

IMPORTANT FORMULAS FOR HVAC ENGINEERS

SENSIBLE COOLING LOAD

$$Q_s (\text{Kw}) = 1.2 \times \dot{m}_w (\text{m}^3/\text{s}) \times \Delta T (\text{°C})$$

$$Q_s (\text{Btu/hr}) = 1.075 \times \dot{m}_w (\text{cfm}) \times \Delta T (\text{°F})$$

LATENT COOLING LOAD

$$Q_l (\text{Kw}) = 2963.6 \times \dot{m}_w (\text{m}^3/\text{s}) \times \Delta x (\text{Kg/Kg})$$

$$Q_l (\text{Btu/hr}) = 4770 \times \dot{m}_w (\text{cfm}) \times \Delta x (\text{lb/lb})$$

TOTAL COOLING LOAD

$$Q_t (\text{Kw}) = 1.2 \times \dot{m}_w (\text{m}^3/\text{s}) \times \Delta H (\text{KJ/Kg})$$

$$Q_t (\text{Btu/hr}) = 4.5 \times \dot{m}_w (\text{cfm}) \times \Delta H (\text{Btu/lb})$$

$$Q_t = Q_s + Q_l$$

SENSIBLE HEAT LOAD OF WALLS

$$Q_s (\text{W}) = A (\text{m}^2) \times U (\text{W/m}^2 \cdot \text{°K}) \times \Delta T (\text{°C})$$

$$Q_s (\text{Btu/hr}) = A (\text{ft}^2) \times U (\text{Btu/hr} \cdot \text{ft}^2 \cdot \text{°F}) \times \Delta T (\text{°F})$$

CHILLED WATER FLOW

$$\dot{m}_w (\text{L/s}) = \frac{Q_t (\text{Kw})}{4.1855 \times \Delta T (\text{°C})}$$

$$\dot{m}_w (\text{GPM}) = \frac{Q_t (\text{Ton}) \times 24}{\Delta T (\text{°F})}$$

For $\Delta T = 16 \text{ °F} = 9 \text{ °C}$

$$\dot{m}_w (\text{GPM}) = Q_t (\text{Ton}) \times 1.5$$

For $\Delta T = 10 \text{ °F} = 5.5 \text{ °C}$

$$\dot{m}_w (\text{GPM}) = Q_t (\text{Ton}) \times 2.4$$

EXHAUST AIR FLOW

$$\dot{m}_w (\text{L/s}) = \frac{V(\text{m}^3) \times ACH (\text{/hr})}{3.6}$$

$$\dot{m}_w (\text{cfm}) = \frac{V(\text{ft}^3) \times ACH (\text{/hr})}{60}$$

DUCT SIZING

$$Q (\text{m}^3/\text{s}) = A (\text{m}^2) \times v (\text{m/s})$$

$$Q (\text{cfm}) = A (\text{ft}^2) \times v (\text{fpm})$$

Rectangular area : $A = W \times H$

Circular area : $A = 3.14 \times R^2$

LOUVERS SIZING

$$Q (\text{m}^3/\text{s}) = F.A. \times A (\text{m}^2) \times v (\text{m/s})$$

$$Q (\text{cfm}) = F.A. \times A (\text{ft}^2) \times v (\text{fpm})$$

Recommended v_{max} for sand trap louvers : $v_{max} = 1 \text{ m/s}$ or 200 fpm

Recommended v_{max} for exhaust louvers: $v_{max} = 2.5 \text{ m/s}$ or 500 fpm

Legend: Q_s =Sensible cooling load ; Q_l =Latent cooling load ; Q_t =Total cooling load ; \dot{m}_w =Volumetric flow ; ΔT =Temperature difference ; Δx =Humidity difference ; ΔH =Enthalpy difference ; A =Area ; U =Thermal transmittance; v =Velocity ; W =Width ; H =Height ; R =Radius ; $F.A.$ =Free area rate ; Q =Air volumetric flow ; V =Volume ; ACH =Air change per hour

Hvac Equations Cheat Sheet

ML Morrison

Hvac Equations Cheat Sheet:

