

Industrial Gas Handbook Gas Separation And Purification

The author looks at the prospects for a transition from natural gas to low carbon gas, which could take several decades, and at how this will depend on the evolution of the fossil fuel industry. She investigates the technologies and energy systems for making the best use of renewable gas resources.

A landmark work covering the major aspects of the science, technology and application of membrane operations and related fields, from basic phenomena to the most advanced applications and future perspectives. Over 1500 concise entries in an A-Z format cover a vibrant field with a multitude of applications in diverse disciplines such as biotechnology, medicine, agro-food and petrochemical industries, environmental protection, as well as drinking water supply. Coverage includes membrane reactors and catalytic design (catalytic membrane reactors). Practically all unit operations of process engineering can be redesigned as membrane unit operations (e. g. membrane distillation, membrane crystallization, membrane stripping, membrane scrubbing). Entries are provided by an international team of experts from academia, research institutions as well as from industry.

Industrial gases are inextricably woven into the fabric of modern manufacturing. From the primary extraction of raw materials, through their intermediate processing to manufacture metals, chemicals and ceramics, to the fabrication of sophisticated industrial, consumer and food products, gases are used across the whole spectrum of industry. The isolation, manufacture and supply of these gases is a major industry in itself; the 300 million tones of gas used each year generates sales in excess of \$20 billion. In terms of tonnage, nitrogen has become the most used industrial gas, finding applications across the whole range of industry. It is still manufactured by liquifying and then distilling air, but as applications develop and demand increases, newer methods of isolation, such as pressure swing absorption and membrane separation will become important. This new book introduces the main industrial gases and the gases industry, it discusses the main technologies for their isolation, separation, manufacture and handling. In addition, the book contains an overview of the main applications of industrial gases and a brief discussion of new production processes and applications. Chemists, chemical engineers, physicists and technologists involved in the research and development, production or utilisation of industrial gases will find this concise book an essential and accessible reference source. For advanced students of these disciplines, the book provides a fascinating overview of this important industry.

This giant reference, sponsored by the American Gas Association and written by a staff of 150 specialists, answers any general or specific engineering information requirement in regard to natural, liquefied petroleum, and manufactured gases. It presents in concise, orderly fashion all "working" facts and data on fuel gases needed by engineers, industry, and government personnel. The Handbook brings together in one volume and 125 chapters all conceivable engineering methods and operating data of the entire gas industry, from source to burner. Tables, graphs, charts, equations, and illustrations clarify and illuminate a text that is crammed with the kind of information that is virtually unobtainable elsewhere.

Membranes already have important applications in artificial organs, the processing of biotechnological products, food manufacture, waste water treatment, and seawater

desalination. Their uses in gaseous mixture separations are, however, far from achieving their full potential. Separation of air components, natural gas dehumidification and sweetening, separation and recovery of CO₂ from biogas, and H₂ from refinery gases are all examples of current industrial applications. The use of membranes for reducing the greenhouse effect and improving energy efficiency has also been suggested. New process intensification strategies in the petrochemical industry have opened up another growth area for gas separation membrane systems and membrane reactors. This two volume set presents the state-of-the-art in membrane engineering for the separation of gases. It addresses future developments in carbon capture and utilization, H₂ production and purification, and O₂/N₂ separation. Topics covered include the: applications of membrane gas separation in the petrochemical industry; implementation of membrane processes for post-combustion capture; commercial applications of membranes in gas separations; simulation of membrane systems for CO₂ capture; design and development of membrane reactors for industrial applications; Pd-based membranes in hydrogen production; modelling and simulation of membrane reactors for hydrogen production and purification; novel hybrid membrane/pressure swing adsorption process for gas separation; molecular dynamics as a new tool for membrane design, and physical aging of membranes for gas separations. Volume 2 looks at problems combined with membrane reactors.

Supplemented with over 200 helpful illustrations, this book offers an exposition of the chemical natures of hypothetical black box membranes and those of specific polymers. Chemical structure at the functional group level is considered as the synthesis of steric and polar factors.

