Air and Vacuum System

Master Specification Design Guide

Amico

DISCLAIMER

The following guide is presented as an aid, in the design and sizing of medical compressed air and vacuum systems. It is not in any way meant to serve as a substitute for an experienced and properly qualified engineer; any pretense for it being sole and sufficient for the proper design of these systems is hereby disclaimed.

It is important to note that this Design Guide is not in any way meant to serve as a substitute for an experienced and properly qualified engineer; any pretense for it being sole and sufficient for the proper design of medical gas systems is hereby disclaimed. It is the intent of Amico Source Corporation that this Design Guide should only be used as a single tool among many; a guideline in conjunction with qualified and experienced engineers. Engineers who have achieved their position by training and practice to know both this Design Guide's applications and limitations, when used in medical compressed air and vacuum system design.

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Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

Introduction

Chapter 1 – Introduction

1.1 Overview

Welcome to the Amico Source Corporation Design Guide for medical gas systems. Whether you are designing your first medical gas system, or a seasoned veteran about to embark on yet another design, we hope that the information provided in this Design Guide will help streamline the process.

When correctly done, it is important to remember that a medical gas design will yield an integrated system, not simply a collection of components. That is, a medical gas system is more than the sum of its parts. Although a compressor or pump can make or take air, a tank can hold air and any dryer can remove moisture, it is the collection of all of these components working together that result in a successful system. The system is successful, by not only delivering air at the appropriate dew point and pressure (or creating suction at the necessary vacuum), but also by being long lasting and efficient. Ultimately, these systems can be seen as tools that are used by physicians and healthcare providers to diagnose, treat and rehabilitate patients. A great tool is not only measured by its efficiency and ease of use, but also on how much attention the user pays to it when trying to accomplish the intended task. Medical gas systems should provide any healthcare facility with compressed air or vacuum (suction) easily and effortlessly, while allowing the facility staff to focus their attention on where it should be – patient care.

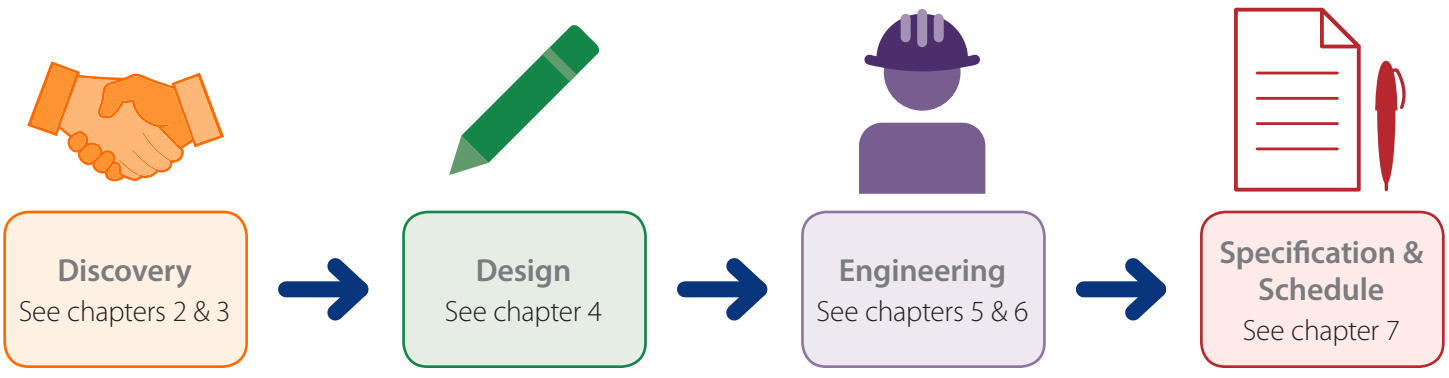
This is the first edition of this Design Guide that Amico Source Corporation has created and as such comments or suggestions for improvement are more than welcome. While we do what we can from our end, it is the knowledge that is gained from those that continually work, service and maintain our systems in the field that form the basis of all of our improvements in design. Your opinion is invaluable to our continued success in this industry and as such we encourage you to voice any concerns you may have regarding both this Design Guide and/or our products as a whole.

1.2 Design Process Scope

The following section outlines the Design Process, around which this Design Guide is centered.

This process is composed of four major phases that will be described in sequence: Discovery, Design, Engineering and Specification/Schedule. Each stage calls for different skills to be applied and should normally be divided among several individuals in an engineering firm. The below illustrates the phases and their sequence, as well as the chapters which cover each stage.

MEDICAL GAS SYSTEM DESIGN PROCESS



1.2.1 PHASE 1: DISCOVERY

The Discovery Stage involves meeting with the client or customer to determine their exact needs and wants. As such, this is the most important stage – it will set the groundwork for which all the other stages are built upon. As with any product, a medical gas system can only serve the purpose it was designed for. If the original design constraints were incorrect or misinterpreted, then the facility can end up with a system inappropriately sized for their needs.

It is important that during client discussions you develop a solid understanding of both the customer and the facility where the equipment will be placed. The forms included in this section are meant only to serve as a guideline for creating your own interview package. We suggest that the forms be filled out while conducting interviews with those people on the client side who will be most knowledgeable about any existing equipment and the intent of new construction. Oftentimes, engineers overlook this step, deeming it unimportant as they feel simply complying with standards should be sufficient enough for the client and the purpose of the equipment. However, while standards serve to establish the minimum requirements for a product, they do not substitute for a clear understanding of your client.

A final memorandum (signed by all relevant parties), detailing the agreed requirements for the project, should be done to conclude the Discovery Stage. Although criteria may change as the project gets underway, such a document will give the engineer confidence that they have captured the intent of the client – before spending the client's finances on design and engineering. As such, the forms included will be helpful in solidifying the agreement on this memorandum.

1.2.2 PHASE 2: DESIGN

The Design Stage deals with composing the various large elements of the system or equipment. It is during this phase that issues such as the wall space for valves, sight lines for alarms, floor space for source equipment and other problems need to be identified and addressed. You should strive to complete this phase as quickly as possible in the Design Process, as any possible conflicts should be resolved before construction begins on the final equipment. The result at the end of this stage is a preliminary layout drawing that details all equipment in their proposed locations. Although things may change during the Engineering Stage, this initial layout drawing is essential for establishing the big picture.

1.2.3 PHASE 3: ENGINEERING

The Engineering Stage requires the largest time commitment of the project. This stage involves the equipment being sized and selected as well as final locations being determined. At this point, you need to continuously liaise with other designers to ensure that the facility is able to support the planned equipment. You need to consult with electrical engineers to ensure the appropriate power and signal wiring are present for the medical source system, alarms and manifolds. Information system planners will need to be informed regarding medical gas requirements to include in their networking requirements and Building Management Systems (BMS). HVAC engineers need to be consulted with to ensure that the existing ventilation and/or air conditioning set-up is sufficient for the planned equipment.

Site preparation may need to be done for any equipment that is to be located outdoors. It is possible that landscaping architects may need to be involved with any outdoor work. This stage is where the medical gas system comes together from what was initially conceived through the design concepts into one complete and cohesive unit.

1.2.4 PHASE 4: SPECIFICATION & SCHEDULE

Finally, with all the above complete, you can proceed to **the Specification** of the planned equipment. This is the second most important stage of the project. The specifications detail exactly what the equipment is and what the client will receive.

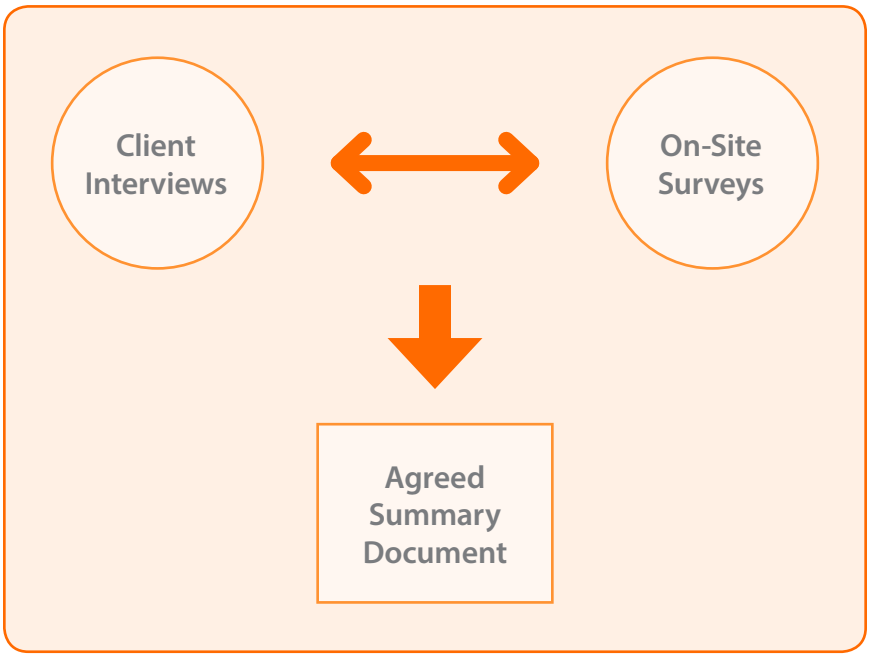
In this chapter, we have included the complete and comprehensive specifications you will need to provide for any medical compressed air, vacuum, WAGD and instrument air plant systems. This chapter will guide you through selecting the required technology and equipment and will be what ensures that the final result is both what you and your client expect.

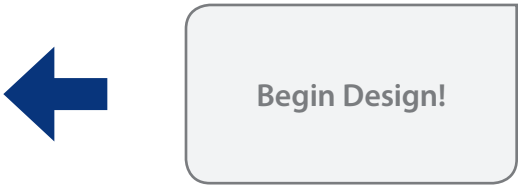
As mentioned before, done properly, your work will yield more than a simple collection of various equipment and materials. It will give you an integrated system, something that offers much more than what it appears. It is no longer a collection of components and thus you should not think of it as so. You, as the engineer, should not allow a contractor to re-engineer your work by submitting components with no other purpose than being cheaper than what was originally presented. Substitutions and value engineering are useful and often vital contributions to the design of any product, however proper reference must be taken from all the knowledge gained in the Discovery Stage. Any alternative that is submitted for consideration must be subject to the same scrutiny that the existing components have received through this standard design process; any last minute acceptances of a "just as good and cheaper" product is simply not engineering.

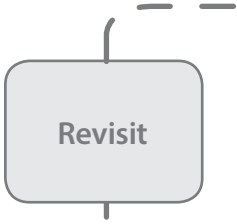
A Visual Design Map of these stages is shown on the next two pages.

VISUAL DESIGN MAP

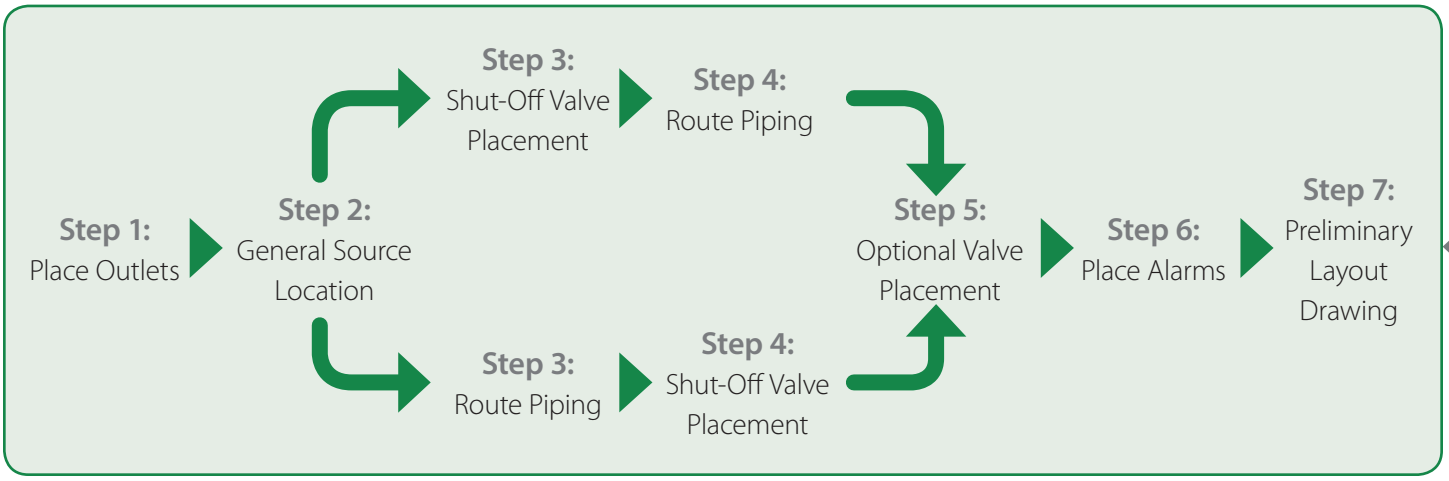
Phase 1: Discovery



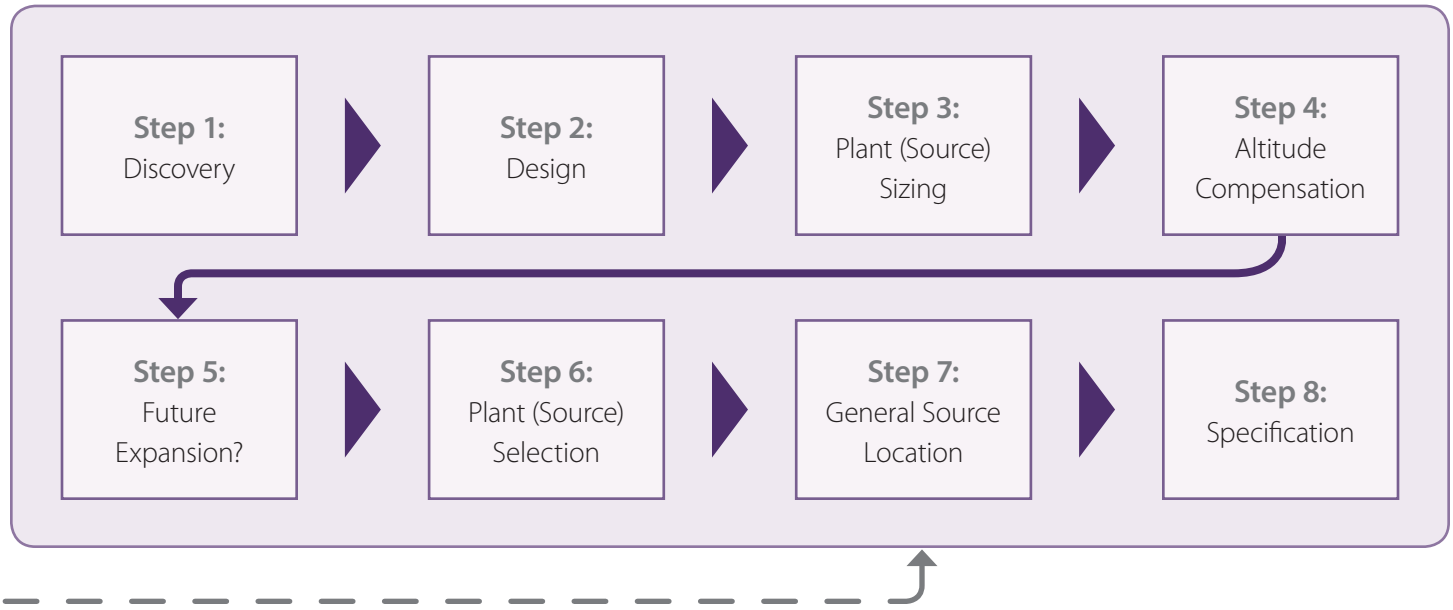




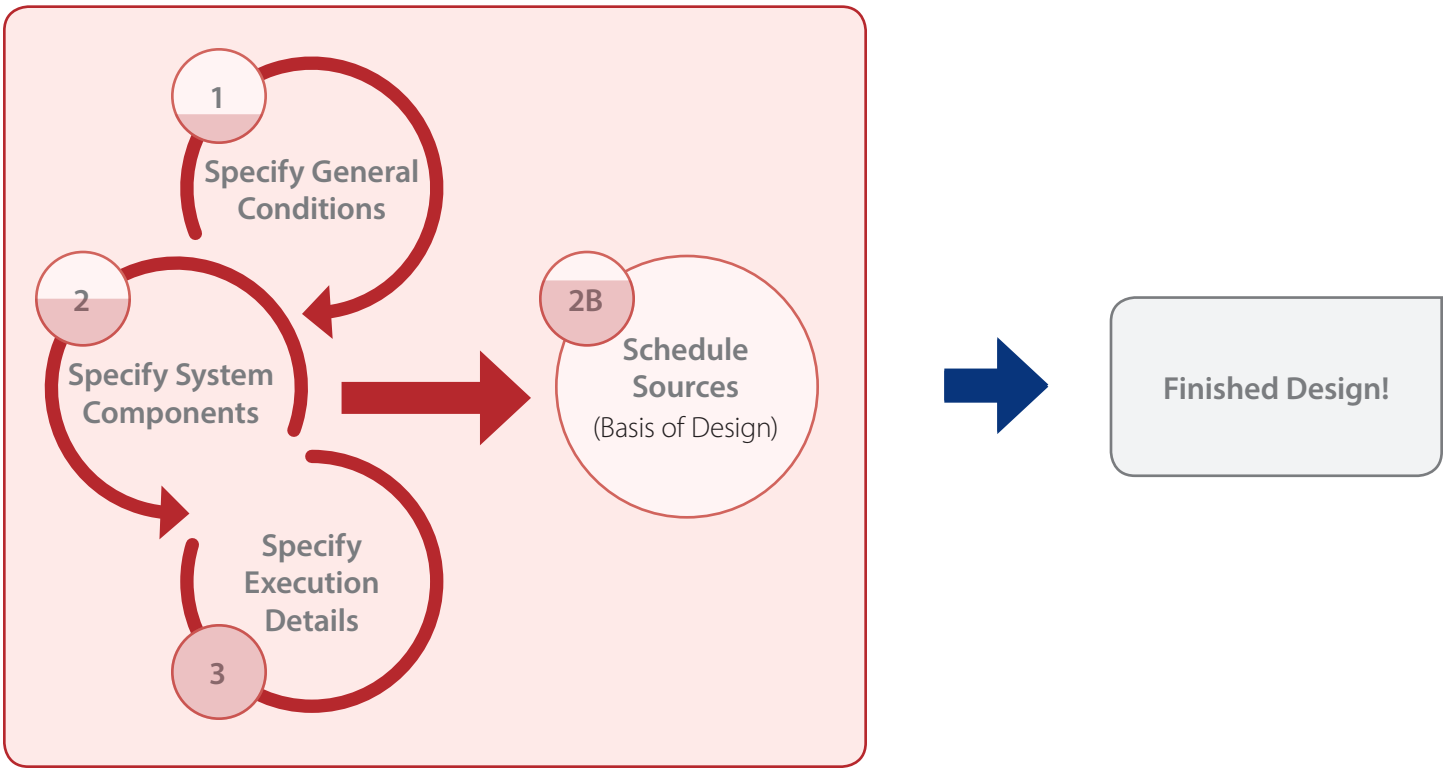
Phase 2: Design



Phase 3: Engineering



Phase 4: Specification & Schedule



1.3 Nomenclature & Relevant Definitions

The following glossary section includes useful definitions for terms that the reader may encounter when progressing through this Design Guide. For any term that is not specifically defined herein or in another chapter, the reader may simply interpret the ordinarily accepted meanings within the context of its use. The Medical Compressed Air (Chapter 5) and Vacuum (Chapter 6) chapters also contain glossary sections, detailing some terms that are specific to those chapters.

GENERAL TERMS

The following fundamental terms will be referenced multiple times throughout each chapter of this Design Guide. Please familiarize yourself with their meanings and contexts of use.

- **Healthcare Facilities** are buildings, portions of buildings,or mobile enclosures in which medical, dental, psychiatric, nursing, obstetrical or surgical care is provided. These types of facilities require medical source systems and this Design Guide is specifically written to address the needs of these types of facilities.
- **A Hospital** is a building (or portion of) that is used on a 24 hour basis for the medical, psychiatric, obstetrical or surgical care of four or more inpatients.
- **Laboratory** refers to a building, space, room or group of rooms intended to be used for activities involving procedures for investigation, diagnosis or treatment. Flammable, combustible and/or oxidizing materials are likely to be used.
- **NFPA 99 Category 1** class systems are facility systems where failure of said equipment is likely to cause major injury or death of patients or caregivers. NFPA 99 contains the requirements for systems that meet this classification. All medical compressed air and vacuum systems from Amico Source Corporation will be designed to meet this Category 1 classification.
- **Medical Gas Equipment Manufacturer (MGEM)** refers to the OEM supplier of the medical air or vacuum system (e.g. Amico Source Corporation).
- **The Submittal Package** is a document that provides complete specifications for the product(s) proposed to be installed as well as system drawings and wiring diagrams where applicable. It includes drawings illustrating the configuration style and overall dimensions of equipment. The submittal is normally provided by the MGEM, during the tendering process.
- **Operation and Maintenance Manual (O&M)** refers to the manual provided with the system submittal that further details the technology used, operating instructions and how to maintain each piece of equipment.
- **Supply Source** refers to the sources of medical air or vacuum suction. It may be more specifically described using the following terms:
    - **Operating Supply** refers to the portion of the supply system that normally supplies the piping systems. The operating supply consists of a primary supply or both a primary and secondary supply.
    - **Primary Supply** refers to the portion of the source equipment that actually supplies the system.
    - **Secondary Supply** refers to the portion of the source equipment that automatically supplies the system when the primary supply is exhausted.
    - **Reserve Supply** refers to that portion of the source equipment that automatically supplies the system in the event of a failure of the primary and secondary operating supply.

- **Pressure** may refer to number of definitions, all of which depend on the context of use. For the scope of this Design Guide, the following distinctions will be made when referring to all instances of pressure.
    - **Absolute Pressure** is the total pressure in a system, with reference to zero pressure.
    - **Ambient Pressure** refers to the total pressure of the referenced environment.
    - **Gauge Pressure** refers to the total pressure above (or below) atmospheric pressure.
    - **High Pressure** is defined as a pressure exceeding 1.38 kPa gauge (200 psig) or 215 psia.
    - **Partial Pressure** refers to the pressure (in absolute units) exerted by a particular gas in a gas mixture.
    - **Positive Pressure** refers to pressure that is higher than ambient atmospheric pressure.
    - **Negative Pressure** refers to a pressure level that is below atmospheric pressure. This is what the term vacuum refers to.
    - **Working Pressure** is defined as a pressure not exceeding 200 psig.
    - **psig** signifies pounds per square inch gauge. It is a unit of pressure measurement with atmospheric pressure as the base/reference point.
    - **psia** signifies pounds per square inch absolute. It is a unit of pressure measurement with zero (0) pressure as the base/reference point.
- **Piping** refers to the tubing or conduit connections of the system. The three (3) main classes of piping are listed below.
    - **Main Lines** refer to piping that connects the source (pumps, receivers, etc.) to the risers or branches or both.
    - **Risers** refer to vertical pipes connecting the system main line(s) with the branch lines on the various levels of the facility.
    - **Branch (Lateral) Lines** refer to the sections of the piping system which serve a room or group of rooms on the same floor of the facility.
- **The Piped Distribution System** is a pipeline network assembly of equipment that starts at and includes the source valve, warning systems (master alarms, local alarms), bulk gas system signal actuating switch wiring, interconnecting piping and all other components up to and including the station outlets/inlets.
    - **Medical air piping systems** include medical air compressors, instrument air, dental air and medical laboratory air piping systems.
    - **Nonmedical laboratory air piping systems** include laboratory low-pressure and laboratory high-pressure air piping systems.
    - **Medical vacuum piping systems** include medical vacuum, WAGD, dental vacuum, HVE and medical laboratory vacuum piping systems.
    - **Non-medical laboratory vacuum piping systems** include laboratory low-vacuum and laboratory high-vacuum piping systems.

SOURCE TERMS

The following terms are fundamental in describing the type of source application for the equipment.

- **Medical Gas** refers to a patient medical gas or medical support gas. It refers to any and all instances for piped oxygen, nitrous oxide, medical air, carbon dioxide, helium, nitrogen, instrument air and mixtures thereof.
    - **Medical Support Gas** refers to nitrogen or instrument air that is used for any medical support purpose or in laboratories where respiration is not part of the treatment. Common uses for medical support gases include removing excess moisture from instruments before further processing as well as operating medical-surgical tools, air-driven booms, pendants or similar applications. Medical support gas falls under the general requirements for medical gases.
    - **Patient Medical Gas** refers to piped gases such as oxygen, nitrous oxide, helium, carbon dioxide and medical air used for the application of human respiration as well as the calibration of medical instruments/devices that will be used for human respiration.
- **Medical Gas System** refers to an assembly of equipment and piping for the distribution of nonflammable medical gases such as oxygen, nitrous oxide, compressed air, carbon dioxide and/or helium. Medical compressed air systems and medical vacuum systems are both examples of medical gas systems.
- **Medical Air** refers to air that is supplied from cylinders, bulk containers or medical air compressors.
- **Medical Air Compressor** is a compressor that is designed to exclude oil from the air stream and compression chamber. Under normal operating conditions, or any single fault failure, the compressor will not add any toxic or flammable contaminants into the compressed air stream.
- **Instrument Air** is air that is intended for the powering of medical devices unrelated to human respiration (such as surgical tools or ceiling arms). Medical and instrument air are distinct systems, to be used for mutually exclusive applications. A medical system cannot be used to provide instrument air. Instrument air is a medical support gas that falls under the general requirements for medical gases.
- **Medical Vacuum Equipment** includes medical, WAGD and healthcare laboratory vacuum producers as well as accessories for healthcare facilities.
- **Medical-Surgical Vacuum System** is a system that is used to provide a source of drainage, aspiration and suction in order to remove bodily fluids from patients. The system is comprised of an assembly of central vacuum-producing equipment and a network of piping for patient suction. System applications include medical, medical-surgical and WAGD uses.
- **Laboratory Vacuum Equipment** includes vacuum producers and accessories for non-medical laboratory facilities.
- **Waste Anesthetic Gas Disposal (WAGD)** refers to the process of capturing and carrying away gases vented from the patient breathing circuit during the normal operation of gas anesthesia or analgesic equipment. It is normally used in medical-surgical applications in healthcare facilities.
- **Anesthetic Gas Scavenging Systems (AGSS)** are used in hospitals to gather gas or aerosolized medication, after it is exhaled by the patient or left in the area of the patient. While often used for anesthesia, they can also be used to collect any other type of gas or aerosolized medication that should not be inhaled by any medical personnel.
- **HVE** refers to high-volume oral evacuation for dental applications in healthcare facilities.

SPECIFICATION TERMS

The following terms are specific to the equipment and materials used for air and vacuum systems. They will most likely be referenced in the specifications outlined in Chapter 7, however may be occasionally found in other chapters as well.

- **Actual Air (ACFM)** is air delivered at the air/vacuum producer inlet. Flow rate is air measured in ACFM (actual L/s).
- **Standard Air (SCFM)** is free air at 68°F (20°C) and 1 atmosphere (29.92 inHg) before compression or expansion and measured in SCFM (standard L/s).
- **Maximum Allowable Working Pressure (MAWP)** describes the maximum pressure that the weakest point of the equipment, system or vessel can handle at a specific temperature during normal operation. The MAWP does not remain constant throughout the life of the equipment; it will reduce due to corrosion, wear and metal fatigue. The operating pressure will be the pressure that a vessel is subjected to during service. The design pressure is the pressure the vessel was originally designed for and is usually 10 to 25 percent above the operating pressure and equal to or slightly lower than the MAWP.
- **Ampacity** refers to the current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.
- **An Ultra-Low Penetration Air (ULPA) Filter** can remove at least 99.999% of dust, pollen, mold, bacteria and any other airborne particles with a size of 100 nanometers (0.1 µm) or larger from the incoming air stream.
- **Hand-Off-Auto (H-O-A) Selector Switches** are used to activate the three modes of operation for the pump/compressor via the controls. "Hand" indicates that the pump/compressor will continue to run as long as the switch is in this position, irrespective of the vacuum or pressure level. "Off" indicates that the pump/compressor is powered down and will not run regardless of the vacuum or pressure level. "Auto" is the default mode of the switch and indicates that the pump/compressor will run when needed, based on the set points of the system and the vacuum or pressure level.
- **The Master Alarm Panel** is a warning system that monitors the operation and condition of the source supply, the reserve source (if present) and the pressure in the main lines of each medical gas and vacuum piping system. These panels are connected directly to the alarm (dry) contacts of the local alarm panel on the source system.
- **Dual Feed** indicates that the system control panel must be wired to allow for more than one incoming power feed. There will be more than one power distribution block within the panel, which should separately power and control an equal number of compressors/pumps (depending on the number of compressors/pumps). When one of these power blocks fails to supply incoming power, the other will continue to maintain power to its associated compressors/pumps. This is useful for facilities that use a back-up generator and ensures that there will never be any drastic interruption to the airflow or vacuum suction levels. When Dual Feed is present, the control panel is no longer a single point connection.
- **Variable Speed/Frequency Drive (VSD/VFD)** refers to an energy saving mechanism built within the control panel of the system. The VSD starts the pump motor at a low frequency, allowing the motor to slowly ramp up to the required speed. This effectively eliminates the high voltage spikes during start-up that are common to systems without a VSD, thus reducing the amount of power the system uses.
- **Lab Purge (Auto Purge)** refers to vacuum systems where an automatic purging system for the pumps is required. This automatic purge mechanism must flush any gasses from the pump in order to prevent the build-up of condensation as the pump cools.

Chapter 2

Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

Relevant Codes, Standards & References

Chapter 2 – Relevant Codes, Standards & References

2.1 Introduction

This chapter will serve as a useful reference for further sections of this Design Guide. What is presented here is a list of the pertinent codes and standards that all parties involved in the project should be aware of when specifying, designing, constructing, commissioning and/or installing medical gas equipment. Also included are notable reference materials that expand on the information included in this Design Guide.

This chapter is not exhaustive and by no means does Amico Source Corporation mandate that all items included here are sole and sufficient for any and all informational purposes. As with any project, the local standards need to be considered and addressed wherever the end location of the equipment will be placed. It is important to contact the local authority that has jurisdiction in the area, should any questions arise throughout the project.

2.2 Compulsory Standards

HEALTHCARE FACILITIES CODE, NFPA 99 2015 EDITION

The National Fire Protection Association (NFPA) is a U.S. associate that creates and maintains standards and codes for nearly every aspect of building design and construction. NFPA 99 refers to the Healthcare Facilities Code which establishes criteria for the levels of healthcare services or systems based on the associated risk to patients, staff or visitors in healthcare facilities. NFPA 99 addresses the requirements for installation, inspection, testing, maintenance, performance and safe practices for facilities, material, equipment and appliance, including medical gas and vacuum systems. For more information, please visit nfpa.org.

NFPA 99 was once an occupancy-based document, but the 2012 edition has adopted a risk-based approach. While the administration of health continues to change and evolve, based on new discoveries and technologies, the risk associated with a given procedure does not change for the patient(s). The code now reflects the level of risk to the patient through clearly defined categories. Refer to Chapter 4: Fundamentals, for a description of each risk assessment category. NFPA 99 is generally accepted as one of the most widely used standards on the best-practice requirements for the installation and use of equipment and on the daily operation of medical gas and vacuum systems in healthcare facilities. It is the standard used for compressed gas, vacuum and WAGD systems in the United States as well as a few other countries.

One of the most significant chapters in NFPA 99 (with respect to the scope of this Design Guide) is Chapter 5: Gas and Vacuum Systems. Please refer to it for the requirements related to performance, maintenance, installation and testing of compressed gas, vacuum and WAGD systems.

2.3 Additional References

The following documents can be used a supplement for more information regarding the requirements of medical gas equipment. They should be consulted as necessary when reading the subsequent chapters of this Design Guide. Always consult the most recent edition for the most accurate information.

2.3.1 INSTALLATION SPECIFIC DOCUMENTS

Document	Description	Individual / Organization
Medical Gas and Vacuum Systems Installation Handbook, 2015 Edition	Provides specific information about the medical gas and vacuum requirements of NFPA 99 along with additional explanatory material. It provides insight as to why the code requirements are there and illustrates how compliance with them can be achieved. It is an excellent reference for those installing, designing or maintaining medical gas and vacuum systems.	Jonathan R. Hart, P.E. National Fire Protection Association (NFPA)
NFPA 70: National Electric Code, 2014 Edition	The NEC is the benchmark for the safe electrical design, installation and inspection to protect both people and property from electrical hazards. It addresses all aspects of electrical details in commercial, residential and industrial occupancies.	National Fire Protection Association (NFPA)
Guidelines for Design and Construction of Hospitals and Outpatient Facilities, 2014 Edition	Addresses considerations that are applicable to all hospitals and outpatient facilities, as well as facilities where inpatient care is provided.	American Institutes of Architects (AIA)
Handbook of Compressed Gas, 5th Edition	This CGA Handbook provides a wealth of information related to all kinds of gases. It covers safety regulations, associated regulations, handling and installation instructions, cleaning properties as well as gas properties. This document is highly recommended as a source of guidance and information.	Compressed Gas Association, Inc. (CGA)
Guide for Medical Gas Supply Systems at Consumer Sites CGA M-1, 3rd Edition	Establishes the minimum requirements for the installation, maintenance and removal of medical gas supply systems at consumer sites.	Compressed Gas Association (CGA)
Plumbing Engineering Design Handbook – Volume 2: Plumbing Systems, 2014 Edition	Chapter 10 has information on designing for Vacuum Systems.	American Society of Plumbing Engineers (ASPE)
Professional Qualifications Standard For Medical Gas Systems Personnel ASSE/ IAPMO/ANSI Series 6000-2015, 2015 Edition	Addresses the minimum requirements for medical gas, bulk medical gas and vacuum systems installers, inspectors, verifiers, maintenance personnel and instructors. It should be consulted for anyone working in the medical gas industry.	American Society of Sanitary Engineers (ASSE)

Document	Description	Individual / Organization
Guide for Medical Gas Installations at Consumer Sites CGA M-1, 3rd Edition	Contains the information necessary to ensure that supplier or consumer owned storage and control systems supplying medical gas are installed and maintained in a safe and consistent manner.	Compressed Gas Association, Inc. (CGA)
Commissioning of Medical Gas Systems in Healthcare Facilities CSA Z318.6-95, 2001 Edition	Applies to the commissioning of medical gas systems in healthcare facilities, providing direction for the proper installation of such systems. It does not cover the utilization of the equipment.	Canadian Standards Association (CSA) Group

2.3.2 PIPING SPECIFIC DOCUMENTS

Document	Description	Individual / Organization
The Copper Tube Handbook, 2011 Edition	Provides a wealth of information related to copper and its use in piping applications. It contains technical details for all types of alloys and advice on many industry uses.	Copper Development Association Inc.
Standard Specification for Seamless Copper Tube for Medical Gas Systems ASTM B819, 2011 Edition	Provides the specifications for Type K and Type L copper tubing, suitable for medical gas systems. Please consult this document to ensure your medical gas copper piping adheres to the standards in this document.	American Society of Testing and Materials (ASTM)
Safe Handling of Compressed Gases CGA P-1, 12th Edition	The CGA P-1 is the primary source for compressed gas safety. Refer to it to ensure that your handling of such materials is not exposing you to unnecessary risk.	Compressed Gas Association, Inc. (CGA)
Characteristics and Safe Handling of Medical Gases CGA P-2, 10th Edition	The CGA P-2 contains information on the safe handling of medical gas and related components.	Compressed Gas Association, Inc. (CGA)

2.3.3 CONTACT INFORMATION FOR CODE-WRITING ORGANIZATIONS

Below you will find the contact information for relevant organizations within the Medical Gas Industry. Should you have any questions pertaining to the applicability of this Design Guide in any part of the Design Process, feel free to contact the relevant organization below for more detailed information regarding their particular code or standard.