HVAC Formulas and Equations Builder's Book Inc., 2007-04-16

American Book Publishing Record, 1999

HVAC Equations, Data, and Rules of Thumb, 2008

HVAC Equations, Data, and Rules of Thumb, 2nd Ed. Arthur Bell, 2007-09-26

The Latest Information and Tricks of the Trade for Achieving First Rate HVAC Designs on Any Construction Job HVAC Equations Data and Rules of Thumb presents a wealth of state of the art HVAC design information and guidance ranging from air distribution to piping systems to plant equipment This popular reference has now been fully updated to reflect the construction industry's new single body of codes and standards Featuring an outline format for ease of use the Second Edition of this all in one sourcebook contains Updated HVAC codes and standards including the 2006 International Building Code Over 200 equations for everything from ductwork to air handling systems ASME and ASHRAE code specifications Over 350 rules of thumb for cooling heating ventilation and more New material including coverage of the new single body of construction codes now used throughout the country Inside This Updated HVAC Design Guide Definitions Equations Rules of Thumb for Cooling Heating Infiltration Ventilation Humidification People Occupancy Lighting and Appliance Equipment Cooling Load Factors Heating Load Factors Design Conditions and Energy Conservation HVAC System Selection Criteria Air Distribution Systems Piping Systems General Hydronic Glycol Steam Steam Condensate AC Condensate Refrigerant Central Plant Equipment Air Handling Units Chillers Boilers Cooling Towers Heat Exchangers Auxiliary Equipment Fans Pumps Motors Controllers Variable Frequency Drives Filters Insulation Fire Stopping Automatic Controls Building Automation Systems Equipment Schedules Equipment Manufacturers Building Construction Business Fundamentals Architectural Structural and Electrical Information Conversion Factors Properties of Air and Water Designer's Checklist Professional Societies and Trade Organizations References and Design Manuals Cleanroom Criteria and Standards

Restaurant Business, 1984 *HVAC Tables, Equations and Rules of Thumb Quick-Card*, 2015-10-22 HVAC Tables Equations Rules of Thumb Quick CardThis 6 page guide provides the basic numbers flow rates and formulas the plumber and mechanics needs based on 2015 International Mechanical Code IMC ASHRAE SMACNAFeatures Cooling Load Factors Cooling Towers Condensers Air Conditioning Heating Load Systems Factors Heat Exchanger Boilers Boilers Steam Piping Systems Humidification Ventilation Air Distribution Systems Ductwork Fans Energy Efficiency Conversions Occupancy Factors Publisher Edition Builder's Book Inc 10 22 2015 ISBN 10 1622701275 ISBN 13 9781622701278 **HVAC Equations, Data, and Rules of Thumb, Third Edition** Arthur A. Bell, W. Larsen Angel, 2015-12-22 This comprehensive volume often called the HVAC bible has been thoroughly updated to cover the latest code changes equipment and techniques HVAC Equations Data and Rules of Thumb 3e offers all of the information an HVAC student or professional needs in one resource The book thoroughly explains the expansion of piping systems and temperature limitations of new materials such as polyethylene polypropylene PVC CPVC and PEX Detailed information is included for all types of facilities including offices hotels hospitals

restaurants commercial spaces and computer rooms This practical handbook reflects all the latest code changes including the ASHRAE standards and explains how to interpret and put them to use It includes completely updated coverage of new pumps chillers air handling units cooling equipment boilers and pipe material You will get complete coverage of sustainability organizations that have become more important since last edition including LEED USGBC Energy Star Features hundreds of equations and rules for everything from ductwork to air handling systems Includes a brand new chapter on sound vibration and acoustics Contains an updated list of equipment manufacturers for all products featured