It is estimated that a large fraction of natural gas reserves are found in locations from where transport is not economical. If these isolated natural gas reserves could be converted to synthetic fuels, they would generate around 250 billion barrels of synthetic oil—a quantity equal to one-third of the Middle East's proven oil reserves. Small-Scale Gas to Liquid Fuel Synthesis explores next-generation technologies geared toward overcoming the significant cost and technical barriers prohibiting the extensive use of conventional gas to liquid (GTL) processes for the exploitation of small and/or isolated natural gas reservoirs. The book highlights key research activities in the framework of two large European projects—Innovative Catalytic Technologies & Materials for Next Gas to Liquid Processes (NEXT-GTL) and Oxidative Coupling of Methane followed by Oligomerization to Liquids (OCMOL)—examining novel technical developments that reduce the costs associated with air fractioning and syngas production. Featuring contributions from internationally respected experts, Small-Scale Gas to Liquid Fuel Synthesis discusses innovative GTL technologies based on recent advances in catalytic membrane systems, reaction engineering, and process design. The book provides academic and industrial researchers with a concise presentation of the current state of the art of low-cost, energy-efficient GTL technologies for small-scale applications.

This book describes the tremendous progress that has been made in the development of gas separation membranes based both on inorganic and polymeric materials. Materials discussed include polymer inclusion membranes (PIMs), metal organic frameworks (MOFs), carbon based materials, zeolites, as well as other materials, and mixed matrix membranes (MMMs) in which the above novel materials are incorporated.

This broad survey of gas membranes covers material, theory, modeling, preparation, characterization (for example, by AFM, IR, XRD, ESR, Positron annihilation spectroscopy), tailoring of membranes, membrane module and system design, and applications. The book is concluded with some perspectives about the future direction of the field.

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Liquefied natural gas (LNG) is a commercially attractive phase of the commodity that facilitates the efficient handling and transportation of natural gas around the world. The LNG industry, using technologies proven over decades of development, continues to expand its markets, diversify its supply chains and increase its share of the global natural gas trade. The Handbook of Liquefied Natural Gas is a timely book as the industry is currently developing new large sources of supply and the technologies have evolved in recent years to enable offshore infrastructure to develop and handle resources in more remote and harsher environments. It is the only book of its kind, covering the many aspects of the LNG supply chain from liquefaction to regasification by addressing the LNG industries' fundamentals and markets, as well as detailed engineering and design principles. A unique, well-documented, and forward-thinking work, this reference book provides an ideal platform for scientists, engineers, and other professionals involved in the LNG industry to gain a better understanding of the key basic and advanced topics relevant to LNG projects in operation and/or in planning and development. Highlights the developments in the natural gas liquefaction industries and the challenges in meeting environmental regulations Provides guidelines in utilizing the full potential of LNG assets Offers advices on LNG plant design and operation based on proven practices and design experience Emphasizes technology selection and innovation with focus on a "fit-for-purpose design Updates code and regulation, safety, and security requirements for LNG applications

Gibbs' Entropic Paradox and Problems of Separation Processes reviews the so-called Gibb's Paradox observed during the mixing of two systems. During the last 150 years, many physicists and specialists in thermodynamics, statistical and quantum mechanics been engaged in the solution of the Gibbs paradox. Many books and journal articles have written on this topic, but a widely accepted answer is still lacking. In this book, the author reviews and analyzes all this data. Based on findings, the book formulates a different approach to this paradox and substantiates it on the basis of physical and statistical principles. The book clearly shows that entropy consists of two parts, static and dynamic. Up to now, entropy has been connected only with the process dynamics. However, the Gibbs paradox is caused by the change in the static component of entropy. Finally, the book includes examples of separation processes and how to optimize them in various fields, including biology, cosmology, crystallography and the social sciences. Provides a precise definition of entropy and allows the formulation of criteria for optimization of separation processes Explains the role of entropy in many processes, facilitating an in-depth analysis and understanding of complicated systems and processes Provides solutions to scientific and applied problems in various scientific disciplines related to separation processes Elucidates entropy's role in many separation systems