Organization	Description	Address	Email/Phone Number	Website Link
AIA: American Institute of Architects	The leading professional membership for licensed architects, setting industry standards for contract documents used in the design and construction industry.	1735 New York Ave., NW Washington, DC 20006-5292 USA	Tel: 800-AIA-3837	aia.org
ANSI: American National Standards Institute	Oversees the creation, promulgation and use of guidelines that impact businesses in a multitude of sectors.	Washington, DC Headquarters: 1899 L Street, 11th Floor NW Washington, DC, 20036 USA	Tel: 202-293-8020 Fax: 202-293-9287	ansi.org
ASPE: American Society of Plumbing Engineers	International organization for professionals skilled in the design, specification and inspection of plumbing systems. The ASPE is dedicated to the growth and advancement of plumbing engineering.	6400 Shafer Ct., Suite 350 Rosemont, IL 60018-4914 USA	Tel: 847-296-0002 Email: info@aspe.org	aspe.org
ASSE: American Society of Sanitary Engineers	An organization dedicated to continually improving the performance, reliability and safety of plumbing systems.	ASSE International: 18927 Hickory Creek Dr., Suite 220 Mokena, Illinois 60448 USA	Tel: 708-995-3019 Fax: 708-479-6139	asse-plumbing.org
ASTM: American Society of Testing and Materials	An international organization dedicated to the development and delivery of voluntary consensus standards for materials, products, systems and services.	ASTM Headquarters: 100 Barr Harbor Drive PO Box C700 West Conshohocken, PA 19428-2959 USA	Tel: 1-877-909-2786 (USA and Canada) 610-832-9585 (International)	astm.org
AWS: American Welding Society	Dedicated to the advancement of the science, technology and application of welding and allied joining and cutting processes worldwide.	8669 NW 36 Street, #130 Miami, Florida 33166-6672 USA	Tel: 800-443-9353 or 305-443-9353	aws.org

Organization	Description	Address	Email/Phone Number	Website Link
CAGI: Compressed Gas Institute	Looking to be the united voice of the compressed air industry, they serve as an unbiased authority on all matters that affect the industry. They provide performance data on various manufacturers for the purposes of educating the customer. Their website is highly recommended.	1300 Sumner Avenue Cleveland, OH 44115 USA	Tel: 216-241-7333 Fax: 216-241-0105 E-mail: cagi@cagi.org	cagi.org
CGA: Compressed Gas Association	Dedicated to the development and promotion of safety standards and safe practices in the industrial gas industry. They cover industrial, medical and specialty gases in compressed or liquefied form and a range of gas handling equipment.	14501 George Carter Way, Suite 103, Chantilly, VA 20151-1788 USA	Tel: 703-788-2700 Fax: 703-961-1831 Email: cga@cganet.com	cganet.com
FGI: Facility Guidelines Institute	Responsible for reviewing and revising the guidelines document on a regular basis.	350 N. Saint Paul St., Suite 100 Dallas, TX 75201 USA	See website.	fgiguidelines.org
JCAHO: Joint Commission on Accreditation of Healthcare Organizations	Accredits and certifies more than 20,500 healthcare organizations and programs in the United States. They are dedicated to continuously improving public health.	Joint Commission Resources: 1515 West 22nd Street, Suite 1300W Oak Brook, IL 60523 USA	Tel: 630-268-7400 (within U.S.) Email: info@jcrinc.com	jointcommission.org
FDA: U.S. Food and Drug Administration	Responsible for protecting public health by assuring safety, efficacy and security of human and veterinary drugs, biological products, medical devices, food supplies, cosmetics and products that emit radiation. They are also responsible for the advancement of public health.	10903 New Hampshire Ave Silver Spring, MD 20993-0002 USA	Tel: 1-888-463-6332	fda.gov/default.htm
MGPHO: Medical Gas Professional Healthcare Organization	Dedicated to advancing the safe design, manufacture, installation, maintenance and inspection/verification of medical air and vacuum systems. MGPHO is actively involved in identifying, understanding and maintaining state and federal standards and dedicated to improving testing and verification techniques.	16339 Kranker Drive, Stilwell, KS 66085-8820 USA	Tel: 913-269-6699 Email: mgpho@me.com	mgpho.org

Organization	Description	Address	Email/Phone Number	Website Link
NFPA: National Fire Protection Association	A global organization devoted to the elimination of death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers this information through more than 300 consensus codes and standards, research, training, education, outreach and advocacy.	1 Batterymarch Park Quincy, MA 02169-7471 USA	Tel: 1-617-770-3000 Fax: 1-617-770-0700	nfpa.org
NIOSH: National Institute of Occupational Safety and Health Centers for Disease Control and Prevention	Produces new scientific knowledge and provides practical solutions vital to reducing risks of injury and death in traditional industries such as agriculture, construction and mining.	395 E Street, SW Patriots Plaza 1, Suite 9200 Washington, DC 20201 USA	Tel: 202-245-0625	cdc.gov/niosh
OSHPD: Office of Statewide Health Planning and Development	California's OSHPD collects data and publishes information related to healthcare infrastructure. They monitor the construction, renovation and seismic compliance safety of hospitals and nursing facilities – and all equipment that goes in these facilities.	Facilities Development Division: 400 R Street Sacramento, CA 95811-6213 USA	Tel: 916-440-8300 Fax: 916-324-9188 Email: FDDwebmaster@oshpd.ca.gov	oshpd.ca.gov
UL: Underwriters Laboratories	Certifies, validates, tests, inspects, audits, advises and trains on a number of categories and services for manufacturers, retailers, policymakers, regulators, service companies and consumers.	See website	Tel: 1-800-595-9844 Email: cec@ul.com	ul.com
USP: United States Pharmacopoeial Convention	The USP is a scientific organization that sets standards for the identity, strength, quality and purity of medicines, food ingredients and dietary supplements manufactured, distributed and consumed worldwide.	12601 Twinbrook Parkway Rockville, MD 20852-1790 USA	Tel: 1-800-227-8772	usp.org

Chapter 3

Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

System Discovery

Chapter 3 – System Discovery

3.1 Introduction

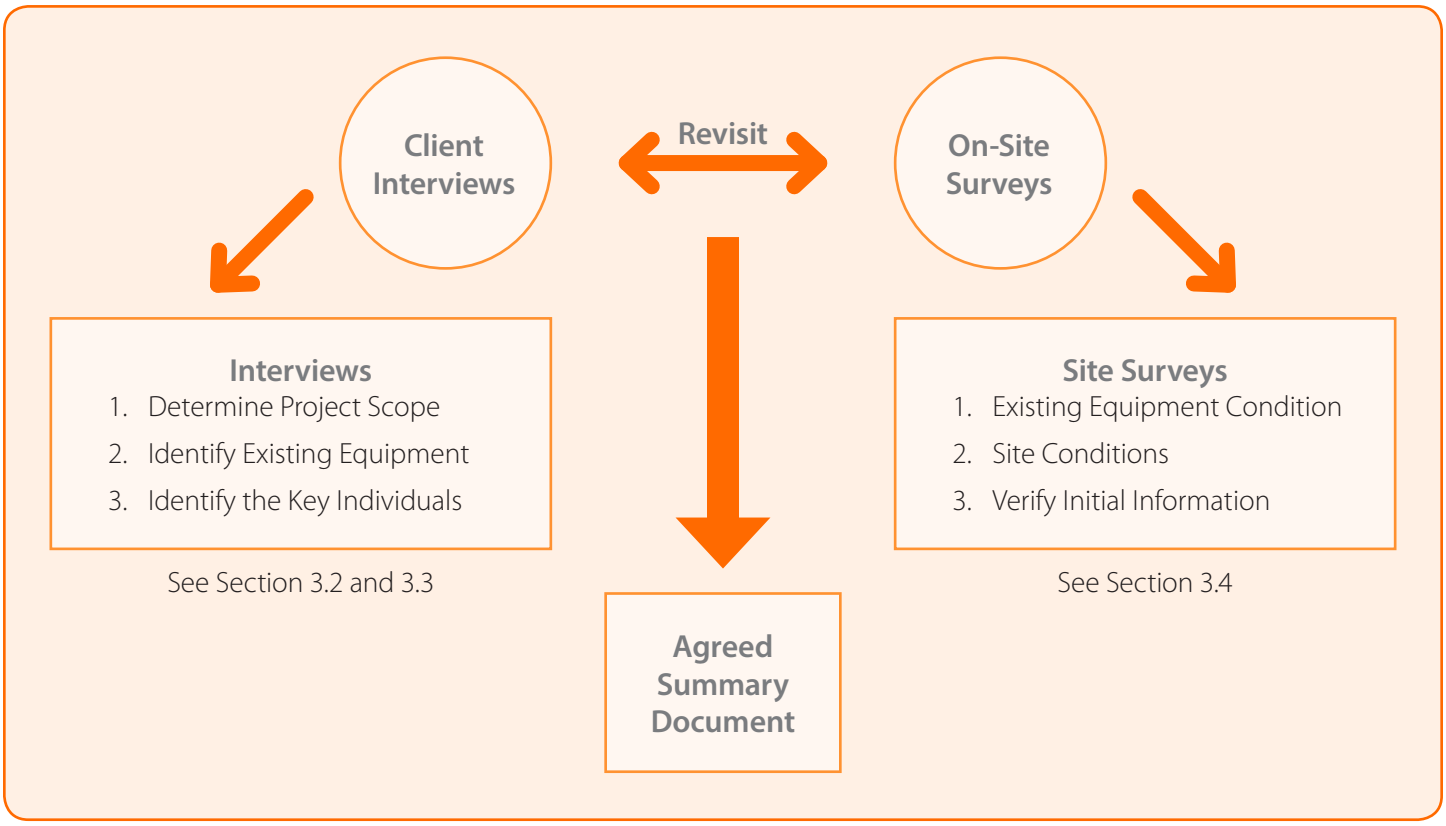
Of all the stages involved in the process of designing, manufacturing, supplying and maintaining a medical gas system, Discovery is arguably the most important phase. It is at this point where:

- ✓ The owner's requirements will be identified
- ✓ Any relevant equipment the owner has will be determined and investigated (in relation to the new system(s) to be put in place)
- ✓ You will understand why the owner wants a particular medical compressed air/vacuum system(s)
- ✓ You will understand how the owner thinks

This is also a great opportunity for you to build a relationship with the client(s) – putting forward new technologies and the advantages of particular configurations for which they might not have had any prior knowledge. Thus, this stage encourages their confidence in your ability to develop the most suitable solution.

The figure below provides a visual description of this stage as well as where to find each section in this chapter.

Phase 1: Discovery



3.2 Who You Need To Know

The Discovery phase begins with identifying the key individuals of the project. Often there will be someone in charge that is the designated representative for the construction program. More than likely they will have found you when you were introduced as the project engineer. Your exchange with this person will form the basis of the client relationship. This should be the person you deal with regularly and they will also be able to coordinate with other client contacts.

In renovation or expansion projects, or where connections with an existing building are necessary, there is another key individual to be aware of. They will have knowledge of the equipment that is already installed in the facility and familiarity on how it works and is maintained. More often than not, they are in the maintenance department and at the mechanic or technician level. We at Amico Source Corporation cannot express enough how important this person is to the project. They will have information and insight earned through first-hand experience, something that cannot be learned from any form of documentation. You should make an effort to find this individual and build a great working relationship with them.

A number of other individuals that will be useful in the discovery stage may include facility engineering staff, gas suppliers, respiratory therapists, anesthesiologists, nurses, facility architect(s), mid-level administrators, laboratory technicians and certainly many others. They may have important contributions throughout the scope of the project and it will be your job to determine when and where to take them into consideration.

3.3 Client Interviews

The two major aspects of the discovery stage are interviewing and surveying. Interviewing is usually completed first and incorporates aspects such as identifying the basic project scope, any additional details about existing equipment, facility preferences, etc.

3.3.1 ON-SITE SURVEYS

After the initial interview, an on-site survey is fundamental to continuing the design process of the system(s). There are three main objectives for a site survey:

1. Determine what equipment the facility already has and its current state of condition. If it is to be used as part of the new project, can it still perform as required and will it be compatible with the new system(s)?
2. Identify site conditions. This includes potential interface issues such as tie-in locations, dimensional space limitations, electrical service type, ventilation ability, etc.
3. Verify information provided to you in the initial interview(s). It is not uncommon to be given poor information by the facility administration, simply out of a lack of knowledge and understanding of what they have and want.

3.3.2 YOUR ALLIES

During on-site surveys, the individual(s) with the knowledge of any pre-existing installed equipment will be extremely helpful. Not only can they swiftly take you to the equipment location(s), but they will also be able to identify any problems and unusual conditions.

Certainly another ally that will be of great help is your local Amico Source Corporation representative. More often than not, they are a distributor that already supports the medical facilities in their territories. They are an invaluable source of knowledge available to you at no cost.

They are in a unique position to assist you with the following:

- ✓ Identifying the key individuals in the facility with relevant knowledge and experience
- ✓ Identifying and determining the status of the existing facility equipment
- ✓ Helping evaluate compliance issues with existing equipment. These may need to be corrected in order to obtain clean certification of your new work.

Should the facility have a third party verifier whom they prefer to use, this individual can also offer support, especially regarding compliance issues. Unfortunately many verifiers today use their verification activities as a cover for selling equipment. Thus, please understand the position the specific verifier has in this regard. If a verifier also represents any specific medical gas equipment manufacturer (MGEM), their recommendations must be taken with some degree of prudence – their responsibility to the MGEM may limit their ability to be impartial when speaking with you. They will assist you in any way they can with their knowledge and experience.

3.4 Using The Interview Guide

The following pages provide a general template for the types of questions to be asked during an interview. It is by no means exhaustive and all-encompassing, but is intended to give you a basis for the development of your own (project-specific) checklist. These questions need only to be asked about the areas that will be affected by the new project.

Obtaining any medical gas surveys that have been performed on the existing system(s) during operation history is crucial. This gives you a better idea of what you're up against. Of course, the most recent survey should be the one taken most into consideration. Should there be any deficiencies encountered when reviewing the surveys, please include the correction of these in the project scope. These corrections (especially for systems under construction or modification) will most likely be required during the final verification stage of the new equipment.

With the information you gather by using the forms on the subsequent pages, we advise that you create a summary document (memorandum) that is read and signed by all relevant parties. This document will serve as an outline for the agreed requirements of the project. Although criteria can and will change down the road, such a document gives the engineer and the client confidence that the intent of the project has been captured accurately before spending time and money.

Background Information Template

Project Name: _____ Form Completed By: _____

Job/Quote Number: _____ Date: ____ / ____ / ____

SYSTEM HISTORY

INTERNAL CONTACT(S)

Name: _____ Phone: _____ Email: _____
Name: _____ Phone: _____ Email: _____
Name: _____ Phone: _____ Email: _____
Name: _____ Phone: _____ Email: _____

EXTERNAL AGENCIES USED FOR MAINTENANCE (IF ANY)

Firm Name: _____ Contact Name: _____
Email: _____ Contact Phone: _____
Firm Name: _____ Contact Name: _____
Email: _____ Contact Phone: _____

PREFERRED VERIFIER

Firm Name: _____ Contact Name: _____
Email: _____ Contact Phone: _____

MOST RECENT SURVEY OF THE SYSTEMS

☐ No Survey applies – project is new work only

Performed by: _____ Date: ____ / ____ / ____

Contact Name: _____ Contact Phone: _____

Email: _____

To what edition of the NFPA standard:

☐ 1996 ☐ 1999 ☐ 2002 ☐ 2005 ☐ 2012 ☐ 2015

(be sure to obtain copies of this survey)

NOTES

_____
_____
_____

Medical Air Template

Project Name: _____ Form Completed By: _____

Job/Quote Number: _____ Date: ____ / ____ / ____

MEDICAL AIR COMPRESSOR SYSTEM

(complete one form per medical air source)

Manufacturer: _____

Technology: _____

Configuration: ☐ Duplex ☐ Triplex ☐ Quadruplex ☐ _____

Horsepower: _____ Model Number: _____

Capacity: _____ SCFM per ☐ Compressor ☐ System

SERIAL NUMBER(S) OF COMPRESSORS

#1 _____ #2 _____

#3 _____ #4 _____

Date installed: _____

Accumulated Run Hours: #1 _____ #2 _____ #3 _____ #4 _____

Lead Cut-In Pressure: _____ psi Lead Cut-Out Pressure: _____ psi

Reserve 1 Cut-In Pressure: _____ psi Reserve 1 Cut-Out Pressure: _____ psi

Reserve 2 Cut-In Pressure: _____ psi Reserve 2 Cut-Out Pressure: _____ psi

Reserve X Cut-In Pressure: _____ psi Reserve X Cut-Out Pressure: _____ psi

Dryer Type: ☐ Refrigerant ☐ Desiccant ☐ Other: _____

Intake in place? ☐ Yes ☐ No Pipe Size _____ Run Length _____

Intake Location: _____

Local Alarms Panel Located: _____

Signals:

☐ Lag in Use [LAG] ☐ Dew Point High [DP]

☐ Compressor Over Temperature (per compressor) [O/T]

☐ High Water in receiver

☐ Other: _____

Master Alarms Panel 1 located: _____ Panel 2 located: _____

Signals:

☐ Lag in Use [LAG] ☐ Dew Point High [DP]

☐ Compressor Over Temperature (per compressor) [O/T]

☐ High Water in receiver

☐ Other: _____

Is the system known to have any NFPA compliance issues?

☐ Yes (list any known)

☐ None are known, but no recent survey exists

☐ None are documented in the most recent survey dated ____ / ____ / ____

NOTES

Instrument Air Template

Project Name: _____ Form Completed By: _____

Project Designation: _____ Date: ____ / ____ / ____

INSTRUMENT AIR SYSTEM

(complete one form per instrument air source)

Manufacturer: _____

Technology: _____

Configuration: ☐ Simplex ☐ Duplex ☐ Triplex ☐ Quadruplex ☐ _____

Horsepower: _____ Model Number: _____

Capacity: _____ SCFM per ☐ Compressor ☐ System

SERIAL NUMBER(S) OF COMPRESSORS

#1 _____ #2 _____

#3 _____ #4 _____

Date installed: _____

Accumulated Run Hours: #1 _____ #2 _____ #3 _____ #4 _____

Lead Cut-In Pressure: _____ psi Lead Cut-Out Pressure: _____ psi

Reserve 1 Cut-In Pressure: _____ psi Reserve 1 Cut-Out Pressure: _____ psi

Reserve 2 Cut-In Pressure: _____ psi Reserve 2 Cut-Out Pressure: _____ psi

Reserve X Cut-In Pressure: _____ psi Reserve X Cut-Out Pressure: _____ psi

Dryer Type: ☐ Refrigerant ☐ Desiccant ☐ Other: _____

Intake in place? ☐ Yes ☐ No Pipe Size _____ Run Length _____

Intake Location: _____

Local Alarms Panel Located: _____

Signals:

☐ Lag in Use [LAG] ☐ Dew Point High [DP]

☐ Compressor Over Temperature (per compressor) [O/T]

☐ High Water in receiver

☐ Other: _____

Master Alarms Panel 1 located: _____ Panel 2 located: _____

Signals:

☐ Lag in Use [LAG] ☐ Dew Point High [DP]

☐ Compressor Over Temperature (per compressor) [O/T]

☐ High Water in receiver

☐ Other: _____

Is the system known to have any NFPA compliance issues?

☐ Yes (list any known)

☐ None are known, but no recent survey exists

☐ None are documented in the most recent survey dated ____ / ____ / ____

NOTES

Medical Vacuum (Suction) Template

Project Name: _____ Form Completed By: _____

Job/Quote Number: _____ Date: ____ / ____ / ____

MEDICAL VACUUM PUMP SYSTEM

(Complete one form per medical vacuum source)

Manufacturer: _____

Technology: _____

System operates at _____ at _____ (enter vacuum level and units of measure)

Configuration: ☐ Duplex ☐ Triplex ☐ Quadruplex ☐ _____

Horsepower: _____ Model Number: _____

Capacity: _____ SCFM per ☐ Pump ☐ System

SERIAL NUMBER(S) OF PUMPS

#1 _____ #2 _____

#3 _____ #4 _____

Date installed: _____

Accumulated Run Hours: #1 _____ #2 _____ #3 _____ #4 _____

Lead Cut-In Vacuum: _____ inHg Lead Cut-Out Vacuum: _____ inHg

Reserve 1 Cut-In Vacuum: _____ inHg Reserve 1 Cut-Out Vacuum: _____ inHg

Reserve 2 Cut-In Vacuum: _____ inHg Reserve 2 Cut-Out Vacuum: _____ inHg

Reserve X Cut-In Vacuum: _____ inHg Reserve X Cut-Out Vacuum: _____ inHg

Is WAGD handled by the system? ☐ Yes ☐ No

Is WAGD in contact with oil in this pump? ☐ Yes ☐ No (if yes, note this as a compliance issue)

Exhaust in place? ☐ Yes ☐ No Size: _____ Run Length: _____

Exhaust Location: _____

Local Alarms Panel Located: _____

Signals:

☐ Lag in Use [LAG]
☐ Compressor Over Temperature (per compressor) [O/T]
☐ High Water in receiver
☐ Other: _____

Master Alarms Panel 1 located: _____ Panel 2 located: _____

Signals:

- ☐ Lag in Use [LAG]
- ☐ Compressor Over Temperature (per compressor) [O/T]
- ☐ High Water in receiver
- ☐ Other: _____

Is the system known to have any NFPA compliance issues?

- ☐ Yes (list any known)

_____

_____

_____

- ☐ None are known, but no recent survey exists
- ☐ None are documented in the most recent survey dated ____ / ____ / ____

NOTES

WAGD Producer System Template

Project Name: _____ Form Completed By: _____

Job/Quote Number: _____ Date: ____ / ____ / ____

WAGD PRODUCER SYSTEM SYSTEM

(complete one form per WAGD source; for dual use systems please use the vacuum pump form)

Manufacturer: _____

Technology: _____

System operates at _____ at _____ (enter vacuum level and units of measure)

Configuration: ☐ Simplex ☐ Duplex ☐ Triplex ☐ Quadruplex ☐ _____

Horsepower: _____ Model Number: _____

Capacity: _____ SCFM per ☐ Producer ☐ System

SERIAL NUMBER(S) OF PRODUCERS

#1 _____ #2

#3 _____ #4 _____

Date installed: _____

Accumulated Run Hours: #1 _____ #2 _____ #3 _____ #4 _____

Lead Cut-In Vacuum: _____ inHg Lead Cut-Out Vacuum: _____ inHg

Reserve 1 Cut-In Vacuum: _____ inHg Reserve 1 Cut-Out Vacuum: _____ inHg

Reserve 2 Cut-In Vacuum: _____ inHg Reserve 2 Cut-Out Vacuum: _____ inHg

Reserve X Cut-In Vacuum: _____ inHg Reserve X Cut-Out Vacuum: _____ inHg

Exhaust in place? ☐ Yes ☐ No Size: _____ Run Length: _____

Exhaust Location: _____

Local Alarms Panel Located: _____

Signals:

- ☐ Lag in Use [LAG]
- ☐ Compressor Over Temperature (per compressor) [O/T]
- ☐ High Water in receiver
- ☐ Other: _____

Master Alarms Panel 1 located: _____ Panel 2 located: _____

Signals:

- ☐ Lag in Use [LAG]
- ☐ Compressor Over Temperature (per compressor) [O/T]
- ☐ High Water in receiver
- ☐ Other: _____

Is the system known to have any NFPA compliance issues?

☐ Yes (list any known)

☐ None are known, but no recent survey exists

☐ None are documented in the most recent survey dated ____ / ____ / ____

NOTES

Chapter 4

Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

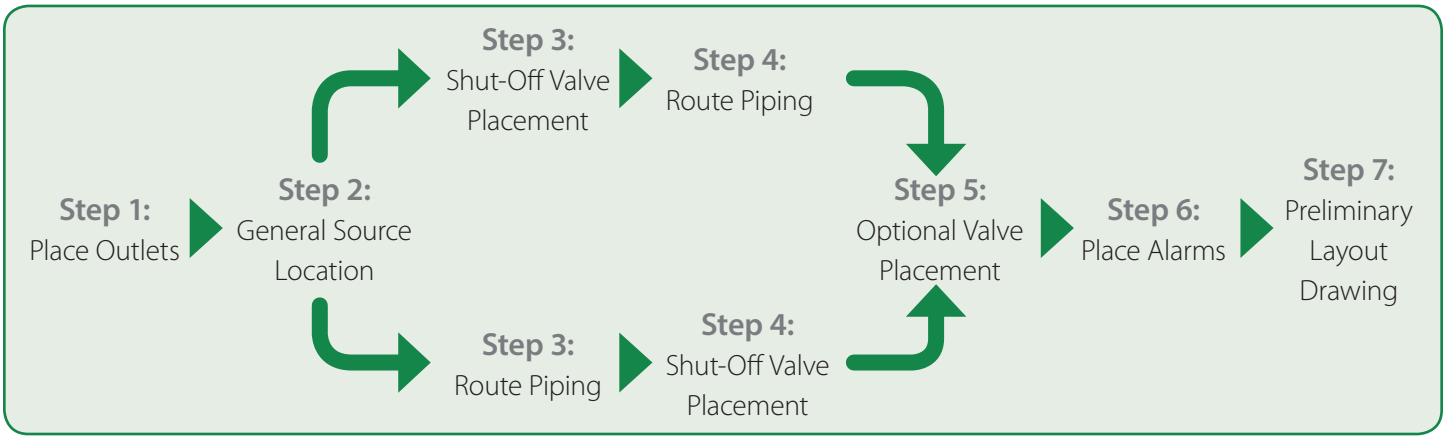
The System Design & Layout

Chapter 4 – The System Design & Layout

4.1 Introduction

This is the layout stage of the design process, where intended equipment is placed into the appropriate construction plans. Different engineering firms will handle this phase in different ways; some have the project engineer and CAD operators work together, whereas others have the engineer solely responsible for the project. Thus, the flow of the various steps detailed here are interchangeable to a certain degree. There is no one procedure that will universally work better than another, as long as all of the segments described in this chapter are given appropriate attention and consideration. The figure below provides a visual description of this stage, as well as where to find each section in this chapter.

Phase 2: Design



Step 1: Place Outlets	See Section 4.4 • Place on either side of patient bed
Step 2: General Source Location	See Section 4.5 • Not outdoors • Maintenance and ventilation access • Installation access
Step 3: Shut-Off Valve Placement	See Section 4.6 • Zone valves, service valves, riser valves, main line valve and source valve
Step 4: Route Piping	See Section 4.7 • Outlets » branch lines » zone valves » service valves » riser valves » mains » main line valve /source valve
Step 5: Optional Valve Placement	See Section 4.8 • Service valves • Expansion valves
Step 6: Place Alarms	See Sections 4.9 • Local alarms • Master alarms • Area alarms
Step 7: Preliminary Layout Drawing	See Section 4.10 • General idea for medical gas piped distribution system

4.2 The Drawing Space

It is generally recommended to indicate medical gas on design documents by presenting it on its own set of drawings, within the plumbing and mechanical drawings. Medical gas drawings are then normally designated "MG-X" to distinguish them from plumbing and other drawings.

You should start with a comprehensive set of architectural drawings which include the following:

- ✓ The room designations. The placement of the outlets is driven by occupancy and the intended occupancy of each space is necessary for a successful layout.
- ✓ The locations of all doors and exits, including fire doors.
- ✓ Location of fire walls and designated fire zones.
- ✓ If possible, include intended locations for ceiling service items (e.g. columns, booms/pendants, etc.) in the OR, ICU, or any other location. This will help you determine the maximum allowable heights in various areas of each room.
- ✓ The elevations and details of headwalls and all ceiling service equipment, by occupancy (if they exist).
    - Often, this equipment passes through an iterative process where the engineer must determine the medical gases before these products are finalized.
    - It is important to know from the Discovery Stage (Chapter 3), which areas are intended to be fitted with headwalls and ceiling services and which will be fitted with in-wall outlets.
    - Coordination with the architect might be required for the final design of these products.
- ✓ The intended location of the patient.
    - Usually this will be shown by an outline of the bed on architectural drawings.

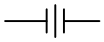
4.3 Associated Symbols

Although a universal symbology for medical gas does not presently exist, the table below lists symbols commonly used by Amico Source Corporation in our piping and instrumentation diagrams (P&IDs). Other symbols are just as valid, provided they are unique for medical gas and properly tabulated/described.

MEDICAL GAS SYSTEM SYMBOLOGY

Upon receiving the submittal drawings from Amico Source Corporation, feel free to consult this table for additional reference.

Name/Item	Symbol	Description
Pipeline Specific Symbols		
Medical Compressed Air Piping	—MA—	Used to indicate all piping that goes from the medical air system to the facility.
Medical Compressed Air Intake Piping	—MA-IN—	Used to indicate the piping line coming from the facility roof, to the medical air system (as per NFPA 99 requirements).
Medical (Surgical) Vacuum Piping	—MV—	Used to indicate the piping coming from the facility to the medical vacuum system.
Vacuum Exhaust Piping	—VE—	Used to indicate the piping going from the medical vacuum system, to the facility roof (as per NFPA 99 requirements).
Instrument Air Piping	— IA —	Used to indicate piping lines that are connected to instruments. Please note that the line pressure will be high, due to NFPA 99 requirements of instrument air system needing a minimum 200 psi discharge pressure.
Compressed Air Piping	—CA—	Used to indicate any piping that does not correspond strictly to the medical air system.
Waste Anesthesia Gas Disposal Piping	—WAGD—	Indicates any and all piping related to WAGD producer systems.
Medical Carbon Dioxide Piping	—CO2—	Indicates all piping related to carbon dioxide and their respective manifolds.
Medical Oxygen Piping	—O2—	Indicates all piping related to carbon dioxide and their respective manifolds.
Medical Nitrogen Piping	—N2—	Indicates all piping related to nitrogen and its respective manifolds.
Medical Nitrous Oxide Piping	—NO—	Indicates all piping related to nitrous oxide and its respective manifolds.
Shutoff Valve and Box		Used to indicate zone and service valves, meant to isolate particular areas in the facility from the source system.
Source System Specific Symbols		
Air Compressor		Provides compressed air for the facility. Common technologies used include scroll and reciprocating.
Vacuum Pump		Provides vacuum (suction) for the facility. Common technologies used include contactless claw dry, rotary vane dry, and rotary vane lubricated.
Pressure Relief Valve		Used as a safety precaution to relieve pressure at critical points in compressed air systems.
Air-Cooled After Cooler		Cools the air coming directly after the compression cycle.

Name/Item	Symbol	Description
Solenoid Valve		Solenoid valves are electromechanical valves normally used for purging applications. N/C indicates normally closed (and thus when energized the valve opens); N/O indicates normally open (and thus when energized the valve closes).
Union		Unions are used to provide locations to remove hard piping. They will be found in any areas where removing surrounding piping is necessary for maintenance.
Flex Connector (Hose)		Flexhoses are used to connect piping together; their flexibility allows for the absorption of vibration. Intake and Discharge flexes for all source systems will be shipped loose.
Pressure Switch		These are mechanical switches that are activated via pressure levels.
Temperature Switch/Sensor		These are used as a safety measure for compressor/ pump overheat. Switches cut off a pre-defined temperatures, while sensors will give the readout of the temperature in real time.
Gauge		Used to display the pressure or vacuum level.
Isolation Valve (Ball Valve)		Shuts off flow for all associated downstream components (used to close or open).
Inlet Filter		Used to remove incoming particulate from the air system intake line, before reaching the compressor.
Dryer Filters: 1. Oil Coalescing Filter 2. Pre-Filter 3. After Filter 4. Sterile Filter		1. Removes any excess oil from the air stream. 2. Removes particulate and excess moisture before entering the dryers. 3. Removes desiccant from the air stream. 4. Provides sterilization to the air stream.
Activated Carbon Filter		Used with Oil based compressors, to remove any oil from the system.
Moisture Separator		Meant to remove any moisture from the location
Regulator		Used to regulate the pressure to necessary levels.
Check Valve	 OR 	Permits flow in only one direction, thereby preventing backflow.

4.4 Step 1: Outlets

Outlets are placed in each area as requested by the client and as required by standards in every room. The type of outlet should be based on the usage and occupancy of the room. It is recommended to place outlets on either side of the patient bed, as applicable. For settings where there are multiple outlets of the same type, they should be separated evenly between the two sides. Although it is possible to place outlets in firewalls, it is best to avoid doin g so. Try to place outlets on other walls as much as possible.

When headwalls, consoles, ceiling services or other architectural equipment are to be used to organize the outlets, this equipment should be detailed with elevations on the plans. It is good practice to ensure that all such elevations are used as the primary reference for the outlet locations and numbers.

4.5 Step 2: General Source Location

The next step should be determining a general location where the source equipment will be placed. More than likely, this will require an iterative process as the sizing and dimensions of the equipment are not known at this point. Regardless, you must choose a location for the equipment in order to determine the placement of other related components. Usually, a general location will have been determined by the architect and space will already have been designated. If so, please use this location for the equipment. However, it is imperative to ensure that the assigned location is large enough for the equipment and its recommended service envelope (see the System Selection Tables in Chapters 5 and 6). If not, you may be forced to find an alternate suitable location. In either case, it is possible to test various locations for their appropriateness based on the equipment you intend to place there.

For medical air compressors, vacuum pumps, WAGD producers and instrument air compressors, the intended location must have (at a minimum) the following characteristics:

1. **The location will not be outdoors.** Amico Source Corporation does not advocate lifesaving systems to be installed outdoors, especially without protection. The weather will play a major factor in the functionality of these systems. For medical air systems, condensation no longer stays in the gaseous stage when temperature drops below freezing. It will form ice crystals that can coalesce to restrict the flow of the system. For vacuum systems, when the temperature falls below freezing, the lubrication oil (or gear oil) will thicken to the point where the motor (or gears) will no longer be functional. Thus, avoid all possible locations (such as on the roof, or an outdoor enclosure) that expose the equipment to such conditions.
2. **The location will have sufficient space for equipment, maintenance access and ventilation.** Amico Source Corporation recommends 2' (24") minimum clearance on all sides and 3' (36") in front of the control panel. Under exceptional circumstances, this space can be reduced. However, at this stage of the design and development process, it is recommended to allow the full envelope if possible.
3. **The location allows for easy installation access.** More often than not, rooms are sized in relation to the equipment size, however actually getting the equipment inside the room presents a challenge. Thus, it is important to visualize and examine the route the intended equipment must travel in order to be installed. Consider overhanging pipe that reduces the height of a doorway or ceiling, support beams and other objects blocking the path that may pose a challenge when the system(s) have been delivered. This can also create a problem for replacement equipment, as space is considerably limited when the facility is up and running for a few years.

4. **The location has more than adequate ventilation.** It is imperative that the operating conditions of the equipment never exceed that with which they were designed for. Amico Source Corporation mandates that the equipment location must never exceed temperatures greater than 105°F (40°C), under any circumstances. This includes when the equipment is running. Ventilation must be able to carry away generated heat from the equipment. It may be necessary to air-condition the location as well, depending on the climate and overall equipment characteristics. This step may be difficult to accomplish without an accurate value of the heat output of the equipment. Once the system(s) have been sized, selected and specified at the end of this design process, you will have a value of the power output (given in BTU/hr) to revisit this step. Consult your local Amico Source Corporation representative for a rough value if needed.
5. **The location has the capability to support the required electrical service.** If the originally intended location does not have appropriate electrical service or will require these to be relocated, the expense of providing this electrical service may justify moving the location elsewhere.
6. **Access to water and chilled water if needed for the technology chosen.** e.g. Liquid Ring Systems.

4.6 Step 3: Shut-Off Valve Placement (Valve Locations)

Once the source system(s) have been located, shutoff valves are to be placed according to NFPA 99. It is possible to work form the source outward, or from the outlets back towards the source.

4.6.1 ZONE VALVES

Working from the outlets back, the zone valves are to be placed first. Zone valves are the only valves that are accessible to floor staff.

For zone valve placement guidelines, please consult your local Amico Corporation representative. A few general notes regarding zone valves follow.

- ✓ The ideal location for a zone valve is along the best available exit path for facility staff. The staff should be able to pass by the zone valve during an emergency exit of the facility.
- ✓ If a person is standing at the zone valve and within the same space as the outlets controlled by it, then the valve is poorly placed. A wall, door or other physical and fire resistive barrier must separate the outlets from the valve.
- ✓ The swing path of nearby doors must be considered. If the valve location will be blocked when a door is opened, it is not a suitable location. In case of emergency, valves must always be seen and not obstructed by open doors.
- ✓ Zone valves must not be located in public or insecure areas. They should be located in busy staff corridors, where they can be easily and frequently monitored.
- ✓ Allow for sufficient wall space for the valve to physically fit in the location.

Conflict between the above notes may occur and thus there are situations where some principles may need to be compromised to allow for others. Use your best judgement in conjunction with the client's input to determine the most suitable location.

Note: Should you prefer to run pipe at this time, you certainly may as this is an equally valid next step. Working in this sequence will require you to proceed to step 7 and then return to step 4 afterwards. The process detailed in this Design Guide calls for placing valves before piping, as this is what Amico Source Corporation recommends.

4.6.2 SERVICE VALVES

Determine the location of the service valves. The primary function of a service valve is to allow work on the zone valve without having to shut down the entire system. However, they are rarely used as zone valves are rarely serviced. Most service valves will in fact never be used (which is a good thing) but they are required by NFPA 99. Common guidelines for service valve locations are as follows:

- ✓ Service valves should be found where any line departs from the main line, riser or significant branch to serve a zone valve
- ✓ There can be no zone valve without a service valve on its source side, but zone valves can share a service valve
- ✓ Service valves are to be on the same floor as the zone valve they serve
- ✓ Service valves are to be located close to the main line, branch or riser in secure areas and locked open

For additional information regarding Service Valves, please consult your local Amico Corporation representative.

4.6.3 RISER VALVES

Determine the location of the riser valves. Riser Valves or Branch Valves have the following general notes as guidelines:

- ✓ Riser valves should be found at the base of each riser, before the riser passes into the next floor. If the main line runs through the basement, the riser valve will be located in the basement where the line turns up. It is required where the main line turns up as well as required for every location where a riser tees off the main.
- ✓ It is good practice to think of riser valves as branch valves. Thus, they should be installed where any major branch separates from the main line. A major branch is any line that serves two or more zones.
- ✓ Riser valves should be placed in secure locations that are only accessible by the main staff.

For additional information regarding Riser Valves, please consult your local Amico Corporation representative.

4.6.4 MAIN LINE VALVE AND SOURCE VALVE

Determine the location of the main line valves and source valves. The main line valve can be optional, however the source valve is mandatory. Please note that the source valve is included with Amico Source Corporation's medical compressed air and vacuum equipment, unless identified otherwise. If specifying Amico Source Corporation equipment, you may proceed straight to the main line valve section below and ignore the source valve section.

The general guidelines for the source valve are as follows:

- ✓ The function of the source valve is to separate the source from the facility pipeline. Every source must have a source valve. By closing the source valve, you should be able to remove and replace the source equipment in its entirety. The source valve also serves as the dividing line between source equipment and pipeline equipment. (Both have its own operation characteristics.)
- ✓ The source valve must be found at, or very near, the equipment and within the same room. Since this room or enclosure will already be secure, there is no need to secure the source valve.

- ✓ The source valve must be accessible to any maintenance personnel working on the equipment without a ladder or any other special tools.

The general guidelines for the main line valve are as follows:

- ✓ If the source equipment is inside the building and already includes a source valve, the main line valve can be considered optional.
- ✓ Should the source equipment be located outside the building, the main line valve must be placed at the point where the pipe enters the building. For example, consider a bulk oxygen system that is located away from the building. The source valve is required to be out on the pad with the equipment, so the main line valve must be at the point where the piping will enter the building.
- ✓ Should the source equipment be physically within the building, but can only be accessed by exiting the building and re-entering the source enclosure, a main line valve will be required.
- ✓ If the equipment is physically mounted on an outside wall (e.g. a manifold on the outside of the building), NFPA 99 allows the exclusion of the main line valve.

4.7 Step 4: Route Piping

The next step of the process will be to create the piping route. In general, outlets route to branch lines, branch lines will route to zone valves, zone valves must route to service valves, service valves will route to riser (branch) valves, riser valves will route to the mains and the mains will connect to the main line valves. A few general guidelines for this process are as follows:

- ✓ Piping should be configured to make the route as short as practically possible.
- ✓ Wherever possible, route piping down hallways instead of through walls. If a wall only serves as a partition and does not reach the deck above, the piping can be run over the walls. Running lines through firewalls is not advised, as that will reduce the fire-stopping capability of that wall.
- ✓ Avoid drawing piping which will be difficult or impossible to install. It is important to keep in mind that medical gas piping cannot be bent, so having odd turns will not suffice. 90° and 45° elbows and tees are fine, however anything with a larger angle will pose a problem in the pressure or vacuum level of the line.
- ✓ Piping should be routed in such a way to minimize fittings and turns. Although some compromises with other trades will need to be made, medical gas (and in particular medical vacuum) piping must have an absolute minimum amount of turns. Should potential conflicts with ductwork, stacks, electrical lines etc. occur, strive to route the piping smoothly around these obstacles – as opposed to having the installer use multiple fittings to navigate around them.
    - The more fittings and bends that are present in the pipeline, the greater the head loss for the medical gas. This means that the pressure drop in the line will be greater, ultimately affecting the end flow or suction the patient will be receiving.
- ✓ Avoid making "U" traps or low spots in vacuum piping routes. In an ideal design, the vacuum piping should be sloped to the pump inlet. This will allow any liquid to run off before reaching the pump. Although in practice, this is very difficult to implement, it should be a consideration to keep in mind when designing the pipe routes.
- ✓ It is standard practice for zone valves to run from the source into the left side and to the outlets/inlets from the right side. This is due to the standard construction of the zone valve, where the gauge is on its right hand side. In your drawings, it is extremely important to indicate this orientation. There are few circumstances where this orientation can be reversed and problems later on will not occur.

- ✓ Zone valves are to never be connected in series, so that shutting down one zone valve will force the shutdown of another. Each zone valve must separately run to a service valve. However, multiple zone valves may come through a single service valve.
- ✓ Piping that is to be run underground has specific NFPA requirements that must be met. Consult your local Amico Corporation representative for more information regarding underground piping.

Note: If you chose to route piping before the placement of valves, please return to step 4.

4.8 Step 5: Optional Valve Placement

After the piping route has been more or less determined, you may consider the placement of optional valves. NFPA 99 allows for the placement of valves wherever desired for service or expansion. The only requirement is that these valves must be secure (not available for public access). Most facilities also prefer to have these valves locked open, however this is optional and to your discretion.

Common guidelines for in-line valves are as follows:

- ✓ In-line valves are to be used in order to separate isolation rooms (burn units, tuberculosis, infectious disease, etc.) within a zone.
- ✓ For single zones which control multiple rooms, insert in-line valves so that each room can be isolated from the zone.
- ✓ An in-line valve is recommended to be inserted wherever a system makes a natural break (e.g. moving from Ward A to Ward B or from the ICU to the recovery room).
- ✓ You may consider placing in-line valves wherever a distinctive piece of equipment is installed, e.g. headwalls or power columns.
- ✓ Future valves are valuable when an area is planned for expansion or renovation in the near future. They are normally placed at the end of a run; closed, locked and end-capped.
    - Future valves should be considered at the ends of all major lines and at least one should be considered for each floor.
    - For example: a future valve on each floor right at the riser can serve as the service valve should that floor ever need additional zones.

4.9 Step 6: Place Alarms

Determine the location of the alarm components. There are three categories of alarms that need to be located on your drawings:

1. Local Alarms (see 4.9.2) are found within medical air, vacuum, WAGD and instrument air systems. Simplified local alarms (local signals) may also be found with manifolds and at the bulk gas station.
2. Master Alarms (see 4.9.1) are found in specific areas where the facility staff can see and react to them.
3. Area Alarms are found in patient care areas. They are required in every location considered a critical care or life support area and in any area that is considered an anesthetizing location. Area alarms will include pressure and vacuum readouts for the system.

The NFPA handbook provides a useful test for determining whether a specific location would need an alarm. Should the medical gases or vacuum fail during a procedure in that occupancy room, would the procedure need to be terminated prematurely? In relation, would the patient outcomes be negatively impacted (injury or death) by this premature termination? If the answer to either of these questions is yes, then the area is considered critical care for the purpose of alarms.

This test serves as a reminder of the fundamental reason of the existence of an alarm: to give the facility staff quick notification that a gas or vacuum system is failing, so they can ensure the safety and well-being of their patient(s).

A normal panel location is in the nurse's station; however, this is not often the best location. A good panel location should be:

- ✓ Visible at all times. The alarm panel should not be behind open doors, parked equipment, beds or any other obstacles.
- ✓ Staffed 24/7.
- ✓ In an area where the alarm should be loud enough to be heard over the surrounding ambient noise.

