidizing depends on temperature. Desirable temperatures vary with the type of varnish. High relative humidity retards surface oxidation and allows internal gases to escape as chemical oxidizers cure the varnish from within. Thus, a bubble-free surface is maintained with a homogeneous film throughout.

Rate of Crystallization

The cooling rate determines the size of crystals formed from a saturated solution. Both temperature and relative humidity affect the cooling rate and change the solution density by evaporation.

In coating pans for pills, a heavy sugar solution is added to the tumbling mass. As water evaporates, sugar crystals cover each pill. Moving the correct quantity of air over the pills at the correct temperature and relative humidity forms a smooth, opaque coating. If cooling and drying are too slow, the coating will be rough, translucent, and have an unsatisfactory appearance. If the cooling and drying are too fast, the coating will chip through to the interior.

Rate of Biochemical Reaction

Fermentation requires both temperature and humidity control to regulate the rate of biochemical reactions. Many fermentation vessels are jacketed to maintain consistent internal temperatures. Fermentors are held at different temperatures, depending on the process involved. In brewing, typical fermentor temperatures range from 45 to 52°F. Because of vessel jacketing, tight control of room temperature may not be required. Usually, space temperatures should be held as close as practical to the process temperature inside the fermentation vessel.

Designing such spaces should take into account gases and other by-products generated by fermentation. Typically, carbon dioxide is the most prevalent by-product of fermentation in brewing and presents the greatest potential hazard if a fermentor overpressurizes the seal. Provide adequate ventilation in case carbon dioxide escapes the process.

In biopharmaceutical processes, hazardous organisms can escape a fermentor; design of spaces using these fermentors should allow containment. Heat gains from steam-sparged vessels should also be accounted for in such spaces.

Product Accuracy and Uniformity

Air temperature and cleanliness affect quality in manufacturing precision instruments, lenses, and tools. When manufacturing tolerances are within 0.0002 in., close temperature control (typically

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T. Nejat Veziroğlu



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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

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 **Heating, Ventilating, and Air-Conditioning Applications** Mr. Rohit Manglik, 2024-01-03 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels

Handbook of Applied Thermal Design Eric C. Guyer, 1999-02-01 Gives a foundation to the four principle 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 **ASHRAE Handbook & Product Directory**

American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1979 The Architecture of Sound Rob Bullen, 2025-03-20 This book highlights the range of issues involved in designing interior spaces for acoustics that is ensuring that the sound of a space matches its function The book presents the principles of acoustic design together with practical advice on how to apply those principles The fundamental elements of background sound intruding sound sound quality and speech intelligibility are each described with design goals calculation procedures and advice on implementation Contemporary challenges associated with integrating acoustics and sustainable building design are also covered Finally two types of space school classrooms and hospital wards are considered in detail as examples **Mechanical and Electrical Equipment for Buildings** Walter T. Grondzik, Alison G. Kwok, 2019-10-08 The definitive guide to the design of

environmental control systems for buildings now updated in its 13th Edition Mechanical and Electrical Equipment for Buildings is the most widely used text on the design of environmental control systems for buildings helping students of architecture architectural engineering and construction understand what they need to know about building systems and controlling a building's environment With over 2 200 drawings and photographs this 13th Edition covers basic theory preliminary building design guidelines and detailed design procedure for buildings of all sizes It also provides information on the latest technologies emerging design trends and updated codes Presented in nine parts Mechanical and Electrical Equipment for Buildings Thirteenth Edition offers readers comprehensive coverage of environmental resources air quality thermal visual and acoustic comfort passive heating and cooling water design and supply daylighting and electric lighting liquid and solid waste and building noise control This book also presents the latest information on fire protection electrical systems and elevator and escalator systems This Thirteenth Edition features Over 2 200 illustrations with 200 new photographs and illustrations All new coverage of high performance building design Thoroughly revised references to codes and standards ASHRAE IES USGBC LEED Living Building Challenge WELL Building Standard and more Updated offering of best in class ancillary materials for students and instructors available via the book's companion website Architect Registration Examination ARE style study questions available in the instructor's manual and student guide Mechanical and Electrical Equipment for Buildings has been the industry standard reference that comprehensively covers all aspects of building systems for over 80 years This Thirteenth Edition has evolved to reflect the ever growing complexities of building design and has maintained its relevance by allowing for the conversation to include why as well as how to