Offers detailed coverage of the perochemical applications of large-volume industrial gases. The text examines the factors that influence the cost of producing and delivering

gases and the economic reasons for choosing specific manufacturing methods. It emphasizes the commercial areas that employ industrial gases as feedstocks. Natural gas has become the world's primary supply of energy in the last decades. It is naturally occurring from the decomposition of organic materials, over the past 150 million years ago, into hydrocarbons. It is considered one of the most useful energy sources and the fastest growing energy source in the world. This book presents state-of-the-art advances in natural gas emerging technologies. It contains ten chapters divided into three sections that cover natural gas technology, utilization, and alternative. Processes for clearing gases from dust in wet-type dust separators are widely applied in many industries for technological purposes and environmental control. Among goals of these processes is to ensure high efficiency of dust removal with minimum energy costs. This book presents the newest scientific research data under the theory and practice of wet clearing of industrial gases from dispersion particles. The authors consider the modern aspects of the separation process and gas-dispersed impurities. The book covers three main sections on working out and research of the following types of wet gas purifiers: dynamic scrubbers, wet gas clean apparatuses of shock-inertial act, and bubble dust traps. Each section considers the engineering and technological aspects of circuit design, including the theoretical fundamentals of process of gas cleaning, trial and error methods and calculation of apparatuses of wet gas cleaning, and construction of new gas clean apparatuses, their operational characteristics, and recommendations about application. In the literature there are no reliable methods of efficient clearing of gas emissions in scrubbers. This creates complexities at calculation and designing of these apparatuses and also complicates process intensification. The authors develop methods of calculation of process of gas cleaning on the basis of studying of hydrodynamic characteristics of apparatuses. The Handbook of Membrane Separations: Chemical, Pharmaceutical, and Biotechnological Applications provides detailed information on membrane separation technologies as they have evolved over the past decades. To provide a basic understanding of membrane technology, this book documents the developments dealing with these technologies. It explores chemical, pharmaceutical, food processing and biotechnological applications of membrane processes ranging from selective separation to solvent and material recovery. This text also presents in-depth knowledge of membrane separation mechanisms, transport models, membrane permeability computations, membrane types and modules, as well as membrane reactors. The conventional approach for energy saving in a process system is to maximize heat recovery without changing any process conditions by using pinch technology. "Self-heat recuperation technology" was developed to achieve further energy saving in the process system by eliminating the necessity for any external heat input, such as firing or imported steam. Advanced Energy Saving and its Applications in Industry introduces the concept of self-heat recuperation and the application of such technology to a wide range of processes from heavy chemical complexes to other processes such as drying and gas separation processes, which require heating and cooling during operation. Conventional energy saving items in a utility system are applied and implemented based on a single site approach, however, when looking at heavy chemical complexes, it was apparent that the low-grade heat discharged as waste from a refinery could also be used in an adjacent petrochemical plant. There could therefore be a large energy

saving potential by utilizing the surplus heat across the sites. *Advanced Energy Saving and its Applications in Industry* assesses conventional approaches to industrial energy saving and explains and outlines new methods to provide even greater energy saving potential. *Advanced Energy Saving and its Applications in Industry* provides a key resource and research tool for all those involved in developing the energy efficiency of industrial processes. Researchers, industry professionals and even students with an interest in green engineering will find the summaries of the conventional and suggested new methods useful when attempting to advance further development within this field. Written by an internationally-recognized team of natural gas industry experts, the fourth edition of *Handbook of Natural Gas Transmission and Processing* is a unique, well-researched, and comprehensive work on the design and operation aspects of natural gas transmission and processing. Six new chapters have been added to include detailed discussion of the thermodynamic and energy efficiency of relevant processes, and recent developments in treating super-rich gas, high CO₂ content gas, and high nitrogen content gas with other contaminants. The new material describes technologies for processing today's unconventional gases, providing a fresh approach in solving today's gas processing challenges including greenhouse gas emissions. The updated edition is an excellent platform for gas processors and educators to understand the basic principles and innovative designs necessary to meet today's environmental and sustainability requirement while delivering acceptable project economics. Covers all technical and operational aspects of natural gas transmission and processing. Provides pivotal updates on the latest technologies, applications, and solutions. Helps to understand today's natural gas resources, and the best gas processing technologies. Offers design optimization and advice on the design and operation of gas plants.

Almost every modern manufacturing process relies on industrial gases, and sales of such gases are expected to rise by around 45% over the next five years. Here, experienced and authoritative experts from one of the two world's largest producer of industrial gases impart their knowledge on atmospheric, noble and synthesized gases, carbon dioxide, LNG, acetylene and other fuel gases, as well as special and medical gases. Modern applications, e.g., the use of hydrogen in fuel cells, are included as well. This practical text is rounded off by a section on logistics.