Should the best location for different alarms be the same, it is acceptable to combine multiple alarms into a single panel. For example, in a central nursing station that is utilized for two different units. Each unit will have its own zone valve, but the best location for both alarms is that shared nursing station, in a single panel combing both alarms.

For anesthetizing locations, a single alarm for multiple zones is allowed (instead of the single alarm for each zone, required of critical care). The amount of alarms used will depend on the actual layout of the anesthetizing locations to be monitored. If the operating rooms are all grouped around a core central nurses' station, then all of the alarms can be handled with a single panel inside this central station. If however the locations are spread out with their own staff workspace and no central station, multiple alarms will be required to ensure each room is sufficiently monitored.

The location of an area alarm for these anesthetizing locations should:

- ✓ Be close to the anesthetizing location. Keep in mind that when the alarm goes off, the facility staff will need to advise each location that there is an alarm with the vacuum system. (Provided that there are no alarms in each location). The larger the distance, the more time needed to address the issue, potentially putting the patients' well being at risk.
- ✓ Have a staff member in the immediate vicinity.
- ✓ Not have any obstructions blocking the alarm panel. (e.g. doors, equipment, etc.)
- ✓ Allow the alarm to be heard over an appropriate area including any obstructing noise from nearby equipment, doors, etc.

Once the panels have been placed, the next step is to position the alarm sensors. The location of these sensors must be correct relative to the zone valve. Under NFPA rules, in-line valves and service valves can be considered non-existent when placing alarm sensors. It is good practice for sensors to be placed on the patient side of service valves. This makes the sensor easily accessible.

Common guidelines for the placement of alarm sensors are as follows:

- ✓ For critical care locations, where an area alarm will monitor a single zone, the sensor should be placed on the patient side of the zone valve. Closing the valve should activate the alarm.
- ✓ In anesthetizing locations where multiple zones may be monitored by a single area alarm, the sensor should be placed on the source side of all the zone valves. Thus, closing any or all of the zone valves should not activate the alarm. The alarm should only sound if there is a source failure or closure of a valve closer to the source.
- ✓ For non-critical care areas, it is recommended to place the sensors on the patient side of the zone valve.
- ✓ Alarm sensors must be placed on gas specific demand checks. A demand check is an automatic valve, keyed by gas for non-interchangeability, which allows the sensor to be removed for testing or replacement without shutting down the system.

The sensors may be placed in the alarm and a small pipe run to the panel or they may be placed on the pipe and wired to the panel. This will depend on the alarm system used and the decision can be made between trades based on what is easier – wherever the alarm gives the option. The specification must define this responsibility.

For more information on alarms, please consult your local Amico Corporation representative.

4.9.1 MASTER ALARMS

Master alarms (or source alarms) serve the purpose of monitoring the sources and giving warning of any issues developing within the source equipment themselves. There are two master alarm panels required:

1. One panel needs to be placed in the principal workspace of the person responsible for the systems. This usually refers to the engineering/maintenance/facilities department and the alarm is often found in the reception area behind the dispatcher's desk. However, this is not the only location that it can be placed and oftentimes it is not the most ideal location. Alternative locations can include the operating engineer's office in the boiler room, at the Building Management System (BMS) main terminal, in the respiratory therapy department, in the anesthesia department, or any other location determined to best ensure that the alarm is seen and can be swiftly attended to by the appropriate party.
2. The second panel must be placed in a location that will be occupied whenever the facility is in operation. Potential locations include the security office, reception, the BMS central terminal room or any other location that will ensure the alarm is seen and a call can be made swiftly to the appropriate party.

Once the panels have been placed, the sensors for system pressure/vacuum need to be placed. These should go on the patient side of the main line valve (if it exists), or on the patient side of the source valve (if the main line valve does not exist).

For more information on master alarms, please consult your local Amico Corporation representative.

4.9.2 LOCAL ALARMS

Note: You can skip this step if you intend to specify Amico Source Corporation equipment. Local alarm panels are included in all Amico Source Corporation equipment, no separate local alarm panel will be necessary.

Most purchased medical systems will provide a local alarm directly from the system. Local alarm panels are needed if the system was not purchased to comply with NFPA 99 from factory. The panel serves to display key indicators of failure in the source equipment and will be placed in the same room or enclosure as the equipment itself. The panel should be located so as to be visible when personnel are viewing the system from the front. It is acceptable to combine multiple sources into a single panel if there are sufficient indicators available and the panel can be clearly seen from the front of all applicable equipment.

4.10 STEP 7: PRELIMINARY LAYOUT

At this point in the design stage, you will have a preliminary complete layout that includes all required valves, alarms and the necessary outlets for each patient location. You will thereby have a rough design of the medical gas system.

The next stage will be calculating the sizes of each piece of source equipment, detailing it, selecting the exact equipment from a standard catalog and then return to this drawing to confirm the initial preliminary estimations are still viable. Naturally some adjustments will need to be made, particularly in the physical size of the selected equipment against the available space. Generally speaking, you will have completed a layout that is reasonably close to the final one.

The next stages are system-specific and can be taken in any order – depending on which equipment is desired.

Here's where to find each:

Chapter 5 – Medical Compressed air Systems

Chapter 6 – Medical Vacuum (Suction) Systems

After the sources are complete and selected, we will complete the specification of the system in Chapter 7 – Specification & Schedule. A basis of design will then be selected, detailing the information of this example system on the schedule.

Chapter 5

Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

Chapter 5 – Medical Compressed Air Systems

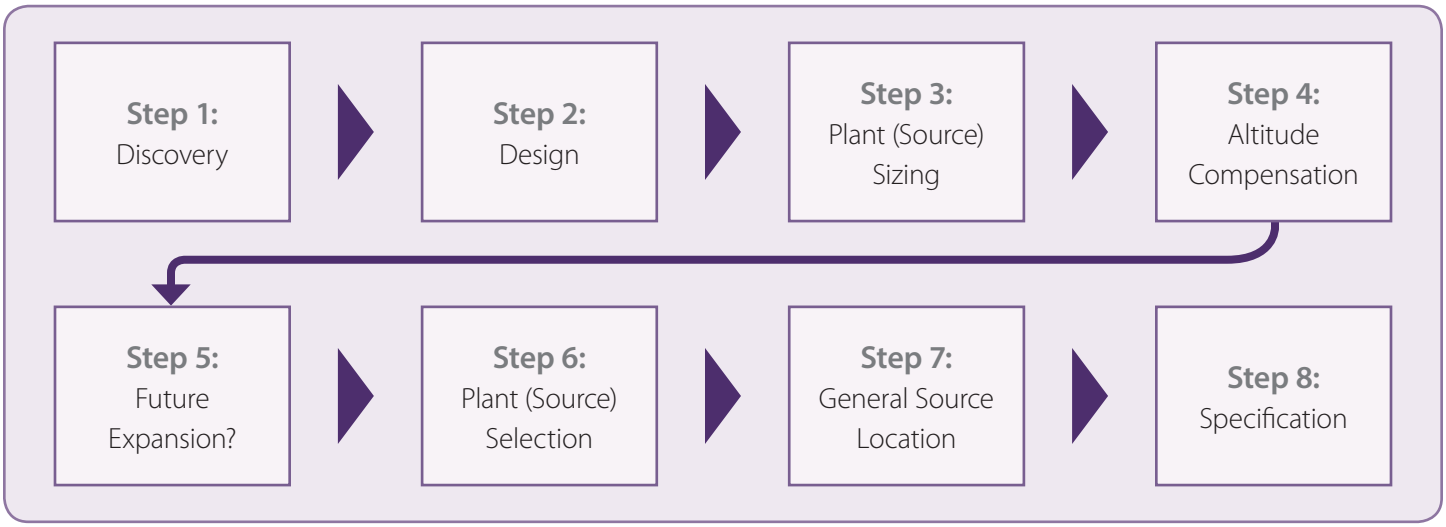
Medical Air Systems Glossary

ACFM	Actual Cubic Feet per Minute is an expression of actual air volume, generally corrected for and in reference to a particular pressure
ICFM	Inlet Cubic Feet Per Minute refers to conditions at the inlet of the compressor prior to any restrictions or temperature changes (e.g. inlet filters, inter-coolers, discharge manifolds, etc.)
Continuous Duty	Operational reference to compressors operating 24 hours a day, continuously
Continuous Duty Rated	Air compressors which can operate continuously (24 hours per day) if necessary but normally only operate on demand
Desiccant Dryer	Consists of two towers, whereby the desiccant bed in one tower dries the air stream while a purge of dry air regenerates the desiccant bed in the other tower.
Dew Point	Temperature and pressure at which medical air will condense water vapor into liquid water within the medical air pipeline system.
Dew Point/CO Monitor	Monitors dew point and carbon monoxide levels in medical air.
Displacement	Theoretical physical volume of the air in the compressor chamber based upon 100% pumping efficiency, with no allowances made for heat, friction, clearances or other losses in the compression cycle.
Duplex System	Systems comprised of two compressors, each rated for 100% Peak Calculated Load (PCL)
LPM	Liters per Minute is a measure of the flow rate of a gas
NTP	Normal Temperature and Pressure is generally accepted as 70˚F (20˚C), 14.969 psi/29.92 inHg barometric pressure and 36% relative humidity
Oil-Free Compressor	Compressor which keeps oil separated from the compression chamber by means of seals
Oil-Less Compressor	Compressor which does not require oil for any of its operational tasks.
Peak Calculated Load (PCL)	The maximum estimated demand a medical facility will require of a medical air system. Calculated at SCFM at 100 psig
SCFM	Standard Cubic Feet per Minute is an expression of air at NTP.
Simultaneous Demand	Operating reference to a condition where all Lead and Reserve compressors run simultaneously to satisfy demand in excess of the Lead compressor's capability
Triplex Systems	Medical air system with three compressors, each sized for 50% PCL
Quadruplex System	Medical air system with four compressors, each sized for 33% PCL.

How To Use This Section

The following section is structured so that the medical compressed air system for a project may be established and executed in a logical and simple progression. A Design Example is given at the end of this chapter to further illustrate the process. The figure below shows a visual description of this stage and where to find each section in this chapter.

Phase 3: Engineering



Step 1: Discovery	See Sections 5.2.1 and 6.2.1 • Existing equipment • Evaluation of site conditions • Verify number of outlets/inlets
Step 2: Design	See Sections 5.2.2 and 6.2.2 • Identify number of outlets necessary for system to supply
Step 3: Plant (Source) Sizing	See Sections 5.2.3 and 6.2.3 • NFPA plant sizing method
Step 4: Altitude Compensation	See Sections 5.2.4 and 6.2.4 • Correction factors for facility elevation
Step 5: Future Expansion?	See Sections 5.2.5 and 6.2.5 • Adding capacity for future requirements
Step 6: Plant (Source) Selection	See Sections 5.2.6 and 6.2.7 • Choose appropriate technology and configuration • System selection tables
Step 7: General Source Location	See Sections 5.2.7 and 6.2.7 • Place equipment on plan drawings • Pipe route and size • Minimum clearance requirements
Step 8: Specification	See Sections 5.2.8 and 6.2.8 • Detail technology and system details • Schedule equipment

The Basic Milestones In Designing A Medical Air System Are As Follows:

- Definitions – these are provided in the glossary at the beginning of this chapter, which contains terminology that may be utilized within this chapter. These terms may also be helpful in understanding and specifying the appropriate medical air system for your medical facility. Refer to Chapter 1 for a more comprehensive list of useful terms and their meanings.
- Design – this general outline pertains to the procedural involvement in designing your medical compressed air system(s).
- Sizing and Selecting the Medical Compressed Air System – step by step guide illustrating how to calculate the Peak Calculated Load (PCL) requirements for the medical facility.
- Installation – steps to building and installing your medical compressed air system(s).

5.1 Introduction

The NFPA 99 standard for Medical Air is based on a simple but essential foundation: the air should start clean and stay clean. This foundation means that the patient should be provided with air that is of equal or better quality than the air from outside.

All compressors included herein are deemed suitable for medical use according to NFPA standards. For further information on NFPA compliant medical systems, please consult your local Amico Source Corporation representative.

THE FOUR ESSENTIALS TO BUILDING A MEDICAL AIR SYSTEM

1. The intake air location must never be contaminated by placing the medical compressed air systems in a poorly ventilated area.
2. Medical air must be available at all times, even during a single failure of a component in the system. NFPA only requires duplex systems, however it is recommended to size up the system in the event where a compressor is down (ie. duplex to triplex). This would prevent a single compressor to carry the entire load.
3. Medical air must be dry. No liquid water should develop during normal operation.
4. Medical air must be free of contamination. Any contamination that is produced during operation must be removed prior to feeding air to the patient.

The NFPA 99 standard provides a bottom-line regarding the requirements of a medical air system. It is important for the engineer to take the standard and design/specify a system which will meet and exceed this bottom-line. The performance of critical components such as after-cooler, moisture separator, dryer, vibration isolator, etc. should be specified in detail to prevent inferior parts being used on a medical air system. Additional features such as alarm logging and email alarm alerts are also good engineering practice. These features are new technologies in the industry, which allows faster response time for the facility if an issue arises.

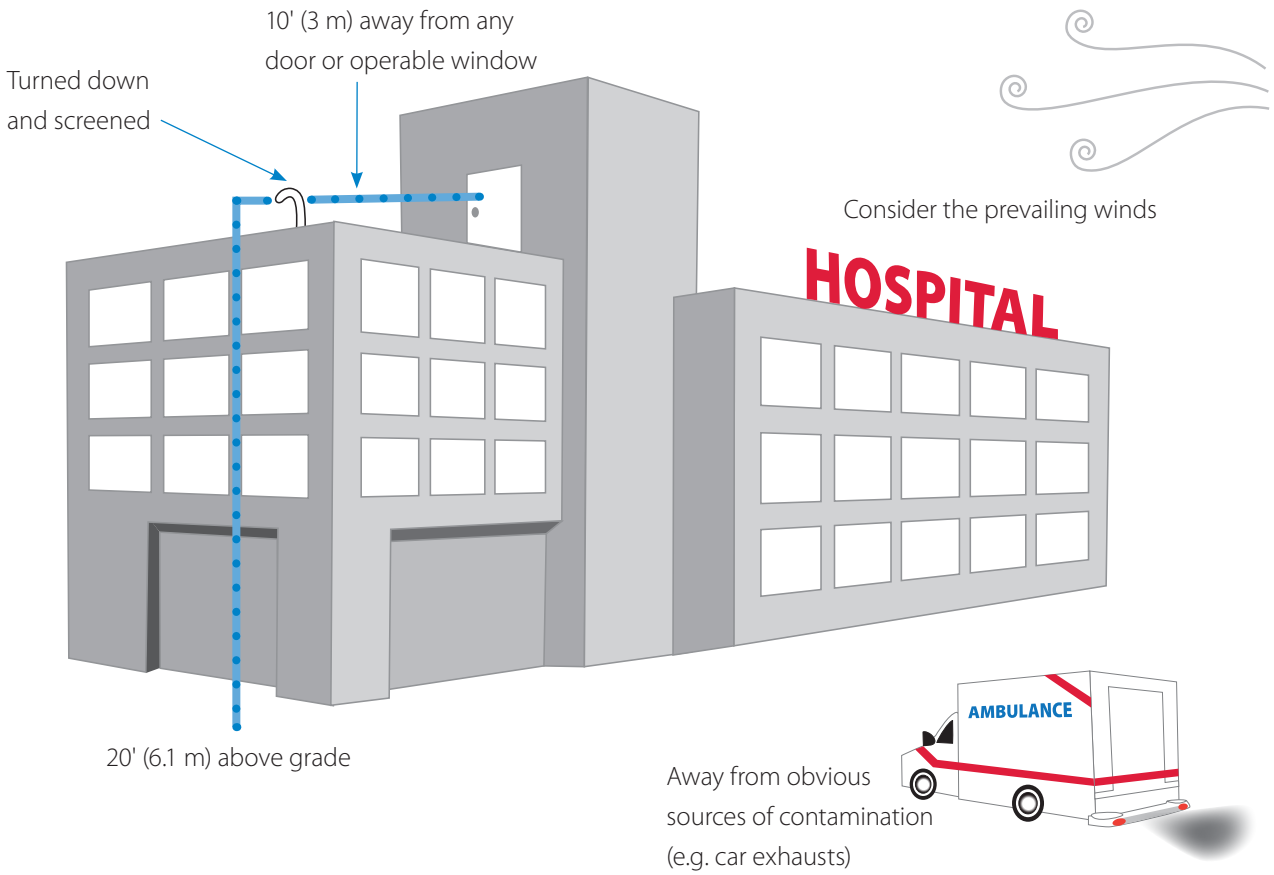
This section of the design guide provides engineers with a starting point on how to design a medical air system into their facility. There are other considerations that need to be taken into account which are not mentioned in this section. This design guide will provide you with quick access to basic knowledge on medical air systems.

5.2 Steps to Implementing the Medical Compressed Air System

5.2.1 STEP 1: DISCOVERY

1. Should existing equipment be incorporated along with the medical compressed air system(s), determine the dimensions, type, capacity and current loading of the existing equipment. Ensure the existing equipment is compatible with the current standard.
2. Verify the number and type of all areas in the facility which will require medical air outlets.
3. Determine the maximum number of ventilators that will be used. Special attention should be taken on the model and their average air flow rate requirement.
4. Examine the location intended for the air intake carefully, as NFPA mandates that the intake be located at a minimum of 10' (3 m) from any door or operable window; 20' (6.1 m) above grade. Consideration should be taken so that the inlet will not be exposed to contaminated air under any wind and weather conditions. See diagram below for an illustrated example.
5. An air source equal to or better than outside air can be used as a medical air intake if it is available 24/7 on a consistent basis. Ventilating systems with a fan motors or drive belts located in the airstream shall not be used as a source of medical air intake.
6. The intake opening shall be turned downward and screened. It shall be accessible to authorized personnel for cleaning, inspection and servicing. The inlet should also be located away from loading docks or parking locations. It is advisable to place the intake at a height above any other intakes or vents on the same roof. For further details regarding the rules and regulations in choosing your medical air system location, please refer to the latest edition of NFPA specification guide.

AIR INTAKE LOCATION



7. If the medical air system is not already piped to the proposed location, determine a routing for the intake piping and note it on the building drawings. Piping downstream of the compressor shall be routed in a manner such that it is not subjected to temperatures lower than 40°F (4°C).
8. Determining the location of the air plant, ventilation and air conditioning should be considered. During operation, the system will produce heat which will need to be dissipated. Most medical systems seen on the market will provide a BTU value which estimates the heat discharged from the system. This value should be derived from the horsepower of the motor following the laws of thermodynamics. Since the only input of energy to the system is electrical power, we can assume that the worst case scenario is for all the electrical power to be converted to heat energy. Some manufacturers do decrease that value claiming it to be a tested value. These values should be taken with some skepticism.
9. Determine the availability of electrical service.
10. Refer to §3.3.9 of Chapter 7, Part 3 (on pages 129-130) for specification requirements of medical air system inlets.

5.2.2 STEP 2: DESIGN

Follow directions for laying out piped medical gases – the process is outlined in Chapter 4 of this Design Guide. This will provide the count of outlets necessary, which is compulsory for the subsequent steps.

5.2.3 STEP 3: PLANT SIZING

There are several available methods for sizing Medical Air. In this Design Guide, only the National Fire Protection Association (NFPA) method will be discussed.

THE NFPA PLANT SIZING METHOD – MEDICAL AIR

1. Count all outlets within the infrastructure that will utilize the air compressor system (see table on the next page). In situations where the exact type of room cannot be located within the table, please select the one which most closely approximates the room as indicated in the chart.
2. Once the total amount of outlets are entered, multiply all variables across the table (left to right) to apply the simultaneous usage factor.
3. Obtain an estimate of the air requirements by adding up the values of the columns (top to bottom).
4. NFPA recommends the inclusion of additional capacity for potential ventilator use. However, this ventilator factor causes significant problems and is usually the cause behind gross over-sizing for medical air plants. Therefore, extreme caution should be taken.

Please refer to the table on the next page to obtain an average flow that is required within the facility. This chart is also available at **amico.com/files/product/files/amico_source_equipment_sizing_guide.xls**

MEDICAL AIR – SCFM CALCULATION TABLE

Location of Outlets	Units Required	Units	Outlet CFM	Simultaneous Use (%)
Surgical Procedures				
Pre-Op Holding	0	Bed(s)	1	10
Major Invasive	0	Room(s)	3.5	100
Minor Invasive	0	Room(s)	2	100
Trauma and Emergency	0	Room(s)	3	100
Catherization and Lab work	0	Room(s)	1	10
Endoscopy	0	Room(s)	2	100
Recovery	0	Bed(s)	1.5	50
Tests and Outpatient Procedures				
X-ray, CAT, NMR, PET scans	0	Room(s)	1.5	30
Dialysis	0	Bed(s)	1.5	30
Exam and Minor Treatment	0	Room(s)	1	10
EEG/EKG	0	Room(s)	1	10
Pulmonary Function	0	Bed or outlet	1.5	30
Respiratory Care	0	Bed or outlet	1.5	30
Observation	0	Bed or outlet	1	10
Perinatal and Pediatric				
Birthing or LDRP	0	Room(s)	1	100
Delivery Room	0	Room(s)	0.5	100
Nursery	0	Bed(s)	0.5	10
NICU	0	Bed(s)	1.5	50
Intensive Care				
Adult ICU, CCU, etc.	0	Bed(s)	2	50
Pediatric ICU (Except NICU)	0	Bed(s)	2	50
Emergency (not surgical)	0	Bed(s)	2	10
Equipment Maintenance				
Workrooms	0	Outlet(s)	1.5	10
Laboratory				
Medical Lab Uses	0	Outlet(s)	1.5	25
Other				
Patient rooms	0	Room(s)	0.5	10
Ventilator	0	Unit(s)	3	50
Location 1: Critical*	0	Outlet(s)	6	100
Location 2: Non Critical*	0	Outlet(s)	3.5	100
Location 3: Support Gas*	0	Outlet(s)	5	100
Location 4:	0	Outlet(s)		

* May be used alone if you wish to only count outlets needed. You may change that field as you see fit.

Future Expansion	
Peak calculated demand in SCFM based on free air SCFM at 50 psi:	0.00

Note:

1. The SCFM above is based on a peak outlet demand of 50 psi. Air compressors however operate at 100 psi. When sizing a compressor, you must calculate the compressor capacity for operation at 100 psi.
2. You need to consider several environmental factors when sizing the compressors, including: altitude, intake air temperature and relative humidity. Variance among these factors considerably affects flow output and thus compressor selection.
3. Air outlets in labs used for analysis, research or teaching should be supplied by a separate compressed air system and not the medical air system.
4. All sizing methods are approximations. If an existing compressor is being replaced, the operating characteristics of that compressor can be an important gauge of likely future use. For example, if an existing 5 hp compressor provides an ample amount of medical air, but the sizing tables yield larger requirements; it may be suitable to use a smaller compromise unit as opposed to simply relying on the results from the Sizing Guide.

5.2.4 STEP 4: ALTITUDE ADJUSTMENTS

It is important to keep in mind that for compressors operating at a higher altitude (over 1000 feet above sea level), we must take into consideration the reduced flow output and decreased performance of the air compressor. In such cases, the required sizing will need to be adjusted by taking the total PCL (from the Medical Air – SCFM Calculation Table on page 54) and multiplying it by the correction factor in the table below.

ALTITUDE COMPENSATION CHART

Altitude	Multiplier Used for Required SCFM (Hg)
Sea Level	1.00
1000' (305 m)	1.01
2000' (609 m)	1.03
3000' (900 m)	1.05
4000' (1219 m)	1.06
5000' (1525 m)	1.08
6000' (1828 m)	1.10
7000' (2133 m)	1.12
8000' (2438 m)	1.15
9000' (2743 m)	1.17
10,000' (3048 m)	1.19

5.2.5 STEP 5: COMPENSATING FOR FUTURE EXPANSION

When selecting a system, it is important to consider a size that will accommodate the future. While this is a good idea, it can also cause issues. One common issue when oversizing is heat and moisture. On oil-less reciprocating compressors, for example, the performance of the compressor depends on the ability to heat the compressor head so moisture does not accumulate inside the compressor. By having an oversized system, the compressor is not allowed to run as often as it needs to keep the heat up. The heating and cooling cycle causes moisture to build up on the wrist pin of the piston and soon the wrist pin will seize, causing compressor failure. In addition to issues affecting the system, the oversized system requires additional costs and there is a possibility that the hospital drops the plan to expand later on. Instead, engineers should specify a system that is suitable for expansion without purchasing the compressor unit itself.

In an expandable system, the system control panel should have provisions to connect the extra pump(s) required after the expansion. A base should be provided to mount the new pump when expanding. An intake and discharge connection isolated by ball valves should be provided to connect the future pump(s) into the system without stopping the service of the medical vacuum system. The inlet, discharge and electrical connections of the system should also be sized ready for the expansion to occur.

5.2.6 STEP 6: PLANT SELECTION

1. Select a preferred technology (see the Technology Comparison Chart). More specific assistance in selecting a technology may be obtained by contacting your local Amico Source Corporation representative.
2. Select the horsepower of the preferred technology which will match or exceed the flow that was previously determined in the sizing guide (tolerance percentage from the sizing guide is a good idea). See the Visual Selection Guide on page 58 for the standard air system from the System Selection Tables in this chapter.
3. **Note:** for some technologies, there is more than one plant layout configuration (see page 57 for the Quick Guide to Configurations). Should more than one layout be available for selection, choose the one best suited to the site conditions. When in doubt as to which arrangement is most suitable for a particular situation, please feel free to contact your local Amico Source Corporation representative for educated recommendations.
4. Reference the System Information Sheets on the tables starting on page 59 for the particular system selected. This chart includes all currently essential information regarding the system and should be utilized as a quick reference in all subsequent steps.

Technology Comparison Chart

Amico Source Corporation offers several technologies for medical compressed air, each of which has its own advantages and drawbacks. This table summarizes these as an aid in the selection of the correct technology for your specific application.

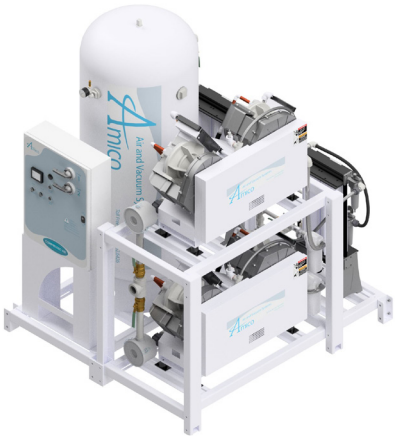
Characteristics	Scroll	Dry Reciprocating	Lubricated Reciprocating	Rotary Screw
Format	• Modular Stacking • Horizontal Tank Mount • Skid Mount	• Modular Stacking • Horizontal Tank Mount • Skid Mount	• Modular Stacking • Horizontal Tank Mount • Skid Mount	• Enclosed Unit
Lubrication	Oil Free	Oil Free	Lubricated	Oil Free
dBa*	74	84	82	72
SCFM*	32.0 at 120 psig	32.5 at 100 psig	32.8 at 100 psig	85 at 100 psig
LPM*	651 at 828 kPa	920 at 689 kPa	929 at 689 kPa	2407 at 689 kPa
High Pressure Application	Moderate	Moderate	Very Good	Poor
Maintenance	Low	Moderate	Moderate	High
Advantages	• Compact and low weight • Reliable • Low noise level (very quiet and vibration free) • No oil needed	• Customizable configuration • Extremely reliable • Best efficiency CFM/HP • Able to produce high horsepower with one compressor unit • No oil needed	• High pressure application • Very reliable • Low wear	• Enclosed in a cabinet • Lower running temperature • Suitable for high demand application
Disadvantages	• Less convenient when servicing large capacities	• Louder than scroll • Larger in size	• Oil needed to run • More vibrations	• High operating cost due to the need for water to cool • High maintenance • Difficult to install
Manufacturer	Hitachi	Hitachi	Champion	Hitachi

* All values are taken on pump at 10 hp except Rotary Screw which is taken at 20 hp

Quick Guide to Configuration

MODULAR STACKING CONFIGURATION

New **A-Frame** modular stacking configuration allows two compressors to run simultaneously with a smaller footprint and compact design. Compressor assemblies include at least one compressor and one motor.

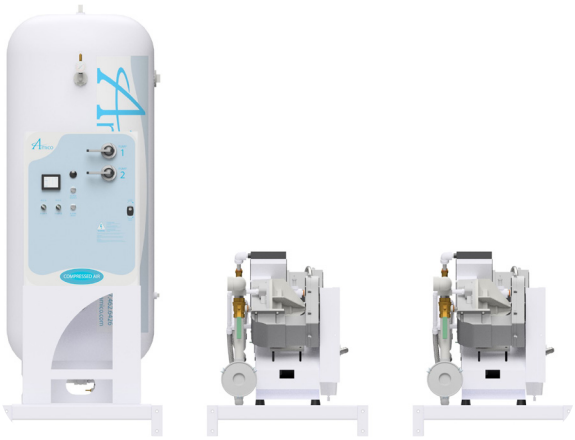


HORIZONTAL TANK MOUNT

The compressors are mounted on a horizontal tank which is large enough to accommodate bigger compressors and accessories than the Modular Stacking Configuration. This system is factory piped and wired to a single inlet, outlet and electrical connection.

SKID MOUNT

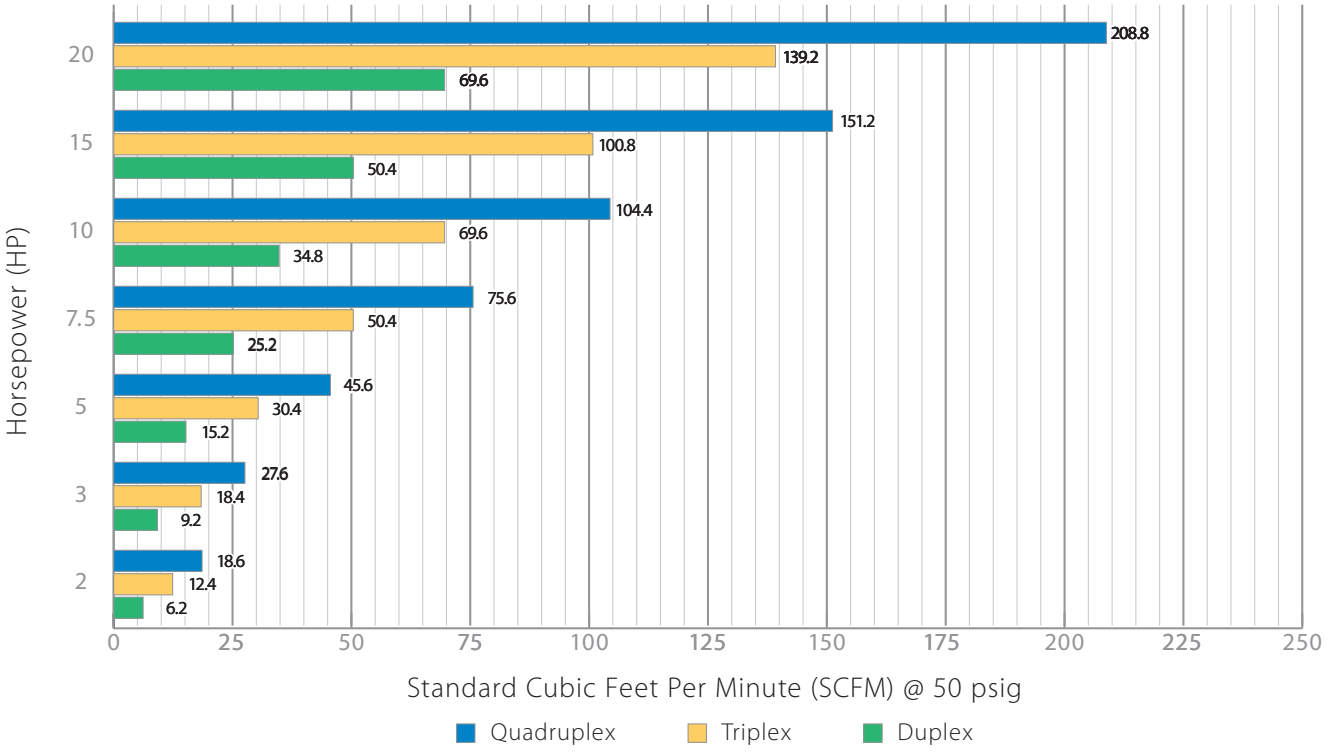
These systems are mounted on a separate skid. This configuration is suitable for larger compressors. This type of system is also designed for ease of transportation.



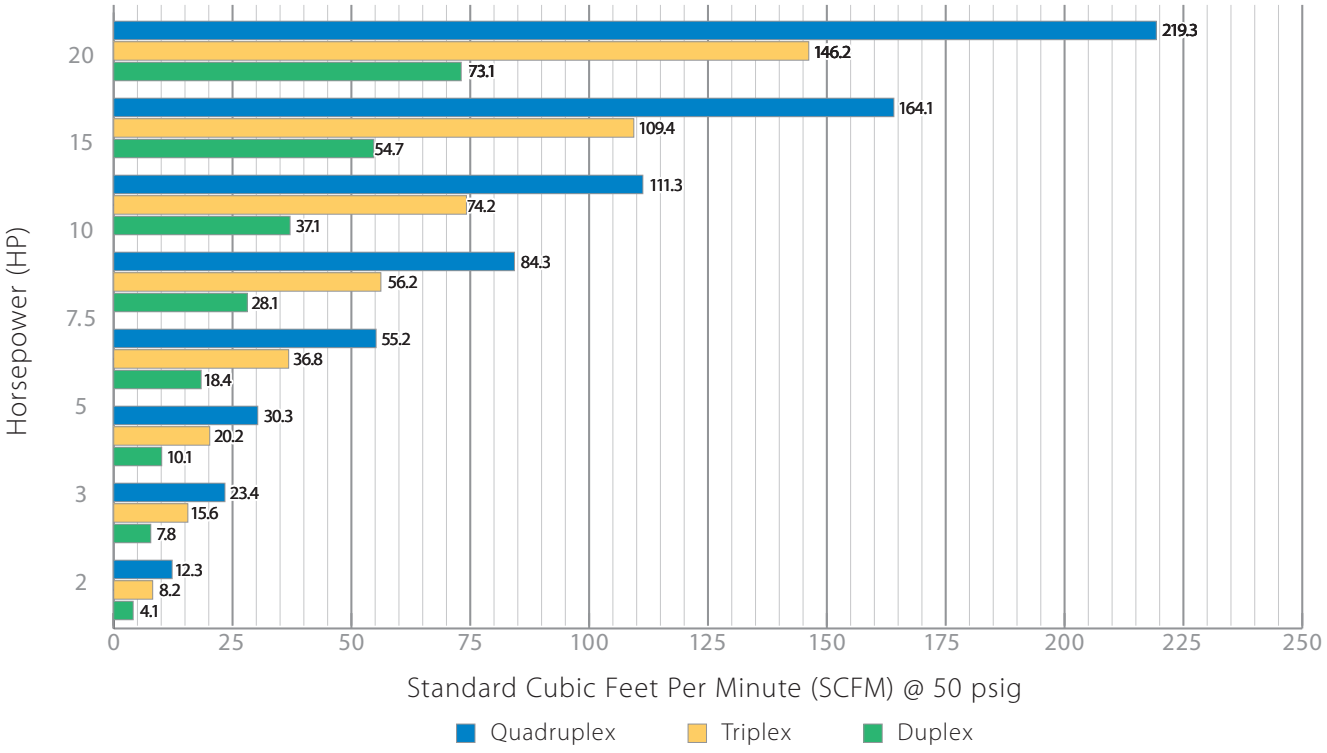
Standard Air System Visual Selection Guide

Please use our Sizing Guide spreadsheet to calculate the SCFM required for your facility. You can find this interactive spreadsheet at **amico.com/files/product/files/amico_source_equipment_sizing_guide.xls**

SCROLL TECHNOLOGY VISUAL SELECTION GUIDE



RECIPROCATING TECHNOLOGY VISUAL SELECTION GUIDE



AMICO SOURCE MEDICAL AIR SYSTEM SELECTION TABLE (OIL-LESS SCROLL SYSTEMS)

Model	System Layout	HP (kW)	NFPA System Capacities SCFM (LPM)		Complete System Dimensions* inches (metres)			
			at 50 psig	at 120 psig	Width	Length	Height	Total Sq. Ft. Required (M^2)
Modular Stacking (SS) Configuration								
A-SCD-D-200P-SS-N-020	Modular Stacking Duplex	2 (1.49)	6.2 (176)	5.6 (159)	67 (1.70)	74 (1.88)	91 (2.31)	34.4 (3.20)
A-SCD-D-200P-SS-N-030	Modular Stacking Duplex	3 (2.24)	9.2 (261)	8.5 (241)	67 (1.70)	74 (1.88)	91 (2.31)	34.4 (3.20)
A-SCD-D-200P-SS-N-050	Modular Stacking Duplex	5 (3.73)	15.2 (430)	14.1 (399)	67 (1.70)	74 (1.88)	91 (2.31)	34.4 (3.20)
A-SCD-D-200P-SS-N-075	Modular Stacking Duplex	7.5 (5.59)	25.2 (714)	24.0 (680)	67 (1.70)	74 (1.88)	91 (2.31)	34.4 (3.20)
A-SCD-D-200P-SS-N-100	Modular Stacking Duplex	10 (7.46)	34.8 (985)	32.0 (906)	67 (1.70)	74 (1.88)	91 (2.31)	34.4 (3.20)
A-SCD-D-200P-SS-N-150	Modular Stacking Duplex	15 (11.2)	50.4 (1427)	48.0 (1359)	67 (1.70)	74 (1.88)	91 (2.31)	34.4 (3.20)
A-SCD-D-200P-SS-N-200	Modular Stacking Duplex	20 (14.9)	69.6 (1971)	64.0 (1812)	67 (1.70)	74 (1.88)	91 (2.31)	34.4 (3.20)
A-SCD-T-200P-SS-N-020	Modular Stacking Triplex	2 (1.49)	12.4 (351)	11.2 (317)	100 (2.54)	74 (1.88)	91 (2.31)	51.4 (4.78)
A-SCD-T-200P-SS-N-030	Modular Stacking Triplex	3 (2.24)	18.4 (521)	17.0 (481)	100 (2.54)	74 (1.88)	91 (2.31)	51.4 (4.78)
A-SCD-T-200P-SS-N-050	Modular Stacking Triplex	5 (3.73)	30.4 (861)	28.2 (799)	100 (2.54)	74 (1.88)	91 (2.31)	51.4 (4.78)
A-SCD-T-200P-SS-N-075	Modular Stacking Triplex	7.5 (5.59)	50.4 (1427)	48.0 (1359)	100 (2.54)	74 (1.88)	91 (2.31)	51.4 (4.78)
A-SCD-T-200P-SS-N-100	Modular Stacking Triplex	10 (7.46)	69.6 (1971)	64.0 (1812)	100 (2.54)	74 (1.88)	91 (2.31)	51.4 (4.78)
A-SCD-T-200P-SS-N-150	Modular Stacking Triplex	15 (11.2)	100.8 (2854)	96.0 (2718)	133 (3.38)	55 (1.40)	91 (2.31)	50.8 (4.73)
A-SCD-T-200P-SS-N-200	Modular Stacking Triplex	20 (14.9)	139.2 (3942)	128.0 (3625)	133 (3.38)	55 (1.40)	91 (2.31)	50.8 (4.73)
A-SCD-Q-200P-SS-N-020	Modular Stacking Quadruplex	2 (1.49)	18.6 (527)	16.8 (476)	108 (2.74)	74 (1.88)	91 (2.31)	55.5 (5.15)
A-SCD-Q-200P-SS-N-030	Modular Stacking Quadruplex	3 (2.24)	27.6 (782)	25.5 (722)	108 (2.74)	74 (1.88)	91 (2.31)	55.5 (5.15)

Model	System Layout	HP (kW)	NFPA System Capacities SCFM (LPM)		Complete System Dimensions* inches (metres)			
			at 50 psig	at 120 psig	Width	Length	Height	Total Sq. Ft. Required (M^2)
Modular Stacking (SS) Configuration								
A-SCD-Q-200P-SS-N-050	Modular Stacking Quadruplex	5 (3.73)	45.6 (1291)	42.3 (1198)	108 (2.74)	74 (1.88)	91 (2.31)	55.5 (5.15)
A-SCD-Q-200P-SS-N-075	Modular Stacking Quadruplex	7.5 (5.59)	75.6 (2141)	72.0 (2039)	141 (3.58)	55 (1.40)	91 (2.31)	53.9 (5.01)
A-SCD-Q-200P-SS-N-100	Modular Stacking Quadruplex	10 (7.46)	104.4 (2956)	96.0 (2718)	141 (3.58)	55 (1.40)	91 (2.31)	53.9 (5.01)
A-SCD-Q-200P-SS-N-150	Modular Stacking Quadruplex	15 (11.2)	151.2 (4282)	144.0 (4078)	141 (3.58)	61 (1.55)	91 (2.31)	59.7 (5.55)
A-SCD-Q-200P-SS-N-200	Modular Stacking Quadruplex	20 (14.9)	208.8 (5913)	192.0 (5437)	141 (3.58)	61 (1.55)	91 (2.31)	63.6 (5.91)
Horizontal Tank Mount (TH) Configuration								
A-SCD-D-080P-TH-N-020	Horizontal Tank Mount Duplex	2 (1.49)	6.2 (176)	5.6 (159)	40 (1.02)	86 (2.18)	73 (1.85)	23.9 (2.22)
A-SCD-D-080P-TH-N-030	Horizontal Tank Mount Duplex	3 (2.24)	9.2 (261)	8.5 (241)	40 (1.02)	91 (2.31)	73 (1.85)	25.3 (2.36)
A-SCD-D-120P-TH-N-050	Horizontal Tank Mount Duplex	5 (3.73)	15.2 (430)	14.1 (399)	40 (1.02)	91 (2.31)	74 (1.88)	25.3 (2.36)
A-SCD-D-120P-TH-N-075	Horizontal Tank Mount Duplex	7.5 (5.59)	25.2 (714)	24.0 (680)	44 (1.11)	91 (2.31)	74 (1.88)	27.8 (2.59)
A-SCD-D-120P-TH-N-100	Horizontal Tank Mount Duplex	10 (7.46)	34.8 (985)	32.0 (906)	44 (1.11)	91 (2.31)	81 (2.06)	27.8 (2.59)

*System dimensions subject to change without notice. Please ensure that your copy of this chapter is up to date.

