

# Solar Air Systems A Design Handbook Solar Air Systems Series

*Compressors and Compressed Air Systems Best Practices for Compressed Air Systems Unmanned Combat Air Systems Control Systems for Heating, Ventilating, and Air Conditioning Solar Air Systems - Built Examples Improving Compressed Air System Performance Solar Air Systems Solar Air Systems Air Conditioning Principles and Systems Air Conditioning Principles and Systems Heating, Ventilating, Air Conditioning & Dehumidifying Systems Technical Manual HVAC Principles and Systems Commercial Energy Auditing Reference Handbook, Third Edition Principles of Heating, Ventilation, and Air Conditioning in Buildings Integration of Air Conditioning and Heating into Modern Power Systems Plant Equipment & Maintenance Engineering Handbook Cool Air-conditioning America Air Conditioning and Refrigeration Repair Audel Air Conditioning Air Conditioning and Refrigeration Engineering An Introduction to Compressed Air Systems Proceedings of the 11th International Symposium on Heating, Ventilation and Air Conditioning (ISHVAC 2019) Automatic Controls for Heating and Air Conditioning Today's Technician: Automotive Heating & Air Conditioning Classroom Manual and Shop Manual, Spiral bound Version Air conditioning and Refrigeration Repair Made Easy Principles of Heating, Ventilation and Air Conditioning with Worked Examples Sustainable Air Conditioning Systems Air Conditioning Electrical Control Systems for Heating and Air Conditioning Air Conditioning System Design Air Conditioning Refrigerating Data Book HVAC Control in the New Millennium Desiccant Heating, Ventilating, and Air-Conditioning Systems Air Conditioning Systems Air Conditioning Principles And Systems: An Energy Approach 4Th Ed. Rebuilding Hermetic Units for Refrigeration and Air Conditioning Systems Modern Architecture and Climate Audel HVAC Fundamentals, Volume 3*

Eventually, you will entirely discover a supplementary experience and endowment by spending more cash. still when? pull off you acknowledge that you require to get those all needs once having significantly cash? Why dont you try to acquire something basic in the beginning? Thats something that will lead you to comprehend even more nearly the globe, experience, some places, in the same way as history, amusement, and a lot more?

It is your no question own grow old to show reviewing habit. along with guides you could enjoy now is **Solar Air Systems A Design Handbook Solar Air Systems Series** below.

**Unmanned Combat Air Systems** Sep 02 2022 The U.S. Navy's Unmanned Combat Air System aircraft currently in development will transform naval aviation, extending its reach while dramatically reducing its cost, according to naval weapons expert Norman Friedman. In this his latest weapons book, he describes the new X-47B and shows how these new aircraft offer tactics that manned aircraft cannot duplicate. He calls

the X-47B a natural extension of the evolving networked form of drone warfare that can be used for a variety of missions, including intelligence, surveillance and reconnaissance, and time sensitive targeting. Friedman makes the important point that an unmanned attack aircraft can also be seen as an extension of some current missiles that interact with remote human controllers. The book includes an extensive appendix describing the world's military unmanned aircraft.

**Proceedings of the 11th International Symposium on Heating, Ventilation and Air Conditioning (ISHVAC 2019)** Nov 11 2020 This book presents selected papers from the 11th International Symposium on Heating, Ventilation and Air Conditioning (ISHVAC 2019), with a focus on HVAC techniques for improving indoor environment quality and the energy efficiency of heating and cooling systems. Presenting inspiration for implementing more efficient and safer HVAC systems, the book is a valuable resource for academic researchers, engineers in industry, and government regulators.

**An Introduction to Compressed Air Systems** Dec 13 2020 This publication provides introductory technical guidance for mechanical engineers and other professional engineers and construction managers interested in compressed air systems. Here is what is discussed: 1. INTRODUCTION, 2. AIR INTAKE, 3. AIR COMPRESSORS, 4. AIR DISCHARGE PIPE, 5. AFTERCOOLERS AND SEPARATORS, 6. AIR DRYER, 7. AIR RECEIVER, 8. PIPING, 9. GENERAL DESIGN AND EQUIPMENT SCHEDULES, 10. REFERENCES.