A guide to membrane separation based on a variety of porous materials with promising separation applications *Microporous Materials for Separation Membranes* offers an in-depth guide that explores microporous materials? potential for membrane applications. The authors?two experts on the topic?examine a wide range of porous materials that have application potential including: microporous silica, porous carbons, zeolites, metal-organic frameworks (MOFs), and porous organic frameworks (POFs). Comprehensive in scope, the book covers a broad range of topics on membrane separations such as: hydrogen recovery, carbon dioxide capture, air purification, hydrocarbon

separation, pervaporation, and water treatment. In addition, this up-to-date resource explores the most recent materials for preparing microporous membranes and explores the most promising applications for industrial use. This important book:

- Examines the use of microporous materials as membranes to perform with different gases and liquids
- Offers an overview of the basic knowledge of membrane separation and an intense examination of separations
- Describes the state-of-the-art of membrane separation with porous materials
- Highlights the most promising applications of industrial interest

Written for scientists working in the fields of membranes, gas and liquid, *Microporous Materials for Separation Membranes* offers a valuable guide to the potential of microporous materials for membrane applications.

Gas Separation by Adsorption Processes provides a thorough discussion of the advancement in gas adsorption process. The book is comprised of eight chapters that emphasize the fundamentals concept and principles. The text first covers the adsorbents and adsorption isotherms, and then proceeds to detailing the equilibrium adsorption of gas mixtures. Next, the book covers rate processes in adsorbers and adsorber dynamics. The next chapter discusses cyclic gas separation processes, and the remaining two chapters cover pressure-swing adsorption. The book will be of great use to students, researchers, and practitioners of disciplines that involve gas separation processes, such as chemical engineering.

An international and interdisciplinary team of leading experts from both academia and industry report on the wide range of hot applications for MOFs, discussing both the advantages and limits of the material. The resulting overview covers everything from catalysis, H₂ and CH₄ storage and gas purification to drug delivery and sensors. From the Contents:

- Design of Porous Coordination Polymers/Metal-Organic Frameworks: Past, Present and Future
- Design of Functional Metal-Organic Frameworks by Post-Synthetic Modification
- Thermodynamic Methods for Prediction of Gas Separation in Flexible Frameworks
- Separation and purification of gases by MOFs
- Opportunities for MOFs in CO₂ capture from flue gases, natural gas and syngas by adsorption
- Manufacture of MOF thin films on structured supports for separation and catalysis
- Research status of Metal-Organic Frameworks for on-board cryo-adsorptive hydrogen storage applications
- Separation of xylene isomers
- Metal-Organic Frameworks as Catalysts for Organic Reactions
- Biomedical applications of Metal Organic Frameworks
- Metal Organic Frameworks for Biomedical Imaging
- Luminescent Metal-Organic Frameworks
- Deposition of thin films for sensor applications
- Industrial MOF Synthesis
- MOF shaping and immobilisation

A must-have for every scientist in the field.

The development of a new class of nanocomposite membranes has served as one of the most prominent strategies to address the intrinsic limitations of conventionally used polymeric and inorganic membranes. Nanocomposite membranes consist of nanosized inorganic nanomaterials that are incorporated

into the structure of continuous polymer matrices. Owing to the exceptional properties exhibited by the nanomaterials, the resultant nanocomposite membranes demonstrate higher selectivity and permeability that surpass the Robeson upper boundary limit. *Nanocomposite Membranes for Gas Separation* provides a comprehensive review of the advances made in the development and application of gas separation nanocomposite membranes. In particular, the book covers the focuses on the fabrication, modification, characterization and applications of nanocomposite membranes for gas separation. It is an important reference source both for materials scientists, environmental engineers and chemical engineers who are looking to understand how nanocomposite membranes are being used to create better techniques for gas separation. Provides detailed insights in the fabrication, modification, characterization and applications of nanocomposite membranes for gas separation Shows how nanotechnology is being used to address current limitations of the development of polymeric and inorganic membranes for gas separation, including low separation performance in terms of permeability and selectivity Explores the potential of nanocomposite membranes to help create more effective gas separation techniques