AMICO SOURCE MEDICAL AIR SYSTEM SELECTION TABLE (OIL-LESS RECIPROCATING SYSTEMS)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			at 50 psig	at 120 psig	Width	Length	Height	Total Sq. Ft. Required (M^2)
Modular Stacking (SS) Configuration								
A-RED-D-200P-SS-N-010	Modular Stacking Duplex	1 (0.75)	4.1 (116)	3.3 (93)	67 (1.70)	75 (1.91)	91 (2.31)	34.9 (3.25)
A-RED-D-200P-SS-N-020	Modular Stacking Duplex	2 (1.49)	7.8 (221)	6.6 (187)	67 (1.70)	75 (1.91)	91 (2.31)	34.9 (3.25)
A-RED-D-200P-SS-N-030	Modular Stacking Duplex	3 (2.24)	10.1 (286)	9.4 (266)	67 (1.70)	75 (1.91)	91 (2.31)	34.9 (3.25)
A-RED-D-200P-SS-N-050	Modular Stacking Duplex	5 (3.73)	18.4 (521)	15.4 (436)	67 (1.70)	75 (1.91)	91 (2.31)	34.9 (3.25)
A-RED-D-200P-SS-N-075	Modular Stacking Duplex	7.5 (5.59)	28.1 (796)	23.3 (660)	67 (1.70)	75 (1.91)	91 (2.31)	34.9 (3.25)
A-RED-D-200P-SS-N-100	Modular Stacking Duplex	10 (7.46)	37.1 (1050)	32.5 (920)	67 (1.70)	75 (1.91)	91 (2.31)	34.9 (3.25)
A-RED-D-200P-SS-N-150	Modular Stacking Duplex	15 (11.2)	54.7 (1549)	47.7 (1351)	67 (1.70)	77 (1.96)	91 (2.31)	35.8 (3.33)
A-RED-D-200P-SS-N-200	Modular Stacking Duplex	20 (14.9)	73.1 (2070)	61.8 (1750)	123 (3.12)	87 (2.21)	100 (2.54)	74.3 (6.90)
A-RED-T-200P-SS-N-010	Modular Stacking Triplex	1 (0.75)	8.2 (232)	6.6 (187)	100 (2.54)	75 (1.91)	91 (2.31)	52.1 (4.85)
A-RED-T-200P-SS-N-020	Modular Stacking Triplex	2 (1.49)	15.6 (442)	13.2 (374)	100 (2.54)	75 (1.91)	91 (2.31)	52.1 (4.85)
A-RED-T-200P-SS-N-030	Modular Stacking Triplex	3 (2.24)	20.2 (572)	18.8 (532)	100 (2.54)	75 (1.91)	91 (2.31)	52.1 (4.85)
A-RED-T-200P-SS-N-050	Modular Stacking Triplex	5 (3.73)	36.8 (1042)	30.8 (872)	100 (2.54)	75 (1.91)	91 (2.31)	52.1 (4.85)
A-RED-T-200P-SS-N-075	Modular Stacking Triplex	7.5 (5.59)	56.2 (1591)	46.6 (1320)	100 (2.54)	77 (1.96)	91 (2.31)	53.5 (4.98)
A-RED-T-200P-SS-N-100	Modular Stacking Triplex	10 (7.46)	74.2 (2101)	65.0 (1841)	100 (2.54)	77 (1.96)	91 (2.31)	53.5 (4.98)
A-RED-T-200P-SS-N-150	Modular Stacking Triplex	15 (11.2)	109.4 (3098)	95.4 (2701)	133 (3.38)	65 (1.65)	91 (2.31)	60.0 (5.58)
A-RED-T-200P-SS-N-200	Modular Stacking Triplex	20 (14.9)	146.2 (4140)	123.6 (3500)	175 (4.45)	87 (2.21)	100 (2.54)	105.7 (9.43)
A-RED-Q-200P-SS-N-010	Modular Stacking Quadruplex	1 (0.75)	12.3 (348)	9.9 (280)	108 (2.74)	75 (1.91)	91 (2.31)	56.3 (5.23)

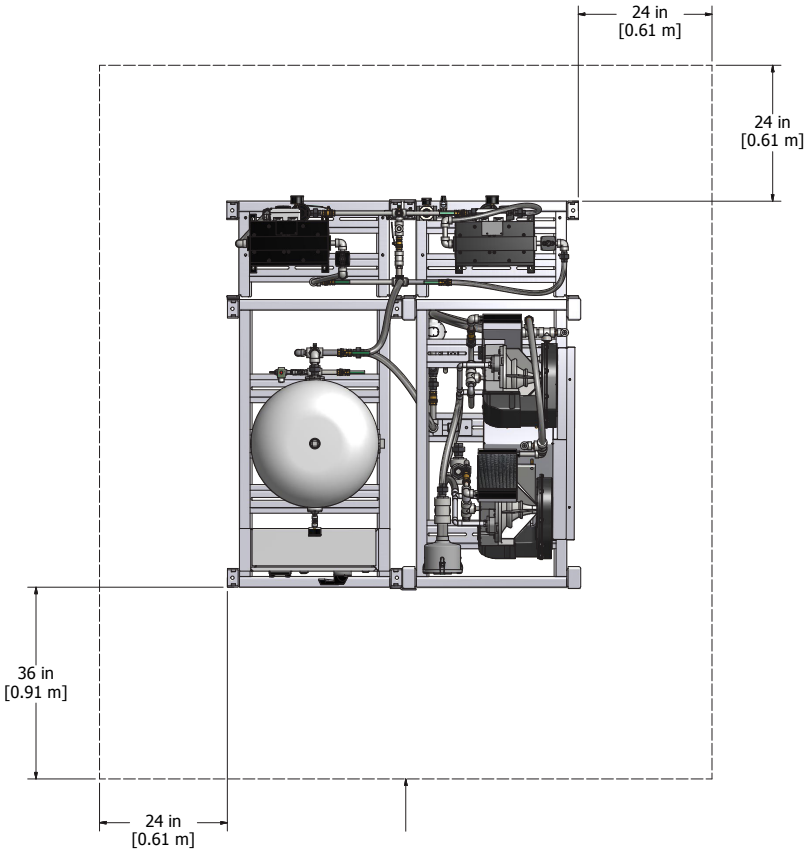
Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			at 50 psig	at 120 psig	Width	Length	Height	Total Sq. Ft. Required (M^2)
Modular Stacking (SS) Configuration								
A-RED-Q-200P-SS-N-020	Modular Stacking Quadruplex	2 (1.49)	23.4 (663)	19.8 (561)	108 (2.74)	75 (1.91)	91 (2.31)	56.3 (5.23)
A-RED-Q-200P-SS-N-030	Modular Stacking Quadruplex	3 (2.24)	30.3 (858)	28.2 (799)	108 (2.74)	75 (1.91)	91 (2.31)	56.3 (5.23)
A-RED-Q-200P-SS-N-050	Modular Stacking Quadruplex	5 (3.73)	55.2 (1563)	46.2 (1308)	108 (2.74)	77 (1.96)	91 (2.31)	57.8 (5.37)
A-RED-Q-200P-SS-N-075	Modular Stacking Quadruplex	7.5 (5.59)	84.3 (2387)	69.9 (1979)	141 (3.58)	70 (1.78)	91 (2.31)	68.5 (6.37)
A-RED-Q-200P-SS-N-100	Modular Stacking Quadruplex	10 (7.46)	111.3 (3152)	97.5 (2761)	141 (3.58)	70 (1.78)	91 (2.31)	68.5 (6.37)
A-RED-Q-200P-SS-N-150	Modular Stacking Quadruplex	15 (11.2)	164.1 (4647)	143.1 (4052)	142 (3.61)	70 (1.78)	91 (2.31)	69.0 (6.43)
A-RED-Q-200P-SS-N-200	Modular Stacking Quadruplex	20 (14.9)	219.3 (6210)	185.4 (5250)	175 (4.45)	87 (2.21)	100 (2.54)	105.7 (9.83)
Horizontal Tank Mount (TH) Configuration								
A-RED-D-080P-TH-N-010	Horizontal Tank Mount Duplex	1 (0.75)	4.1 (116)	3.3 (93)	45 (1.14)	90 (2.29)	74 (1.88)	28.1 (2.61)
A-RED-D-120P-TH-N-010	Horizontal Tank Mount Duplex	1 (0.75)	4.1 (116)	3.3 (93)	45 (1.14)	96 (2.44)	77 (1.96)	30.0 (2.79)
A-RED-D-080P-TH-N-020	Horizontal Tank Mount Duplex	2 (1.49)	7.8 (221)	6.6 (187)	45 (1.14)	90 (2.29)	74 (1.88)	28.1 (2.61)
A-RED-D-120P-TH-N-020	Horizontal Tank Mount Duplex	2 (1.49)	7.8 (221)	6.6 (187)	45 (1.14)	96 (2.44)	77 (1.96)	30.0 (2.79)
A-RED-D-080P-TH-N-030	Horizontal Tank Mount Duplex	3 (2.24)	10.1 (286)	9.4 (266)	45 (1.14)	90 (2.29)	73 (1.85)	28.1 (2.61)
A-RED-D-120P-TH-N-030	Horizontal Tank Mount Duplex	3 (2.24)	10.1 (286)	9.4 (266)	45 (1.14)	96 (2.44)	77 (1.96)	30.0 (2.79)
A-RED-D-080P-TH-N-050	Horizontal Tank Mount Duplex	5 (3.73)	18.4 (521)	15.4 (436)	45 (1.14)	90 (2.29)	73 (1.85)	28.1 (2.61)
A-RED-D-120P-TH-N-050	Horizontal Tank Mount Duplex	5 (3.73)	18.4 (521)	15.4 (436)	45 (1.14)	88 (2.24)	78 (1.98)	27.5 (2.55)

*System dimensions subject to change without notice. Please ensure that your copy of this chapter is up to date.

SYSTEM SELECTION TABLES NOTES:

- ✓ System dimensions do not include the maintenance space – refer to Step 7: General Layout below for an understanding of the system maintenance requirements. In all cases, the National Electrical Code requires a minimum clearance of
  3' (92 cm) in front of the control cabinet.
- ✓ Should your systems require smaller spaces, please contact your local Amico Source Corporation representative.
- ✓ All systems listed have standard sized receivers. Larger receivers usually change the overall dimensions.
- ✓ Skid mounted systems are omitted from the tables, as they are equivalent to modular stacking systems. Dimensions for skid mounted systems are only used for informational purposes (as they can vary) and thus are not included.
- ✓ For higher horsepower systems (those that require an increased system capacity), please contact your local Amico Source Corporation representative for more information.
- ✓ These tables represent the standard configurations of Amico Source Corporation, they do not represent all configurations we are capable of producing.
- ✓ More details on all these systems can be found on the spec sheets for the system type selected and the spec sheet should be consulted when doing final layout. These spec sheets can be found at **amico.com/nfpa-air-downloads**.
- ✓ Additional information can also be found in the Schedule section (§7.2.1 on page 133), located in Chapter 7 – Specification & Schedule.

5.2.7 STEP 7: GENERAL LAYOUT



minimum clearance for maintenance and ventilation

1. Place the air plant in scale on the plan drawings in the designated location. At the end of Chapter 4, you will have created a preliminary layout drawing for the entire medical gas piped distribution system (that includes the source location). It is now time to revisit that drawing. Ensure that the plant has sufficient space on all sides for maintenance access and proper ventilation. Amico Source Corporation recommends 2' (24") minimum clearance on all sides and 3' (36") in front of the control panel; it is sometimes possible to reduce this clearance with exact knowledge of maintenance access requirements.

   It is imperative that you contact your local Amico Source Corporation representative if circumstances allow for less space as custom systems will require more engineering time to ensure that not only the system operates smoothly, but also that maintenance can be easily performed.
2. Place the equipment in elevation views as appropriate.
3. On the plan, finalize the pipe routing for the intake.
4. Size the intake piping to ensure that no restriction of airflow (and thus pump starvation) occurs in the intake line; the sizing process is iterative:
   - Start with the total actual length of piping and make an estimate for the line size (see the Exhaust Pipe Sizing table below).
   - Using your estimated size, add equivalent lengths for the fittings employed.
   - Check that the size of the intake piping is still suitable at the new equivalent length. Should there be any discrepancies, re-estimate the next larger size and repeat the steps above.

     The line may also be sized more precisely by conducting an actual calculation. Intake piping must be sized to induce no more than a 4" water column vacuum at the compressor when all compressors are operating. (Please use total capacity for this calculation with all compressors running, not NFPA capacity).

     For unusual lengths or other circumstances, please contact your local Amico Source Corporation representative for assistance.
5. Finalize the connection to the distribution piping and size the system piping.

INTAKE PIPE SIZING TABLE

Unit	Flow Basis SCFM at 50 psi (LPM at 345 kPa)	Maximum Allowable Equivalent Run (Feet)								
Minimum Nominal Pipe Size		1"	1.25"	1.5"	2"	2.5"	3"	4"	5"	6"
Duplex 1 Hp	5 (141.6)	68	200	500	2000					
Duplex 2 Hp	12.2 (345.5)	22	65	180	650	1800				
Duplex 3 Hp	18.4 (521)		30	70	290	850	2200			
Duplex 5 Hp	30.2 (855)		12	30	120	360	890			
Duplex 7.5 Hp	44.2 (1252)			10	60	180	450			
Duplex 10 Hp Triplex 7.5 Hp	66.3 (1877)			8	35	110	250	1000		

Unit	Flow Basis SCFM at 50 psi (LPM at 345 kPa)	Maximum Allowable Equivalent Run (Feet)								
Minimum Nominal Pipe Size		1"	1.25"	1.5"	2"	2.5"	3"	4"	5"	6"
Duplex 15 Hp Triplex 10 Hp Quadruplex 7.5 Hp	108 (3058)				16	48	120	480	1400	
Duplex 20 Hp Triplex 10 Hp	120.8 (3421)					28	70	280	810	
Triplex 15 Hp	132.6 (3755)					25	60	250	750	1800
Triplex 20 Hp Quadruplex 15 Hp	181.2 (5131)					13	33	130	400	1000
Quadruplex 20 Hp	241.6 (6841)						19	80	240	600
Quadruplex 20 Hp	660 (18689)							20	60	140
Quadruplex 20 Hp	880 (24919)							13	40	95

Fittings Equivalent Lengths									
Minimum Nominal Pipe Size	1"	1.25"	1.5"	2"	2.5"	3.5"	4"	5"	6"
Elbows	2.5'	3'	4'	5.5'	7'	9'	12.5'	16'	19'
Tee (Branch/Run)	4.5'	5.5'/.5'	7'/.5'	9'/.5'	12/.5'	15'/1'	21'/1'	27'/1.5'	34'/2'

5.2.8 STEP 8: SPECIFICATION & SCHEDULE

1. In Chapter 7 of this Design Guide, please select the sections appropriate to the technology and system layout desired. You will find a comprehensive list of all the specifications necessary for each type of system.
2. Should any exceptional requirements be necessary (e.g. BACNET connection capability, Dual Feed, etc.), please incorporate and make a special note of them in the specification as well.
3. Schedule in the drawings the medical air plant selected; including at the very least:
    - A general system model or identification number, that is specific to the MGEM.
    - The capacity per compressor and total system capacity (per NFPA).
    - An estimate of sound level produced by the total system (per NFPA).
    - Horsepower or kW per compressor.
    - Voltage, frequency (Hz) and phase desired.

Chapter 7 will provide a typical schedule for all of the systems listed in the System Selection Tables of this chapter.

Chapter 6

Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

Medical Vacuum (Suction) Systems

Chapter 6 – Medical Vacuum (Suction) Systems

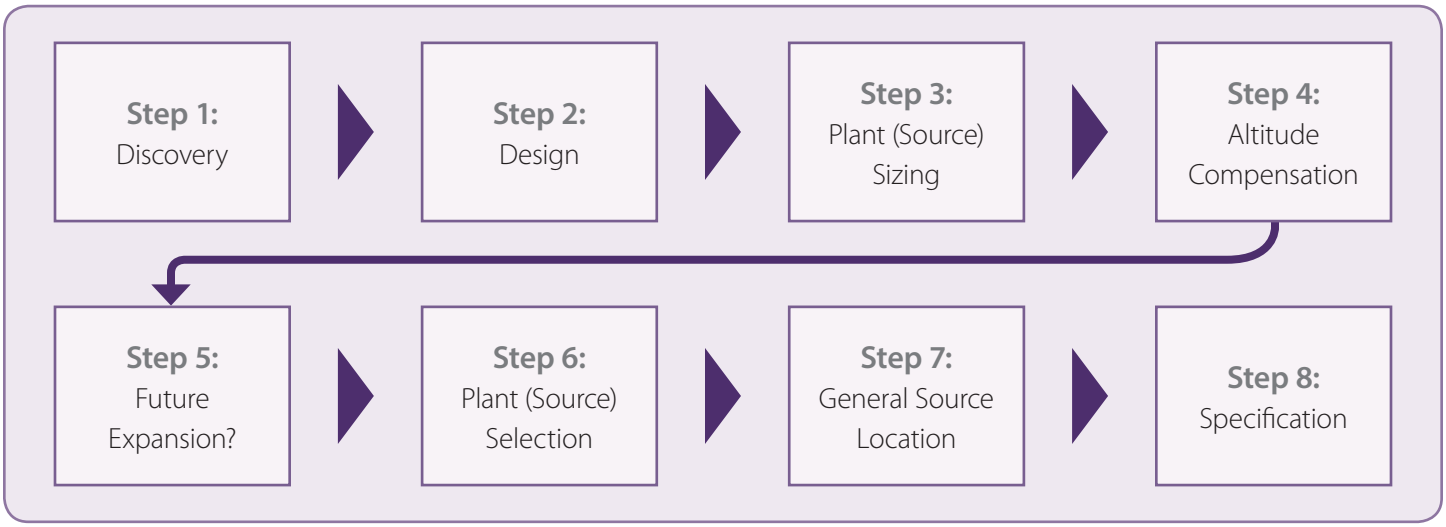
Medical Vacuum Systems Glossary

ACFM	Actual Cubic Feet per Minute is an expression of actual air volume, generally corrected for and in reference to a particular pressure
Continuous Duty	Operational reference to compressors operating 24 hours a day, continuously
Continuous Duty Rated	Vacuum systems which can operate continuously (24 hours per day) if necessary but normally only operate on demand
Displacement	Theoretical physical volume of the air in the pump chamber based upon 100% pumping efficiency, with no allowances made for heat, friction, clearances or other losses in the compression cycle
Duplex System	Systems comprised of two pumps, each rated for a 100% Peak Calculated Load (PCL) pipeline system
Intermittent Duty	Reference to pumps not capable of operating continuously (e.g. pump design requires periodic shutdown for cooling or oil transfer)
LPM	Liters per Minute is a measure of the flow rate of a gas
NTP	Normal Temperature and Pressure is generally accepted as 70˚F (20˚C), 14.969 psi/29.92 inHg barometric pressure and 36% relative humidity
Peak Calculated Load (PCL)	The maximum estimated demand a medical facility will require of a medical vacuum system, calculated at SCFM at 483 mmHg (20 inHg)
SCFM	Standard Cubic Feet per Minute is an expression of air at NTP
Simultaneous Demand	Operating reference to a condition where all Lead and Reserve pumps run simultaneously to satisfy demand in excess of the Lead pump's capability
Source End Vacuum	The vacuum (negative pressure) level required at the vacuum system source in order to provide the vacuum level at terminal units (outlets) required by the specific suction regulators utilized in the facility
Timed Alternation	In medical vacuum applications, all systems should be able to operate on a timed alternation basis to ensure equal wear of the vacuum pumps; this means that the Lead and Lag pumps will alternate on a timed basis
Triplex Systems	Medical vacuum system with three compressors, each sized for 50% PCL
Quadruplex System	Medical vacuum system with four compressors, each sized for 33% PCL

How To Use This Section

The following section is structured so that the medical vacuum system for a project may be developed and executed in a logical and simple progression. A Design Example is given at the end of this chapter to further illustrate the process. The figure below shows a visual description of this stage and where to find each section in this chapter.

Phase 3: Engineering



Step 1: Discovery	See Sections 5.2.1 and 6.2.1 • Existing equipment • Evaluation of site conditions • Verify number of outlets/inlets
Step 2: Design	See Sections 5.2.2 and 6.2.2 • Identify number of outlets necessary for system to supply
Step 3: Plant (Source) Sizing	See Sections 5.2.3 and 6.2.3 • NFPA plant sizing method
Step 4: Altitude Compensation	See Sections 5.2.4 and 6.2.4 • Correction factors for facility elevation
Step 5: Future Expansion?	See Sections 5.2.5 and 6.2.5 • Adding capacity for future requirements
Step 6: Plant (Source) Selection	See Sections 5.2.6 and 6.2.7 • Choose appropriate technology and configuration • System selection tables
Step 7: General Source Location	See Sections 5.2.7 and 6.2.7 • Place equipment on plan drawings • Pipe route and size • Minimum clearance requirements
Step 8: Specification	See Sections 5.2.8 and 6.2.8 • Detail technology and system details • Schedule equipment

The Basic Milestones In Designing The Medical Vacuum System Are As Follows:

- Definitions – these are provided in the glossary at the beginning of this chapter, which contains terminology that may be utilized within this chapter. These terms may also be helpful in understanding and specifying the appropriate medical vacuum system for your medical facility. Refer to Chapter 1 for a more comprehensive list of useful terms and their meanings.
- Design – this general outline pertains to the procedural involvement in designing your medical vacuum system(s).
- Sizing and Selecting the Medical Vacuum System – Step by step guide illustrating how to calculate the Peak Calculated Load (PCL) requirements for the medical facility.
- Installation – steps to building and installing your medical vacuum system(s).

6.1 Introduction

Determining the appropriate medical vacuum system is simple compared to other medical source systems. Currently in the market, there are multiple technologies available for use on medical vacuum systems. Most of them will comply with NFPA with little or no modification. Each technology has its merits and downfalls; therefore, the decision on which technology to use is up to the client. Consideration must be made between the initial cost compared to the maintenance cost during the life of the equipment. NFPA only requires duplex systems, however, it is recommended to size up the system in the event where a pump is down (ie. duplex to triplex). This would prevent a single pump to carry the entire load.

In the medical industry, most clients will use the term "suction" while most engineers will call it "vacuum". The units in which vacuum is measured at is inches of mercury ("Hg or inHg) and the flow rate is measured in cubic feet per minute (CFM), just like the medical air systems. There is a high misconception from many clients between the vacuum level and the flow rate. For example, a nurse would call the maintenance technician regarding an issue with poor suction when the regulator is set to maximum. The maintenance would go to the medical vacuum equipment and attempt to adjust the vacuum level to a higher setting. After returning to the office, the technician would call the nurse that turned up the vacuum level, but the nurse would continue to complain that there is still not enough vacuum at her inlet. This confusion is cause by the inability for both the nurse and the technician to understand the difference between vacuum level and flow rate. Instead of the lack of suction, the correct terminology is poor flow rate.

In order to create an effective medical vacuum system, this difference in terminology must be kept in mind throughout the process. Providing flow is normally a piping problem, but the distinction between suction and flow is important to understand as it also affects pump selection. Giving a higher ultimate vacuum may be helpful, but it rarely solves the flow problem – only larger diameter pipes are capable of achieving that. Simply seeking a higher vacuum level may actually squander our client's financial resources and fail to provide an effective solution to their problem.

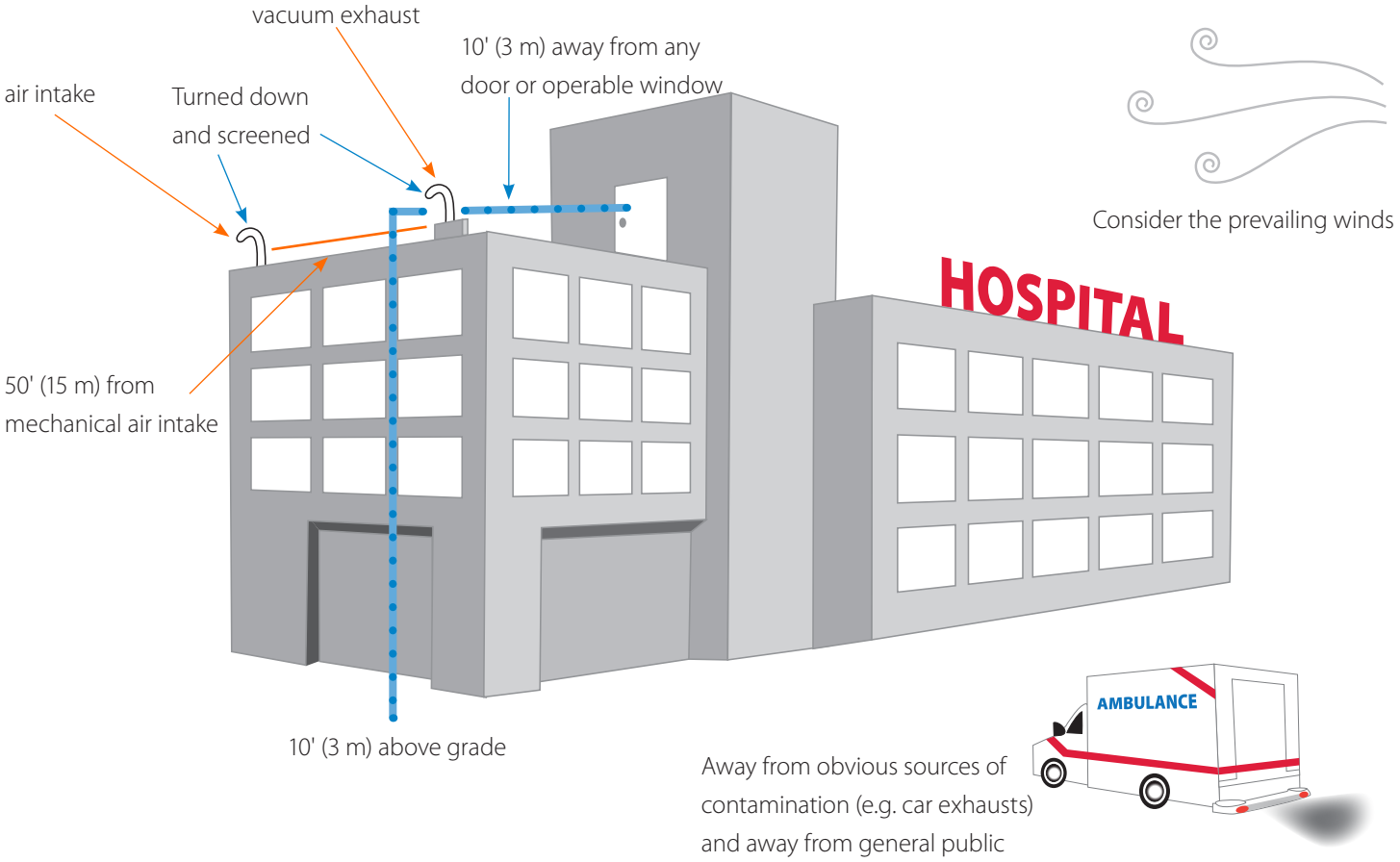
The method we will be using in this Design Guide for sizing vacuum sources will follow the latest edition of The National Fire Protection Association Standard (NFPA). This method is commonly used in the US and other countries as we understand its restrictions and from experience we know that it works quite well.

6.2 Steps to Implementing the Medical Vacuum (Suction) System

6.2.1 STEP 1: DISCOVERY

1. Should existing equipment be incorporated along with the medical vacuum system(s); determine the dimensions, type, capacity and current loading of the existing equipment. Ensure the existing equipment is compatible with the current standard.
2. Verify the number type and inlet count of all areas in the facility which require medical vacuum inlets.
3. Determine if there are unusual circumstances which may increase vacuum use. An example of this would be in a surgery center. Rather than using the vacuum system once in a while for surgery, they also have the patient recovery room where patients are connected to the vacuum for a period of time after surgery. The continual supply of vacuum to this specialized surgery center causes a steady large demand on the vacuum pump, affecting the pump to degrade more rapidly.
4. Examine the location intended for the exhaust. NFPA mandates the vacuum system exhaust be located outdoors to avoid possible contamination of the intake system (e.g. the medical air intake system). The exhaust shall be located a minimum of 10' (3 m) from any other door or openings, 50' (15 m) from any mechanical air intake and a minimum of 10' (3 m) above grade. The end of the exhaust shall be turned downward and screened. Ensure that the exhaust is in a location that is unlikely to blow contaminated air where people may be or where it cannot disperse. (Ref. NFPA 99 5.1.3.6.7). See diagram below for an illustrated example. The exhaust piping for a medical vacuum system shall be connected only to the system and not used for any other purpose. Consideration should also be given to the effects of prevailing winds and/or accumulated snow on the exhaust(s).

VACUUM EXHAUST LOCATION



5. If the vacuum system is not already piped to the intended location, determine a routing for the exhaust piping and note it on the building drawings. Piping for medical vacuum systems shall be routed in such a way that it is not subjected to temperatures lower than 40°F (4°C). The exhaust shall be free of loops and dips in order to eliminate potential trapping of condensate or oil.
6. When determining the location of the vacuum plant, ventilation and air conditioning should be considered. During operation, the system will produce heat which will need to be dissipated. Most medical vacuum systems seen on the market will provide you with a BTU value which estimates the heat discharged from the system. This value should be derived from the horsepower of the motor following the laws of thermodynamics. Since the only input of energy to the system is electrical power, we can assume that the worst case scenario is for all of the electrical power to be converted to heat energy. Some manufacturers do decrease that value claiming it to be a tested value. These values should be taken with some skepticism.
7. Determine the availability of electrical service.
8. Refer to §3.3.10 of Chapter 7, Part 3 (on page 130) for specification requirements of medical vacuum system exhausts.

6.2.2 STEP 2: DESIGN

Follow directions for laying out piped medical gases – the process is outlined in Chapter 4 of this Design Guide. This will provide the count of necessary outlets which is compulsory for the subsequent steps.

6.2.3 STEP 3: PLANT SIZING

There are several methods available for sizing medical vacuum systems. For the purposes of this Design Guide, only the National Fire Protection Association (NFPA) Method will be discussed.

THE NFPA PLANT SIZING METHOD – MEDICAL VACUUM

1. Review the NFPA 99 Standard before sizing a medical vacuum system.
2. Medical-surgical vacuum sources shall consist of two or more vacuum pumps sufficient to serve the peak calculated demand with the largest single vacuum pump out of service.
3. Using the information in the Vacuum – PCL (SCFM) Calculation Table, follow the steps below to determine the peak calculated load (PCL) requirements for the medical facility.
4. Count all outlets within the infrastructure that will utilize the vacuum pump system (see the table on the next page). In situations where the exact type of room cannot be located within the table, please select the one which most closely approximates the room as indicated in the chart.
5. Once the total amount of outlets are entered, the next step entails multiplying all variables across the table (left to right) to apply the simultaneous usage factor.
6. Obtain an estimate of vacuum requirements by adding the columns (top to bottom).

The Design Example at the end of this chapter will illustrate how to use the Vacuum – PCL (SCFM) Calculation Table. At this point, we recommend you visit the Amico Source Corporation website for an electronic version of this Sizing Guide.

Please refer to the table on the next page to obtain an average flow that is required within the facility. This chart is also available at **amico.com/files/product/files/amico_source_equipment_sizing_guide.xls**

VACUUM – PCL (SCFM) CALCULATION TABLE

Location of Outlets	Units Required	Units	Outlet CFM	Simultaneous Use (%)
Anesthetizing Locations				
Operating Room	3/Room	Room(s)	3.5	100
Cystoscopy	3/Room	Room(s)	2	100
Delivery	3/Room	Room(s)	1	100
Special Procedures (open heart, transplants, etc)	3/Room	Room(s)	4	100
Emergency / Major Trauma Room	3/Room	Room(s)	3	100
Other Anesthetizing Locations	2/Room	Room(s)	1	50
Evacuation Vacuum	2/Room	Room(s)	2	100
Acute Care Locations (Non-Anesthetizing Locations)				
Recovery Room	3/Bed	Bed(s)	1.5	50
Intensive Care Units (except cardiac)	3/Bed	Bed(s)	2	75
Cardiac ICU	2/Bed	Bed(s)	1	50
Emergency Rooms	2/Bed	Bed(s)	1	100
Special Procedure (x-ray, dialysis, etc)	2/Room	Room(s)	1.5	30
Catherization Lab	2/Room	Room(s)	1	10
Surgical Excision Rooms	1/Room	Room(s)	1	10
Neonatal ICU	2/Bed	Bed(s)	1	50
Sub-Acute Care Areas (Non-Anesthetizing Locations)				
Patient Room - Surgical	1/Bed	Bed(s)	1.5	15
Patient Room - Medical	1/Bed	Bed(s)	1	10
Exam and Treatment Rooms	1/Room	Room(s)	1	10
Nursery	1/4 Bassinets	Bassinet(s)	1	10
Nursery Premature	1/4 Bassinets	Bassinet(s)	1	25
Other Patient Rooms				
Respiratory Care Dept.	1/Room	Room(s)	1.5	10
Teaching	1/Room	Room(s)	1.5	10
Autopsy	1/Table	Table(s)	1.5	10
Location 1: Vac*	0	Outlet(s)	3	100
Location 2:	0	Outlet(s)		
Location 3:	0	Outlet(s)		
Location 4:	0	Outlet(s)		

*Maybe used alone if you wish to only count outlets needed. You may change that field as you see fit.

Future Expansion	0.00
Peak calculated demand in SCFM	5.00
Altitude Above Sea Level, Feet	0.00
Peak calculated demand in SCFM, altitude adjusted	5.00

Note:
The sizing method provided is only approximate and should be used carefully. The interview conducted during the discovery phase is a critical consideration when using the sizing guide. If a system is to be replaced, the performance will provide a clear indication of the current usage of the system. For example, during discovery phase, the customer is looking to replace their existing 7.5 Hp duplex system. The current system can pull enough flow for the facility without the pump operating excessively. The sizing guide yields a 10 Hp system with the information you collected, it is plausible that the 7.5 Hp system is sufficient for the new system instead of the 10 Hp yielded from the sizing guide.

6.2.4 STEP 4: ALTITUDE ADJUSTMENTS

If a pump is to be operated at higher elevations, the Peak Calculated Demand (from the previous table) should be multiplied by the appropriate correction factor (see table below). This method of correction assumes upsizing the pump to hold as close to the standard vacuum level (19 inHg) as possible. It also indicates the ratio of ACFM at sea level versus the ACFM at the higher altitude.

ALTITUDE COMPENSATION CHART

Altitude	Normal Barometric Pressure	Multiplier Used for Required SCFM (Hg)
Sea Level	760 mmHg (29.92")	1.00
500' (152 m)	747 mmHg (29.39")	1.02
1,000' (305 m)	733 mmHg (28.86")	1.04
1,500' (457 m)	720 mmHg (28.33")	1.06
2,000' (609 m)	707 mmHg (27.82")	1.08
2,500' (762 m)	694 mmHg (27.32")	1.10
3,000' (900 m)	681 mmHg (26.82")	1.12
3,500' (1,067 m)	669 mmHg (26.33")	1.14
4,000' (1,219 m)	656 mmHg (25.84")	1.16
5,000' (1,525 m)	633 mmHg (24.90")	1.20
6,000' (1,828 m)	609 mmHg (23.98")	1.25
7,000' (2,133 m)	587 mmHg (23.09")	1.30
8,000' (2,438 m)	565 mmHg (22.23")	1.35
9,000' (2,743 m)	543 mmHg (21.93")	1.40
10,000' (3,048 m)	523 mmHg (20.58")	1.45

A good rule of thumb is for every 1000' in elevation above sea level, the vacuum pump will lose about 1 inHg (in terms of maximum vacuum output).

6.2.5 STEP 5: COMPENSATING FOR FUTURE EXPANSION

When selecting a system, it is important to consider a size that will accommodate the future. While this is a good idea, it can also cause issues. One common issue when oversizing is heat and moisture. On lubricated rotary vane pumps, for example, the performance and longevity of the pump depends greatly on the performance of the oil inside. A pump that does not start regularly has cool oil which has significantly decreased operational characteristic than warm oil. Cool oil doesn't flow as well as warm oil, which causes more strain on the pump and motor. The longevity in this case was affected by oversizing the system. In addition to the issues affecting the system, the oversized system requires additional costs and there is a possibility that the hospital drops the plan to expand later on. Instead, engineering should specify a system that is suitable for expansion without purchasing the pump unit itself.

In an expandable system, the system control panel should have provisions to connect the extra pumps required after the expansion. A base should be provided to mount the new pump(s) when expanding. Intake and discharge connections isolated by ball valves should be provided to connect the future pump(s) into the system without stopping service of the medical vacuum system. The inlet, exhaust and electrical connections of the system should also be sized ready for the expansion to occur.

6.2.6 STEP 6: PLANT SELECTION

1. Select a preferred technology (see the Technology Comparison Chart on the next page). More specific assistance in selecting a technology may be obtained by contacting your local Amico Source Corporation representative.
2. Select the horsepower of the preferred technology which will match or exceed the flow that was previously determined in the sizing guide (tolerance percentage from the sizing guide is a good idea). See the Standard Vacuum System Visual Selection Guide on page 79 for the standard vacuum system from the System Selection Tables in this chapter.
3. **Note:** for some technologies, there is more than one plant layout configuration (see page 77 for the Quick Guide to Configurations). Should one or more layout be available for selection, choose the one best suited to the site conditions. When in doubt as to which arrangement is most suitable for a particular situation, please feel free to contact your local Amico Source Corporation representative for educated recommendations.
4. Reference the System Information Sheets in the tables starting on page 80 for the particular system selected. This chart entails all of the essential information regarding the system and should be utilized as a quick reference in all of the succeeding steps.

Technology Comparison Chart

Amico Source Corporation offers several technologies for medical vacuums, each of which has its own advantages and drawbacks. This chart summarizes the features of these technologies as an aid in the selection of the correct technology for your specific application.