HVAC Equations, Data, and Rules of Thumb, 2nd Ed. Arthur Bell, 2007-10-14 The Latest Information and Tricks of the Trade for Achieving First Rate HVAC Designs on Any Construction Job HVAC Equations Data and Rules of Thumb presents a wealth of state of the art HVAC design information and guidance ranging from air distribution to piping systems to plant equipment This popular reference has now been fully updated to reflect the construction industry's new single body of codes and standards Featuring an outline format for ease of use the Second Edition of this all in one sourcebook contains Updated HVAC codes and standards including the 2006 International Building Code Over 200 equations for everything from ductwork to air handling systems ASME and ASHRAE code specifications Over 350 rules of thumb for cooling heating ventilation and more New material including coverage of the new single body of construction codes now used throughout the country Inside This Updated HVAC Design Guide Definitions Equations Rules of Thumb for Cooling Heating Infiltration Ventilation Humidification People Occupancy Lighting and Appliance Equipment Cooling Load Factors Heating Load Factors Design Conditions and Energy Conservation HVAC System Selection Criteria Air Distribution Systems Piping Systems General Hydronic Glycol Steam Condensate AC Condensate Refrigerant Central Plant Equipment Air Handling Units Chillers Boilers Cooling Towers Heat Exchangers Auxiliary Equipment Fans Pumps Motors Controllers Variable Frequency Drives Filters Insulation Fire Stopping Automatic Controls Building Automation Systems Equipment Schedules Equipment Manufacturers Building Construction Business Fundamentals Architectural Structural and Electrical Information Conversion Factors Properties of Air and Water Designer's Checklist Professional Societies and Trade Organizations References and Design Manuals Cleanroom Criteria and Standards **Common HVAC Formulas** Charles Nehme, Welcome to the world of HVAC formulas Whether you're a seasoned professional or just starting out understanding the fundamental formulas is crucial for navigating the complexities of heating ventilation and air conditioning systems This book aims to be your comprehensive guide providing clear explanations practical applications and valuable resources to help you excel in the field Why are formulas important in HVAC Formulas are the language of HVAC They enable you to Design and size equipment Accurately calculate the capacity and performance requirements of heating and cooling systems for various spaces Troubleshoot problems Analyze system performance and diagnose issues by comparing calculated values with actual measurements Optimize efficiency Ensure your system operates at its peak efficiency minimizing energy consumption and

costs. Maintain comfort. Design and operate systems that deliver the desired temperature and humidity levels contributing to a comfortable and healthy indoor environment. This book is not just a collection of formulas. It delves into the underlying principles behind them, aiding comprehension and application in real world situations. You'll find clear explanations. Each formula is presented with a breakdown of its components, simplifying understanding even for those unfamiliar with the technical jargon. Step by step examples. Practical examples guide you through the application of formulas, allowing you to build confidence and problem solving skills. Real world scenarios. The book incorporates scenarios you might encounter in the field, showcasing how formulas are used to solve practical problems. Essential resources. A comprehensive list of resources at the end provides additional information and tools to further your knowledge. Whether you're an engineer, technician, contractor, or simply interested in understanding your own HVAC system, this book is designed to empower you with the knowledge and skills you need to succeed. Let's embark on this journey together and unlock the power of HVAC formulas.

4090 Sheet Metal / HVAC Pro Calc Calculator Calculated Industries, 2021-08-15 The Sheet Metal HVAC Pro Calc is a versatile calculator that enables tradesmen to calculate complex problems with dedicated key functions that are labeled in standard industry terms. The calculator has other advanced built in construction math functions to enable HVAC and sheet metal tradesmen to do their work alongside other trades. In addition to the built in functions this calculator can handle order of operation using the parenthesis operators. It can also perform square, cube, square root and cube root calculations. Plus it works as a regular calculator with typical symbols. The calculator can be used to determine ArcK constant for convenient Arc length solutions. And it has an offset functions for S shaped bends in ductwork. It can also help solve the layout for wrapper length, centerline radius and the angle. Features CUSTOM HVAC velocity and velocity pressure FPM VP MPS KPa. ArcK constant for convenient Arc length solutions and offset functions. FUNCTIONS AND TERMINOLOGY consistent with sheet metal and HVAC trade terminology. x y r radius theta and Seg Radius functions works in and converts between feet, inch fractions, decimal feet and inches and metric. also converts between polar and rectangular coordinates. PARENTHESES OPERATORS allows you to easily enter complex formulas. order of operations calculations retain familiar mathematical hierarchy as a default preference. trigonometric operation and sequence and you can calculate square, square root, cube and cube root easy non 90 triangles and right angle solutions for ductwork length and angles. MEMORY STORAGE conveniently stores frequently used constants or interim solutions. Memory swap lets you easily insert stored values into current calculations and simultaneously store calculated values while recalling and displaying Memory contents. other settable User Preferences. INVALUABLE TRADE TOOL PAYS FOR ITSELF by reducing headaches, saving time and preventing expensive material errors on all your projects. Comes with a rugged shock, dust and moisture resistant Armadillo Gear protective case, quick reference guide and complete user's guide, a long life battery and a one year limited warranty.