Gas separation membranes offer a number of benefits over other separation technologies, and they play an increasingly important role in reducing the environmental impacts and costs of many industrial processes. This book describes recent and emerging results in membrane gas separation, including highlights of nanoscience and technology, novel polymeric and inorganic membrane materials, new membrane approaches to solve environmental problems e.g. greenhouse gases, aspects of membrane engineering, and recent achievements in industrial gas separation. It includes: Hyperbranched polyimides, amorphous glassy polymers and perfluorinated copolymers Nanocomposite (mixed matrix) membranes Polymeric magnetic membranes Sequestration of CO₂ to reduce global warming Industrial applications of gas separation Developed from sessions of the most recent International Congress on Membranes and Membrane Processes, *Membrane Gas Separation* gives a snapshot of the current situation, and presents both fundamental results and applied achievements.

Can hydrogen and electricity supply all of the world's energy needs? *Handbook of Hydrogen Energy* thoroughly explores the notion of a hydrogen economy and addresses this question. The handbook considers hydrogen and electricity as a permanent energy system and provides factual information based on science. The text focuses on a large cross section o

Volume 1 deals with the origins of process gases and describes recovery, properties and composition. It covers as well the shale gas, the production from hydrocarbon rich deep shale formations, being one of the most quickly expanding trends in onshore domestic gas exploration. Vol. 2: *Composition and Processing of Gas Streams*. Vol. 3: *Uses of Gas and Effects*.

This book covers properties, processing, and applications of conducting polymers. It discusses properties and characterization, including photophysics and transport. It then moves to processing and morphology of conducting polymers, covering such topics as printing, thermal processing, morphology evolution, conducting polymer composites, thin films

In the last 10 years there have been major advances in fundamental understanding and applications and a vast portfolio of new polymer structures with unique and tailored properties was developed. Work moved from a chemical repeat unit structure to one more based on structural control, new polymerization methodologies, properties, processing, and applications. The 4th Edition takes this into account and will be completely rewritten and reorganized, focusing on spin coating, spray coating, blade/slot die coating, layer-by-layer assembly, and fiber spinning methods; property characterizations of redox, interfacial, electrical, and optical phenomena; and commercial applications.

Volume 1 of a 4-volume series is a concise, authoritative and an eminently readable and enjoyable experience related to hydrogen production, storage and usage for portable and stationary power. Although the major focus is on hydrogen, discussion of fossil fuels and nuclear power is also presented where appropriate. This monograph is written by recognized experts in the field, and is both timely and appropriate as this decade will see application of hydrogen as an energy carrier, for example in transportation sector. The world's reliance on fossil fuels is due to the ever growing need for energy to sustain life and on-going progress; however exploitation also brings consequences such as emission of carbon, nitrogen and sulfur dioxides into the atmosphere. The collective influence of these photochemical gases is production of acid rain and an alternation of global temperatures, leading to record high temperatures in many parts of the world. The fossil fuel is unsustainable and thus there is a critical need for alternative sustainable energy resources. One universal energy carrier is hydrogen, which is the focus of this volume. This book is suitable for those who work in the energy field as technical experts, including engineers and scientists, as well as managers, policy and decision-makers, environmentalists and consultants. Students and practitioners such as lectures, teachers, legislators and their aids in the field of energy will find this book invaluable and a practical handbook or guide in the field of sustainable energy with emphasis on hydrogen as an energy carrier.

Offers a comprehensive overview of membrane science and technology from a single source Written by a renowned author with more than 40 years' experience in membrane science and technology, and polymer science Covers all major current applications of membrane technology in two definitive volumes Includes academic analyses, applications and practical problems for each existing membrane technology Includes novel applications such as membrane reactors, hybrid systems and optical resolution as well as membrane fuel cells

Polymeric Gas Separation Membranes is an outstanding reference devoted to

discussing the separation of gases by membranes. An international team of contributors examines the latest findings of membrane science and practical applications and explores the complete spectrum of relevant topics from fundamentals of gas sorption and diffusion in polymers to vapor separation from air. They also compare membrane processes with other separation technologies. This essential book will be valuable to all practitioners and students in membrane science and technology.