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 Hydrogen Energy T. Veziroglu, 2012-12-06 There are three important problems facing the world depletion of fossil fuels demand for more energy and the pollution of our environment The world contains limited amounts of fossil fuels They are being depleted at an ever growing rate Peoples of the world are demanding more and more energy This is due to the desires of peoples to improve their standard of living and the standard of living is directly proportional to the energy consumed In addition the world is demanding a cleaner environment to live in Many of us scientists and engineers believe that replacing fossil fuels with the inexhaustible and clean synthetic fuel hydrogen produced from non fossil primary sources of energy will answer the above problems Hydrogen as the fuel of the post fossil fuel era was predicted more than a hundred years ago by that great forecaster of the future Jules Verne in his novel *The Mysterious Island* Water decomposed into its primitive elements and decomposed doubtless by electricity which will then have become a powerful and manageable force Yes my friends I believe that water will one day be employed as fuel that hydrogen and oxygen which constitute it used singly or together will furnish an inexhaustible source of heat and light of an intensity of which coal is not capable I believe then that when the deposits of coal are exhausted we shall heat and warm ourselves with water Water will be the coal of the future *Thermal Systems Design* Richard J. Martin, 2022-01-19 *Thermal Systems Design* Discover a project based approach to thermal systems design In the newly revised Second Edition of *Thermal Systems Design Fundamentals and Projects* accomplished engineer and educator Dr Richard J Martin offers senior undergraduate and graduate students an insightful exposure to real world design projects The author delivers a brief review of the laws of thermodynamics fluid mechanics heat transfer and combustion before moving on to a more expansive discussion of how to apply these fundamentals to design common thermal systems like boilers combustion turbines heat pumps and refrigeration systems The book includes design prompts for 14 real world projects teaching students and readers how to approach tasks like preparing Process Flow Diagrams and computing the thermodynamic details necessary to describe the states designated therein Readers will learn to size pipes ducts and major equipment and to prepare Piping and Instrumentation Diagrams that contain the instruments valves and control loops needed for automatic functioning of the system The Second Edition offers an updated look at the pedagogy of conservation equations new examples of fuel rich combustion and a new summary of techniques to mitigate against thermal expansion and shock Readers will also enjoy Thorough introductions to thermodynamics fluid mechanics and heat transfer including topics like the thermodynamics of state flow in porous media and radiant exchange A broad exploration of combustion fundamentals including pollutant formation and control combustion safety and simple tools for computing thermochemical equilibrium when product gases contain carbon monoxide and hydrogen Practical discussions of process flow diagrams including intelligent CAD equipment process lines valves and instruments and non engineering items In depth examinations of advanced thermodynamics including customized functions to compute thermodynamic properties of air combustion products water steam and ammonia right in the user's Excel