HVAC Procedures and Forms Manual Herbert Wendes, 2002 Developed over the course of many years of on the job projects involving HVAC

energy auditing testing balancing and cost estimating and refined through feedback from thousands of engineers and technicians who have used them the forms contained in this manual are concise comprehensive and optimally organized for easy reference Complete sets of forms are provided for all aspects of testing and balancing energy auditing indoor quality diagnosis and load calculations The first edition entitled HVAC Energy Audit Balancing Forms Manual compiled these time saving forms for the first time in a single reference This enhanced second edition adds a new chapter on technical management providing procedures for achieving thorough systematic and accurate problem solving troubleshooting and decision making in building systems management and contracting [HVAC: the Handbook of Heating, Ventilation and Air Conditioning for Design and Implementation + 4090 Sheet Metal / HVAC Pro Calc Calculator \(Set\)](#) Ali Vedavarz, Sunil Kumar, Muhammed Iqbal Hussain, Calculated Industries, 2021-08-15 With over 1 000 pages covering all fundamental and practical HVAC design procedures and methods this classic reference contains a wealth of information that is of great use to the HVAC designer and practitioner as well as to the student mastering the intricacies of HVAC fundamentals Unlike any other handbook of its kind HVAC provides an in depth treatment of topics via modular self contained chapters that serve both as a manual for the experienced professional and as a fundamental reference for others Each self contained chapter places emphasis on graphical and tabular presentations of data that are useful for easy understanding of fundamentals and solving problems of design installation and operation You are sure to find everything you need right here in one complete volume The Sheet Metal HVAC Pro Calc is a versatile calculator that enables tradesmen to calculate complex problems with dedicated key functions that are labeled in standard industry terms The calculator has other advanced built in construction math functions to enable HVAC and sheet metal tradesmen to do their work alongside other trades In addition to the built in functions this calculator can handle order of operation perform square cube square root and cube root calculations determine ArcK constant for convenient Arc length solutions and has an offset functions for S shaped bends in ductwork It can also help solve the layout for wrapper length centerline radius and the angle It works as a regular calculator with typical symbols Together HVAC The Handbook of Heating Ventilation and Air Conditioning for Design and Implementation and the Sheet Metal HVAC Pro Calculator are the perfect combination resource providing instant access to metrics and measurements with the flip of a page and press of a button This incredible set is a must have for students and professionals in the HVAC field Features in Print and Calculator Bell and Gossett ESP PLUS software provides calculations for the selection of equipment such as hydraulic pumps heat exchangers and hydronic and steam system components It also helps select commercially available equipment and components Trane Load 700 heating and cooling load calculation software allows the user to use detailed geometric weather and exposure parameters to accurately estimate load during the heating and cooling cycles Primarily uses U S customary units but also uses both SI and U S units in some cases Custom HVAC and Sheet Metal functions let you simplify Test and Balance TAB with built in Fan Law function CFM RPM SP and BHP velocity

and velocity pressure Functions and Terminology consistent with sheet metal and HVAC trade terminology Parenthesis Operator allows you to easily enter complex formulas Memory Storage conveniently stores frequently used constants or interim solutions **HVAC Procedures & Forms Manual, Second Edition** Wendes,2020-12-22 Developed over the course of many years of on the job projects involving HVAC energy auditing testing balancing and cost estimating and refined through feedback from thousands of engineers and technicians who have used them the forms contained in this manual are concise comprehensive and optimally organized for easy reference Complete sets of forms are provided for all aspects of testing and balancing energy auditing indoor quality diagnosis and load calculations The first edition entitled HVAC Energy Audit Balancing Forms Manual compiled these time saving forms for the first time in a single reference This enhanced second edition adds a new chapter on technical management providing procedures for achieving thorough systematic and accurate problem solving troubleshooting and decision making in building systems management and contracting **HVAC**

Inspection Notes: Up to Code Gil Taylor,2005-03-21 Introducing McGraw Hill's Inspection Notes Series From tradesmen to engineers to building inspectors everyone involved with the building industry needs to be certain that their work will pass inspection Inspection Notes are innovative on the job cheat sheets packed with practical information that will save time and money and ensure that all facets of a construction job are up to code There is no easier way for busy building professionals to do their jobs thoroughly and efficiently while avoiding costly mistakes Every title in the series features A pocket sized format for handy reference to complex information calculations and diagrams for instant clarification of complicated data Clear role definitions of who is responsible for each facet of a construction project Easy to follow explanations of complicated codes