**Air Conditioning Principles and Systems** Feb 24 2022 This is a new edition of the standard air conditioning installation/service text, emphasizing energy conservation. It contains new material on heating and computer programs, and new load calculation problems. The book provides thorough coverage of the fundamentals of air conditioning, explains relationships of theory to design of new systems, and discusses troubleshooting of existing systems. Air conditioning and refrigeration equipment and systems, and refrigeration absorption systems and heat pumps are all covered. Computer programs for load estimating are also described, and there are many illustrative examples of real-world situations. The text is consistent with all ASHRAE load estimating guidelines.

[Today's Technician: Automotive Heating & Air Conditioning Classroom Manual and Shop Manual, Spiral bound Version](#) Sep 09 2020 Updated to reflect the latest trends, technology, and relevant ASE Education Foundation standards, this integrated, two-book set covers theory and hands-on content in separate Classroom and Shop Manuals. This

innovative approach allows students to learn fundamental climate control theory, including basic physics related to heat transfer, before applying their knowledge through practical, hands-on shop work. Cross-references in each manual link related material, making it easy to connect classroom learning to lab and shop activity. Important Notice: Media content referenced within the product description or the product text may not be available in the ebook version.

**Principles of Heating, Ventilation and Air Conditioning with Worked Examples** Jul 08 2020 "This book presents the most current design procedures in heating, ventilation and air conditioning (HVAC), available in handbooks, like the ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) Handbook-2013 Fundamentals, in a way that is easier for students to understand. Every effort is made to explain in detail the fundamental physical principles that form the basis of the various design procedures. A novel feature of the book is the inclusion of about 15 worked examples in each chapter, carefully chosen to highlight the diverse aspects of HVAC design. The solutions for the worked examples clarify the physical principles behind the design method. In addition, there are problems at the end of each chapter for which numerical answers are provided. The book includes a series of MATLAB programs that may be used to solve realistic HVAC design problems, which in general, require extensive and repetitive calculations."--

**Modern Architecture and Climate** Jul 28 2019 How climate influenced the design strategies of modernist architects Modern Architecture and Climate explores how leading architects of the twentieth century incorporated climate-mediating strategies into their designs, and shows how regional approaches to climate adaptability were essential to the development of modern architecture. Focusing on the period surrounding World War II—before fossil-fuel powered air-conditioning became widely available—Daniel Barber brings to light a vibrant and dynamic architectural discussion involving design, materials, and shading systems as means of interior climate control. He looks at projects by well-known architects such as Richard Neutra, Le Corbusier,

Lúcio Costa, Mies van der Rohe, and Skidmore, Owings, and Merrill, and the work of climate-focused architects such as MMM Roberto, Olgyay and Olgyay, and Cliff May. Drawing on the editorial projects of James Marston Fitch, Elizabeth Gordon, and others, he demonstrates how images and diagrams produced by architects helped conceptualize climate knowledge, alongside the work of meteorologists, physicists, engineers, and social scientists. Barber describes how this novel type of environmental media catalyzed new ways of thinking about climate and architectural design. Extensively illustrated with archival material, *Modern Architecture and Climate* provides global perspectives on modern architecture and its evolving relationship with a changing climate, showcasing designs from Latin America, Europe, the United States, the Middle East, and Africa. This timely and important book reconciles the cultural dynamism of architecture with the material realities of ever-increasing carbon emissions from the mechanical cooling systems of buildings, and offers a historical foundation for today's zero-carbon design.

### **Heating, Ventilating, Air Conditioning & Dehumidifying Systems**

Dec 25 2021

[Plant Equipment & Maintenance Engineering Handbook](#) Jun 18 2021 The Best On-the-Job Guide to Industrial Plant Equipment and Systems This practical, one-of-a-kind field manual explains how equipment in industrial facilities operates and covers all aspects of commissioning relevant to engineers and project managers. *Plant Equipment and Maintenance Engineering Handbook* contains a data log of all major industrial and power plant components, describes how they function, and includes rules of thumb for operation. Hundreds of handy reference materials, such as calculations and tables, plus a comprehensive listing of electrical parts with common supplier nomenclature are also included in this time-saving resource. FEATURES DETAILED COVERAGE OF: Compressors \* Air conditioning \* Ash handling \* Bearings and lubrication \* Boilers \* Chemical cleaning and Flushing \* Condensers and circulating water systems \* Controls \* Conveyor systems \* Cooling towers \* Corrosion Deaerators \* Diesel and gas turbines \* Electrical \* Fans \* Fire protection