workbook Perfect for students and instructors in capstone design courses Thermal Systems Design Fundamentals and Projects is also a must read resource for mechanical and chemical engineering practitioners who are seeking to extend their engineering know how to a wide range of unfamiliar thermal systems *1995 ASHRAE Handbook* American Society of Heating, Refrigerating and Air-Conditioning Engineers,1995 *Clay's Handbook of Environmental Health* Stephen Battersby,2016-07-01 Clay s Handbook of Environmental Health since its first publication in 1933 has provided a definitive guide for the environmental health practitioner or reference for the consultant or student This 21th edition continues as a first point of reference reviewing the core principles techniques and competencies and then outlining the specialist subjects It has been refocused on the current curriculum of the UK s Chartered Institute of Environmental Health but should also readily suit the generalist or specialist working outside the UK **Energy: Management, Supply and Conservation** Clive Beggs,2012-06-25 With more and more concern being expressed over the Earth s dwindling energy resources as well as rising pollution levels the subject of energy management and conservation is becoming increasingly important Over half of all energy consumed is used in buildings so effective management of buildings whether commercial or domestic is vital This book is a comprehensive text dealing with the theory and practice of the supply of energy to consumers energy management and auditing and energy saving technology It will be a core text on courses on energy management and building services as well as updating professionals in the building sector **Radiant Heating and Cooling Handbook** Richard Watson,Kirby Chapman,2002-01-29 Design radiant heating and cooling systems with help from top experts The first and only professional guide of its kind Radiant Heating and Cooling Handbook is packed with tools that make the work of HVAC systems designers engineers and technicians go more smoothly and easily Relating heating and cooling theory to the principles of thermal comfort this expert handbook by pros Richard Watson and Kirby Chapman provides all the help you need to select design size and position the most popular and efficient systems for industrial commercial and residential applications You get Case studies that clarify application and installation of every system type Models for coupling radiant and forced air heating and cooling for the ultimate in comfortable energy saving interiors Examples and sample calculations to solve real world radiant heating and cooling problems in building contracting and engineering Equations strategies and analyses to help you set parameters from sizing and cost to human comfortability **Planning & Designing Health Care Facilities in Developing Countries** Shashikant Sharma,Saurabh Singh,2024-07-16 Building a clinically integrated workplace with a high level of clinical competence requires careful considerations of Hospital Planning For greenfield or brownfield hospital projects clinicians and C Suite executives need to acquire capabilities to address the planning needs of any organization This book aims to provide both theoretical and practical inputs for the Planning Designing of Health Care Facilities in Developing Countries It clearly indicates the steps to be followed facts to be weighed and components to be considered to arrive at a correct planning solution With health reform looming and the revenue base shifting rapidly we need to integrate patient

safety concerns in the design process Key Features Liberal use of tables and figures to support conclusions illustrate concepts and display quantitative information making it easier for readers to understand and refer to large quantities of data Integrates the international norms for planning and designing health care facilities into the developing country setting Handbook and ready reckoner for C Suite executives hospital engineers project consultants and hospital administration students

Advances in Solar Energy Technology H.P. Garg,2012-12-06 The purpose of writing this three volume Advances in Solar Energy Technology is to provide all the relevant latest information available in the field of Solar Energy Applied as well as Theoretical to serve as the best source material at one place Attempts are made to discuss topics in depth to assist both the students i e undergraduate postgraduate research scholars etc and the professionals i e Consultancy design and contracting firms Chapter 1 starts with a brief history of solar houses active heating one of the oldest and still the widely used application of Solar Energy Various methods of build ing heating and other general aspects such as building form and functions are also described Various components of active solar heating of building like solar collector storage system control unit auxiliary heat source etc are discussed very briefly Three types of solar active heating of buildings like Solar air systems solar liquid systems and solar assisted heat pump systems are discussed in detail in this chapter Design details and performance of nine typical solar houses which are in use in different climatic conditions and using some newer concepts are also discussed in depth in this chapter

Building Control Systems ,2000 Beginning with an overview of the benefits of the modern building control system the authors go on to describe the different controls and their applications and include advice on their set up and tuning for stable operation

Heat Transfer L.C. Wrobel,C.A. Brebbia,2016-11-21 No detailed description available for Heat Transfer

National Fire Codes National Fire Protection Association,1998

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vertebrate animal with a backbone what are four important characteristics common to most animals multicellular organization heterotrophy movement sexual reproduction and development how is cell specialization related to multicellularity

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animal tissues are commonly grouped into four main types epithelial connective muscle and nervous figure 32 2 as you read in unit five plants also have a hierarchical organization although plant anatomy and animal anatomy differ they are adapted to a shared set of challenges as shown in figure 32 3 concept 32 1 animal form and function

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1 which of the following statements accurately describes animals a all animals are multicellular all are heterotrophic and all lack cell walls b all animals are multicellular some are heterotrophic and some lack cell walls c some animals are multicellular all are heterotrophic and all lack cell walls d

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