Thorough and detailed indexes to make information retrieval a snap **Testing and Balancing HVAC Air and Water Systems, Fifth Edition** Samuel C. Sugarman,2020-11-26 Thoroughly revised this book provides the reader with an understanding of the principles and practices of testing and balancing TAB heating ventilating and air conditioning HVAC air and water systems For the novice and the experienced testing and balancing technician it is a field reference book of procedures equations and information tables Divided into five parts Part I has general and specific balancing procedures for constant air volume systems variable air volume systems return air systems and fans and fan performance Part II covers testing and balancing fume hood systems and cleanrooms commissioning HVAC systems centrifugal pumps and pump performance analog and digital controls and water balancing procedures using flow meters system components and temperatures Part III covers fans pumps air distribution water distribution motors electrical fluid flow psychrometrics refrigeration and instrument usage and care Part IV includes equations and tables New to this edition Part V has information and additional test and balance procedures and graphics for chapters 1 7 and 13 14 TAB Data and Test forms are in the new addendum as well Provides the readers with revised information about the principles and practices of testing and balancing TAB heating Represents a field reference guide for both the novice and experienced testing and balancing technician Includes a new section with

information and additional test and balance procedures and graphics *HVAC Calculations, Precision in Heating, Ventilation, and Air Conditioning* Charles Nehme, Welcome to HVAC Calculations Precision in Heating Ventilation and Air Conditioning This book is designed to be your comprehensive guide to the world of HVAC calculations offering a deep dive into the foundational principles practical applications and advanced techniques that underpin this vital field Whether you are a student aspiring to join the HVAC industry a seasoned professional seeking to sharpen your skills or a curious homeowner interested in understanding the inner workings of your heating and cooling systems this book is tailored to meet your needs The Journey Ahead Our journey begins with a solid grounding in the fundamental concepts of heat transfer and load calculations We ll explore the mathematics and physics that govern the movement of heat preparing you to determine the heating and cooling requirements of any space As we progress we ll delve into the intricacies of HVAC system components ductwork design control systems and maintenance practices You ll gain a comprehensive understanding of how these elements work together to provide comfortable and energy efficient indoor environments In later chapters we ll venture into the exciting world of emerging HVAC trends innovations and the challenges that lie ahead You ll glimpse the future of HVAC from sustainable and smart systems to cutting edge technologies that will shape the industry Your Learning Companion Throughout this book you ll find explanations examples and practical insights to deepen your knowledge and enhance your problem solving skills Real world scenarios and case studies will illustrate the relevance of HVAC calculations in various contexts In addition to the main content we ve included an appendix with a wealth of additional resources to aid your continued learning and exploration of HVAC systems Our Wish for You As authors our goal is to empower you with the knowledge and tools needed to excel in the field of HVAC calculations We hope this book inspires your curiosity sparks your passion for precision and equips you to contribute to the creation of comfortable efficient and sustainable indoor environments Whether you re an HVAC enthusiast a dedicated professional or simply someone seeking a deeper understanding of the systems that make our modern lives comfortable we invite you to embark on this educational journey with us Together we ll navigate the complexities of HVAC calculations and uncover the secrets to precision in heating ventilation and air conditioning Let the exploration begin Sincerely Charles Nehme HVAC Q A What is HVAC HVAC stands for heating ventilation and air conditioning It is a system of technology that controls the temperature humidity and ventilation of indoor and restricted spaces How does HVAC work HVAC systems typically use a combination of heating and cooling elements fans and ductwork to control the indoor environment The specific components and operation of an HVAC system will vary depending on the type of system and the specific needs of the building What are the different types of HVAC systems There are many different types of HVAC systems but some of the most common include Central heating and cooling systems Split systems Ductless mini split systems Heat pumps Furnaces Air conditioners How do I choose the right HVAC system for my home When choosing an HVAC system for your home there are a number of factors to consider such as the

size of your home the climate you live in your budget and your energy efficiency goals It is important to consult with a qualified HVAC professional to get the best advice for your specific needs What is the best way to maintain my HVAC system The best way to maintain your HVAC system is to have it inspected and serviced by a qualified professional on a regular basis This will help to ensure that your system is operating efficiently and safely You should also change your air filter regularly according to the manufacturer s recommendations Short answer HVAC stands for heating ventilation and air conditioning It is a system of technology that controls the temperature humidity and ventilation of indoor and restricted spaces There are many different types of HVAC systems and the best way to choose the right one for your home is to consult with a qualified HVAC professional To maintain your HVAC system have it inspected and serviced by a qualified professional on a regular basis and change your air filter regularly