\* Fuels and combustion \* Piping \* Pumps Turbines \* Vibration \* Water treatment

*Commercial Energy Auditing Reference Handbook, Third Edition* Sep 21 2021 Designed to serve as a comprehensive resource for performing energy audits in commercial facilities, this revised practical desk reference for energy engineers has been updated and expanded. All focal areas of the building energy audit and assessment are covered, with new chapters on water efficiency and feedback and behavior in energy management. Updated topics include compressed air, computer modeling, data center efficiency, measurement and verification, lighting, laundries, HVAC economizer savings and building vacancy along with manufacturing unit operations and calculating savings from automatic controls.

*Solar Air Systems* Mar 28 2022 Active solar systems for air heating are a straightforward yet effective way of using solar energy for space heating and tempering ventilation air. They offer some unique advantages over solar water systems, can offer improved comfort and fuller use of solar gains than passive solar systems and are a natural fit with mechanically ventilated buildings. They can be economical, with short pay-back periods and can act not only as space heating or ventilation air heating but also for water pre-heating, sunshading, electricity generation (with hybrid photovoltaic systems) and can help induce cooling. This design handbook takes architects and building engineers through the process of designing and selecting an active solar system from the six types presented, optimizing the system using nomograms and curves, and finally dimensioning the components of the system. Tips are offered regarding the construction and how to avoid problems. The book will provide essential design information for all architects, building engineers and other building design professionals and all those concerned to reduce the environmental impact of buildings.

**HVAC Control in the New Millennium** Jan 02 2020 Advances in personal computer control and sensor technology are leading the advances in building controls as we enter the new millennium. Pushing the technology are potentially high reductions in operating costs from

increased operational efficiency. Building conditioning now accounts for about 20% of the total energy consumed in the U.S., so computer-optimized HVAC systems can make a major contribution in reducing our national energy use. This book examines how the latest advances in distributed technology will be used in commercial systems. Topics include the full scope of current and emerging HVAC control technologies, covering personal computer-based systems, expert systems, fiber optic infrared technologies, wireless communication, self-optimizing software sensors, micro technology, distributed direct digital control, control bus techniques and more.

**Air Conditioning System Design** Mar 04 2020 Air Conditioning System Design summarizes essential theory and then explains how the latest air conditioning technology operates. Load calculations, energy efficiency, and selection of technology are all explained in the context of air conditioning as a system, helping the reader fully consider the implications of design decisions. Whether users need to figure out how to apply their mechanical engineering degree to an air conditioning design task or simply want to find out more about air conditioning technology for a research project, this book provides a perfect guide. Approaches air conditioning as a system, not just a collection of machines Covers the essential theory on fluid flow and the latest in A/C technology in a very readable and easy-to-use style Explains the significance of factors, such as climate and thermal comfort as A/C design considerations Addresses design using a range of air conditioning technologies, such as evaporative cooling, VRF systems, psychromatic software, and dessicant dehumidification

**Solar Air Systems - Built Examples** Jun 30 2022 Thirty-five different buildings with successfully installed solar air systems are described and documented. The building types cover single family houses, apartment buildings, schools, sports halls, and industrial commercial buildings with six different configurations of solar air systems used. Each example building is described over several pages, with plans, performance details and illustrations provided. This is supplemented by a summary of the types of system used.

**Solar Air Systems** Apr 28 2022 First Published in 2000. Routledge is an imprint of Taylor & Francis, an informa company.

**Technical Manual** Nov 23 2021 Published By Direction Of The Commander, Naval Air Systems Command.

**Integration of Air Conditioning and Heating into Modern Power Systems** Jul 20 2021 This book focuses on the integration of air conditioning and heating as a form of demand response into modern power system operation and planning. It presents an in-depth study on air conditioner aggregation, and examines various models of air conditioner aggregation and corresponding control methods in detail. Moreover, the book offers a comprehensive and systematic treatment of incorporating flexible heating demand into integrated energy systems, making it particularly well suited for readers who are interested in learning about methods and solutions for demand response in smart grids. It offers a valuable resource for researchers, engineers, and graduate students in the fields of electrical and electronic engineering, control engineering, and computer engineering.