Characteristics	Contact-Less Claw	Liquid Ring – Water Sealed	Lubricated Rotary Vane	Oil Free Rotary Vane	Rotary Screw
Reliability When Maintained	Good	Excellent	Good	Moderate	Good
Longevity of Pump	Good	Excellent	Good	Moderate	Good
Operating Cost for 150 ACFM at 24 inHg	Low	High	Moderate	High	High
Altitude	Poor (1)	Excellent	No Limit	Poor (1)	Poor (1)
Maintenance	Low, Easy *	Low, Can be Complex	High, Can be Complex	Moderate, Easy	High, Can be Complex
Efficiency	Very High	Low	High	Moderate	Low
VFD Capability	Very High	Low	No	Low	Low
Advantages	• Low operating cost • Excellent choice for dedicated anaesthesia evacuation system • Low maintenance	• Pump life, ambient temperature indifferent • Excellent choice for a dedicated anaesthesia system	• High vacuum • Long vane life • No water and sewage costs • Low noise level • Air cooled design • No rust and scale problems • Low operating cost	• Low maintenance • Low run temperature	• Good for high hp application • Enclosed unit
Disadvantages	• High initial cost • Higher noise level compared to other systems • Higher heat load or higher running temperature	• Dependence on a reliable supply of water • Good water quality is crucial to avoid premature failures due to scale build-up	• High maintenance • Unsuitable for a dedicated anaesthesia evacuation system • Cannot take a slug of water	• Much shorter vane life than lubricated pumps • Lower capacity per horsepower than other designs	• Requires a large footprint • No customization allowed
Sizing Error Tolerance	Good	Excellent	Poor (2)	Good	Good
Suitability for Dedicated WAGD	Excellent (4)	Excellent	DO NOT USE	Poor (3)	DO NOT USE
Ambient Temperature	Limit of 100°F	No Limit if Water is Cool	Limit of 100°F	Limit of 100°F	Limit of 110°F
dB at 10 hp	83	76	76	81	89**
Top Vacuum	22 inHgV**	26 inHgV	29 inHgV	23 inHgV	29 inHgV
Manufacturer	Busch	Travaini, Dekker	Busch	Becker, Busch	Quincy

* Indicates the pump is highly recommended where this characteristic is desired.

** At 20 hp

(1) Pumps can be operated at higher elevations if a lower ultimate vacuum is accepted or life of vanes is reduced.

(2) Lubricated rotary vane machines may not easily tolerate being undersized.

(3) Oil free rotary vanes use graphite vanes which are not generally suitable with elevated oxidizer concentrations. Some manufacturers claim they can be rendered.

(4) In the O_2 assured version.

Quick Guide to Configurations

MODULAR STACKING CONFIGURATION

Modular stacking configurations have multiple pump assemblies vertically stacked adjacent to the tank that are separable for shipping. Vacuum pump assemblies include at least one pump and one motor.

SPACE-SAVER CONFIGURATION

Vertical configurations have two pumps stacked on a single vertical tank. This configuration is only suitable for smaller vacuum pumps or pumps with very little inherent vibration such as Contact-less Claws. It is the most space-efficient of all medical vacuum configurations.

HORIZONTAL TANK MOUNT

The vacuum pumps are mounted on a horizontal tank which is large enough to accommodate bigger pumps and accessories than the Space-Saver. The system is factory piped and wired to a single inlet, outlet and electrical connection.

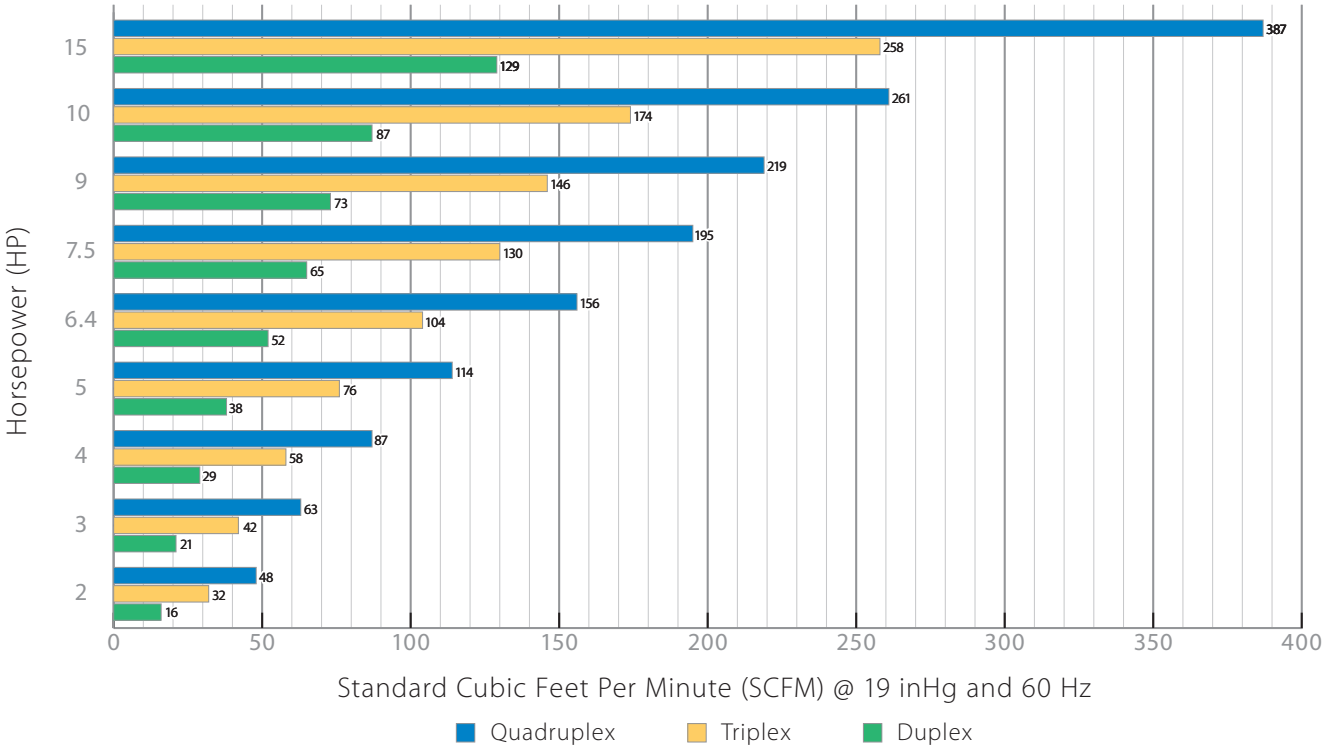
SKID MOUNT

These systems are mounted on separate skids. This configuration is suitable for larger vacuum pumps. This type of vacuum system is also designed for ease of transportation.

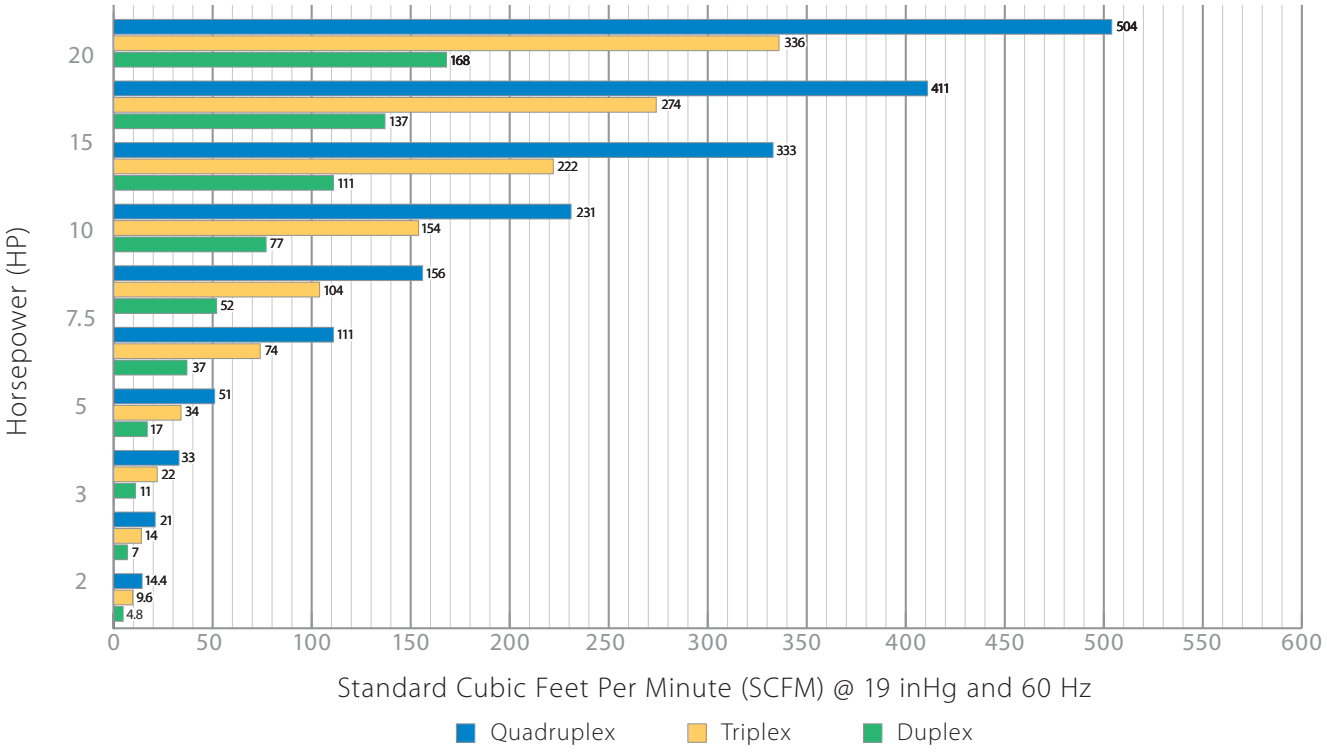
Standard Vacuum System Visual Selection Guide

Please use our Sizing Guide spreadsheet to calculate the SCFM required for your facility. You can find this interactive spreadsheet at **amico.com/files/product/files/amico_source_equipment_sizing_guide.xls**

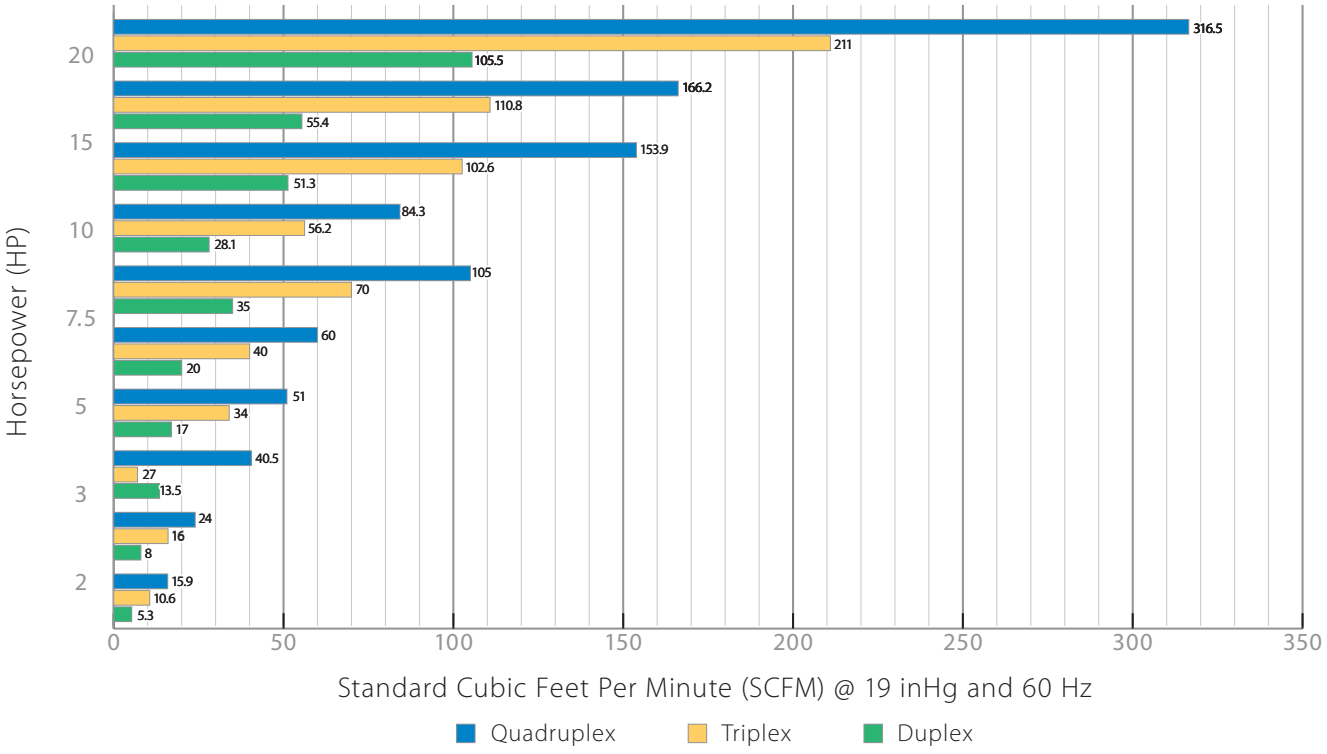
CONTACTLESS CLAW TECHNOLOGY VISUAL SELECTION GUIDE



LUBRICATED ROTARY VANE TECHNOLOGY VISUAL SELECTION GUIDE



DRY ROTARY VANE TECHNOLOGY VISUAL SELECTION GUIDE



AMICO SOURCE MEDICAL VACUUM SYSTEM SELECTION TABLE (DRY CONTACT-LESS CLAW SYSTEMS)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
Modular Stacking (SS) Configuration								
V-CCD-D-200P-SS-N-020	Modular Stacking Duplex	2 (1.49)	13.3 (377)	16.0 (453)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-CCD-D-200P-SS-N-030	Modular Stacking Duplex	3 (2.24)	17.5 (496)	21.0 (595)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-CCD-D-200P-SS-N-040	Modular Stacking Duplex	4 (2.98)	24.2 (685)	29.0 (821)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-CCD-D-200P-SS-N-050	Modular Stacking Duplex	5 (3.73)	31.7 (898)	38.0 (1076)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-CCD-D-200P-SS-N-064	Modular Stacking Duplex	6.4 (4.77)	43.3 (1226)	52.0 (1472)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-CCD-D-200P-SS-N-075	Modular Stacking Duplex	7.5 (5.59)	54.2 (1535)	65.0 (1841)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-CCD-D-200P-SS-N-090	Modular Stacking Duplex	9 (6.71)	60.8 (1722)	73.0 (2067)	67 (1.70)	65 (1.65)	91 (2.31)	30.2 (2.81)
V-CCD-D-200P-SS-N-100	Modular Stacking Duplex	10 (7.46)	72.5 (2053)	87.0 (2464)	74 (1.88)	67 (1.70)	91 (2.31)	34.4 (3.20)
V-CCD-D-200P-SS-N-150	Modular Stacking Duplex	15 (11.2)	107.5 (3044)	129.0 (3653)	74 (1.88)	75 (1.91)	91 (2.31)	66.7 (6.19)
V-CCD-T-200P-SS-N-020	Modular Stacking Triplex	2 (1.49)	26.7 (756)	32.0 (906)	67 (1.70)	55 (1.40)	95 (2.41)	25.6 (2.38)
V-CCD-T-200P-SS-N-030	Modular Stacking Triplex	3 (2.24)	35 (991)	42.0 (1189)	67 (1.70)	55 (1.40)	95 (2.41)	25.6 (2.38)
V-CCD-T-200P-SS-N-040	Modular Stacking Triplex	4 (2.98)	48.3 (1368)	58.0 (1642)	67 (1.70)	55 (1.40)	95 (2.41)	25.6 (2.38)
V-CCD-T-200P-SS-N-050	Modular Stacking Triplex	5 (3.73)	63.3 (1792)	76.0 (2152)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-CCD-T-200P-SS-N-064	Modular Stacking Triplex	6.4 (4.77)	86.7 (2455)	104.0 (2945)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-CCD-T-200P-SS-N-075	Modular Stacking Triplex	7.5 (5.59)	108.3 (3067)	130.0 (3681)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-CCD-T-200P-SS-N-090	Modular Stacking Triplex	9 (6.71)	121.6 (3443)	146.0 (4134)	100 (2.54)	70 (1.78)	91 (2.31)	48.6 (4.52)
V-CCD-T-200P-SS-N-100	Modular Stacking Triplex	10 (7.46)	145 (4106)	174.0 (4927)	100 (2.54)	67 (1.70)	91 (2.31)	46.5 (4.32)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
V-CCD-T-200P-SS-N-150	Modular Stacking Triplex	15 (11.2)	215 (6088)	258.0 (7306)	100 (2.54)	75 (1.91)	91 (2.31)	52.1 (4.85)
V-CCD-Q-200P-SS-N-020	Modular Stacking Quadruplex	2 (1.49)	40.0 (1133)	48.0 (1359)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-CCD-Q-200P-SS-N-030	Modular Stacking Quadruplex	3 (2.24)	52.5 (1487)	63.0 (1784)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-CCD-Q-200P-SS-N-040	Modular Stacking Quadruplex	4 (2.98)	72.5 (2053)	87.0 (2464)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-CCD-Q-200P-SS-N-050	Modular Stacking Quadruplex	5 (3.73)	95.0 (2690)	114.0 (3228)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-CCD-Q-200P-SS-N-064	Modular Stacking Quadruplex	6.4 (4.77)	130.0 (3681)	156.0 (4417)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-CCD-Q-200P-SS-N-075	Modular Stacking Quadruplex	7.5 (5.59)	162.5 (4601)	195.0 (5522)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-CCD-Q-200P-SS-N-090	Modular Stacking Quadruplex	9 (6.71)	182.4 (5165)	219.0 (6201)	101 (2.57)	65 (1.65)	91 (2.31)	45.6 (4.24)
V-CCD-Q-200P-SS-N-100	Modular Stacking Quadruplex	10 (7.46)	217.5 (6159)	261.0 (7391)	101 (2.57)	75 (1.91)	91 (2.31)	52.6 (4.91)
V-CCD-Q-200P-SS-N-150	Modular Stacking Quadruplex	15 (11.2)	322.5 (9132)	387.0 (10959)	115 (2.92)	75 (1.91)	91 (2.31)	60.0 (5.58)
Space Saver (TS) Configuration								
V-CCD-D-080P-TS-N-020	Space-Saver Duplex	2 (1.49)	13.3 (377)	16.0 (453)	55 (1.40)	52 (1.32)	92 (2.34)	19.9 (1.85)
V-CCD-D-080P-TS-N-030	Space-Saver Duplex	3 (2.24)	17.5 (496)	21.0 (595)	55 (1.40)	52 (1.32)	92 (2.34)	19.9 (1.85)
V-CCD-D-080P-TS-N-040	Space-Saver Duplex	4 (2.98)	24.2 (685)	29.0 (821)	55 (1.40)	52 (1.32)	92 (2.34)	19.9 (1.85)
V-CCD-D-080P-TS-N-050	Space-Saver Duplex	5 (3.73)	31.7 (898)	38.0 (1076)	55 (1.40)	52 (1.32)	92 (2.34)	19.9 (1.85)
V-CCD-D-120P-TS-N-064	Space-Saver Duplex	6.4 (4.77)	43.3 (1226)	52.0 (1472)	57 (1.45)	58 (1.47)	95 (2.41)	23.0 (2.13)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
V-CCD-D-120P-TS-N-075	Space-Saver Duplex	7.5 (5.59)	54.2 (1535)	65.0 (1841)	57 (1.45)	58 (1.47)	95 (2.41)	23.0 (2.13)
V-CCD-D-120P-TS-N-090	Space-Saver Duplex	9 (6.71)	60.8 (1722)	73.0 (2067)	57 (1.45)	58 (1.47)	95 (2.41)	23.0 (2.13)
V-CCD-D-120P-TS-N-100	Space-Saver Duplex	10 (7.46)	72.5 (2053)	87.0 (2464)	57 (1.45)	58 (1.47)	95 (2.41)	23.0 (2.13)
Horizontal Tank Mount (TH) Configuration								
V-CCD-D-080P-TH-N-020	Horizontal Tank Mount Duplex	2 (1.49)	13.3 (377)	16.0 (453)	55 (1.40)	75 (1.91)	65 (1.65)	28.6 (2.66)
V-CCD-D-080P-TH-N-030	Horizontal Tank Mount Duplex	3 (2.24)	17.5 (496)	21.0 (595)	55 (1.40)	75 (1.91)	65 (1.65)	28.6 (2.66)
V-CCD-D-080P-TH-N-040	Horizontal Tank Mount Duplex	4 (2.98)	24.2 (685)	29.0 (821)	55 (1.40)	75 (1.91)	65 (1.65)	28.6 (2.66)
V-CCD-D-080P-TH-N-050	Horizontal Tank Mount Duplex	5 (3.73)	31.7 (898)	38.0 (1076)	55 (1.40)	75 (1.91)	65 (1.65)	28.6 (2.66)
V-CCD-D-120P-TH-N-064	Horizontal Tank Mount Duplex	6.4 (4.77)	43.3 (1226)	52.0 (1472)	60 (1.52)	88 (2.24)	70 (1.78)	36.7 (3.41)
V-CCD-D-120P-TH-N-075	Horizontal Tank Mount Duplex	7.5 (5.59)	54.2 (1535)	65.0 (1841)	60 (1.52)	88 (2.24)	70 (1.78)	36.7 (3.41)
V-CCD-D-120P-TH-N-090	Horizontal Tank Mount Duplex	9 (6.71)	60.8 (1722)	73.0 (2067)	60 (1.52)	88 (2.24)	70 (1.78)	36.7 (3.41)
V-CCD-D-120P-TH-N-100	Horizontal Tank Mount Duplex	10 (7.46)	72.5 (2053)	87.0 (2464)	60 (1.52)	88 (2.24)	70 (1.78)	36.7 (3.41)

*System dimensions are subject to change without notice. Please ensure that your copy of this chapter is up to date.

AMICO SOURCE MEDICAL VACUUM SYSTEM SELECTION TABLE (DRY ROTARY VANE SYSTEMS)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
Modular Stacking (SS) Configuration								
V-RVD-D-200P-SS-N-012	Modular Stacking Duplex	1.2 (0.89)	4.4 (125)	5.3 (150)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-017	Modular Stacking Duplex	1.7 (1.27)	6.7 (190)	8.0 (227)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-030	Modular Stacking Duplex	3 (2.24)	11.3 (320)	13.5 (382)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-040	Modular Stacking Duplex	4 (2.98)	14.2 (402)	17.0 (481)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-054	Modular Stacking Duplex	5.4 (4.03)	16.7 (473)	20.0 (566)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-064	Modular Stacking Duplex	6.4 (4.77)	29.2 (827)	35.0 (991)	67 (1.70)	65 (1.65)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-074	Modular Stacking Duplex	7.4 (5.52)	23.4 (663)	28.1 (796)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-089	Modular Stacking Duplex	8.9 (6.64)	42.7 (1209)	51.3 (1453)	67 (1.70)	65 (1.65)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-121	Modular Stacking Duplex	12.1 (9.02)	46.2 (1308)	55.4 (1569)	67 (1.70)	65 (1.65)	91 (2.31)	25.6 (2.38)
V-RVD-D-200P-SS-N-177	Modular Stacking Duplex	17.7 (13.2)	87.9 (2489)	105.5 (2987)	74 (1.88)	68 (1.73)	91 (2.31)	34.9 (3.25)
V-RVD-T-200P-SS-N-012	Modular Stacking Triplex	1.2 (0.89)	8.9 (252)	10.6 (300)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVD-T-200P-SS-N-017	Modular Stacking Triplex	1.7 (1.27)	13.4 (379)	16.0 (453)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVD-T-200P-SS-N-030	Modular Stacking Triplex	3 (2.24)	22.6 (640)	27.0 (765)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVD-T-200P-SS-N-040	Modular Stacking Triplex	4 (2.98)	28.4 (804)	34.0 (963)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVD-T-200P-SS-N-054	Modular Stacking Triplex	5.4 (4.03)	33.4 (946)	40.0 (1133)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVD-T-200P-SS-N-064	Modular Stacking Triplex	6.4 (4.77)	58.4 (1654)	70.0 (1982)	67 (1.70)	65 (1.65)	97 (2.46)	30.2 (2.81)
V-RVD-T-200P-SS-N-074	Modular Stacking Triplex	7.4 (5.52)	46.4 (1314)	56.2 (1591)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
V-RVD-T-200P-SS-N-089	Modular Stacking Triplex	8.9 (6.64)	85.4 (2418)	102.6 (2905)	67 (1.70)	65 (1.65)	97 (2.46)	30.2 (2.81)
V-RVD-T-200P-SS-N-121	Modular Stacking Triplex	12.1 (9.02)	92.4 (2616)	110.8 (3138)	107 (2.72)	74 (1.88)	91 (2.31)	54.9 (5.11)
V-RVD-T-200P-SS-N-177	Modular Stacking Triplex	17.7 (13.2)	175.8 (4978)	211.0 (5975)	107 (2.72)	80 (2.03)	91 (2.31)	59.4 (5.52)
V-RVD-Q-200P-SS-N-012	Modular Stacking Quadruplex	1.2 (0.89)	13.3 (377)	15.9 (450)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-Q-200P-SS-N-017	Modular Stacking Quadruplex	1.7 (1.27)	20.1 (569)	24.0 (680)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-Q-200P-SS-N-030	Modular Stacking Quadruplex	3 (2.24)	33.9 (960)	40.5 (1147)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVD-Q-200P-SS-N-040	Modular Stacking Quadruplex	4 (2.98)	42.6 (1206)	51.0 (1444)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-RVD-Q-200P-SS-N-054	Modular Stacking Quadruplex	5.4 (4.03)	50.1 (1419)	60.0 (1699)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-RVD-Q-200P-SS-N-064	Modular Stacking Quadruplex	6.4 (4.77)	87.6 (2481)	105.0 (2973)	101 (2.57)	65 (1.65)	91 (2.31)	45.6 (4.24)
V-RVD-Q-200P-SS-N-074	Modular Stacking Quadruplex	7.4 (5.52)	70.2 (1988)	84.3 (2387)	101 (2.57)	65 (1.65)	91 (2.31)	45.6 (4.24)
V-RVD-Q-200P-SS-N-089	Modular Stacking Quadruplex	8.9 (6.64)	128.1 (3627)	153.9 (4358)	101 (2.57)	65 (1.65)	91 (2.31)	45.6 (4.24)
V-RVD-Q-200P-SS-N-121	Modular Stacking Quadruplex	12.1 (9.02)	138.6 (3925)	166.2 (4706)	115 (2.92)	70 (1.78)	91 (2.31)	55.9 (5.20)
V-RVD-Q-200P-SS-N-177	Modular Stacking Quadruplex	17.7 (13.2)	263.7 (7467)	316.5 (8962)	115 (2.92)	80 (2.03)	91 (2.31)	63.9 (5.93)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
Space Saver (TS) Configuration								
V-RVD-D-080P-TS-N-012	Space-Saver Duplex	1.2 (0.89)	4.4 (125)	5.3 (150)	35 (0.89)	45 (1.14)	77 (1.96)	10.9 (1.02)
V-RVD-D-080P-TS-N-017	Space-Saver Duplex	1.7 (1.27)	6.7 (190)	8.0 (227)	37 (0.94)	45 (1.14)	77 (1.96)	10.9 (1.02)
V-RVD-D-080P-TS-N-030	Space-Saver Duplex	3 (2.24)	11.3 (320)	13.5 (382)	37 (0.94)	50 (1.27)	80 (2.03)	12.8 (1.19)
V-RVD-D-080P-TS-N-040	Space-Saver Duplex	4 (2.98)	14.2 (402)	17.0 (481)	47 (1.19)	57 (1.45)	86 (2.18)	18.6 (1.73)
V-RVD-D-120P-TS-N-054	Space-Saver Duplex	5.4 (4.03)	16.7 (473)	20.0 (566)	47 (1.19)	57 (1.45)	86 (2.18)	18.6 (1.73)
V-RVD-D-120P-TS-N-074	Space-Saver Duplex	7.4 (5.52)	23.4 (663)	28.1 (796)	55 (1.40)	58 (1.47)	86 (2.18)	22.2 (2.06)
Horizontal Tank Mount (TH) Configuration								
V-RVD-D-080P-TH-N-012	Horizontal Tank Mount Duplex	1.2 (0.89)	4.4 (125)	5.3 (150)	34 (0.86)	75 (1.91)	60 (1.52)	17.7 (1.64)
V-RVD-D-080P-TH-N-017	Horizontal Tank Mount Duplex	1.7 (1.27)	6.7 (190)	8.0 (227)	36 (0.91)	75 (1.91)	60 (1.52)	18.8 (1.74)
V-RVD-D-080P-TH-N-030	Horizontal Tank Mount Duplex	3 (2.24)	11.3 (320)	13.5 (382)	40 (1.02)	75 (1.91)	60 (1.52)	20.8 (1.95)
V-RVD-D-080P-TH-N-040	Horizontal Tank Mount Duplex	4 (2.98)	14.2 (402)	17.0 (481)	43 (1.09)	75 (1.91)	64 (1.63)	22.4 (2.08)
V-RVD-D-120P-TH-N-054	Horizontal Tank Mount Duplex	5.4 (4.03)	16.7 (473)	20.0 (566)	55 (1.40)	80 (2.03)	64 (1.63)	30.6 (2.84)
V-RVD-D-120P-TH-N-074	Horizontal Tank Mount Duplex	7.4 (5.52)	23.4 (663)	28.1 (796)	55 (1.40)	80 (2.03)	64 (1.63)	30.6 (2.84)

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AMICO SOURCE MEDICAL VACUUM SYSTEM SELECTION TABLE (LUBRICATED ROTARY VANE SYSTEMS)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
Modular Stacking (SS) Configuration								
V-RVL-D-200P-SS-N-010	Modular Stacking Duplex	1 (0.75)	4.0 (113)	4.8 (136)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-015	Modular Stacking Duplex	1.5 (1.12)	5.8 (164)	7.0 (198)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-020	Modular Stacking Duplex	2 (1.49)	9.2 (261)	11.0 (311)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-030	Modular Stacking Duplex	3 (2.24)	14.2 (401)	17.0 (481)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-050	Modular Stacking Duplex	5 (3.73)	19.2 (544)	23.0 (651)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-051	Modular Stacking Duplex	5 (3.73)	21.7 (614)	26.0 (736)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-052	Modular Stacking Duplex	5 (3.73)	30.8 (872)	37.0 (1048)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-075	Modular Stacking Duplex	7.5 (5.59)	43.3 (1226)	52.0 (1472)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-100	Modular Stacking Duplex	10 (7.46)	54.2 (1535)	65.0 (1841)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-101	Modular Stacking Duplex	10 (7.46)	64.2 (1818)	77.0 (2180)	67 (1.70)	55 (1.40)	91 (2.31)	25.6 (2.38)
V-RVL-D-200P-SS-N-150	Modular Stacking Duplex	15 (11.2)	92.5 (2619)	111.0 (3143)	92 (2.33)	80 (2.03)	91 (2.31)	51.1 (4.73)
V-RVL-D-200P-SS-N-200	Modular Stacking Duplex	20 (14.9)	114.2 (3233)	137.0 (3879)	92 (2.33)	80 (2.03)	91 (2.31)	51.1 (4.73)
V-RVL-D-200P-SS-N-250	Modular Stacking Duplex	25 (18.6)	140.0 (3964)	168.0 (4757)	92 (2.33)	80 (2.03)	91 (2.31)	51.1 (4.73)
V-RVL-T-200P-SS-N-010	Modular Stacking Triplex	1 (0.75)	8.0 (227)	9.6 (272)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVL-T-200P-SS-N-015	Modular Stacking Triplex	1.5 (1.12)	11.7 (331)	14.0 (396)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVL-T-200P-SS-N-020	Modular Stacking Triplex	2 (1.49)	18.3 (518)	22.0 (623)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVL-T-200P-SS-N-030	Modular Stacking Triplex	3 (2.24)	28.3 (801)	34.0 (963)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVL-T-200P-SS-N-050	Modular Stacking Triplex	5 (3.73)	38.4 (1087)	46.0 (1303)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
V-RVL-T-200P-SS-N-051	Modular Stacking Triplex	5 (3.73)	43.4 (1229)	52.0 (1472)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVL-T-200P-SS-N-052	Modular Stacking Triplex	5 (3.73)	61.7 (1747)	74.0 (2095)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVL-T-200P-SS-N-075	Modular Stacking Triplex	7.5 (5.59)	86.7 (2455)	104.0 (2945)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVL-T-200P-SS-N-100	Modular Stacking Triplex	10 (7.46)	108.4 (3070)	130.0 (3681)	67 (1.70)	55 (1.40)	97 (2.46)	25.6 (2.38)
V-RVL-T-200P-SS-N-101	Modular Stacking Triplex	10 (7.46)	128.3 (3633)	154.0 (4361)	67 (1.70)	65 (1.65)	97 (2.46)	30.2 (2.81)
V-RVL-T-200P-SS-N-150	Modular Stacking Triplex	15 (11.2)	185.0 (5239)	222.0 (6286)	138 (3.51)	80 (2.03)	91 (2.31)	76.7 (7.13)
V-RVL-T-200P-SS-N-200	Modular Stacking Triplex	20 (14.9)	228.3 (6465)	274.0 (7759)	138 (3.51)	80 (2.03)	91 (2.31)	76.7 (7.13)
V-RVL-T-200P-SS-N-250	Modular Stacking Triplex	25 (18.6)	280.0 (7929)	336.0 (9514)	138 (3.51)	80 (2.03)	91 (2.31)	76.7 (7.13)
V-RVL-Q-200P-SS-N-010	Modular Stacking Quadruplex	1 (0.75)	12.0 (340)	14.4 (408)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-RVL-Q-200P-SS-N-015	Modular Stacking Quadruplex	1.5 (1.12)	17.5 (496)	21.0 (595)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-RVL-Q-200P-SS-N-020	Modular Stacking Quadruplex	2 (1.49)	27.5 (779)	33.0 (934)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-RVL-Q-200P-SS-N-030	Modular Stacking Quadruplex	3 (2.24)	42.5 (1203)	51.0 (1444)	101 (2.57)	55 (1.40)	91 (2.31)	38.6 (3.60)
V-RVL-Q-200P-SS-N-050	Modular Stacking Quadruplex	5 (3.73)	57.6 (1631)	69.0 (1954)	115 (2.92)	65 (1.65)	91 (2.31)	51.9 (4.82)
V-RVL-Q-200P-SS-N-051	Modular Stacking Quadruplex	5 (3.73)	65.1 (1843)	78.0 (2209)	115 (2.92)	65 (1.65)	91 (2.31)	51.9 (4.82)
V-RVL-Q-200P-SS-N-052	Modular Stacking Quadruplex	5 (3.73)	92.5 (2619)	111.0 (3143)	115 (2.92)	65 (1.65)	91 (2.31)	51.9 (4.82)
V-RVL-Q-200P-SS-N-075	Modular Stacking Quadruplex	7.5 (5.59)	130.0 (3681)	156.0 (4417)	115 (2.92)	65 (1.65)	91 (2.31)	51.9 (4.82)

Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
V-RVL-Q-200P-SS-N-100	Modular Stacking Quadruplex	10 (7.46)	162.6 (4604)	195.0 (5522)	115 (2.92)	65 (1.65)	91 (2.31)	51.9 (4.82)
V-RVL-Q-200P-SS-N-101	Modular Stacking Quadruplex	10 (7.46)	192.5 (5451)	231.0 (6541)	115 (2.92)	65 (1.65)	91 (2.31)	51.9 (4.82)
V-RVL-Q-200P-SS-N-150	Modular Stacking Quadruplex	15 (11.2)	277.5 (7858)	333.0 (9430)	144 (3.66)	80 (2.03)	91 (2.31)	80 (7.43)
V-RVL-Q-200P-SS-N-200	Modular Stacking Quadruplex	20 (14.9)	342.5 (9699)	411.0 (11638)	144 (3.66)	80 (2.03)	91 (2.31)	80 (7.43)
V-RVL-Q-200P-SS-N-250	Modular Stacking Quadruplex	25 (18.6)	420.0 (11893)	504.0 (14272)	144 (3.66)	80 (2.03)	91 (2.31)	80 (7.43)
Space Saver (TS) Configuration								
V-RVL-D-080P-TS-N-010	Space-Saver Duplex	1 (0.75)	4.0 (113)	4.8 (136)	28 (0.71)	45 (1.14)	75 (1.91)	8.8 (0.81)
V-RVL-D-080P-TS-N-015	Space-Saver Duplex	1.5 (1.12)	5.8 (165)	7.0 (198)	35 (0.89)	47 (1.19)	82 (2.08)	11.4 (1.06)
V-RVL-D-080P-TS-N-020	Space-Saver Duplex	2 (1.49)	9.2 (260)	11.0 (311)	35 (0.89)	47 (1.19)	82 (2.08)	11.4 (1.06)
V-RVL-D-080P-TS-N-030	Space-Saver Duplex	3 (2.24)	14.2 (401)	17.0 (481)	40 (1.02)	50 (1.27)	82 (2.08)	13.9 (1.29)
V-RVL-D-120P-TS-N-050	Space-Saver Duplex	5 (3.73)	19.2 (544)	23.0 (651)	41 (1.04)	55 (1.40)	89 (2.26)	15.7 (1.46)
V-RVL-D-120P-TS-N-051	Space-Saver Duplex	5 (3.73)	21.7 (615)	26.0 (736)	41 (1.04)	55 (1.40)	89 (2.26)	15.7 (1.46)
V-RVL-D-120P-TS-N-052	Space-Saver Duplex	5 (3.73)	30.8 (872)	37.0 (1048)	60 (1.52)	66 (1.68)	89 (2.26)	27.5 (2.55)
V-RVL-D-120P-TS-N-075	Space-Saver Duplex	7.5 (5.59)	43.3 (1227)	52.0 (1472)	60 (1.52)	66 (1.68)	89 (2.26)	27.5 (2.55)
V-RVL-D-120P-TS-N-100	Space-Saver Duplex	10 (7.46)	54.2 (1535)	65.0 (1841)	60 (1.52)	66 (1.68)	85 (2.16)	27.5 (2.55)
V-RVL-D-120P-TS-N-101	Space-Saver Duplex	10 (7.46)	64.2 (1817)	77.0 (2180)	60 (1.52)	66 (1.68)	99 (2.51)	27.5 (2.55)

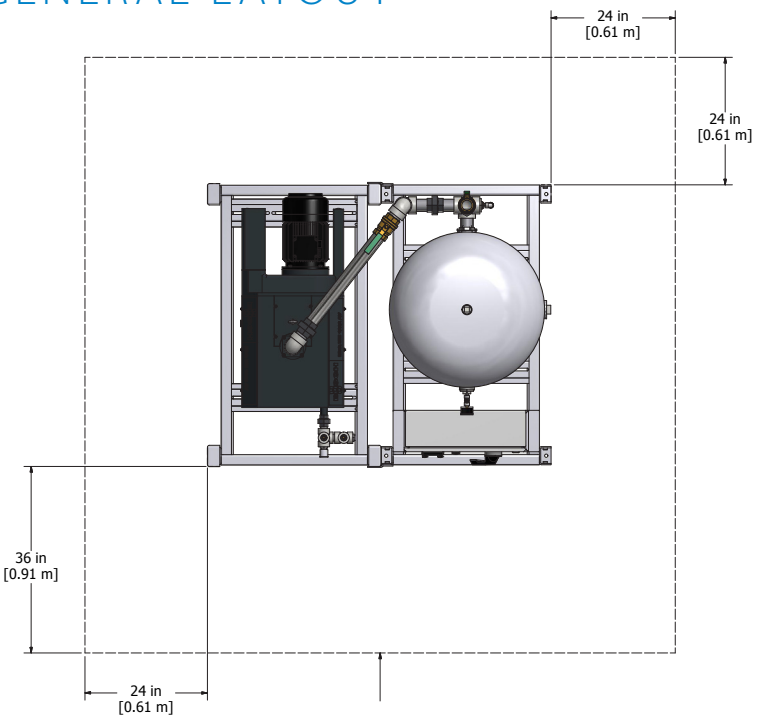
Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
Horizontal Tank Mount (TH) Configuration								
V-RVL-D-080P-TH-N-010	Horizontal Tank Mount Duplex	1 (0.75)	4.0 (113)	4.8 (136)	28 (0.71)	75 (1.91)	60 (1.52)	14.6 (1.36)
V-RVL-D-080P-TH-N-015	Horizontal Tank Mount Duplex	1.5 (1.12)	5.8 (165)	7.0 (198)	35 (0.89)	75 (1.91)	60 (1.52)	18.2 (1.70)
V-RVL-D-080P-TH-N-020	Horizontal Tank Mount Duplex	2 (1.49)	9.2 (260)	11.0 (311)	35 (0.89)	75 (1.91)	60 (1.52)	18.2 (1.70)
V-RVL-D-080P-TH-N-030	Horizontal Tank Mount Duplex	3 (2.24)	14.2 (401)	17.0 (481)	40 (1.02)	75 (1.91)	60 (1.52)	20.8 (1.95)
V-RVL-D-120P-TH-N-050	Horizontal Tank Mount Duplex	5 (3.73)	19.2 (544)	23.0 (651)	43 (1.09)	80 (2.03)	65 (1.65)	23.9 (2.21)
V-RVL-D-120P-TH-N-051	Horizontal Tank Mount Duplex	5 (3.73)	21.7 (615)	26.0 (736)	43 (1.09)	80 (2.03)	65 (1.65)	23.9 (2.21)
V-RVL-D-120P-TH-N-052	Horizontal Tank Mount Duplex	5 (3.73)	30.8 (872)	37.0 (1048)	60 (1.52)	80 (2.03)	65 (1.65)	33.3 (3.09)
V-RVL-D-120P-TH-N-075	Horizontal Tank Mount Duplex	7.5 (5.59)	43.3 (1227)	52.0 (1472)	60 (1.52)	80 (2.03)	65 (1.65)	33.3 (3.09)
V-RVL-D-120P-TH-N-100	Horizontal Tank Mount Duplex	10 (7.46)	54.2 (1535)	65.0 (1841)	60 (1.52)	89 (2.26)	65 (1.65)	37.1 (3.73)
V-RVL-D-120P-TH-N-101	Horizontal Tank Mount Duplex	10 (7.46)	64.2 (1817)	77.0 (2180)	60 (1.52)	89 (2.26)	65 (1.65)	37.1 (3.73)

*System dimensions are subject to change without notice. Please ensure that your copy of this chapter is up to date.