HVAC Heating Load Calculations and Principles A. Bhatia,2014-11-01 The prime requirement in respect of the indoor climate in a building is that room temperature should be at a comfortable level regardless of the weather conditions outside As soon as the ambient temperature is lower than the indoor temperature heat flows out from the building through its boundary surfaces the building envelope At the same time the building also loses heat through air infiltration i e the inward leakage of outdoor air into the building through gaps and cavities in walls roofs doors and windows Bearing in mind the fact that the indoor temperature in most buildings is maintained at a little over 65 F this means throughout most of the year the building is losing heat to its surroundings This 5 hour course discusses the stepwise procedure to determine the rate of heat loss through building elements using a process called heat loss calculation You will learn how to extrapolate your calculation of a maximum hourly rate into an annual energy usage rate You will also learn some useful tips on saving heating energy The course includes one sample example for better understanding of the concept Learning ObjectiveAt the end of this course the reader will 1 Describe the factors affecting comfort in winter2 Describe the overall heat transfer coefficient U value and its relationship to resistance R value 3 Understand the basic equation of heat loss through building elements such as walls roof and glass4 Understand the basic equation of heat loss through floor slab and basement5 Understand the basic equation of heat loss through ventilation and infiltration6 Understand the concept of degree days and how it is used to estimate the annual heat loss7 Understand the three basic modes of heat transfer conduction convection and radiation8 Understand the difference between the k values C values R values and U values 9 Learn by examples to calculate the series resistance and U values of a composite wall 10 Learn how to determine the infiltration and ventilation air flow rate 11 Understand by an example the detailed methodology to heat loss calculations12 Understand the basic terminology and definitions related to air conditioning load calculations

A Guide to HVAC Building Services Calculations K. A. Pennycook,David Churcher,David Bleicher,Building Services Research and Information Association,2007 **A Practical Guide to HVAC Building Services Calculations** Gay Lawrence Race,Sally Mitchell,2003 **HVAC Cooling Load - Calculations and Principles** A. Bhatia,2014-10-16 Heating and cooling load

calculations are carried out to estimate the required capacity of heating and cooling systems which can maintain the required conditions in the conditioned space To estimate the required cooling or heating capacities one has to have information regarding the design indoor and outdoor conditions specifications of the building specifications of the conditioned space such as the occupancy activity level various appliances and equipment used etc and any special requirements of the particular application For comfort applications the required indoor conditions are fixed by the criterion of thermal comfort while for industrial or commercial applications the required indoor conditions are fixed by the particular processes being performed or the products being stored Generally heating and cooling load calculations involve a systematic and stepwise procedure which account for all the building energy flows In practice a variety of methods ranging from simple rules of thumb to complex transfer function methods are used to arrive at the building loads This short quick book provides a procedure for preparing a manual calculation for cooling load using CLTD CLF method suggested by ASHRAE and includes two detailed examples For more advanced methods such as TFM the reader should refer to ASHRAE and other handbooks Learning ObjectiveAt the end of this course the student should be able to 1 Understand the basic terminology and definitions related to air conditioning load calculations 2 Explain the differences between heating and cooling load design considerations3 Explain the difference between 1 space heat gain v s cooling load 2 space cooling v s cooling load and 3 external loads v s internal loads4 Differentiate between sensible and latent loads5 List commonly used methods for estimating cooling loads 6 Estimate the internal and external cooling loads using CLTD CLF method from building specifications design indoor and outdoor conditions occupancy etc 7 Describe various equations and the information sources to determine conductive load through opaque building elements 8 Describe various equations and information sources to determine the solar transmission load through glazing 9 Describe various equations and information sources to determine the internal load due to people lights and power appliances 10 Determine the supply air flow rate11 Learn by examples the detailed methodology to cooling load calculations12 Learn the functional parameters of software programs such as TRACE 700 and CHVAC

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