

Basic principles of vacuum technology, brief overview

1 Introduction

Basic principles of vacuum technology

What is a vacuum?

A vacuum is a space entirely devoid of matter ("absolute vacuum"). In practice we talk about a vacuum when the air pressure in a space lies below atmospheric pressure.

Vacuum ranges



Units of measurement

There are a large number of national and international units of measurement. The most commonly used units are Pascal (Pa) and bar.

- 100 Pa = 1 hPa
- 1 hPa = 1 mbar
- 1 mbar = 0.001 bar

The vacuum level is often expressed as a % value. However, these are always relative values.

- 0% = Rough vacuum
- 1% = Medium vacuum
- 10% = High vacuum
- 99% = Ultra-high vacuum

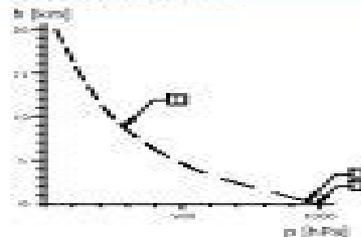
What is a vacuum used for?

The vacuum plays a vital role in research in the fields of chemistry, biology and physics. It is also indispensable in many industrial processes.

Measuring the pressure of vacuum

In the rough vacuum range, the pressure gauges used are mainly mechanical, but some digital pressure gauges are also used. In the high and ultra-high vacuum range, highly sensitive pressure gauges are used.

Atmospheric pressure



- 1. Mount Everest
- 2. Festo
- 3. Sea level

Understanding vacuum

Air is a gas mixture with gases. 10^{25} particles per m^3 of air at one bar air pressure.

Particles exert pressure or force on the walls of a defined space. The fewer particles there are in the space, the lower the force exerted on the walls.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

100% vacuum would mean that there are no particles present. Pressure = 0.

Vacuum specification options

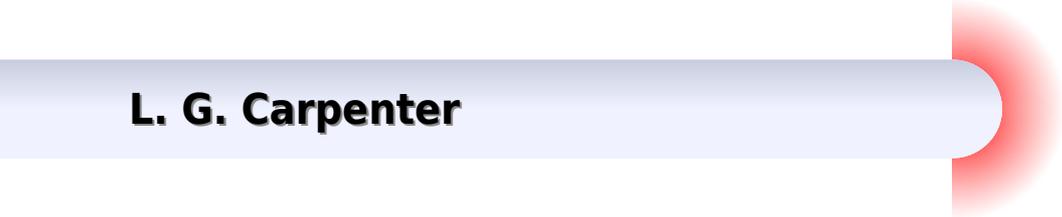
A vacuum can be specified as an absolute value, i.e. with a positive sign from 1 to 0 bar, with 0 as absolute zero. Or it can be specified as a relative value with a negative sign from 0 to -1 bar, with 0 as a reference point, or as a %.

Effects of changes on vacuum technology

As altitude increases, the air pressure in the atmosphere falls. This same effect reduces the attainable vacuum level of an ejector. Nevertheless, the performance level of 80% remains unchanged in this case.

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L. G. Carpenter



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pressure On earth we typically create a vacuum by connecting a pump capable of moving gas to a relatively leak free vessel Through operation of the gas pump the number of gas molecules per unit volume is decreased within the vessel As soon as one creates a vacuum natural forces in this case entropy work to restore equilibrium pressure the practical effect of this is that gas molecules attempt to enter the evacuated space by any means possible It is useful to think of vacuum in terms of a gas at a pressure below atmospheric pressure In even the best vacuum vessels ever created there are approximately 3 500 000 molecules of gas per cubic meter of volume remaining inside the vessel The lowest pressure environment known is in interstellar space where there are approximately four molecules of gas per cubic meter Researchers are currently developing vacuum technology components pumps gauges valves etc using micro electro mechanical systems MEMS technology Miniature vacuum components and systems will open the possibility for significant savings in energy cost and will open the doors to advances in electronics manufacturing and semiconductor fabrication In conclusion an understanding of the basic principles of vacuum technology as presented in this summary is essential for the successful execution of all projects that involve vacuum technology Using the principles described above a practitioner of vacuum technology can design a vacuum system that will achieve the project requirements

Industrial Vacuum 101 - Second Edition Dan Bott,2011-10-01 The first of a three part series designed to highlight the principles of Vacuum Science and Technology This book is written for those who are new to vacuum and covers many of the topics that are used in industrial rough vacuum applications such as pressure conversions flow conversions pumpdown of closed systems vacuum technologies filtration and vacuum piping Readers will gain a working fluency of the words terms and concepts used in sizing and applying vacuum pumps to industrial and manufacturing processes In addition this book provides tips on the application and installation of vacuum pump accessories This book is complete with a glossary of common terms and a chapter dedicated to sample problems on major topics

Basic Vacuum Technology, 2nd edition A. Chambers,1998-01-01 Vacuum technology is widely used in many manufacturing and developmental processes and its applications grow in scope and sophistication It is an inter disciplinary subject embracing aspects of mechanical electrical and chemical engineering chemistry and materials science while having a broad foundation in physics In spite of its technological importance and perhaps because of its cross disciplinary nature substantial teaching and training is not widely available Basic Vacuum Technology aims to give readers a firm foundation of fundamental knowledge about the subject and the ability to apply it This book is an introductory text on how to use vacuum techniques It provides a good grounding in the basic scientific principles and concepts that underlie the production and measurement of vacua The authors describe how these are applied in representative low medium high and ultra high vacuum systems and explain the most important practical aspects of the operation of a large variety of pumps components and measuring instrumentation The book introduces numerical methods for analysis and prediction of the behavior of vacuum systems in terms of the properties of their individual elements and enables readers to recognize and resolve problems with