SYSTEM SELECTION TABLES NOTES

- ✓ System dimensions do not include the maintenance space – refer to Step 7: Genral Layout (on the next page) for an understanding of the system maintenance requirements. In all cases, the National Electrical Code requires a minimum clearance of 3' (92 cm) in front of the control cabinet.
- ✓ Should your systems be required to have smaller spaces, please contact your local Amico Source Corporation representative.
- ✓ All systems listed have standard sized receivers. Larger receivers usually change the overall dimensions.
- ✓ Skid mounted systems are omitted from the tables, as they are equivalent to the modular stacking systems. Dimensions for skid mounted systems are only used for informational purposes (as they can vary) and thus are not included.
- ✓ For higher horsepower systems (those that require an increased system capacity), please contact your Local Amico Source Corporation representative for more information.
- ✓ These tables represent the standard configurations of Amico Source Corporation; they do not represent all configurations we are capable of producing.
- ✓ More details on all these systems can be found on the spec sheets for the system selected and the spec sheet should be consulted when doing final layout. These spec sheets can be found on **www.amico.com**.
- ✓ Additional information can also be found on the Schedule section (§7.2.2 on page 138), located in Chapter 7 (Specification & Schedule).

6.2.7 STEP 7: GENERAL LAYOUT



minimum clearance for maintenance and ventilation

1. Place the plant in scale on the plan drawings in the designated location. At the end of Chapter 4, you will have created a preliminary layout drawing for the entire medical gas piped distribution system (that includes the source location). It is now time to revisit that drawing. Ensure that the plant has sufficient space on all sides for maintenance access and proper ventilation. Amico Source Corporation recommends 2' (24") minimum clearance on all sides and 3' (36") in front of the control panel; it is sometimes possible to reduce this clearance with exact knowledge of maintenance access requirements.

   It is imperative that you contact your Local Amico Source Corporation representative if circumstances allow for less space – custom systems will require more engineering time to ensure both the system operates smoothly and that maintenance can be easily performed.
2. Place the equipment in elevation views as appropriate.
3. On the plans, finalize the routing for the exhaust.
4. Size the exhaust piping to ensure that no restriction of airflow (and thus back pressure) occurs in the exhaust line; the sizing process is iterative:
   - Start with the total actual length of piping and make an estimate for the line size (see the exhaust pipe sizing table on the next page).
   - By using your estimated size, add equivalent lengths for the fittings employed.
   - Check that the size of the intake piping is still acceptable at the new equivalent length. If not, re-estimate the next larger size and repeat the steps above.

     The line can also be sized more precisely by performing an actual calculation. Exhaust piping must be sized to induce no more than 4" (100 mm) of water column back pressure at the pump outlet, when all pumps are running. Please use the total capacity for this calculation with all pumps running, not NFPA capacity.

     For unusual lengths or other circumstances, please contact your local Amico Source Corporation representative for assistance.
5. Finalize the connection to the distribution piping and size the system piping.

EXHAUST PIPE SIZING TABLE

Unit	Flow Basis SCFM at 50 psi (LPM at 345 kPa)	Maximum Allowable Equivalent Run (Feet)							
Minimum Nominal Pipe Size		1.5"	2.0"	2.5"	3.0"	4.0"	5.0"	6.0"	8.0"
Duplex 1.5 Hp	12	450							
Duplex 2 Hp	20	170	700						
Duplex 3 Hp	36	65	250	800					
Duplex 5 Hp	74	16	65	200	475				
Duplex 7.5 Hp	138			60	150	600	1,900		
Duplex 10 Hp	178			45	100	425	1,200		
Duplex 15 Hp	240				55	225	675	1,600	
Duplex 20 Hp	272				45	180	525	1,300	
Duplex 25 Hp	336				25	110	325	800	
Triplex 5 Hp	113		30	50	225	900			
Triplex 7.5 Hp	207				75	300	900		
Triplex 10 Hp	267				45	180	550	1,400	
Triplex 15 Hp	375					100	300	700	
Triplex 20 Hp	409					80	250	600	
Triplex 25 Hp	504					60	175	425	
Quadruplex 7.5 Hp	275				45	190	550	1,400	
Quadruplex 10 Hp	355					110	325	800	
Quadruplex 15 Hp	478					65	190	450	
Quadruplex 20 Hp	542						50	150	350
Quadruplex 25 Hp	670						35	170	425

Fittings Equivalent Lengths									
Minimum Nominal Pipe Size	1"	1.25"	1.5"	2"	2.5"	3.5"	4"	5"	6"
Elbows	2.5'	3.0'	4.0'	5.5'	7.0'	9.0'	12.5'	16.0'	19.0'
Tee (Branch/Run)	4.5'	5.5'/.5'	7'/.5'	9'/.5'	12/.5'	15'/1'	21'/1'	27'/1.5'	34'/2'

6.2.8 STEP 8: SPECIFICATION & SCHEDULE

1. In Chapter 7 of this Design Guide, please select the sections appropriate to the technology and system layout desired. You will find a comprehensive list of all the specifications necessary for each type of system.
2. Should any exceptional requirements be necessary (e.g. Variable Frequency/Speed Drive [VFD/VSD], soft starters, BACNET connection capability, Dual Feed, etc.), please incorporate and note them in the specification as well.
3. Schedule in the drawings the medical vacuum plant selected, including at the very least:
    - A general system model or identification number, specific to the MGEM
    - The capacity per pump and total system capacity (per NFPA)
    - An estimate of sound level produced by the total system (per NFPA)
    - Horsepower or kW per pump
    - Voltage, frequency (Hz) and phase desired

Chapter 7 will provide a typical schedule for all of the systems listed in the System Selection Tables of this chapter.

Chapter 7

Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

Specification & Schedule

Chapter 7 – Specification & Schedule

Introduction

This chapter is divided into two main sections and serves as the final phase of the design process for medical compressed air and vacuum systems. The first section deals with the Specification. The necessary equipment will have been appropriately sized and selected based on facility requirements (as per Chapter 4 in this Design Guide) and the equipment will have been clearly illustrated in drawings (see Chapters 5 and 6). The Specification is what serves as the binding legal document, tying everything together regarding what the facility will be getting for the system(s).

It should be noted that there is an important distinction between the Specification and the drawings. The drawings are what will be used to build the system, from a practical point of view. The Specification serves to illustrate what cannot be shown visually on drawings, stating and highlighting key design elements and functions in words. The Specification also illustrates installation technique and verification – two very important aspects that cannot be shown on drawings, but can be detailed exactly through language. Thus, it is the Specification which ultimately dictates the requirements of the medical gas system. Any product that is unable to comply with the chosen Specification simply cannot be used.

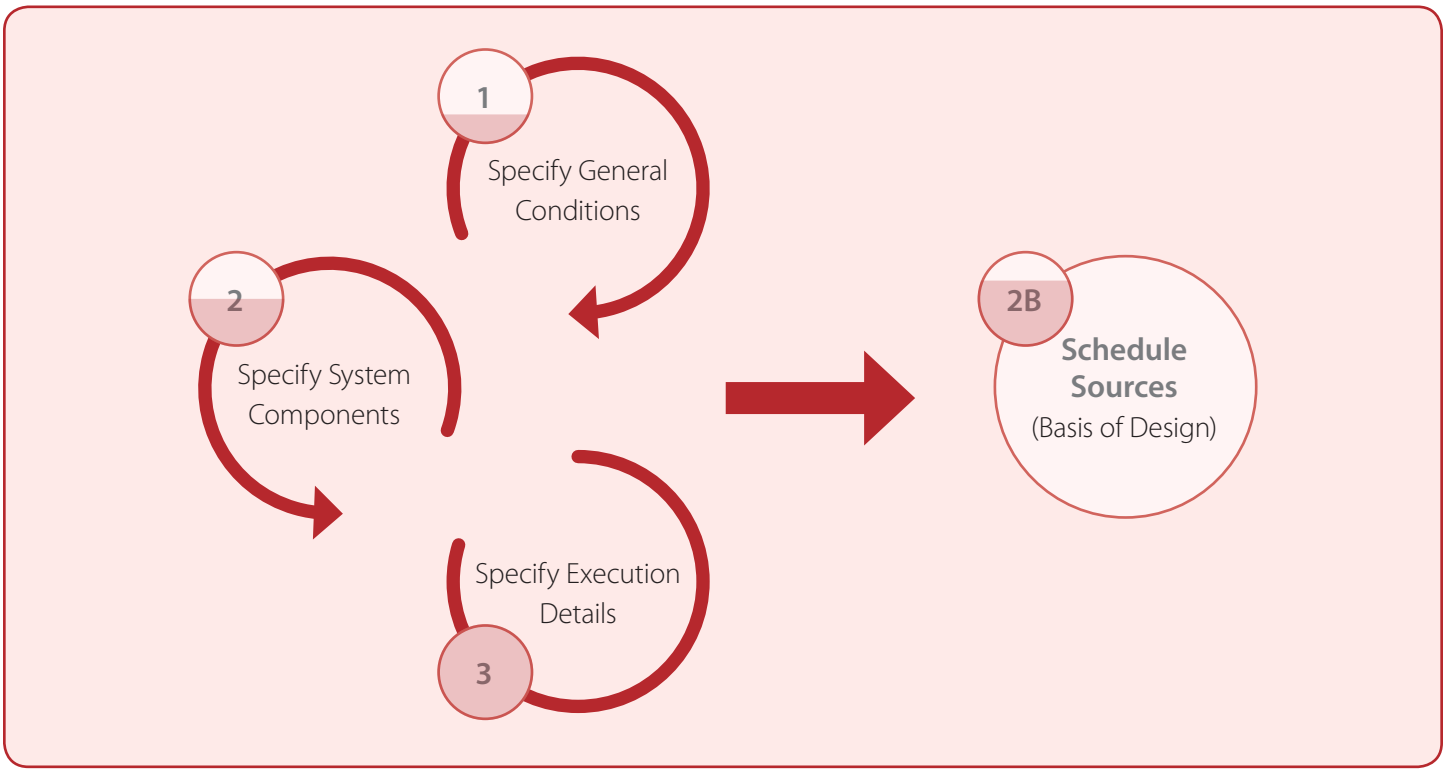
Please note that this Specification is being constantly updated and revised by Amico Source Corporation. Please ensure your copy is the most recent version available.

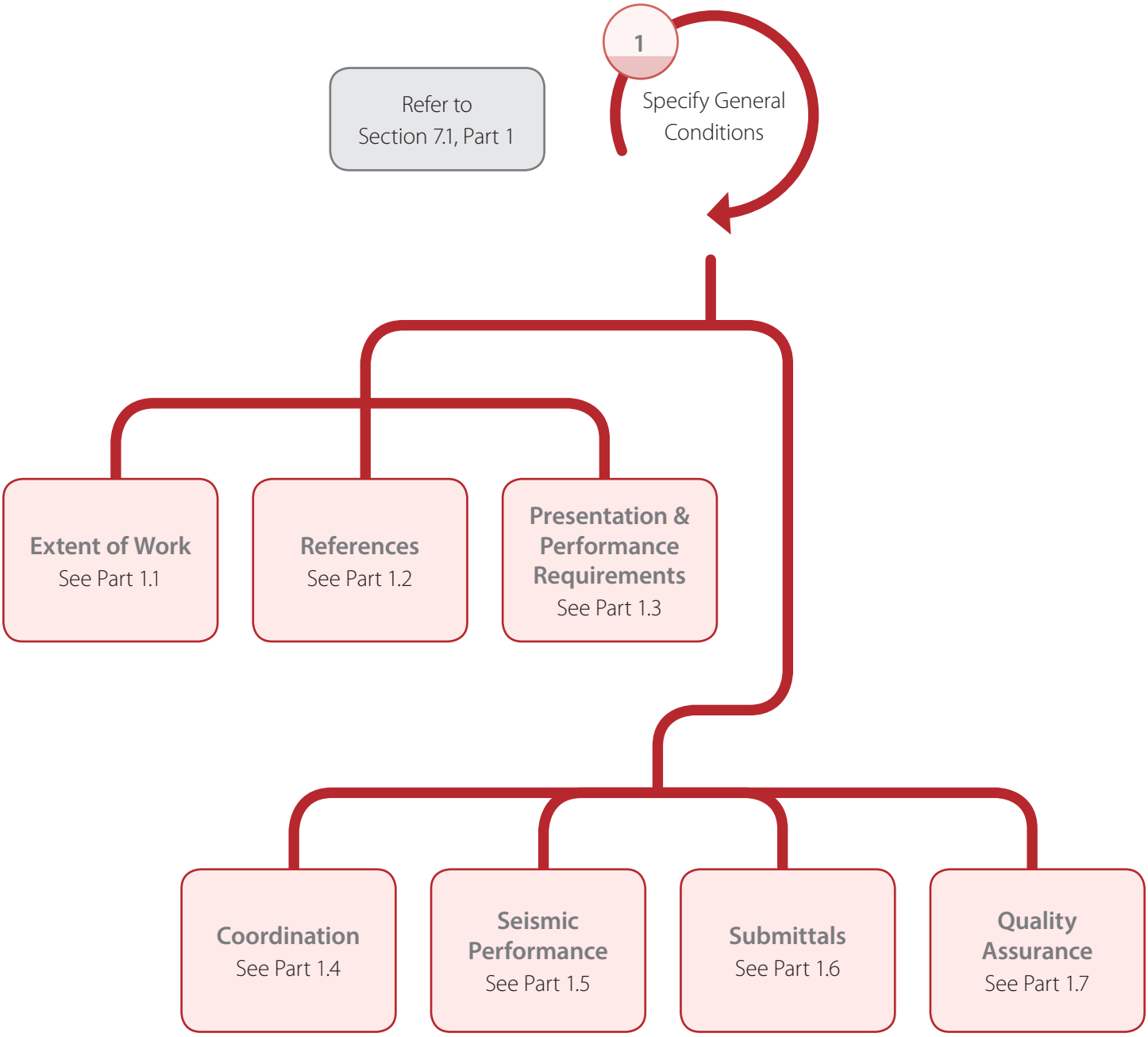
The second section contains the Schedule. For everything that is found in the Specification, you should refer to the Schedule afterwards. While the Specification is a written general document that outlines key design elements, the Schedule is what lists the specific criteria for the equipment. Thus, it serves as a quick summary of the Specification and will be the last piece of equipment that an engineer puts in a project. Its main purpose is to provide actual details of a precise piece of equipment that the engineer would use to satisfy the client's needs. While the Specification details what the system must be, it is the Schedule that provides an example (basis of design) that complies within the Specification. Consequently, the final product shall be made as per the Schedule. More often than not, you will see the Schedule located on the drawings. You can now see how the Specification (the written document delineating the design), the Schedule (an example of a basis of design) and the drawings (visual schematics of the basis of design) all go hand in hand with each other.

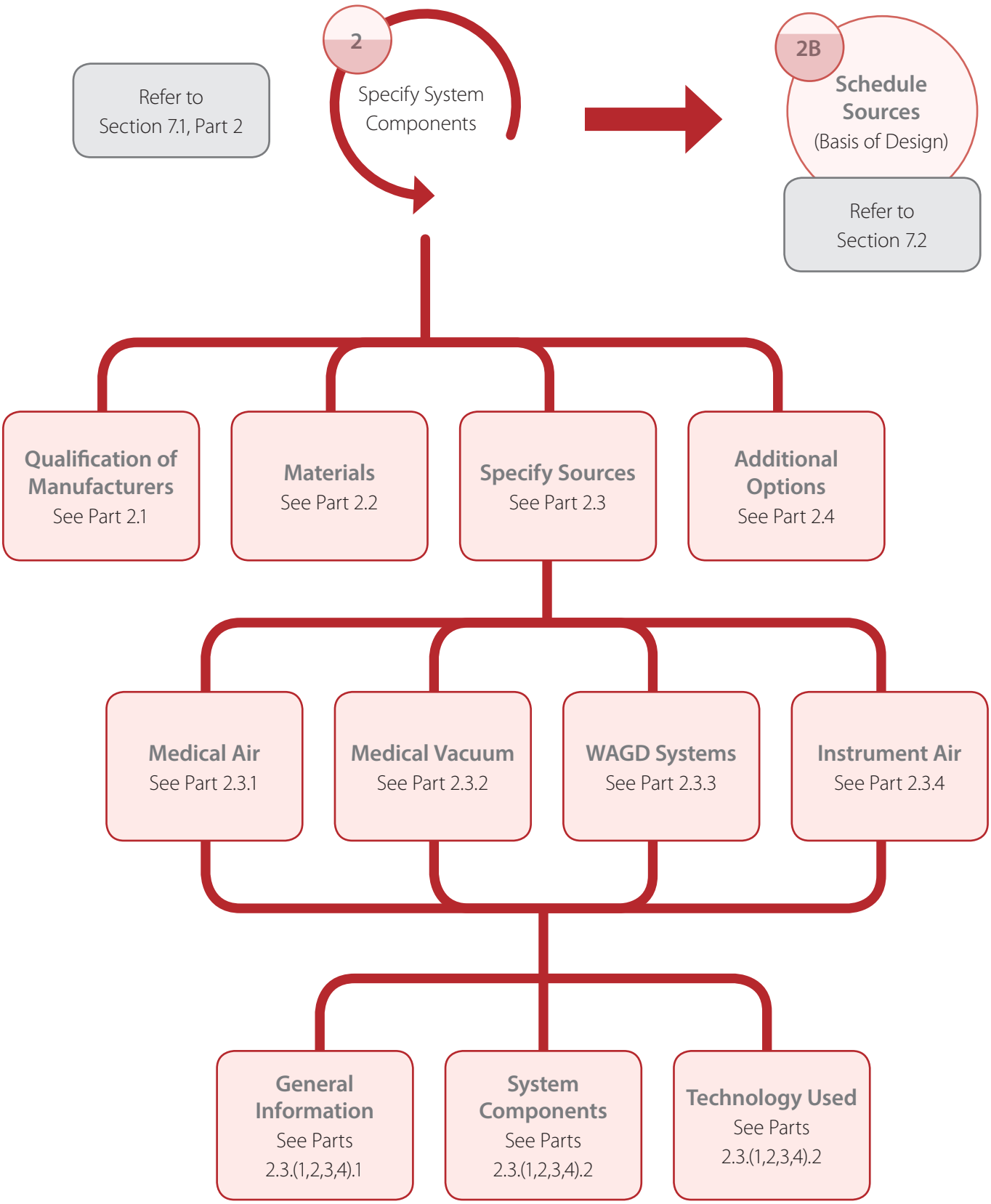
The second part of this chapter will provide the Schedule associated with all equipment from the System Selection Tables of Chapter 5 (Medical Compressed Air Systems) and 6 (Medical Vacuum [Suction] Systems). As with the Specification, this Schedule is being constantly updated by Amico Source Corporation. Please ensure that your copy is the most recent version available. Should you feel there are elements of a specific design you wish to use that are missing from this Specification, feel free to contact your local Amico Source Corporation representative for more information regarding your needs.

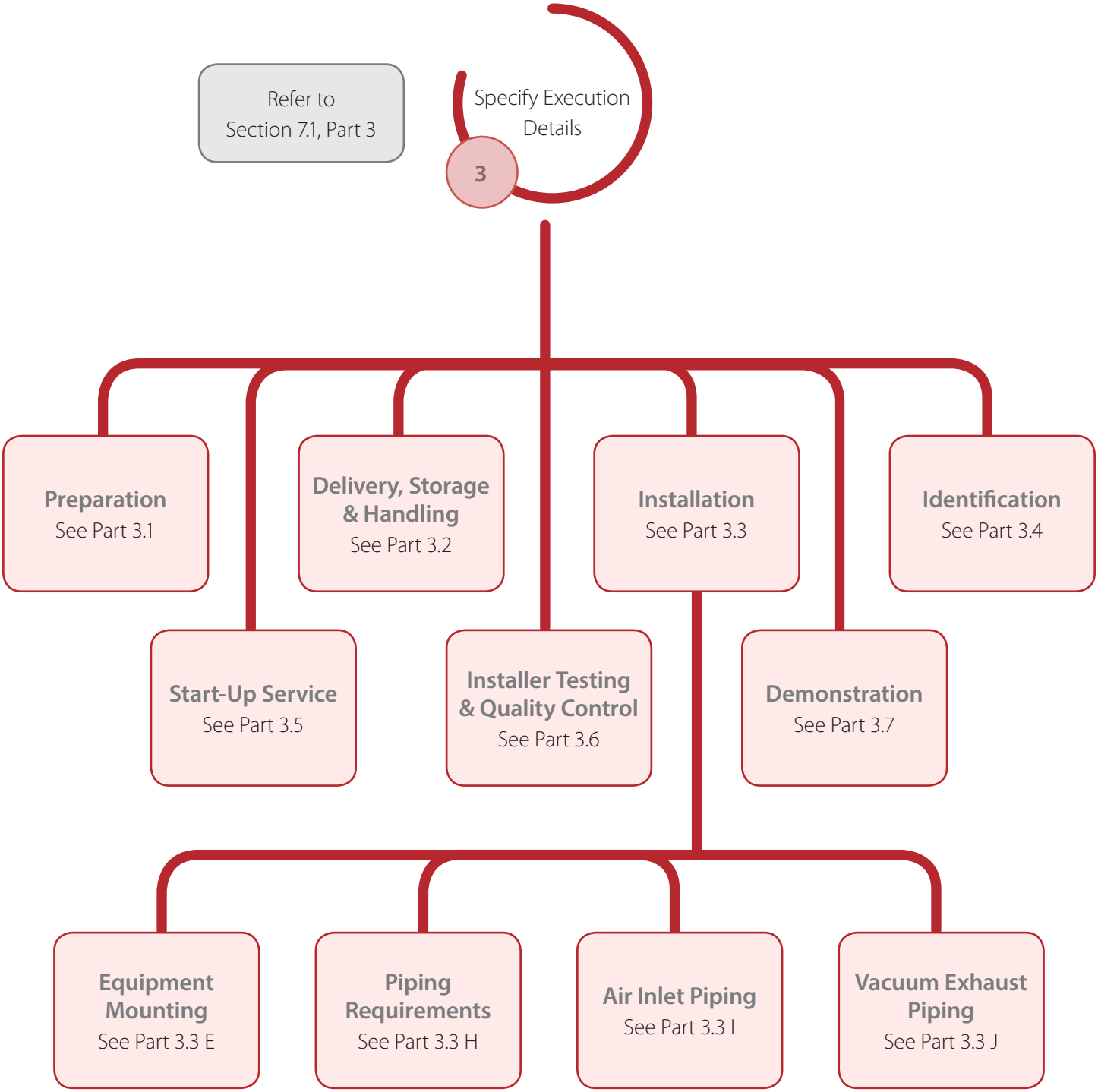
At this point, we recommend referring to Chapter 1 again for a list of the commonly used terms in the medical gas industry and their corresponding meanings, depending on their contextual use. These terms will be especially important in this Specification and Schedule chapter. The figure on the next page provides a visual description of this stage, as well as where to find each section in this chapter.

Phase 4: Specification & Schedule




1
Specify General Conditions
Refer to Section 7.1, Part 1
Extent of Work
See Part 1.1
References
See Part 1.2
Presentation & Performance Requirements
See Part 1.3
Coordination
See Part 1.4
Seismic Performance
See Part 1.5
Submittals
See Part 1.6
Quality Assurance
See Part 1.7


Refer to
Section 7.1, Part 2
2
Specify System
Components
2B
Schedule
Sources
(Basis of Design)
Refer to
Section 7.2
Qualification of
Manufacturers
See Part 2.1
Materials
See Part 2.2
Specify Sources
See Part 2.3
Additional
Options
See Part 2.4
Medical Air
See Part 2.3.1
Medical Vacuum
See Part 2.3.2
WAGD Systems
See Part 2.3.3
Instrument Air
See Part 2.3.4
General
Information
See Parts
2.3.(1,2,3,4).1
System
Components
See Parts
2.3.(1,2,3,4).2
Technology Used
See Parts
2.3.(1,2,3,4).2


Refer to
Section 7.1, Part 3
Specify Execution
Details
3
Preparation
See Part 3.1
Delivery, Storage
& Handling
See Part 3.2
Installation
See Part 3.3
Identification
See Part 3.4
Start-Up Service
See Part 3.5
Installer Testing
& Quality Control
See Part 3.6
Demonstration
See Part 3.7
Equipment
Mounting
See Part 3.3 E
Piping
Requirements
See Part 3.3 H
Air Inlet Piping
See Part 3.3 I
Vacuum Exhaust
Piping
See Part 3.3 J

7.1 System Specification

Note to Specifier:
Choices are indicated via **bold green** wording. Choose one of the listed options. Notes will be indicated in **bold** wording where applicable.

PART 1: GENERAL CONDITIONS

1.1 SUMMARY OF THE EXTENT OF WORK

1. This section pertains to all associated labor, equipment and services necessary for the installation of compressed air and vacuum systems. This includes medical air, medical vacuum, waste anesthesia gas disposal (WAGD), instrument air and laboratory air systems; as shown in the drawings and specified below.
    - A1. Oxygen systems shall be completed to the source valve and ready for connection to the bulk gas supply system.
    - A2. Medical vacuum, WAGD and medical air systems must be complete, started, tested and ready for use.
    - A3. Any specific gas system shall also be complete, started, tested and ready for use.
2. Owner furnished materials necessary for system installation under this section:
    - A1. The supply of gases must be provided in cylinders or containers appropriate for manifolds.
    - A2. The initial supply of liquid gas (oxygen, nitrogen, etc.).

1.2 REFERENCES

All references below refer to the most recent edition. Please see Chapter 2 for a more detailed summary of the relevant codes, standards and references.

1. National Fire Protection Association (NFPA), NFPA 99: Healthcare Facilities.
2. National Fire Protection Association (NFPA), NFPA 70: NEC National Electrical Code.
3. American Society of Sanitary Engineers (ASSE) 6010: Professional Qualification Standards for Medical Gas System Installers.
4. American Society of Sanitary Engineers (ASSE) 6030: Professional Qualification Standards for Medical Gas System Verifiers.

1.3 PRESENTATION AND PERFORMANCE REQUIREMENTS

1. All materials used shall be new and of the best possible grade and quality obtainable, with first class workmanship in every respect. Contractor shall be responsible for ensuring compliance with any and all local, state/provincial and/or federal codes.
2. All necessary elements and associated accessories shall be provided for complete systems per NFPA 99 most recent edition.
3. Connections to owner furnished equipment will be made by the contractor.
4. Piping must be installed as shown on the system drawings, using appropriate methods of fabrication, grading, testing, repairing, cleaning and other procedures.
5. The related wiring essential for the electrical power of air compressor(s), vacuum pump(s), WAGD producer(s), ceiling columns, alarms and any modular accessories associated with the system(s) will be part of the electrical contract. It will be the responsibility of the contractor for any further electrical services that are required by any additional equipment supplied by them.

6. Installer pressure testing, cross connection testing and final testing per NFPA 99 most recent addition and specified procedures.
7. **Note to Specifiers:**

   If CONTRACTOR will retain Verifier, use the following paragraph:

   - Retain a qualified third party verifier acceptable to the engineer and owner to perform and attest to final verification of the systems. Make corrections as needed, including additional testing in order to illustrate full and unqualified certification.

   If OWNER will retain Verifier, use the following paragraph:

   - Coordinate with owner retained verifier for final verification of the systems. Make corrections as needed, including additional testing if necessary to illustrate full and unqualified certification

1.4 COORDINATION

1. The medical gas contractor will coordinate with all other trades to ensure installations are timely. A reasonable amount of effort will be made to avoid any conflicts or interference.
2. Collaborate with the metal stud partition installer and/or mason to ensure anchors, sleeves and similar items are provided in satisfactory time. Chases and openings must also be correctly sized and prepared.
3. A single MGEM will supply medical gas outlets in walls, ceilings and all other related equipment, fitting to the owner.
   A1. The MGEM chosen to manufacture the source equipment shall also be the manufacturer of the pipeline equipment.
4. Medical gas contractor will be responsible for the supply and installation of the master alarm system and accompanying signal wiring. The contractor will also be responsible for the proper termination, testing and marking of the alarm panels. The electrical contractor shall be responsible for providing power wiring to each alarm panel.
5. Coordinate with the Medical Gas Verifier to deliver a complete, tested and fully functional medical gas installation that is ready for the owner's use.

1.5 SEISMIC PERFORMANCE

The medical gas system will be OSHPD rated to withstand the effects of a Richter scale seismic event of either **1.58, 2.0 OR 2.5.**

1. Vacuum producers and accessories and air compressors and accessories, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   A1. The term "withstand" means the system must function in the same capacity both before and after the seismic event. The vacuum producer/air compressor and receiver/separator will remain in place without separation of any parts when subjected to the seismic forces specified. The unit must be fully operational after the seismic event.

1.6 SUBMITTALS

1. Furnish the following as one complete package:
   A1. The MGEM submittals will include the following information:
      a. The complete specifications for the product(s) proposed to be installed, system drawings and wiring diagrams; where applicable.
      b. Medical Air, Vacuum and WAGD systems will also include the following information:
         b1. Drawings indicating configuration style and overall dimensions. Methods of assembly/disassembly and sizes of system subsections must be available upon request.

b2. Additional details that can be found in the Operating and Maintenance Manual, such as:

i. Compressor/pump and system capacity, expressed in SCFM.

ii. Motor details specifying the manufacturer, frame type, service factor, horsepower, current draw and RPM.

iii. Air filter information, including type and replacement element.

iv. Pressure regulators, including type and manufacturer.

v. Dew point monitor and sensor technology used, outlining the calibration interval, annual drift in degrees and recommended replacement interval.

vi. Carbon monoxide monitor and sensor technology used, outlining the calibration interval, annual drift in ppm and recommended replacement interval.

vii. Air Dryer information, including type, manufacturer and design dew point at least -20˚F (-6˚C) at 100 psig (689 kPa).

viii. Overall NFPA system sound pressure, given in A-weighted decibels (dBa).

ix. Overall NFPA power output, given in BTU/hr (heat output).

c. Other medical gas products shall include the following:

c1. Outlet keying system.

c2. Alarm networking instructions.

d. Complete installation instructions, for use of the installer.

e. Statement of specific compliance with NFPA 99 (most recent edition) and the paragraphs most relevant to the equipment and intended system(s).

f. Complete maintenance schedules, including recommendations on preventative maintenance procedures.

g. General information on training programs available for maintenance personnel.

h. Name and contact information for installation assistance, start-up, warranty and service.

i. A copy of the MGEM warranty policy, which encompasses all system components. Warranties which only cover specific components or contain exclusions are not acceptable.

2. Medical Gas Verifier Submittals shall include the following information:

A1. Name, contact information, MGPHO Credential Number and reference list. This reference list must include at least three references on past projects of similar size and complexity.

A2. A notarized affidavit from the verifier, which will state their intention to verify the project. The verifier will therefore be disqualifying themselves from supplying any equipment which will be included in the scope of their verification. Obviously, any verifier who supplies equipment cannot be allowed to verify that equipment.

A3. Statement declaring that the MGEM has no fiduciary interest in the verifier and that the verifier is not an agent or representative of the MGEM.

A4. Statement declaring that the installing contractor has no fiduciary interest in the verifier and that the verifier has no fiduciary interest in the contractor.

3. Any pre-approval information:

A1. Written pre-approval is required for equipment not exactly matching specifications. The above information under Submittals must be provided along with a cover letter detailing the exact areas of deviation.

A2. A pre-approval request must be received by the Engineer no less than three days prior to bid.

1.7 QUALITY ASSURANCE

1. Installer Qualifications:
    - A1. Laboratory Vacuum Equipment for Non-medical Laboratory Facilities: an employer with workers trained and approved by the MGEM.
    - A2. Medical Vacuum Equipment for Healthcare Facilities: qualify installers according to ASSE 6010.
2. Testing Agency Qualifications:
    - A1. An independent testing agency, with the experience and capability to conduct the vacuum equipment testing indicated.
    - A2. The agency shall provide Verifiers who are both ASSE Series 6030 certified and MGPHO credentialed in a way that is acceptable to authorities having jurisdiction in the area.
    - A3. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.
3. Regulatory Requirements:
    - A1. All electrical control systems and medical gas alarms are to be UL listed as assemblies with label affixed.
    - A2. Medical air, instrument air, medical vacuum and WAGD controls are to be wired in accordance with NEC.
    - A3. All air purification components shall be in compliance with CAGI performance verification as per ISO 8573.1 standards.
    - A4. The MGEM will include with submittals, an affidavit testing to compliance with all relevant paragraphs of NFPA 99 most recent edition.
    - A5. The MGEM personnel assembling medical air, instrument air, vacuum and WAGD systems must meet NFPA 99: 5.1.10.10.11 "Qualification of Installers" and hold medical gas endorsements as under ASSE 6010.
    - A6. The contractor must furnish documentation attesting that all installed piping materials are purchased cleaned and in compliance with the requirements of NFPA 99: 5.1.10.1 and NFPA 5.1.10.2.
    - A7. The contractor must furnish copies of ASSE 6010 qualifications for all workers installing medical gas piping.
4. Installation and Start-up: The MGEM must be available to provide factory authorized representatives to evaluate installation and execute initial start-up.
5. Warranty Policy:
    - A1. The warranty will be complete, including all components of the system and is the responsibility of the MGEM. Warranties which limit the responsibility of the MGEM for any system component or which pass through the MGEM to another manufacturer are not acceptable.
    - A2. The warranty will include on site repairs, including travel, labor and parts. Travel and labor on complete systems must be covered to the very least for eighteen months from the date of shipment, or twelve months from start-up – whichever occurs sooner. Consult MGEM for further details.
    - A3. All medical gas pipeline components shall be covered for a minimum of twenty four months from start-up.
    - A4. Shipping and installation costs after the first eighteen months from ship date will not be the responsibility of the MGEM.
    - A5. The replacement of defective parts must be covered by the MGEM for thirty months from the date of shipment or twenty-four months from start-up, whichever occurs sooner. Consult MGEM for further details.
6. Maintenance:
    - A1. The MGEM will demonstrate a national factory direct service capability to perform major overhauls, if deemed necessary and appropriate. This will be at the sole discretion of the MGEM.
    - A2. MGEM will offer a list of preventative maintenance recommendations for the equipment.
    - A3. MGEM must have the capability to provide formal maintenance training courses, for the owner and any other interested parties.

7. Verification: The medical gas contractor shall deliver to the owner a complete system certification without qualifications.

PART 2: SYSTEM COMPONENTS

2.1 QUALIFICATION OF MANUFACTURER(S)

1. One MGEM shall supply the medical compressed air or vacuum system(s) and associated equipment to include outlets, valves and gauges, valve boxes, alarm panels, manifolds, medical air, instrument air, vacuum and WAGD sources.
    A1. The MGEM chosen to manufacture the source equipment shall also be the manufacturer of the pipeline equipment.
    A2. This package shall be designed, manufactured and tested in the U.S. and Canada by the MGEM prior to shipment.
2. The MGEM shall have a product specialist available to periodically check with the contractor during installation of the pipeline system equipment. The MGEM shall provide service support to the facility after turnover and will have a factory trained service technician available within 250 miles of the facility.
3. Approved MGEMs: medical compressed air/vacuum systems, medical gas alarms and associated piping
    A1. Amico Source Corporation
    A2. Alternate by other company with pre-approval (see 7.1 Part 1, §1.6.3 on page 103).
4. Written pre-approval must be presented for all equipment from other manufacturers.

2.2 MATERIALS

1. All pressurized air system piping shall be of the following quality:
    A1. Seamless ASTM B-819, Type K or L hard drawn seamless medical gas brass tubing. The tubing will be identified through markings "OXY," "MED," "OXY/MED," "OXYACR," or "ACR/MED" in green (Type K) or blue (Type L).
    A2. All interconnecting pipe fittings shall be made of brass (painted white) and designed for use with brazed connections – compliant with ANSI B16.22.
    A3. All tubing, fittings, valves and other piping components must be specially cleaned for oxygen service at a facility that is properly equipped. This includes cleaning, rinsing and purging the material in accordance with the requirements of NFPA 5.1.10.1.1 and delivered to the job site cleaned and capped. On site cleaning of the interior surfaces of tubes, valves, fittings and any other related component will not be allowed.
    A4. Brazing alloy shall be BCuP-5 alloy or equivalent, with at least a 1000°F (537.8°C) melting point.
2. All vacuum tubing shall be of the following quality
    A1. Type "L," "M" or ASTM B-280 ACR copper.
    A2. Tubing shall be brazed with BPCuP-5 alloy or equivalent, with at least a 1000°F (537.8°C) melting point.
3. Dissimilar metals can be isolated from copper tubing through copper plated hangers or hangers with plastic isolators.
4. All support structures shall be a minimum of 7 gauge steel.
5. All interconnecting pipe fittings shall be made of brass, painted white.
6. System base, frames, control cabinet and receiver shall all be powder coated for a durable and attractive finish.

2.3 SUBSYSTEMS

2.3.1: MEDICAL COMPRESSED AIR SYSTEMS

Note: It is the job of the specifier to determine the size of the air system required and place on the medical gas schedule. Chapters 4 and 5 will have given you the necessary information and the Schedule section at the end of this chapter will provide basis-of-design examples.