Drawing on Frank G. Kerry's more than 60 years of experience as a practicing engineer, the *Industrial Gas Handbook: Gas Separation and Purification* provides from-the-trenches advice that helps practicing engineers master and advance in the field. It offers detailed discussions and up-to-date approaches to process cycles for cryogenic separation of air, adsorption processes for front-end air purification, and related process control and instrumentation. The book uses SI units in accordance with international industry and covers topics such as chronological development, industrial applications, air separation technologies, noble gases, front end purification systems, insulation, non-cryogenic separation, safety, cleaning for oxygen systems, economics, and product liquefaction, storage, and transportation. No other book currently available takes the practical approach of this book — they are either outdated, too theoretical, or narrow in focus. In a clear and effective presentation, *Industrial Gas Handbook: Gas Separation and Purification* covers the principles and applications of industrial gas separation and purification.

Handbook of Natural Gas Transmission and Processing gives engineers and managers complete coverage of natural gas transmission and processing in the most rapidly growing sector to the petroleum industry. The authors provide a unique discussion of new technologies that are energy efficient and environmentally appealing at the same time. It is an invaluable reference on natural gas engineering and the latest techniques for all engineers and managers moving to natural gas processing as well as those currently working on natural gas projects. Provides practicing engineers critical information on all aspects of gas gathering, processing and transmission First book that treats multiphase flow transmission in great detail Examines natural gas energy costs and pricing with the aim of delivering on the goals of efficiency, quality and profit

This manual contains necessary and useful information and data in an easily accessible format relating to the use of membranes. Membranes are among the most important engineering components in use today, and each year more and more effective uses for membrane technologies are found - for example: water purification, industrial effluent treatment, solvent dehydration by per-vaporation, recovery of volatile organic compounds, protein recovery, bioseparations and many others. The pace of change in the membrane industry has been accelerating rapidly in recent years, occasioned in part by the demand of end-users, but also as a result of the investment in R&D by manufacturers. To reflect these changes the author has obtained the latest information from some of the leading suppliers in the business. In one complete volume this unique handbook gives practical guidance to using selected membrane processes in individual

industries while also providing a useful guide to equipment selection and usage. The monograph consists of ten chapters, with three basic themes. First, gas-separation technology is introduced and the sources and uses of industrial gases are described. The second part includes a description of those industries which use gas separation and an analysis of the gas-separation processes themselves. The last part describes the plant hardware and its design.

Liquid-Gas and Solid-Gas Separators, part of the Industrial Equipment for Chemical Engineering set, details the magnetic properties of solids and their separation in a magnetic field. After a thorough description of the electronic filter and its functioning, numerical examples are given for the functioning of Venturi (which is a convergent–divergent). The centrifugal separator with superimposed plates theory is also developed alongside the screw-mud-pump. The author also provides the methods needed for understanding the equipment used in applied thermodynamics in the hope of encouraging students and engineers to self build the programs they need. Chapters are complemented with appendices that provide additional information and associated references. Presents a comprehensive example of a real-world simulation of a venturi Examines a centrifugal decanter designed to separate the components of a liquid–solid Details the magnetic properties of solids and their separation in a magnetic field To address the issue of discharge of untreated industrial effluent in the water body causing pollution, adoption of cleaner production technologies and waste minimization initiatives are being encouraged. The book explains each related technology elaborately and critically analyses the same from practical application point of view. In-depth characterization, environmental and health effects and treatment of various industrial effluents are discussed with case studies. Limitations, challenges and remedial actions to be taken are included at the end of each chapter. Chapters are arranged as per specific type of effluents from various industries like textile, tannery/leather plant, and oil refinery.

Solid—Gas Separation presents a brief and highly technical account of the principles and technology of gas-cleaning. The book deals with three associated aspects of gas-cleaning: the relevant dimensionless groups, the efficiency of separation and the economics of gas cleaning. The text begins with the discussion of the principles of particle separation and classification of equipment; general characteristics of equipment; and dimensionless groups for modeling and equipment scale-up.

Subsequent chapters are devoted to the examination of the efficiency of separation, aero-mechanical dry separators, scrubbers, electrostatic precipitators, and filters. The last chapter deals with the economics of gas-cleaning equipment selection.

Environmental and industrial engineers will find the text very useful.

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