**Control Systems for Heating, Ventilating, and Air Conditioning** Aug 01 2022 Control Systems for Heating, Ventilating and Air Conditioning, Sixth Edition is complete and covers both hardware control systems and modern control technology. The material is presented without bias and without prejudice toward particular hardware or software. Readers with an engineering degree will be reminded of the psychrometric processes associated with heating and air conditioning as they learn of the various controls schemes used in the variety of heating and air conditioning system types they will encountered in the field. Maintenance technicians will also find the book useful because it describes various control hardware and control strategies that were used in the past and are prevalent in most existing heating and air conditioning systems. Designers of new systems will find the fundamentals described in this book to be a useful starting point, and they will also benefit from descriptions of new digital technologies and energy management systems. This technology is found in modern building HVAC system designs.

Air Conditioning May 06 2020 This expanded edition of David Chadderton's *Air Conditioning* is a textbook for undergraduate courses in building services and environmental engineering, and for BTEC continuing education diploma, higher national diploma and certificate courses in building services engineering. It will also be of considerable help to students on national certificate and diploma programmes. The book includes a new chapter on application of fans to air duct systems.

*Desiccant Heating, Ventilating, and Air-Conditioning Systems* Dec 01 2019 This book presents the necessary fundamental knowledge in the research, development, design, selection, and application of desiccant heating, ventilating, and air-conditioning systems. It covers the established installations in different climatic conditions and building types. In addition, advanced performance evaluation techniques are presented, covering thermodynamic, economic, and environmental aspects. Hence, the book is an important resource for undergraduate and graduate students, design and installation engineers, researchers and scientists, building owners and occupants, and energy and environmental policy makers.

**Automatic Controls for Heating and Air Conditioning** Oct 11 2020 International Series in Heating and Ventilation, Volume 15: Automatic Controls for Heating and Air Conditioning: Principles and Applications details the relationship between theory and practice in implementing an automated system for thermal regulation. The title first deals with the sensors and methods for quantifying the two variables mainly of interest in building services systems, temperature and humidity. Next, the selection covers the application of controls to a number of specific areas of building environmental services. The text also discusses controller mechanisms and circuits, along with controller characteristics. The fifth chapter deals with basic theory of linear automatic control, while the sixth chapter talks about the analysis of non-linear systems. The book will be of great interest to engineers and technicians who deal with cooling and heating systems.

**Air Conditioning Principles and Systems** Jan 26 2022 Using a minimum of mathematics, this book explores the fundamental concepts

of air conditioning and their application to systems—explaining all concepts in a clear, practical manner, and focusing on problems and examples typically encountered on the job. This book contains the most recent and industry-wide accepted information on load calculations, design data, equipment information, and use of the Internet. Specific chapter topics cover the scope and uses of air conditioning; physical principles; heating loads; furnaces and boilers; hydronic piping systems and terminal units; cooling load calculations; psychrometrics; fluid flow in piping and ducts; piping, valves, ducts, and insulation; fans and air distribution devices; centrifugal pumps, expansion tanks, and venting; air conditioning systems and equipment; refrigeration systems and equipment; automatic controls; energy utilization and conservation; instrumentation, testing, and balancing; and planning and designing the HVAC system; and solar heating and cooling systems. For consulting engineers, mechanical contractors, HVAC engineers, designers, project managers, and facilities managers.

Air Conditioning and Refrigeration Engineering Jan 14 2021 An air conditioning system consists of components and equipment arranged in sequential order to control and maintain an indoor environment. The goal is to provide a healthy and comfortable climate with acceptable air quality while being energy efficient and cost effective. *Air Conditioning and Refrigeration Engineering* covers all types of systems from institutional and commercial to residential. The book supplies the basics of design, from selecting the optimum system and equipment to preparing the drawings and specifications. It discusses the four phases of preparing a project: gathering information, developing alternatives, evaluating alternatives, and selling the best solution. In addition, the author breaks down the responsibilities of the engineer, design documents, computer aided design, and government codes and standards. *Air Conditioning and Refrigeration Engineering* provides you with an easy reference to all aspects of the topic. This resource addresses the most current areas of interest, such as computer-aided design and drafting, desiccant air conditioning and energy conservation. It is a thorough and convenient guide to air conditioning and

refrigeration engineering.