1. General Information:
   - A1. Provide a complete medical air source, complying with NFPA 99: 5.1.3.6 in all respects, as specified and scheduled on the drawings and as manufactured by Amico Source Corporation. An alternate MGEM may be used to provide an equal or comparable system, after pre-approval.
   - A2. The complete package will contain **(#) (Scroll/Reciprocating)** air compressor(s), associated equipment and piping, one ASME air receiver, one desiccant air dryer package and one control panel. The unit will be able to meet the required demand with one compressor out of operation. All capacities are to be indicated in SCFM at necessary pressures.
     - a. The air plant package will be factory assembled, wired, piped and tested; electric motor driven; air cooled; with continuous duty air compressors and receivers that deliver air quality equal to intake air.
   - A3. For maintenance and ventilation of the system, Amico Source Corporation recommends 2' (24") minimum clearance on all sides and 3' (36") in front of the control panel.
   - A4. The furnished and installed unit will be a standard catalog item of the MGEM (Amico Source Corporation), who is regularly engaged (with a minimum five years of experience) in the business of providing packaged systems for hospitals and other facilities.
   - A5. The furnished and installed medical air system will meet or exceed the requirements of NFPA 99's most recent edition as relevant to the equipment; it will be extensively tested before shipment.
   - A6. The unit will supply medical air continuously for the life of the equipment. All components must be at least duplexed and valved to permit service to any component during maintenance operation or any condition of single fault failure, without interrupting air supply to the facility.
   - A7. The system will be completely factory assembled, requiring only interconnection between modules on site if necessary (depending on configuration). Systems requiring site assembly other than interconnection between modules are not acceptable. However, the remounting of components detached for shipping is permitted.
     - a. Each module will be sized to fit within a standard 36" doorway on a standard pallet jack.
   - A8. The system intake, exhaust and power connection at the control panel will be the only field (single point) connections required. All components shall be completely pre-piped and pre-wired to single-point service connections.
   - A9. All interconnecting piping and wiring shall be completed and operationally tested prior to shipment.
   - A10. Liquid tight conduit, fittings and junction boxes for all control and power wiring will be provided by the MGEM.
   - A11. The system shall include individual compressor inline intake filters, discharge check valves, safety relief valves, stainless steel intake and discharge flexible connectors, isolation valves, air cooled aftercoolers for each compressor, high discharge temperature shut down switches, pressure control switches as well as poly tubing for gauge and switches.
   - A12. General Requirements for Air Compressors:
     - a. Comply with NFPA 99: Health Care Facilities Code for compressed air equipment and accessories for medical compressed air systems.
     - b. Mounting Frame: fabricate base and attachment to air compressor and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to the building structure.

c. Each compressor unit shall be equipped with a distinct aftercooler with separate cooling fan designed for a maximum approach temperature of 7°C (15°F) at 37.8°C (100°F) ambient.

d. All moving parts (fans, pulleys and belts) shall be fully protected by OSHA acceptable enclosures and guards.

e. A temperature sensor at the outlet of each compressor cylinder or air-end shall provide a high temperature alarm and shut down that compressor if exceeded. Systems employing a single switch for multiple cylinders or air-ends are not acceptable.

A13. The compressor modules and motors shall be fully isolated from the main base by means of a four point, heavy-duty isolation system.

A14. Flexible connections between compressor units and the structure shall be provided for all inlets and outlets.

a. Vibration flexes shall be all stainless steel and of sufficient length to achieve full isolation.

b. Systems using rubber tubing flex connectors with hose clamps are not acceptable.

c. Systems with short flex connections providing only nominal isolation are not acceptable.

Specifier: Adjust A15 as necessary, when other electrical specs (voltage/phase/frequency) are required.

A15. The compressor motors must be NEMA rated, open drip proof, 3600 rpm, continuous duty. The motors will be suitable for **(208 V/230 V/460 V), three phase, 60 Hz.**

2. System Components:

A1. The **control panel** and all associated components will be built, labeled and listed in a UL 508A certified panel shop. It will have a NEMA 12 enclosure and abide by the following requirements.

a. Provide in the control cabinet door, the following:

a1. 16 bit, full color, VGA resolution touch screen display for system functions and system level control. All monitoring must be done on a single screen, multiple screens are not acceptable.

a2. A separate disconnect handle with door interlock for each compressor unit.

a3. Audio sounder capable of 90 dB at 3 feet, with noise reduction and mute function available on the door.

a4. LED run indicators on H-O-A switches, indicating which compressor is running.

b. Provide in the control cabinet interior, the following:

b1. Externally operable circuit breakers with door interlocks, control circuit transformers with fused primary and secondary circuits, H-O-A switches and magnetic starters with (three/single) phase overload protection.

b2. Full voltage motor starters with overload protection – one per compressor unit.

b3. Alarm contacts must be provided for remote annunciation for all alarm points.

b4. Circuit breaker disconnects, one for each compressor unit operated through the door disconnect handle.

b5. Controls circuitry shall be 120 volts AC and 24 volts DC.

b6. Redundant 120 volt AC control circuit transformers including power seeking function in the event one power supply fails.

b7. Power distribution terminal block convenient for main power entry.

b8. All internal components needed for operation of the control system as described below.

i. Volt free contacts for connection to master alarms.

ii. No proprietary controls and/or circuitry boards are to be present – all components readily available from local and standard electrical suppliers.

c. The control panel shall provide for the following functions:

c1. The reserve compressor(s) must be able to start automatically if the lead compressor fails to operate.

c2. Audible and visual local alarms for compressor temperature malfunction and reserve compressor in use.

c3. Display of pressure, dew point and carbon monoxide level on a single "home" screen display for at-a-glance checking.

c4. Digital display of the dew point (either in °F or °C) and CO in ppm on screen.

i. The panel will have an audible and visual alarm to indicate if the level of CO exceeds 10 parts per million by volume (ppm).

ii. The panel will have an audible and visual alarm to indicate if the dew point exceeds 35°F (1.7°C).

iii. Alarm setting shall be adjustable to allow the system to adapt to any future change in code.

c5. Automatic lead/lag sequencing and alternation. Display shall clearly show status of each compressor unit including the running unit, next-unit-in-sequence and units unavailable to run.

c6. Manual reset for thermal malfunction shutdown.

c7. Runtime for each compressor unit.

c8. In the event of control failure, the system shall activate all alarms and operate on a simple on/off basis until repaired.

c9. When H-O-A selectors are in Auto mode, the system shall operate on a programmable logic controller. The pressure switch shall only be activated as a backup system.

c10. Controls shall provide visual and audible alarm indications and isolated contacts for remote alarm for at least Dew Point High, CO High, Lag Compressor in Use and High Temperature for each compressor unit.

c11. Controls shall provide automatic indication of major maintenance intervals.

c12. Controls shall provide distinct separate indication on the control screen of alarms related to compressor versus alarms related to the system and quality of air.

c13. Alarm shall be stated on the main screen in plain language and indicate the nature of the alarm. Labeled indication lights are not permitted.

c14. Controls shall provide isolated dry contacts for remote alarms required by NFPA 99: Section 5.1.9 related to Medical Air Compressor Systems.

c15. Dryers shall be controlled from the control panel with controls integrated into the touchscreen system to allow dryer switching. External or separate controllers and switches are not acceptable.

i. Must be able to cycle automatically between dryer towers.

ii. Dryer purge flow control using an integral, dew point based purge control system. Purge controllers using desiccant temperature are not acceptable.

iii. Both dryers shall be allowed to operate at the same time by overriding dryer select function during maintenance procedures.

iv. Must be able to indicate dryer operation, status and dew point on the same screen.

c16. Control system shall log and allow review of all alarm and shutdown events.

c17. Control system shall be highly redundant and robust allowing for multiple failures before becoming unable to deliver air (or air of quality required). Control systems which can result in inability to deliver air (or air of quality required) in event of failure of any single component are not acceptable.

c18. All control and alarm functions must remain energized while any compressor in the system remains electrically online.

c19. Controls shall include an integral web gate using standard Ethernet allowing observation of system operating parameters from any remote location on the same network with any standard web browser. Systems requiring special or additional separate software are not acceptable.

c20. Language selection options should include English, French and/or Spanish.

c21. Email alert feature for any and all alarms must be available.

A2. The **inlet air filters** are to be a combination inlet air filter-silencer, appropriate for remote installation and maintenance for each compressor.

a. The housing shall be weatherproof with silencer tubes or alternate methods of sound reduction.

b. The filter elements shall be of a dry paper type, with at least 99% removal efficiency standard to two microns.

c. Each filter must be sized to match the individual capacity of the connected air compressor.

A3. The furnished **desiccant dryer package** and its associated components will be sized for peak calculated demand and will have the following requirements:

a. NFPA 99 compliant dual desiccant air dryers with no standalone controller.

b. There shall be two identical banks of air treatment equipment; piped in parallel and provided with valves to bypass either filter set for element replacement, maintenance and repair work while still treating medical compressed air through the other set.

c. Each dryer must be capable of delivering a targeted pressure dew point of -25°F (-31.7°C)

d. Dual pre-filters, after-filters, pressure regulator valves, dew point monitor, CO monitor and system safety valves will all come equipped as standard.

d1. Duplexed final line regulators shall be factory mounted and piped at the outlet of each dryer.

e. Dryers will be completely pre-piped and pre-wired to single-point service connections.

f. There shall be two identical banks of air treatment equipment, piped in parallel and provided with valves to bypass either filter set for element replacement, maintenance and repair work while still treating medical compressed air through the other set.

g. Each bank must consist of three stages:

g1. The 1st stage is a prime efficiency coalescing pre-filter rated for 0.01 microns, with filtered differential pressure gauge (element change indicator) and an electric solenoid auto drain valve controlled by the main control system. Separate controllers are not acceptable.

g2. The 2nd stage is a desiccant heatless air dryer.

g3. The 3rd stage is a prime efficiency particulate afterfilter rated for 1 micron, with differential pressure gauge (element change indicator).

h. Sensors for dew point and CO sensors shall be provided with a DISS demand check valve per NFPA 99: Section 5.1.8.2.4.

A4. The **air receiver(s)** shall be as follows:

a. Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

b. Interior Finish: ASME construction of ferrous and/or non-ferrous materials. Corrosion-resistant coating. ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 construction with two-part, epoxy-lined coating providing rust protection that is equal to or better than what is normally achieved through galvanizing.

c. Pressure Rating: Rated for a maximum 200 psig MAWP at 400°F (204.4°C) and full air service, bearing appropriate code symbols.

d. Accessories: Equipped with pressure gauge, safety relief valve, three valve bypass, sight (liquid-level) glass and automatic electronic time based tank drain with manual valve drain override.

d1. The three valve bypass will allow for draining of the receiver without interrupting the air service as well as isolating the tank for repair maintenance.

e. The receiver shall comply with all requirements of Section VIII (unfired pressure vessels) of the ASME Boiler and Pressure Vessel Code.

f. The receiver will be factory mounted (unless specified in the drawings) and factory piped.

Specifier: Select the paragraphs below, relevant to the preferred technology

FOR SCROLL TECHNOLOGY

A5. The **air compressor(s)** will be belt driven, oil-less scroll; single stage; continuous duty; with air-cooled construction and absolutely no oil needed for operation. It will also have the following requirements:

a. The compressors should contain one fixed and one orbiting scroll head, with PTFE seals on the tips between scroll halves.

b. Absolutely no oil needed for operation. Units requiring re-lubrication are not acceptable.

c. The compressors will be rated for at least 828 kPa (120 psig) discharge pressure.

d. Orbiting bearing and crank pin bearings are to be grease lubricated, with maintenance intervals of 10,000 hours. Units that will require re-lubrication more often will not be accepted.

e. Compressor(s) will be mounted near motor(s) in such a way that provides easy adjustment of belt tension.

e1. For 2-10 hp compressors, belt tensioning shall be achieved with a sliding motor mounting base (Straight-Base) adjustable with a power screw.

e2. For 15-20 hp compressors, belt tensioning shall be achieved with a dual sliding compressor mounting base (A-Frame), adjustable with a power screw.

f. Vibration mounting is provided as per NFPA; the compressors and motors will be fully isolated from the package base by means of flexible rubber (neoprene) mounts.

g. Noise level at 3' shall not exceed 75 dB(A) per pump for 10 horsepower and under 79 dB(A) per pump for 15 horsepower and above.

h. All moving parts (fans, pulleys and belts) shall be fully protected by OSHA acceptable enclosures and guards.

i. Each compressor will be equipped with isolation valve, check valve, safety relief valve, electric motor, belts, belt guard, aftercooler, moisture separator and T.M.P.D. (thermal malfunction protection device).

i1. The discharge of piping of each compressor shall incorporate a check valve to prevent reverse rotation of the scroll at shutdown.

j. Compressors shall be field serviceable allowing tip seal change and bearing lubrication. Non-field serviceable scroll compressors are not acceptable.

k. Standard preventative maintenance shall be limited to replacing the belt(s) as necessary. Scroll tip seals should only be replaced after a minimum of 10,000 hours of operation.

FOR RECIPROCATING TECHNOLOGY

A5. The **air compressor(s)** will be belt driven, single stage, air-cooled, reciprocating style and the following requirements:

a. The compressor should be a single stage compressor with two or three compressing heads.

b. The cylinder shall be guided with a PTFE rider band.

c. Absolutely no oil needed for operation.

d. The compressors will be rated for at least 758.4 kPa (110 psig) discharge pressure.

e. Crankcase ventilation shall be filtered to prevent dust and insects from entering the crankcase.

f. Compressor(s) will be mounted near motor(s) in such a way that provides easy adjustment of belt tension.

g. The valve(s) will be corrosion resistant with stainless steel connecting rods.

h. Noise level at 3' shall not exceed 84 dB(A) per pump.

i. All moving parts (fans, pulleys and belts) shall be fully protected by OSHA acceptable enclosures and guards.

j. Each compressor will be equipped with isolation valve, check valve, safety valve, electric motor, belts, belt guard, aftercooler with separator and T.M.P.D. (thermal malfunction protection device).

k. Vibration mounting is provided as per NFPA; the compressors and motors will be fully isolated from the package base by means of spring isolators.

l. The standard preventative maintenance shall be limited to replacing the belt(s) as necessary. Valve plate and rider band should only be replaced after a minimum of 10,000 hours of operation or three years.

2.3.2: MEDICAL VACUUM (SUCTION) SYSTEMS

Note: It is the job of the specifier to determine the size of the vacuum system required and place on the medical gas schedule. Chapters 4 and 6 will have given you the necessary information and the Schedule section at the end of this chapter will provide basis-of-design examples.

1. General Information:

A1. Provide a complete medical vacuum source, complying with NFPA 99: 5.1.3.7 in all respects, as specified and scheduled on the drawings and as manufactured by Amico Source Corporation. An alternate MGEM may be used to provide an equal or comparable system, after pre-approval.

A2. The complete package will contain **(#) (contactless claw/dry rotary vane/ lubricated rotary vane)** vacuum pump(s), one ASME air receiver and one control panel, along with the associated equipment and piping. The unit will be able to meet the required demand with one pump out of operation. All capacities are to be indicated in SCFM at 19 inHg.

a. Each pump shall have a built-in anti-suck-back valve mounted at the pump inlet.

b. Each pump shall be equipped with one pump isolation ball valve, one inlet check valve, one inlet stainless steel flex connector and one discharge stainless steel connector.

Specifier: If Bacterial Filters are to be included in the vacuum plant, please also include Option C below.

c. One bacterial removal inlet filter per pump. The bacterial filter shall meet the requirements of the DHSS for infectious disease units with complete bacterial removal to 99.97% at 0.1 microns.

c1. The bacterial filter will be designed for the removal of liquids, solids and sub-micron particles. It will be rated for ULPA or UL media to the least.

c2. The bacterial filter will come equipped with a pressure drop indicator gauge, providing visual status of when the element should be replaced. Elements should be replaced no more frequently than twice annually, depending on usage.

c3. The bacterial filter will come equipped with brass valves and fittings for contaminated liquid release.

c4. The bacterial filter will have an easily removable and sterilizable glass flask.

c5. The bacterial filter will come with a high-impact and shatter resistant see-through bucket.

A3. For maintenance and ventilation of the system, Amico Source Corporation recommends 2' (24") minimum clearance on all sides and 3' (36") in front of the control panel.

A4. This furnished and installed unit will be a standard catalog item of the MGEM (Amico Source Corporation), who is regularly engaged (with a minimum of five years of experience) in the business of providing packaged systems for hospitals and other facilities.

A5. The furnished and installed medical vacuum system will meet or exceed the requirements of NFPA 99's most recent edition as relevant to the equipment and will be extensively tested before shipment.

A6. The unit will supply medical vacuum continuously for the life of the equipment. All components must be at least duplexed and valved (or check valved as specified in NFPA 99) to permit service to any component during maintenance operation or any condition of single fault failure, without interrupting vacuum supply to the facility.

A7. The system will be completely factory assembled, requiring only interconnection between modules on site if necessary (will depend on configuration). Systems requiring site assembly other than interconnection between modules are not acceptable. However, the remounting of components detached for shipping is permitted.

a. Each module will be sized to fit within a standard 36" doorway on a standard pallet jack.

b. System shall be tank mounted or built entirely on a single base or a base which can be separated (into modules) in the field for rigging. If separable, bases shall be prepared for separation at the factory.

c. System shall be completely factory assembled having field connections limited to one inlet line, one electrical conduit as well as power and exhaust equal to the amount of pumps.

c1. A single point of connection to the intake of the system shall be provided.

c2. A single point of connection to the electrical panel of the system shall also be provided.

d. Systems requiring site assembly, other than interconnection between modules or reattachment of sections separated on site at contractor's convenience, are not acceptable. Remounting of components detached for shipping is permitted.

A8. The system intake and power connection at the control panel will be the only field (single point) connections required. Exhaust lines will be connected to each pump.

A9. All interconnecting piping and wiring shall be completed and operationally tested prior to shipment.

A10. Liquid tight conduit, fittings and junction boxes for all control and power wiring will be provided by the MGEM.

A11. System base, frames, control cabinet and receiver shall all be powder coated for a durable and attractive finish.

2. System Components:

A1. The **control panel** and all associated components will be built, labeled and listed in a UL 508A certified panel shop. It will have a NEMA 12 enclosure and abide by the following requirements.

a. Provide in the control cabinet door, the following:

a1. Full color, 16 bit, VGA resolution touch screen display for system functions and system level control. All monitoring must be done on a single screen, multiple screens are not acceptable.

a2. A separate disconnect handle with door interlock for each pump unit.

a3. Audio sounder capable of 90 dB at 3 feet, with noise reduction and mute function available on the door.

a4. LED run indicators on H-O-A switches, indicating which pump is running.

b. Provide in the control cabinet interior, the following:

b1. Externally operable circuit breakers with door interlocks, control circuit transformers with fused primary and secondary circuits, H-O-A switches and magnetic starters with (three/single) phase overload protection.

b2. Full voltage motor starters with overload protection – one per pump unit.

b3. Alarm contacts must be provided for remote annunciation for all alarm points.

b4. Circuit breaker disconnects, one for each pump unit operated through the door disconnect handle.

b5. Controls circuitry shall be 120 Volts AC and 24 Volts DC.

b6. Redundant 120 Volt AC control circuit transformers including power seeking function in the event one power supply fails.

b7. Power distribution terminal block convenient for main power entry.

b8. All internal components needed for operation of the control system as described below.

i. Volt free contacts for connection to master alarms.

ii. No proprietary controls and/or circuitry boards are to be present – all components readily available from local and standard electrical suppliers.

c. The control panel shall provide for the following functions:

c1. The reserve pump(s) must be able to start automatically if the lead pump fails to operate.

c2. Audible and visual local alarms are for pump temperature malfunction, reserve pump in use.

c3. Display of vacuum level on a single "home" screen display for at-a-glance checking.

c4. Automatic lead/lag sequencing and alternation. Display shall clearly show status of each pump unit including the running unit, next-unit-in-sequence and units unavailable to run.

c5. Manual reset for thermal malfunction shutdown.

c6. Runtime for each pump unit.

c7. In the event of control failure the system shall activate all alarms and operate all pumps until repaired.

c8. When H-O-A selectors are in Auto mode, system shall operate on programmable logic controller.

c9. Controls shall provide visual and audible alarm indication and isolated contacts for remote alarm for at least Low Vacuum Level, Lag Pump in Use and High Temperature for each pump unit.

c10. Controls shall provide automatic indication of major maintenance intervals.

c11. Controls shall provide distinct separate indication on the control screen of alarms related to pump versus alarms related to the system.

c12. Alarm shall be stated on the main screen in plain language indicating the nature of the alarm. Labeled indication lights are not permitted.

c13. Controls shall provide isolated dry contacts for remote alarms required by NFPA 99: Section 5.1.9 related to Medical Vacuum Pump System.

c14. Control system shall log and allow review of all alarm and shutdown events.

c15. Control system shall be highly redundant and robust allowing for multiple failures before becoming unable to deliver vacuum required. Control systems which can result in inability to deliver vacuum required in event of failure of any single component are not acceptable.

c16. All control and alarm functions must remain energized while any pump in the system remains electrically online.

c17. Controls shall include an integral web gate using standard Ethernet allowing observation of system operating parameters from any remote location on the same network with any standard web browser. Systems requiring special or additional separate software are not acceptable.

c18. Language selection options should include English, French and/or Spanish.

c19. Email alert feature for any and all alarms must be available.

A2. The **vacuum receiver(s)** shall be as follows:

a. Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

b. Interior Finish: ASME construction of ferrous and/or non-ferrous materials. Corrosion-resistant coating: ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 construction with two-part, epoxy-lined coating providing rust protection that is equal to or better than what is normally achieved through galvanizing.

c. Pressure Rating: Rated for a maximum 200 psig MAWP at 400°F (204.4°C) and full vacuum service; capable of withstanding 29.9" gauge HgV.

d. Accessories: Equipped with manual valve drain, a source shut off valve and a means for bypassing the receiver (isolation valve) to allow for repair and maintenance.

e. The tank isolation valve will allow for draining of the receiver without interrupting the vacuum service.

f. The receiver shall comply with all requirements of Section VIII (unfired pressure vessels) of the ASME Boiler and Pressure Vessel Code.

g. The receiver will be factory mounted (unless otherwise specified in the drawings) and factory piped.

Specifier: Select the paragraphs below, relevant to the preferred technology

FOR OIL LESS (DRY) CONTACTLESS CLAW TECHNOLOGY

A3. The **vacuum pump(s)** will be continuous duty, high efficiency, oil-less and frictionless contact-less claw style rotary pumps.

a. Compact rotary claw positive displacement pumps.

b. Factory assembled, mounted as a single piped, wired and factory-tested package.

c. Air-cooled with no water requirements, pump chamber must be oil free (no seal or lubricant necessary).

d. The vacuum pump drive shall be direct driven; torque is transmitted from the flanged motor to the pump through a shaft coupling. The rotors are synchronized by gears.

d1. Each motor will be TEFC NEMA C-face. The motors will be suitable for **(208 V/230 V/460 V)**, three phase, 60 Hz.

d2. Belt drives shall not be permitted.

e. Each pump will contain: acoustic enclosure, rubber mount vibration isolators, oil sight glass, inlet screen, anti-suck-back valve on inlet, vacuum relief valve (select models) and threaded NPT inlet/outlet connections.

f. Each pump will include the following piping control components: flexible inlet and outlet couplings, inlet and outlet shut-off valves and exhaust drip leg. Each pump exhaust shall be isolated by a union fitting, permitting capping for service removal (if necessary).

g. Additional accessories including inlet air filters and bacterial filter/fluid traps are not included in a standard unit, but available as options.

h. Maintenance shall be limited to changing the gearbox oil as needed based on the non-contacting design (not more often than 5000 hours and not less frequent than 20,000 hours). Additional maintenance may include replacing the inlet screen as necessary.

i. V-belt drives will not be acceptable.

j. Vacuum pumps requiring oil in compression chamber will not be acceptable.

FOR OIL LESS (DRY) ROTARY VANE TECHNOLOGY

A3. The **vacuum pump(s)** will be continuous duty, direct driven, completely dry, air-cooled, positive displacement dry rotary vane style pumps.

a. Each pump will be equipped with self-lubricating carbon or graphite vanes.

b. No oil or water is permitted in the pump. No foreign medium is to be used as a lubricating agent.

c. Bearings must be internally lubricated and sealed.

d. Each pump will include the following piping control components: flexible inlet and outlet couplings, inlet and outlet shut-off valves and exhaust drip leg. Each pump exhaust shall be isolated by a union fitting, permitting capping for service removal (if necessary).

e. Vibration isolation is provided by means of rubber mounts.

f. The vacuum pump drive shall be directly driven from the motor to the pump through a shaft coupling.

f1. Each motor will be TEFC NEMA C-face. The motors will be suitable for **(208 V/230 V/460 V)**, three phase, 60 Hz.

f2. Belt drives shall not be permitted.

FOR LUBRICATED ROTARY VANE TECHNOLOGY

A3. The **vacuum pump(s)** shall be of rotary vane (dynamically balanced heavy duty multi-vane), air-cooled, positive displacement design with an integral fully recirculating oil supply.

a. There must be a sight glass to indicate the oil level.

b. The pump(s) must be capable of removing +99.9% of all oil and smoke particles from the exhaust.

c. Each pump must be equipped with at least three non-asbestos vanes.

c1. These vanes must be made of heavy duty aluminum alloys, for maximum heat dissipation.

c2. Vanes must be checked at a minimum of every 10,000 operating hours.

d. Each pump will include the following piping control components: flexible inlet and outlet couplings, inlet shut-off valves and exhaust drip leg. Each pump exhaust shall be isolated by a union fitting, permitting capping for service removal (if necessary).

d1. Rubber hose flex connectors and hose clamps are not acceptable for assembling package.

e. Vibration isolation is provided by means of rubber mounts.

f. Pumps that require external piping for oil lubrication will not be accepted.

f1. The oil lubrication system must be enclosed in one complete module for the minimization of any leaks.

g. The vacuum pump drive shall be directly driven from the motor to the pump through a shaft coupling.

g1. Each motor will be TEFC NEMA C-face. The motors will be suitable for **(208 V/230 V/460 V)**, three phase, 60 Hz.

g2. Belt drives shall not be permitted.

g3. Pumps that require additional electric motors for oil cooling will not be accepted.

h. The maintenance for each pump will include changing the oil as needed (not more often than 500 hours) and replacing the oil separation filter.

h1. Service to the oil filter(s) shall not require disconnection of the exhaust piping.

A4. Vibration mounting is provided as per NFPA; the pumps and motors will be fully isolated from the package base by means of rubber mounts.

A5. Stainless steel non-braided flexible pipe connections for vacuum inlet connections and resilient mounts to support pump skid.

A6. Provide and mount in vacuum piping: vacuum switch with vacuum gauge and DISS demand check valve; the switch to be wired by others to remote master alarm locations.

a. The furnished unit will be equipped with the following accessories: vacuum relief valves, check valves, inlet and discharge flexible connectors, isolation valves, high discharge temperature switches and vacuum gauges.

b. Factory piped intake with integral flex connector for the intake piping.

c. Additional accessories including inlet air filters, bacterial filter/fluid traps and tank three-valve bypass are not included in a standard unit, but available as options.

2.3.3: WASTE ANESTHETIC GAS DISPOSAL (WAGD) SYSTEMS

Note: It is the job of the specifier to determine the size of the WAGD system required and place on the medical gas schedule. Chapters 4 and 6 will have given you the necessary information and the Schedule section at the end of this chapter will provide basis-of-design examples.

1. General Information:

A1. Provide a complete WAGD producer system, complying with NFPA 99: 5.1.3.8 in all respects, as specified and scheduled on the drawings and as manufactured by Amico Source Corporation. An alternate MGEM may be used to provide an equal or comparable system, after pre-approval.

A2. The complete package will contain **(#) (contactless claw / oxygen assured contactless claw)** vacuum pump(s), one ASME air receiver and one control panel, along with the associated equipment and piping. The unit will be able to meet the required demand with one pump out of operation. All capacities are to be indicated in SCFM at 19 inHg.

a. Each pump shall have a built-in, anti-suck-back valve mounted at the pump inlet.

b. Each pump shall be equipped with one pump isolation ball valve, one inlet check valve, one inlet stainless steel flex connector and one discharge stainless steel connector.

Specifier: If Bacterial Filters are to be included on the vacuum plant, please also include Option C below.

c. One bacterial removal inlet filter per pump. The bacterial filter shall meet the requirements of the DHSS for infectious disease units with complete bacterial removal to 99.97% at 0.1 microns.

c1. The bacterial filter will be designed for the removal of liquids, solids and sub-micron particles. It will be rated for ULPA or UL media at a minimum.

c2. The bacterial filter will come equipped with a pressure drop indicator gauge, providing visual status of when the element should be replaced. Elements should be replaced no more frequently than twice annually, depending on usage.

c3. The bacterial filter will come equipped with brass valves and fittings for contaminated liquid release.

c4. The bacterial filter will have an easily removable and sterilizable glass flask.

c5. The bacterial filter will come with a high-impact and shatter resistant see-through bucket.

A3. For maintenance and ventilation of the system, Amico Source Corporation recommends 2' (24") minimum clearance on all sides and 3' (36") in front of the control panel.

A4. This furnished and installed unit will be a standard catalog item of the MGEM (Amico Source Corporation), who is regularly engaged (with a minimum of five years of experience) in the business of providing packaged systems for hospitals and other facilities.

A5. The furnished and installed WAGD producer system will meet or exceed the requirements of NFPA 99's most recent edition as relevant to the equipment and will be extensively tested before shipment.

A6. The unit will supply medical WAGD continuously for the life of the equipment. All components must be at least duplexed and valved (or check valved as specified in NFPA 99) to permit service to any component during maintenance operation or any condition of single fault failure, without interrupting vacuum supply to the facility.

A7. The system will be completely factory assembled, requiring only interconnection between modules on site if necessary (depending on configuration). Systems requiring site assembly other than interconnection between modules are not acceptable. However, the remounting of components detached for shipping is permitted.

a. Each module will be sized to fit within a standard 36" doorway on a standard pallet jack.

b. System shall be tank mounted or built entirely on a single base or a base which can be separated (into modules) in the field for rigging. If separable, bases shall be prepared for separation at the factory.

c. System shall be completely factory assembled having field connections limited to one inlet line, one electrical conduit as well as power and exhaust equal to the amount of pumps.

c1. A single point of connection to the intake of the system shall be provided.

c2. A single point of connection to the electrical panel of the system shall also be provided.

d. Systems requiring site assembly, other than interconnection between modules or reattachment of sections separated on site at contractor's convenience, are not acceptable. Remounting of components detached for shipping is permitted.

a. The system intake and power connection at the control panel will be the only field (single point) connections required. Exhaust lines will be connected to each pump.

b. All interconnecting piping and wiring shall be completed and operationally tested prior to shipment.

c. Liquid tight conduit, fittings and junction boxes for all control and power wiring will be provided by the MGEM.

d. System base, frames, control cabinet and receiver shall all be powder coated for a durable and attractive finish.

2. System Components:

A1. The **control panel** and all associated components will be built, labeled and listed in a UL 508A certified panel shop. It will have a NEMA 12 enclosure and abide by the following requirements.

a. Provide in the control cabinet door, the following:

a1. 16 bit, full color, VGA resolution touch screen display for system functions and system level control. All monitoring must be done on a single screen, multiple screens are not acceptable.

a2. A separate disconnect handle with door interlock for each pump unit.

a3. Audio sounder capable of 90 dB at 3', with noise reduction and mute function available on the door.

a4. LED run indicators on H-O-A switches, indicating which pump is running.

b. Provide in the control cabinet interior, the following:

b1. Externally operable circuit breakers with door interlocks, control circuit transformers with fused primary and secondary circuits, H-O-A switches and magnetic starters with (three/single) phase overload protection.

b2. Full voltage motor starters with overload protection – one per pump unit.

b3. Alarm contacts must be provided for remote annunciation for all alarm points.

b4. Circuit breaker disconnects, one for each pump unit operated through the door disconnect handle.

b5. Controls circuitry shall be 120 VAC and 24 VDC.

b6. Redundant 120 VAC control circuit transformers including power seeking function in the event one power supply fails.

b7. Power distribution terminal block convenient for main power entry.

b8. All internal components needed for operation of the control system as described below.

i. Volt free contacts for connection to master alarms.

ii. No proprietary controls and/or circuitry boards are to be present – all components readily available from local and standard electrical suppliers.

c. The control panel shall provide for the following functions:

c1. The reserve pump(s) must be able to start automatically if the lead pump fails to operate.

c2. Audible and visual local alarms are for pump temperature malfunction, reserve pump in use.

c3. Display of vacuum level on a single "home" screen display for at-a-glance checking.

c4. Automatic lead/lag sequencing and alternation. Display shall clearly show status of each pump unit including the running unit, next-unit-in-sequence and units unavailable to run.

c5. Manual reset for thermal malfunction shutdown.

c6. Runtime for each pump unit.

c7. In the event of control failure the system shall activate all alarms and operate all pumps until repaired.

c8. When H-O-A selectors are in Auto mode, system shall operate on a programmable logic controller.

c9. Controls shall provide visual and audible alarm indication and isolated contacts for remote alarm for at least Low Vacuum Level, Lag Pump in Use and High Temperature for each pump unit.

c10. Controls shall provide automatic indication of major maintenance intervals.

c11. Controls shall provide distinct separate indication on the control screen of alarms related to pumps versus alarms related to the system.

c12. Alarm shall be stated on the main screen in plain language indicating the nature of the alarm. Labeled indication lights are not permitted.

c13. Controls shall provide isolated dry contacts for remote alarms required by NFPA 99: Section 5.1.9 related to Medical Vacuum Pump Systems.

c14. Control system shall log and allow review of all alarm and shutdown events.

c15. Control system shall be highly redundant and robust allowing for multiple failures before becoming unable to deliver vacuum required. Control systems which can result in inability to deliver vacuum required in event of failure of any single component are not acceptable.

c16. All control and alarm functions must remain energized while any pump in the system remains electrically online.

c17. Controls shall include an integral web gate using standard Ethernet allowing observation of system operating parameters from any remote location on the same network with any standard web browser. Systems requiring special or additional separate software are not acceptable.

c18. Language selection options should include English, French and/or Spanish.

c19. Email alert feature for any and all alarms must be available.

A2. The **vacuum receiver(s)** shall be as follows:

a. Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

b. Interior Finish: ASME construction of ferrous and/or non-ferrous materials. Corrosion-resistant coating: ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 construction with two-part, epoxy-lined coating providing rust protection that is equal to or better than what is normally achieved through galvanizing.

c. Pressure Rating: Rated for a maximum 200 psig MAWP at 400°F (204.4°C) and full vacuum service; capable of withstanding 29.9" gauge HgV.

d. Accessories: Equipped with manual valve drain, a source shut off valve and a means for bypassing the receiver (isolation valve) to allow for repair and maintenance.

e. The tank isolation valve will allow for draining of the receiver without interrupting the vacuum service.

f. The receiver shall comply with all requirements of Section VIII (unfired pressure vessels) of the ASME Boiler and Pressure Vessel Code.

g. The receiver will be factory mounted (unless specified in the drawings) and factory piped.

Specifier: Select the paragraphs below, relevant to the preferred technology

FOR OIL LESS (DRY) CONTACTLESS CLAW TECHNOLOGY

A3. The **vacuum pump(s)** will be continuous duty, high efficiency, oil-less and frictionless, contact-less claw style rotary pumps.

a. Compact rotary claw positive displacement pumps.

b. Factory assembled, mounted as a single piped, wired and factory tested package.

c. Air-cooled with no water requirements, pump chamber must be oil free (no seal or lubricant necessary).

d. The vacuum pump drive shall be direct driven; torque is transmitted from the flanged motor to the pump through a shaft coupling. The rotors are synchronized by gears.

d1. Each motor will be TEFC NEMA C-face. The motors will be suitable for **(208 V/230 V/460 V)**, three phase, 60 Hz.

e. Each pump will contain: acoustic enclosure, rubber mount vibration isolators, oil sight glass, inlet screen, anti-suck-back valve on inlet, vacuum relief valve (select models) and threaded NPT inlet/outlet connections.

f. Each pump will include the following piping control components: flexible inlet and outlet couplings, inlet and outlet shut-off valves and exhaust drip leg. Each pump exhaust shall be isolated by a union fitting, permitting capping for service removal (if necessary).

g. Additional accessories including inlet air filters and bacterial filter/fluid traps are not included in a standard unit, but available as options.

h. The maintenance shall be limited to changing the gearbox oil as needed based on the non-contacting design (not more often than 5000 hours and not less frequently than 20,000 hours). Additional maintenance may include replacing the inlet screen as necessary.

i. V-belt drives will not be acceptable.

j. Vacuum pumps requiring oil in the compression chamber will not be acceptable.

FOR OXYGEN ASSURED OIL LESS (DRY) CONTACTLESS CLAW TECHNOLOGY

A3. The **vacuum pump(s)** will be continuous duty, high efficiency, oil less, frictionless and oxygen assured contact-less claw style rotary pumps.

a. The pump(s) must be oxygen (O_2) assured. The pump(s) is/are not permitted to use hydrocarbon oil for the gearbox oil.

b. Compact rotary claw positive displacement pumps.

c. Factory assembled, mounted as a single piped, wired and factory tested package.

d. Air-cooled with no water requirements, pump chamber must be oil free (no seal or lubricant necessary).

e. The vacuum pump drive shall be direct driven; torque is transmitted from the flanged motor to the pump through a shaft coupling. The rotors are synchronized by gears.

e1. Each motor will be TEFC NEMA C-face. The motors will be suitable for **(208 V/230 V/460 V)**, three phase, 60 Hz.

f. Each pump will contain: acoustic enclosure, rubber mount vibration isolators, oil sight glass, inlet screen, anti-suck-back valve on inlet, vacuum relief valve (select models) and threaded NPT inlet/outlet connections.

g. Each pump will include the following piping control components: flexible inlet and outlet couplings, inlet and outlet shut-off valves and exhaust drip leg. Each pump exhaust shall be isolated by a union fitting, permitting capping for service removal (if necessary).

h. Additional accessories including inlet air filters and bacterial filter/fluid traps are not included in a standard unit, but available as options.

i. Maintenance shall be limited to changing the (non-hydrocarbon) gearbox oil as needed based on the non-contacting design (not more often than 5000 hours and not less frequently than 20,000 hours). Additional maintenance may include replacing the inlet screen as necessary.

j. V-belt drives will not be acceptable.

k. Vacuum pumps requiring oil in the compression chamber will not be acceptable.

2.3.4: INSTRUMENT AIR SYSTEMS

Note: It is the job of the specifier to determine the size of the instrument air system required and place on the medical gas schedule. Chapters 4 and 5 will have given you the necessary information and the Schedule section at the end of this chapter will provide basis-of-design examples.

1. General Information:
    - A1. Provide a complete instrument air source, complying with NFPA 99: 5.1.3.9 in all respects, as specified and scheduled on the drawings and as manufactured by Amico Source Corporation. An alternate MGEM may be used to provide an equal or comparable system, after pre-approval.
    - A2. The complete package will contain **(#) (Reciprocating) air compressor(s)**, associated equipment and piping, one ASME air receiver, a desiccant air dryer package and one control panel. The unit will be able to meet the required demand with one compressor out of operation. All capacities are to be indicated in SCFM at necessary pressures.
        - a. The air plant will be factory assembled, wired, piped and tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.
    - A3. For maintenance and ventilation of the system, Amico Source Corporation recommends 2' (24") minimum clearance on all sides and 3' (36") in front of the control panel.
    - A4. This furnished and installed unit will be a standard catalog item of the MGEM (Amico Source Corporation), who is regularly engaged (with a minimum of five years of experience) in the business of providing packaged systems for hospitals and other facilities.
    - A5. The furnished and installed instrument air system will meet or exceed the requirements of NFPA 99's most recent edition as relevant to the equipment and will be extensively tested before shipment.
    - A6. The unit will supply instrument air continuously for the life of the equipment. All components must be at least duplexed and valved to permit service to any component during maintenance operation or any condition of single fault failure, without interrupting air supply to the facility.
    - A7. The system will be completely factory assembled, requiring only interconnection between modules on site if necessary (will depend on configuration). Systems requiring site assembly other than interconnection between modules are not acceptable. However, the remounting of components detached for shipping is permitted.
        - a. Each module will be sized to fit within a standard 36" doorway on a standard pallet jack.
    - A8. The system intake, exhaust and power connection at the control panel will be the only field (single point) connections required. All components shall be completely pre-piped and pre-wired to single-point service connections.
    - A9. All interconnecting piping and wiring shall be completed and operationally tested prior to shipment.
    - A10. Liquid tight conduit, fittings and junction boxes for all control and power wiring will be provided by the MGEM.
    - A11. The system shall include individual compressor inline intake filters, discharge check valves, safety relief valves, stainless steel intake and discharge flexible connectors, isolation valves, air cooled aftercoolers for each compressor, high discharge temperature shut down switches, pressure control switches as well as poly tubing for gauge and switches.
    - A12. General Requirements for Air Compressors:
        - a. Comply with NFPA 99: Health Care Facilities for compressed air equipment and accessories for instrument compressed air systems.
        - b. Mounting Frame: fabricate base and attachment to air compressor and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to the building structure.

c. Each compressor unit shall be equipped with a distinct aftercooler with a separate cooling fan designed for a maximum approach temperature of 7°C (15°F) at 37.8°C (100°F) ambient.

d. All moving parts (fans, pulleys and belts) shall be fully protected by OSHA acceptable enclosures and guards.

e. A temperature sensor at the outlet of each compressor cylinder or air-end shall provide a high temperature alarm and shut down that compressor if exceeded. Systems employing a single switch for multiple cylinders or air-ends are not acceptable.