malfunctioning systems

Overview of Vacuum Technology Timothy A. Gessert, 2021 *Overview of Vacuum Technology* provides the reader a broad treatment of typical systems and components used in the critical field of vacuum technology. It demonstrates where and why certain vacuum components are used in this rapidly evolving area of science. It develops the reader's understanding of how to effectively establish vacuum equipment that will meet both their present and near future needs. This important reference offers guidance on costs of ownership concerns for initial purchase and other less understood costs related to operation and maintenance. This foundation will allow technologists and researchers to acquire vacuum equipment capable of producing a required level of reproducibility as well as maintain the vacuum equipment within the research and production budgets. This important book provides definitions and use cases, principles and key applications, procedures and data evaluation. Discusses the development of gas laws, the transport of gas molecules and vacuum chamber outgassing. Presents descriptions and selection advice for critical components such as gauges, pumps, valves, chambers, feedthroughs and flanges. Scientists, engineers and technologists in semiconductor electronics, photovoltaics, energy and materials science will find this an invaluable reference. Educators and researchers interested in vacuum technology will also find this book a useful resource.

A User's Guide to Vacuum Technology John F. O'Hanlon, Timothy A. Gessert, 2023-10-16 *A USER'S GUIDE TO VACUUM TECHNOLOGY* Choose and understand the vacuum technology that fits your project's needs with this indispensable guide. Vacuum technology is used to provide process environments for other kinds of engineering technology, making it an unsung cornerstone of hundreds of projects incorporating analysis, research and development, manufacturing and more. Since it is very often a secondary technology, users primarily interested in processes incorporating it will frequently only encounter vacuum technology when purchasing or troubleshooting. There is an urgent need for a guide to vacuum technology made with these users in mind. For decades *A User's Guide to Vacuum Technology* has met this need with a user-focused introduction to vacuum technology as it is incorporated into semiconductor, optics, solar cell and other engineering processes. With an emphasis on otherwise neglected subjects and on accessibility to the secondary user of vacuum technology, it balances treatment of older systems that are still in use with a survey of the latest cutting edge technologies. The result promises to continue as the essential guide to vacuum systems. Readers of the fourth edition of *A User's Guide to Vacuum Technology* will also find expanded treatment of gauges, pumps, materials, systems and best operating practices. Detailed discussion of cutting edge topics like ultraclean vacuum and contamination control. An authorial team with decades of combined research and engineering experience. *A User's Guide to Vacuum Technology* is essential for those entering emerging STEM programs, engineering professionals and graduate students working with a huge range of engineering technologies.

Fundamentals of Vacuum Science and System Design for High and Ultrahigh Vacuum, Volume 1 J.R. Gaines, Matthew Healy, 2024-10-17 *Fundamentals of Vacuum Science and System Design for High and Ultrahigh Vacuum Volume 1* Introduction to Vacuum and Systems details the important practical considerations in design of

vacuum systems for various vacuum deposition technologies Topics covered include an introduction to vacuum and end uses molecular density in vacuum molecular flow in various vacuum regimes characteristics of gas composition at various molecular densities general principles of gas solid interactions vacuum pump technology pressure sensors leak detection and the impact of fundamental design decisions and operating practices on vacuum system performance The introductory sections are designed to introduce the reader to basic concepts in vacuum technology More detailed sections provide fundamental descriptions of basic vacuum pumps and pumping mechanisms in current practice and provides insight into the various pros and cons for each approach System design assembly maintenance and trouble shooting are reviewed in detail The book also describes a wide range of pressure measurement approaches and includes several key characterization techniques example applications on systems for rough vacuum high vacuum and ultrahigh vacuum as well as trade offs in system design These perspectives will allow the reader to develop an understanding of all the elements required for a successfully designed assembled and operating system Covers vacuum pump technology taking a system from atmosphere down to high or ultra high vacuum Discusses the fundamental descriptions of vacuum pumps and pumping mechanisms in current practice and provides insight into the various pros and cons for each approach Provides an overview of practical vacuum system operating techniques that will ensure optimal performance and troubleshooting methods to identify system deficiencies

Basic Vacuum Technology A. Chambers,1989 *High-Vacuum Technology* Marsbed H. Hablanian,2017-11-13 Offering a basic understanding of each important topic in vacuum science and technology this book concentrates on pumping issues emphasizes the behavior of vacuum pumps and vacuum systems and explains the relationships between pumps instrumentation and high vacuum system performance The book delineates the technical and theoretical aspects of the subject without getting in too deep It leads readers through the subtleties of vacuum technology without using a dissertation on mathematics to get them there An interesting blend of easy to understand technician level information combined with engineering data and formulae the book provides a non analytical introduction to high vacuum technology *Vacuum Technology: an Introduction* L. G. Carpenter,1970 [Vacuum Technology](#) Alexander Roth,1976 [Vacuum Technology](#) L. G. Carpenter,1983-01-01 **Vacuum Technology** David J Hucknall,Alan Morris,2007-10-31 An accessible and applicable guide to quantitative problem solving in vacuum technology this book is aimed at newcomers students and the experienced practitioner It contains essential information and worked examples for those using vacuum technology in chemical applications and who are involved in the design and operation of vacuum equipment Using step by step solutions of example calculations and formulae Vacuum Technology Calculations in Chemistry sets out to encourage readers to quantify their own systems so that they can ensure efficient operation and fault finding Whilst emphasising the use of appropriate units in calculations and using well known expressions in vacuum technology throughout the book includes formulae necessary for quantitative vacuum technology commonly required data for common gases in tabulated form

schematic diagrams of systems and layouts This book is certain to be a confidence inspiring publication for use in both research and industry

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