Improving Compressed Air System Performance May 30 2022

**Rebuilding Hermetic Units for Refrigeration and Air Conditioning Systems** Aug 28 2019

*Best Practices for Compressed Air Systems* Oct 03 2022 A "how-to"

reference to help compressed air users and service providers improve the operating efficiencies and reliability of their air compressor and compressed air systems. The manual contains more than 300 pages original text, reference appendices, photos, and performance data.

Cool May 18 2021 "[A] history of air conditioning, chronicling the numerous gimmicks, failed attempts, con jobs, and eventual successes . .

. . a surprisingly interesting journey." —San Francisco Book Review The air conditioner is often hailed as one of the modern world's greatest inventions—yet nearly as often blamed for global disaster. It has changed everything from architecture to people's food habits; saved countless lives, and caused countless deaths. First appearing in 1902, when Willis Carrier, an engineer barely out of college, developed the "Apparatus for Treating Air," everyone assumed it would instantly change the world. But the story of air conditioning and its rise to ubiquity is far from simple. In *Cool*, Salvatore Basile tracks two fascinating stories: the struggle to perfect an effective cooling device, and the effort to convince people that they actually needed such a thing. With a cast of characters ranging from Leonardo da Vinci to Richard Nixon and Felix the Cat, *Cool* showcases the myriad reactions to air conditioning as it was developed and introduced to the world. Here is a unique perspective on a common convenience: how we came to rely on it today, and how it might change radically tomorrow.

**Principles of Heating, Ventilation, and Air Conditioning in**

**Buildings** Aug 21 2021 Heating Ventilation and Air Conditioning by J. W. Mitchell and J. E. Braun provides foundational knowledge for the behavior and analysis of HVAC systems and related devices. The emphasis of this text is on the application of engineering principles that features tight integration of physical descriptions with a software program that allows performance to be directly calculated, with results

that provide insight into actual behavior. Furthermore, the text offers more examples, end-of-chapter problems, and design projects that represent situations an engineer might face in practice and are selected to illustrate the complex and integrated nature of an HVAC system or piece of equipment.

*Air-conditioning America* Apr 16 2021 Cooper demonstrates how the lure of the open air, from rooftop schoolrooms to open-air theaters to the front porch, challenged air conditioning. Americans were slow to give up the social rituals of hot-weather living - the cold drink, the cool clothes, the summer vacation - for the comforts of either the window air conditioner or the central system.

*Air Conditioning Refrigerating Data Book* Feb 01 2020

*Air Conditioning Principles And Systems: An Energy Approach 4Th Ed.* Sep 29 2019

AudelAir Conditioning Feb 12 2021 *Air Conditioning: Home and Commercial* is a reference for the installation, operation, and servicing of air conditioning equipment. Topics covered include the fundamental of air conditioning, refrigerants, compressors, condensers, evaporators, control methods, psychrometry, heat leakage, and ventilation requirements, and there is an emphasis on electric motors and controls. *Compressors and Compressed Air Systems* Nov 04 2022 Compressed air has many applications in industry. Delivering compressed air to a manufacturing facility is an expensive operation and it requires costly equipment that consumes significant amounts of electricity and needs frequent maintenance. Roughly 80 to 90 percent of the electricity used to operate compressed air systems is converted to low-temperature waste heat. This lost energy can quickly add up, each year costing individual facilities as much as double the purchase and installation cost (first-cost) of the entire system. The ideal time to think about your compressed air system is before it is installed. Air Compressors deserve independent treatment due to many reasons. There is a wider choice of different types of compressor designs each operating at different efficiencies and suitable for specific application. The type of compressor decided upon has direct implications on the lifetime energy costs. Also the decision as

to a single compressor of large capacity versus multi-compressor installation where each compressor has a smaller capacity than the demand influences the possible energy savings considerably. This 6 -hour Quick Book Course provides comprehensive information on the compressed air systems. This course is relevant to anyone needing to know more about compressed air production and use, relevant health and safety issues, legislation and energy efficiency. Previous knowledge of the subject is not required. The book includes a multiple type quiz comprising 30 questions at the end. Learning Objective At the conclusion of this course, the student will:

- \* Understand various types of compressors; their applications, advantages and limitations;
- \* Understand various types of system controls - their pros and cons;
- \* Understand how the control systems are matched to the needs of the users;
- \* Understand the key components of compressed air system and learn how each component function;
- \* Understand the air storage, air drying, piping, filtration and air cleaning methods;
- \* Understand the limits of dew point suppression in refrigerant and desiccant dryers;
- \* Understand the different types of filters and how coalescing filters benefit in removal of lubricant and moisture;
- \* Understand the difference between SCFM, ICFM and ACFM;
- \* Understand the pros and cons of single loop verses ring main systems;
- \* Understand how to quantify and select appropriate compressor for base and trim demand;
- \* Understand what features to specify and what information to seek when making a compressed air proposal;
- \* Understand the compressed air system assessment procedure and energy audit methodology;
- \* Understand the common losses in compressed air systems and the ways to conserve energy;
- \* Understand the routine maintenance schedule for air compressors;
- \* Learn a generic checklist for energy efficiency in compressed air system;
- \* Understand the engineering formulae and technical relationship between compressor motor power-draw and process variables; and
- \* Learn by example the method for evaluating compressed air costs.

**Air conditioning and Refrigeration Repair Made Easy** Aug 09 2020

This comprehensive book has been developed to quickly train an average

person for the vast commercial and residential refrigeration and air-conditioning market within a short period of time. It provides all the technical knowledge needed to start a successful refrigeration and air-conditioning business anywhere in the world.

**Sustainable Air Conditioning Systems** Jun 06 2020 Air conditioning system is one of the major consumers of electrical energy in many parts of the world today. It represents between 40 and 70% of the energy consumption in commercial buildings. The demand of energy for air conditioning systems is expected to increase further in the next decades due to the population growth, the new economic boom, and the urbanization development. The rapid growth of air conditioning and electricity consumption will contribute further to climate change if fossil and nonrenewable resources are used. More energy-efficient and renewable energy-based air conditioning systems to accomplish space cooling are needed. This book intends to provide the reader with a comprehensive overview of the current state of the art in sustainable air conditioning technologies and focus on the most recent research and development on green air conditioning systems including energy-efficient and renewable energy-based air conditioning systems.

**Air Conditioning and Refrigeration Repair** Mar 16 2021 Discusses preventive maintenance, and troubleshooting

**HVAC Principles and Systems** Oct 23 2021 HVAC - Heating, Ventilation and Air conditioning systems and applications are used everyday by a substantial population in developed and developing countries. Apparently most of the users are not aware of the types and the concepts of these systems. Perhaps many of them feel that there is no need to understand the concepts and applications. However, students/ Technicians and others who would like to learn and deal with the systems need an introductory level book, that would initiate them into this field. This book is planned to include fundamental concepts of HVAC systems and hopefully meet the expectations of students aspiring to learn in general about these systems.

**Air Conditioning Systems** Oct 30 2019 Based on the Air Conditioning Institute Curriculum Guide, this book provides practical information to

supplement and advance skills of the entry-level technician. It focuses on air conditioning systems and the components that make up these systems, while emphasizing information that will be useful to the service technician. The material presented here stresses the competency-based educational approach, preparing readers to exhibit learned skills in several different ways, and put information into practice so that it is useful and maintained. Chapter topics include extensive information on charging procedures; electrical and refrigerant-side troubleshooting; safety and the refrigeration cycle; preventive maintenance; and industry certification. A useful source of knowledge for entry-level technicians and experienced professionals in the air conditioning field.

*Audel HVAC Fundamentals, Volume 3* Jun 26 2019 Keep it cool or heat things up This third volume of Audel's HVAC Library gives you a comprehensive, hands-on guide to installing, servicing, and repairing all basic air-conditioning systems in both new and older construction. You'll

also find complete coverage of specialized heating units-radiators, radiant heating systems, stoves, fireplaces, heat pumps, and indoor/outdoor pool heaters, plus fans, exhaust systems, air filters, and more. It's what you need to complete your HVAC reference library. \* Make accurate calculations for AC system output \* Tailor AC systems for older construction \* Learn to install and service today's popular electronic air cleaners and filters \* Service less common heating systems such as coal-fired furnaces \* Install, maintain, and repair humidifiers and dehumidifiers \* Handle radiators, convectors, and baseboard heating units

**Electrical Control Systems for Heating and Air Conditioning** Apr 04 2020 The purpose of this text is to provide the environmental control professional with a clear understanding of the operation of electrical and electronic components and systems that are utilized in control functions.