A13. The compressor modules and motors shall be fully isolated from the main base by means of a four point, heavy-duty isolation system.

A14. Flexible connections between compressor units and the structure shall be provided for all inlets and outlets.

a. Vibration flexes shall be all stainless steel and of sufficient length to achieve full isolation.

b. Systems using rubber tubing flex connectors with hose clamps are not acceptable.

c. Systems with short flex connections providing only nominal isolation are not acceptable.

Specifier: Adjust A15 below as necessary, when other electrical specs (voltage/phase/frequency) are required.

A15. The compressor motors must be NEMA rated, open drip proof, 3600 rpm, continuous duty. The motors will be suitable for **(208 V/230 V/460 V), three (3) phase, 60 Hz.**

2. System Components:

A1. The **control panel** and all associated components will be built, labeled and listed in a UL 508A certified panel shop. It will have a NEMA 12 enclosure and abide by the following requirements.

a. Provide in the control cabinet door, the following:

a1. 16 bit, full color, VGA resolution touch screen display for system functions and system level control. All monitoring must be done on a single screen, multiple screens are not acceptable.

a2. A separate disconnect handle with door interlock for each compressor unit.

a3. Audio sounder capable of 90 dB at 3 feet, with noise reduction and mute function available on the door.

a4. LED run indicators on H-O-A switches, indicating which compressor is running.

b. Provide in the control cabinet interior, the following:

b1. Externally operable circuit breakers with door interlocks, control circuit transformers with fused primary and secondary circuits, H-O-A switches and magnetic starters with (three/single) phase overload protection.

b2. Full voltage motor starters with overload protection – one per compressor unit.

b3. Alarm contacts must be provided for remote annunciation for all alarm points.

b4. Circuit breaker disconnects, one for each compressor unit operated through the door disconnect handle.

b5. Controls circuitry shall be 120 Volts AC and 24 Volts DC.

b6. Redundant 120 Volt AC control circuit transformers including power seeking function in the event one power supply fails.

b7. Power distribution terminal block convenient for main power entry.

b8. All internal components needed for operation of the control system as described below.

i. Volt free contacts for connection to master alarms.

ii. No proprietary controls and/or circuitry boards are to be present – all components readily available from local and standard electrical suppliers.

c. The control panel shall provide for the following functions:

c1. The reserve compressor(s) must be able to start automatically if the lead compressor fails to operate.

c2. Audible and visual local alarms are for compressor temperature malfunction, reserve compressor in use.

c3. Display of pressure and dew point level on a single "home" screen display for at-a-glance checking.

c4. Digital display of the dew point (either in°F or°C) on screen.

i. The panel will have an audible and visual alarm to indicate if the dew point exceeds 35°F (1.7°C).

ii. Alarm setting shall be adjustable to allow the system to adapt to any future change in code.

c5. Automatic lead/lag sequencing and alternation. Display shall clearly show status of each compressor unit including the running unit, next-unit-in-sequence and units unavailable to run.

c6. Manual reset for thermal malfunction shutdown.

c7. Runtime for each compressor unit.

c8. In the event of control failure, the system shall activate all alarms and operate on a simple on/off basis until repaired.

c9. When H-O-A selectors are in Auto mode, system shall operate on programmable logic controller. Pressure switch shall only be activated as a backup system.

c10. Controls shall provide visual and audible alarm indication and isolated contacts for remote alarm for at least Dew Point High, Lag Compressor in Use and High Temperature for each compressor unit.

c11. Controls shall provide automatic indication of major maintenance intervals.

c12. Controls shall provide distinct separate indication on the control screen of alarms related to compressors versus alarms related to the system and quality of air.

c13. Alarm shall be stated on the main screen in plain language indicating the nature of the alarm. Labeled indication lights are not permitted.

c14. Controls shall provide isolated dry contacts for remote alarms required by NFPA 99: Section 5.1.9 related to Medical Air Compressor Systems.

c15. Dryers shall be controlled from the control panel with controls integral to the touchscreen system to allow dryer switching. External or separate controllers and switches are not acceptable.

i. Must be able to cycle automatically between dryer towers

ii. Dryer purge flow control using an integral dew point based purge control system. Purge controllers using desiccant temperature are not acceptable.

iii. Both dryers shall be allowed to operate at the same time by overriding dryer select function during maintenance procedures.

iv. Must be able to indicate dryer operation, status and dew point on same screen.

c16. Control system shall log and allow review of all alarm and shutdown events.

c17. Control system shall be highly redundant and robust allowing for multiple failures before becoming unable to deliver air (or air of quality required). Control systems which can result in inability to deliver air (or air of quality required) in event of failure of any single component are not acceptable.

c18. All control and alarm functions must remain energized while any compressor in the system remains electrically online.

c19. Controls shall include an integral web gate using standard Ethernet allowing observation of system operating parameters from any remote location on the same network with any standard web browser. Systems requiring special or additional separate software are not acceptable.

c20. Language selection options should include English, French and/or Spanish.

c21. Email alert feature for any and all alarms must be available.

A2. The **inlet air filters** are to be a combination inlet air filter-silencer, appropriate for remote installation and maintenance for each compressor.

a. The housing shall be weatherproof with silencer tubes or alternate methods of sound reduction.

b. The filter elements shall be of a dry paper type, with at least 99% removal efficiency standard to two microns.

c. Each filter must be sized to match the individual capacity of the connected air compressor.

A3. The furnished **desiccant dryer package** and its associated components will be sized for peak calculated demand and will have the following requirements:

a. NFPA 99 compliant dual desiccant air dryers with no standalone controller.

b. There shall be two identical banks of air treatment equipment, piped in parallel and provided with valves to bypass either filter set for element replacement, maintenance and repair work while still treating medical compressed air through the other set.

c. Each dryer must be capable of delivering a targeted pressure dew point of -25°F (-31.7°C)

d. Dual pre-filters, after-filters, pressure regulators valves, dew point monitor and system safety valves will all come equipped as standard.

d1. Duplexed final line regulators shall be factory mounted and piped at the outlet of each dryer.

e. Dryers will be completely pre-piped and pre-wired to single-point service connections.

f. There shall be two identical banks of air treatment equipment, piped in parallel and provided with valves to bypass either filter set for element replacement, maintenance and repair work while still treating medical compressed air through the other set.

g. Each bank must consist of five stages:

g1. The 1st stage is an oil coalescing filter, with filtered differential pressure gauge (element change indicator).

g2. The 2nd stage is a prime efficiency coalescing (pre-filter) rated for 0.01 microns, with filtered differential pressure gauge (element change indicator) and electric solenoid auto drain valve controlled by the main control system. Separate controllers are not acceptable.

g3. The 3rd stage is a desiccant heatless air dryer.

g4. The 4th stage is a prime efficiency particulate afterfilter rated for 1 micron, with differential pressure gauge (element change indicator).

g5. The 5th stage is an activated carbon filter, with filtered differential pressure gauge (element change indicator).

h. Sensors for dew point shall be provided with a DISS demand check valve per NFPA 99: Section 5.1.8.2.4.

A4. The **air receiver(s)** shall be as follows:

a. Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

b. Interior Finish: ASME construction of ferrous and/or non-ferrous materials. Corrosion-resistant coating. ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 construction with two-part, epoxy-lined coating providing rust protection that is equal to or better than what is normally achieved through galvanizing.

c. Pressure Rating: Rated for a maximum 300 psig MAWP at 400°F (204.4°C) and full air service, bearing appropriate code symbols.

d. Accessories: Equipped with pressure gauge, safety relief valve, three valve bypass, sight (liquid-level) glass and automatic, electronic, time-based tank drain with manual valve drain override.

d1. The three valve bypass will allow for draining of the receiver without interrupting the air service, as well as isolating the tank for repair maintenance.

e. The receiver shall comply with all requirements of Section VIII (unfired pressure vessels) of the ASME Boiler and Pressure Vessel Code.

f. The receiver will be factory mounted (unless specified in the drawings) and factory piped.

Specifier: Select the paragraph below, detailing the preferred technology. Please note that Amico Source Corporation recommends not using Scroll Compressor Technology for instrument air applications, due to the high discharge air pressure requirements of NFPA 99.

FOR RECIPROCATING TECHNOLOGY

A5. The **air compressor(s)** will be belt driven, single stage, air-cooled, reciprocating style and meet the following requirements:

a. The compressor can be a single or multi stage compressor with two or three compressing heads.

b. The compressors will be rated for at least 1380 kPa (200 psig) discharge pressure.

c. Compressor(s) will be mounted near motor(s) in such a way that provides easy adjustment of belt tension.

d. The valve(s) will be corrosion resistant with stainless steel connecting rods.

e. Noise level at 3' shall not exceed 89 dB(A) per pump.

f. All moving parts (fans, pulleys and belts) shall be fully protected by OSHA acceptable enclosures and guards.

g. Each compressor will be equipped with isolation valve, check valve, safety valve, electric motor, belts, belt guard, aftercooler with separator and T.M.P.D. (thermal malfunction protection device).

h. Vibration mounting is provided as per NFPA; the compressors and motors will be fully isolated from the package base by means of spring isolators.

i. Standard preventative maintenance shall be limited to replacing the belt(s) as necessary.

2.4 ADDITIONAL OPTIONS

1. Control Panel Adders:

    A1. Dual Feed: The controller will be wired for **(two; choose #)** power circuits, with an equal number **(specify number)** of pumps per circuit.

Specifier: Please note that *Dual Feed Systems* cannot be Single Point Connection (SPC). The areas in the specification that will need to have SPC removed (in terms of the control panel) are as follows:

- ✓ **§1.A8 from 2.3.1: Medical Compressed Air Systems (on page 106) and §1.A8 from 2.3.4: Instrument Air Systems (on page 121)**
- ✓ **§1.A7.c and §1.A8 from 2.3.2: Medical Vacuum Systems (on page 112) and §1.A7.c and §1.A8 from 2.3.3: WAGD Systems (on page 117)**

A2. Lab Purge/Automatic Purge Controls: Panel must incorporate the controls for this solenoid, including length of purge, for this shut down cleaning procedure. See §2.4 #2.A1 for system requirements (on the next page).

A3. Variable Speed/Frequency Drive Controller: All pump motors will be controlled by individual (separate) variable speed controllers, with the following requirements.

a. Controllers must have an individual VSD separately controlling each pump. Controllers that use a single VSD shared between all pumps will not be accepted.

b. The VSD(s) must be incorporated inside the panel; systems that incorporate these drives in separate controllers from the main control panel will not be accepted.

c. VSD faults must include, but are not limited to, ACC – acceleration line 1, A1 – auto ramp, motor rated voltage, low limit frequency and over-current fault.

d. The main control panel screen must be able to manually adjust the minimum output frequency of the VSDs.

e. Design and Rating: the VSD must match the load type such as fans, blowers and pumps and type of connection used between motor and load must be a direct connection.

f. Unit Operating Requirements:

f1. Input AC voltage tolerance of ±5% for 200 V to 240 V and ±10% for 460 V to 480 V.

f2. Input frequency tolerance of 60 Hz, ±6%.

f3. Minimum Efficiency: 96% at 60 Hz, full load.

f4. Minimum Displacement Primary-Side Power Factor: 96%.

f5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

f6. Starting Torque: 100% of rated torque.

f7. Speed Regulation: ±1%.

g. Self-Protection and Reliability Features:

g1. Input transient protection by means of surge suppressors.

g2. Under and over voltage trips, inverter over temperature, overload and overcurrent trips.

g3. Motor Overload Relay: adjustable and capable of NEMA 250, Class 10 performance.

g4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.

g5. Instantaneous line-to-line and line-to-ground overcurrent trips.

g6. Loss-of-phase protection.

g7. Reverse-phase protection.

g8. Short-circuit protection.

g9. Motor over temperature fault.

h. Manual Bypass Starter: magnetic contactor arranged to safely transfer motor between VSD controller outputs and bypass starter when motor is at zero speed.

h1. Unit shall be capable of stable operation (starting, stopping and running), with motor completely disconnected from controller (no load).

h2. Provide manual bypass starters on equipment as indicated on the equipment schedules.

2. System Adders:

A1. Lab Purge/Auto Purge will be for Vacuum and WAGD Systems. Each vacuum pump will be equipped with an auto-purge assembly of the following requirements.

a. The automatic purge (lab purge) system must be able to flush any gases from the pump to prevent condensation as the pump cools.

b. Purge system shall incorporate an electronically controlled solenoid valve that will serve as an isolation valve, per pump.

PART 3: EXECUTION DETAILS

3.1. PREPARATION

Clean all compressed air and vacuum equipment, accessories and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for **[laboratory vacuum/air] [and/or] [medical vacuum/air]** applications, according to CGA G4.1, "Cleaning Equipment for Oxygen Service."

3.2. DELIVERY, STORAGE AND HANDLING

1. The system(s) will be split and crated according to appropriate specifications. The MGEM must make every attempt to split the system into as few pieces as possible in order to consolidate shipping.
2. Store equipment in a clean, dry space with a consistent temperature to prevent any condensation from forming on any part of the system(s). Protect equipment from exposure to dirt, fumes, water, corrosive substances, physical damage and any other effect that would be detrimental to normal operation.
3. Amico Source Corporation does not recommend the storage or installation of lifesaving systems outdoors without protection. Weather has major impact on functionality of the systems. For Compressed Air systems, when the temperature drops below the freezing mark, condensation no longer stays in the gas stage and will coalesce into ice crystals, creating blockage in the flow of the system. As for vacuum systems, when the temperature starts to fall below freezing, the lubricant starts to thicken to the point where the motor will not be functional. Should an outdoor installation be unavoidable, the systems must have some form of enclosure to protect from the elements and prevent the mentioned issues from occurring.

3.3. INSTALLATION

1. Install vacuum equipment for healthcare facilities according to ASSE 6010 and NFPA 99.

A1. Ensure that the exhaust(s) for each vacuum pump is/are fitted with a means of removing the vacuum pump for service or replacement without interruption to the system.

2. General Requirements for Compressed Air Equipment Installation:

A1. Install compressed air equipment to allow maximum headroom unless specific mounting heights are indicated.

A2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.

A3. Install mechanical equipment to facilitate service, maintenance and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

A4. Install equipment to allow right of way for piping installed at required slope.

A5. Install the following devices on Compressed Air equipment:

a. Thermometer, Pressure Gage and Safety Valve: install on each compressed air receiver.

b. Pressure Regulators: install downstream from air compressors, dryers, purification units and filter assemblies.

c. Drain Valves: install on aftercoolers, receivers and dryers. Discharge condensate over nearest floor drain.

3. General Requirements for Non-medical Laboratory Compressed Air Equipment Installation:

A1. Install compressed air equipment, except wall-mounted equipment (and diaphragm air compressors), on concrete bases. Install units anchored to substrate in locations indicated. Maintain manufacturer's recommended clearances. Orient equipment so controls and devices are accessible for servicing.

A2. Install diaphragm air compressors on the floor.

a. Anchor air compressors to surface according to manufacturer's written instructions (and seismic criteria applicable to the project).

4. General Requirements for Medical Compressed Air Equipment Installation:

A1. Install according to ASSE 6010 and NFPA 99.

A2. Install compressed air equipment, except wall-mounted equipment, on concrete bases. Install units anchored to substrate in locations indicated. Maintain manufacturer's recommended clearances. Orient equipment so controls and devices are accessible for servicing.

a. The control panel should be able to be fully extended without hitting any surround obstructions. This ensures ease of accessibility for troubleshooting.

5. Equipment Mounting/System Bases and Site Preparation:

A1. It is the job of the contractor to provide a concrete housekeeping pad (base) under all medical air, vacuum, instrument air and WAGD systems.

a. Construct concrete bases 4" (101.6 mm) high and extend base not less than 6" (152.4 mm) in all directions beyond the maximum dimensions of the equipment, unless otherwise indicated or unless required for seismic anchor support.

b. The concrete used for the pad should have a minimum compressive strength of **[5000 psi (34.5 MPa)] [4500 psi (31 MPa)] [4000 psi (27.6 MPa)] [3500 psi (24.1 MPa)] [3000 psi (20.7 MPa)]** at 28 days.

A2. When the equipment is not factory isolated by the manufacturer, the contractor will provide inertia bases in lieu of the housekeeping pads.

A3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18" (457.2 mm) centers around the full perimeter of concrete base.

A4. Cast anchor bolts will be used to hold the systems onto the pads. Install anchor bolts to elevations required for proper attachment to supported equipment.

A5. For supported equipment, install epoxy-coated anchor bolts that extend through the concrete base and anchor into structural concrete floor.

A6. Install anchor bolts to elevations required for proper attachment to supported equipment.

A7. Coordinate sizes and locations of concrete bases with actual equipment provided.

A8. Construct bases to withstand, without damage to equipment, seismic force required by the local relevant code.

A9. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.

A10. Install vacuum equipment anchored to substrate.

6. Orient equipment so controls and devices are accessible for servicing.
7. Maintain manufacturer's recommended clearances for service and maintenance. Do not undersize these clearances without prior consultation and approval of the MGEM.
8. Piping to and From Systems:

A1. All installation piping shall be done according to the details outlined in NFPA 99: 5.1.10. Brazing procedures will be detailed in NFPA 99: 5.1.10.5; and performed by brazers qualified under NFPA 99: 5.1.10.10.11.

A2. All piping that runs underground will be installed in compliance with NFPA 99: 5.1.10.10.5.

A3. Copper, tubing, valves and fittings must be pre-cleaned and prepared for oxygen service by the manufacturer.

A4. The use of flux is prohibited when making the joints between copper to copper pipes and fittings.

A5. Liquid sealants are not to be used for threaded joints in piping systems; polytetrafluoroethylene (Teflon™) tape should be used instead.

A6. Piping must be supported with pipe trays or hangers at intervals defined in NFPA 99: Table 5.1.10.10.4.5. Piping is not to be supported by other piping. Copper piping must be isolated from dissimilar metals.

A7. Piping that may be exposed to physical damage must be protected.

A8. Piping must be labeled with name of gas service, identification color and direction of flow. Labels are to be placed at least once every 20 feet of linear run or once per story (whichever occurs first).

A9. Piping going through an electromagnetic shield will have an isolation device on each side of the shield.

A10. Drain Valves: install on appropriate receivers and separators. Discharge receiver and separator condensate over nearest floor drain. Discharge separator oral evacuation fluids by direct connection into a sanitary waste piping system.

A11. Where installing piping adjacent to equipment, allow space for service and maintenance. Do not undersize the recommended clearances without prior consultation and approval of the MGEM.

A12. Connect compressed air piping to compressed air equipment, accessories and specialties with shutoff valve and union or flanged connection.

A13. Connect vacuum piping to vacuum equipment, accessories and specialties with shutoff valve and union or flanged connection.

A14. Connect water supply to compressed air equipment that requires water. Include backflow preventer.

A15. Connect water supply to vacuum equipment that requires water. Include backflow preventer.

9. Medical Air System Inlet: the following are requirements for the medical air system inlet locations.

A1. The intake piping for a medical air compressor system should only be connected to the medical air compressor system and not used for any other purpose. It should be made of hard-drawn seamless copper, either ASTM B 819 medical gas tube, ASTM B88 water tube (Type K, L or M) or ASTM B 280 ACR tube; which ensures no contaminants in the form of particulate matter, odor or other gases will be added. This piping is to be labeled and equipped with intake filters that are located inside the healthcare facility, close to the compressor and are easily accessible for servicing.

A2. Place the medical air inlet in an area where there will not be potential hazards such as contamination from engine exhausts, fuel storage vents, toxins or hazardous contaminants such as ethylene oxide (ETO) gas exhaust vents, medical vacuum exhaust vents, particulate matter or odor of any type.

A3. Place the medical air inlet outdoors above the roof level a minimum distance of 10' (3 m) from any door, window, exhaust, other intake or opening in the building and a minimum distance of 20' (6.1 m) above the ground. Intakes shall be turned down and screened and otherwise protected against the entry of vermin, debris and precipitation or water. This is to be done with screening fabricated from or composed of non-corrosive material such as stainless steel or other suitable materials.

A4. If a source is available that is equal to or superior to the outside air (e.g. air already filtered for use in the operating room ventilation systems), it shall be permitted to be used for the medical air compressors. This alternative source of supply air must be available on a continuous 24 hours a day, 7 days per week basis. Ventilating systems having fans with motors or drive belts located in the air stream shall not be utilized as a source of medical air intake.

A5. Medical air intakes for separate compressors shall be permitted to be joined together to one common intake, provided such intake is appropriately sized.

A6. See Chapter 5: Medical Compressed Air Systems for details regarding the minimum inlet pipe sizing required based on the medical air system horsepower, configuration and the total pipe length (including elbows and tees) in the medical air intake line.

10. Medical Vacuum System Exhaust: the following are requirements for the medical vacuum system exhaust locations.

A1. Place the medical vacuum exhaust outdoors in a manner that will minimize the hazards of noise and contamination to the hospital and its environment.

a. The exhaust shall be located away from any door, window, air intake or other openings in buildings with particular attention given to separate levels of intake and discharge. The exhaust will be at a level different from the air intake.

b. Care shall also be exercised to avoid discharge locations contraindicated by prevailing winds, adjacent buildings, topography or other influences that would divert the exhaust into occupied areas or prevent dispersion of the exhaust.

c. Exhaust lines shall be sized to minimize back pressure. Discharge piping shall be free of dips or loops that might trap condensate or oil. If such discharge piping is unavoidable, a trapping drip leg shall be installed to keep the piping free of fluid buildup.

d. The exhaust shall be located at least 30' (10 m) from any door or operable window, 50' (15 m) from any mechanical air intake and a minimum of 10' (3 m) above grade. The end of the exhaust shall be turned downward, screened and otherwise protected against the entry of vermin, debris and precipitation or water. This is to be done with screening fabricated from or composed of non-corrosive material such as stainless steel or other suitable materials.

A2. Medical vacuum exhausts for separate pumps shall be permitted to be joined together to one common exhaust, provided such intake is appropriately sized.

A3. Discharge of pumps utilizing a common exhaust pipe shall be fitted with a check valve, a manual value (locked open) or arranged to permit capping of the active pipe when removing or servicing the pump.

A4. Install a drip leg at the base of each pump exhaust line riser.

A5. Minimum exhaust pipe sizing required based on the medical vacuum system horsepower, configuration and the total pipe length (including elbows and tees) in the medical vacuum exhaust line (see Chapter 6: Medical Vacuum [Suction] Systems).

a. The medical vacuum exhausts are joined together to one common exhaust.

b. Minimum pipe size must be maintained for the total length of exhaust pipe.

c. Use the next larger size pipe in the event the minimum size is not available.

3.4. IDENTIFICATION

1. Identify medical air and vacuum equipment system components and piping with appropriate labels.
2. Identify non-medical air and vacuum laboratory equipment system components and piping with appropriate labels.
3. Identify WAGD system components and piping with appropriate labels.

3.5. START-UP SERVICE

1. Engage a factory-authorized service representative to perform startup service. The MGEM will provide authorized representatives to review installation and perform initial start-up of the system.
    A1. Complete installation and startup checks according to manufacturer's written instructions.
    A2. Check for lubricating oil in lubricated-type equipment.
    A3. Check belt drives for proper tension.
    A4. Verify that air compressor inlet filters and piping are clear.
    A5. Verify that vacuum producer outlet piping is clear.
    A6. Check for equipment vibration-control supports and flexible pipe connectors. Verify that equipment is properly attached to substrate.
    A7. Check safety relief valves for correct settings.
        a. For Compressed Air Systems: ensure that settings are higher than air compressor discharge pressure, but not higher than rating of system components.
    A8. Check for proper seismic restraints.
    A9. Drain **[receiver] [and] [separator]** tank(s).
    A10. Operational Test: after electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    A11. Test and adjust controls and safeties.
2. Verify that equipment is installed and connected according to the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in electrical sections.
4. Prepare written report documenting testing procedures and results to be readily available upon request.

3.6. INSTALLER TESTING AND QUALITY CONTROL

1. Before declaring the lines ready for final verification, the Contractor must follow the procedures for verification described in NFPA 99: 5.1.12.2.
    A1. The Installer must ensure that the MGEM or MGEM authorized distributor has started up all medical air and/or vacuum systems – and that they are in proper operating principle.
2. The MGEM shall offer the services of a factory authorized, factory trained technical representative to check the installation and start up the vacuum system as well as instruct owner's personnel in the operation and maintenance of the unit. A written report confirming that equipment was started and left in satisfactory operating condition shall be provided.
3. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections. Agency shall provide Verifiers who are both ASSE Series 6030 certified and MGPHO credentialed equal to the MGEM's authorized distributor.
4. Manufacturer's Field Service: engage a factory-authorized service representative to test and inspect components, assemblies and equipment installations, including connections.

5. Perform the following tests and inspections (with the assistance of a factory-authorized service representative):
    A1. Medical Vacuum Equipment Testing Coordination: perform tests, inspections, verifications and certification of medical vacuum equipment concurrently with tests, inspections and certification of **[medical vacuum equipment] [medical vacuum piping] [and] [medical gas piping]** systems.
    A2. Medical Compressed Air Equipment Testing Coordination: perform tests, inspections, verifications and certification of medical compressed air equipment concurrently with tests, inspections and certification of **[medical compressed air equipment] [medical compressed air piping] [and] [medical gas piping]** systems.
    A3. Vacuum Preparation: perform medical vacuum equipment tests according to requirements in NFPA 99 for the following:
        a. System operation test.
    A4. Air Preparation: perform medical compressed air equipment tests according to requirements in NFPA 99 for the following:
        a. Air-quality purity test.
        b. System operation test.
    A5. Equipment Verification: comply with requirements in ASSE 6020, ASSE 6030 and NFPA 99 for verification of medical compressed air and vacuum equipment.
    A6. Replace damaged and malfunctioning controls and equipment.
    A7. Testing Certification: certify that specified tests, inspections and procedures have been performed and certify report results. Include the following:
        a. Inspections performed.
        b. Procedures and materials used.
        c. Test methods used.
        d. Results of tests.
6. Components will be considered defective if they do not pass tests and inspections.
7. Prepare test and inspection reports.

3.7 DEMONSTRATION

Engage a factory-authorized service representative to train the owner's maintenance personnel to adjust, operate and maintain equipment.

7.2 System Schedule

7.2.1 MEDICAL COMPRESSED AIR SCHEDULE

The following will provide the schedules for medical compressed air systems, with the basis of design being Amico Source Corporation's standard Compressed Air Products. Please refer to the System Selection Tables in Chapter 5: Medical Compressed Air Systems for footprint dimensions.

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	psig[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
OIL-LESS SCROLL SYSTEMS																
Scroll Modular Stacking (SS) Configuration																
MA-1	Medical Air Compressor	Modular Stacking, Duplex, Oil Free Scroll	Amico Source Corporation	A-SCD-D-200P-SS-N-020	50	6.2 (176)	74	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-2	Medical Air Compressor	Modular Stacking, Duplex, Oil Free Scroll	Amico Source Corporation	A-SCD-D-200P-SS-N-030	50	9.2 (261)	74	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-3	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Scroll	Amico Source Corporation	A-SCD-D-200P-SS-N-050	50	15.2 (430)	74	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-4	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Scroll	Amico Source Corporation	A-SCD-D-200P-SS-N-075	50	25.2 (714)	74	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-5	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Scroll	Amico Source Corporation	A-SCD-D-200P-SS-N-100	50	34.8 (985)	74	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-6	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Scroll	Amico Source Corporation	A-SCD-D-200P-SS-N-150	50	50.4 (1427)	75	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-7	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Scroll	Amico Source Corporation	A-SCD-D-200P-SS-N-200	50	69.6 (1971)	79	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	psig[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MA-8	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Scroll	Amico Source Corporation	A-SCD-T-200P-SS-N-020	50	12.4 (351)	77	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-9	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Scroll	Amico Source Corporation	A-SCD-T-200P-SS-N-030	50	18.4 (521)	77	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-10	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Scroll	Amico Source Corporation	A-SCD-T-200P-SS-N-050	50	30.4 (861)	77	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-11	Medical Air Compressor	Modular Stacking,	Amico Source	A-SCD-T-200P-SS-N-075	50	50.4 (1427)	77	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-12	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Scroll	Amico Source	A-SCD-T-200P-SS-N-100	50	69.6 (1971)	77	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-13	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Scroll	Amico Source	A-SCD-T-200P-SS-N-150	50	100.8 (2854)	78	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-14	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Scroll	Amico Source	A-SCD-T-200P-SS-N-200	50	139.2 (3942)	82	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-15	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Scroll	Amico Source	A-SCD-Q-200P-SS-N-020	50	18.6 (527)	79	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-16	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Scroll	Amico Source	A-SCD-Q-200P-SS-N-030	50	27.6 (782)	79	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-17	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Scroll	Amico Source	A-SCD-Q-200P-SS-N-050	50	45.6 (1291)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-18	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Scroll	Amico Source	A-SCD-Q-200P-SS-N-075	50	75.6 (2141)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	psig[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MA-19	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Scroll	Amico Source	A-SCD-Q-200P-SS-N-100	50	104.4 (2956)	79	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-20	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Scroll	Amico Source	A-SCD-Q-200P-SS-N-150	50	151.2 (4282)	80	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-21	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Scroll	Amico Source	A-SCD-Q-200P-SS-N-200	50	208.8 (5913)	83	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
Scroll Horizontal Tank Mount (TH) Configuration																
MA-22	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Scroll	Amico Source	A-SCD-D-080P-TH-N-020	50	6.2 (176)	74	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-23	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Scroll	Amico Source	A-SCD-D-080P-TH-N-030	50	9.2 (261)	74	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-24	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Scroll	Amico Source	A-SCD-D-120P-TH-N-050	50	15.2 (430)	74	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-25	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Scroll	Amico Source	A-SCD-D-120P-TH-N-075	50	25.2 (714)	74	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-26	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Scroll	Amico Source	A-SCD-D-120P-TH-N-100	50	34.8 (985)	74	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
OIL-LESS RECIPROCATING SYSTEMS																
Reciprocating Modular Stacking (SS) Configuration																
MA-27	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Reciprocating	Amico Source	A-RED-D-200P-SS-N-010	50	4.1 (116)	72	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-28	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Reciprocating	Amico Source	A-RED-D-200P-SS-N-020	50	7.8 (221)	73	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-29	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Reciprocating	Amico Source	A-RED-D-200P-SS-N-030	50	10.1 (286)	74	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-30	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Reciprocating	Amico Source	A-RED-D-200P-SS-N-050	50	18.4 (521)	76	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-31	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Reciprocating	Amico Source	A-RED-D-200P-SS-N-075	50	28.1 (796)	78	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-32	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Reciprocating	Amico Source	A-RED-D-200P-SS-N-100	50	37.1 (1050)	81	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	psig[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MA-33	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Reciprocating	Amico Source	A-RED-D-200P-SS-N-150	50	54.7 (1549)	84	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-34	Medical Air Compressor	Modular Stacking, Duplex, Oil-Free Reciprocating	Amico Source	A-RED-D-200P-SS-N-200	50	73.1 (2070)	84	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-35	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Reciprocating	Amico Source	A-RED-T-200P-SS-N-010	50	8.2 (232)	75	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-36	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Reciprocating	Amico Source	A-RED-T-200P-SS-N-020	50	15.6 (442)	76	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-37	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Reciprocating	Amico Source	A-RED-T-200P-SS-N-030	50	20.2 (572)	77	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-38	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Reciprocating	Amico Source	A-RED-T-200P-SS-N-050	50	36.8 (1042)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-39	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Reciprocating	Amico Source	A-RED-T-200P-SS-N-075	50	56.2 (1591)	81	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-40	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Reciprocating	Amico Source	A-RED-T-200P-SS-N-100	50	74.2 (2101)	84	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-41	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Reciprocating	Amico Source	A-RED-T-200P-SS-N-150	50	109.4 (3098)	87	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-42	Medical Air Compressor	Modular Stacking, Triplex, Oil-Free Reciprocating	Amico Source	A-RED-T-200P-SS-N-200	50	146.2 (4140)	87	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-43	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Recip	Amico Source	A-RED-Q-200P-SS-N-010	50	12.3 (348)	77	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-44	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Recip	Amico Source	A-RED-Q-200P-SS-N-020	50	23.4 (663)	78	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-45	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Recip	Amico Source	A-RED-Q-200P-SS-N-030	50	30.3 (858)	79	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-46	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Recip	Amico Source	A-RED-Q-200P-SS-N-050	50	55.2 (1563)	81	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-47	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Recip	Amico Source	A-RED-Q-200P-SS-N-075	50	84.3 (2387)	83	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-48	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Recip	Amico Source	A-RED-Q-200P-SS-N-100	50	111.3 (3152)	86	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	psig[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MA-49	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Recip	Amico Source	A-RED-Q-200P-SS-N-150	50	164.1 (4647)	89	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-50	Medical Air Compressor	Modular Stacking, Quadruplex, Oil-Free Recip	Amico Source	A-RED-Q-200P-SS-N-200	50	219.3 (6210)	89	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
Reciprocating Horizontal Tank Mount (TH) Configuration																
MA-51	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Recip	Amico Source	A-RED-D-080P-TH-N-010	50	4.1 (116)	72	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-52	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Recip	Amico Source	A-RED-D-120P-TH-N-010	50	4.1 (116)	72	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-53	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Recip	Amico Source	A-RED-D-080P-TH-N-020	50	7.8 (221)	73	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-54	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Recip	Amico Source	A-RED-D-120P-TH-N-020	50	7.8 (221)	73	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-55	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Recip	Amico Source	A-RED-D-080P-TH-N-030	50	10.1 (286)	74	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-56	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Recip	Amico Source	A-RED-D-120P-TH-N-030	50	10.1 (286)	74	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-57	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Recip	Amico Source	A-RED-D-080P-TH-N-050	50	18.4 (521)	76	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MA-58	Medical Air Compressor	Horizontal Tank Mount, Duplex, Oil-Free Recip	Amico Source	A-RED-D-120P-TH-N-050	50	18.4 (521)	76	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

AIR SCHEDULE NOTES:

- ✓ [1] Standard systems are designed to be used for a discharge pressure of 50 psi. Higher pressure systems are available, contact your local Amico Source Corporation representative for more information.
- ✓ [2] hp per compressor.
- ✓ [3] Systems listed operate at 60 Hz; additional voltage, frequency and phase options are available. Please contact your local Amico Source Corporation representative for more information.
- ✓ [4] Expandable System. Replace "—" with "Y" or "N" depending on whether or not the system is sized for future expansion.
- ✓ [5] Minimum Circuit Ampacity (MCA). Can be provided during submittal stage.
- ✓ [6] Maximum Over Current Protection (MOCP). Can be provided during submittal stage.

7.2.2 MEDICAL VACUUM (SUCTION) SCHEDULE

The following will provide the schedules for medical vacuum systems, with the basis of design being Amico Source Corporation's standard Vacuum Products. Please refer to the System Selection Tables in Chapter 6: Medical Vacuum (Suction) Systems for footprint dimensions.

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
CONTACT-LESS CLAW SYSTEMS																
Claw Modular Stacking (SS) Configuration																
MV-1	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-020	19	16.0 (453)	70	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-2	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-030	19	21.0 (595)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-3	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-040	19	29.0 (821)	79	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-4	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-050	19	38.0 (1076)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-5	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-064	19	52.0 (1472)	79	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-6	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-075	19	65.0 (1841)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-7	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-090	19	73.0 (2067)	82	9 (6.71)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-8	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-100	19	87.0 (2464)	83	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-9	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-150	19	129.0 (3653)	82	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-10	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-020	19	32.0 (906)	73	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-11	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-030	19	42.0 (1189)	73	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-12	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-040	19	58.0 (1642)	82	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-13	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-050	19	76.0 (2152)	82	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-14	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-064	19	104.0 (2945)	82	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-15	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-075	19	130.0 (3681)	82	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-16	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-090	19	146.0 (4134)	85	9 (6.71)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-17	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-100	19	174.0 (4927)	86	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-18	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-150	19	258.0 (7306)	85	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-19	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-020	19	48.0 (1359)	75	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-20	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-030	19	63.0 (1784)	75	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-21	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-040	19	87.0 (2464)	84	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-22	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-050	19	114.0 (3228)	84	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-23	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-064	19	156.0 (4417)	84	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-24	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-075	19	195.0 (5522)	84	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-25	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-090	19	219.0 (6201)	87	9 (6.71)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-26	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-100	19	261.0 (7391)	88	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-27	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-150	19	387.0 (10959)	87	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
Claw Space Saver (TS) Configuration																
MV-28	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TS-N-020	19	16.0 (453)	70	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-29	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TS-N-030	19	21.0 (595)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-30	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TS-N-040	19	29.0 (821)	79	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-31	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TS-N-050	19	38.0 (1076)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-32	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TS-N-064	19	52.0 (1472)	79	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-33	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TS-N-075	19	65.0 (1841)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-34	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TS-N-090	19	73.0 (2067)	82	9 (6.71)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-35	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TS-N-100	19	87.0 (2464)	83	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
Claw Horizontal Tank Mount (TH) Configuration																
MV-36	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TH-N-020	19	16.0 (453)	70	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-37	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TH-N-030	19	21.0 (595)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-38	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TH-N-040	19	29.0 (821)	79	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-39	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TH-N-050	19	38.0 (1076)	79	5.4 (4.03)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-40	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TH-N-064	19	52.0 (1472)	79	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-41	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TH-N-075	19	65.0 (1841)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-42	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TH-N-090	19	73.0 (2067)	82	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-43	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TH-N-100	19	87.0 (2464)	83	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
DRY ROTARY VANE SYSTEMS																
RVD Modular Stacking (SS) Configuration																
MV-1	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-012	19	5.3 (150)	67	1.2 (0.89)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-2	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-017	19	8.0 (227)	70	1.7 (1.27)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-3	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-030	19	13.5 (382)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-4	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-040	19	17.0 (481)	72	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-5	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-064	19	52.0 (1472)	79	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-6	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-075	19	65.0 (1841)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-7	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-090	19	73.0 (2067)	82	9 (6.71)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-8	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-100	19	87.0 (2464)	83	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-9	Medical Vacuum Pump	Modular Stacking, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-200P-SS-N-150	19	129.0 (3653)	82	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-10	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-020	19	32.0 (906)	73	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-11	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-030	19	42.0 (1189)	73	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-12	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-040	19	58.0 (1642)	82	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-13	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-050	19	76.0 (2152)	82	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-14	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-064	19	104.0 (2945)	82	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-15	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-075	19	130.0 (3681)	82	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-16	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-090	19	146.0 (4134)	85	9 (6.71)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-17	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-100	19	174.0 (4927)	86	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-18	Medical Vacuum Pump	Modular Stacking, Triplex, Contactless Dry Claw	Amico Source	V-CCD-T-200P-SS-N-150	19	258.0 (7306)	85	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-19	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-020	19	48.0 (1359)	75	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

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			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-20	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-030	19	63.0 (1784)	75	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-21	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-040	19	87.0 (2464)	84	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-22	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-050	19	114.0 (3228)	84	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-23	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-064	19	156.0 (4417)	84	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-24	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-075	19	195.0 (5522)	84	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-25	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-090	19	219.0 (6201)	87	9 (6.71)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-26	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-100	19	261.0 (7391)	88	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-27	Medical Vacuum Pump	Modular Stacking, Quadruplex, Contactless Dry Claw	Amico Source	V-CCD-Q-200P-SS-N-150	19	387.0 (10959)	87	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
Claw Space Saver (TS) Configuration																
MV-28	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TS-N-020	19	16.0 (453)	70	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-29	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TS-N-030	19	21.0 (595)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-30	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TS-N-040	19	29.0 (821)	79	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-31	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TS-N-050	19	38.0 (1076)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-32	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TS-N-064	19	52.0 (1472)	79	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-33	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TS-N-075	19	65.0 (1841)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

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			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-34	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TS-N-090	19	73.0 (2067)	82	9 (6.71)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-35	Medical Vacuum Pump	Space Saver, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TS-N-100	19	87.0 (2464)	83	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
Claw Horizontal Tank Mount (TH) Configuration																
MV-36	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TH-N-020	19	16.0 (453)	70	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-37	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TH-N-030	19	21.0 (595)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-38	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TH-N-040	19	29.0 (821)	79	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-39	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-080P-TH-N-050	19	38.0 (1076)	79	5.4 (4.03)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-40	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TH-N-064	19	52.0 (1472)	79	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-41	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TH-N-075	19	65.0 (1841)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-42	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TH-N-090	19	73.0 (2067)	82	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-43	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Contactless Dry Claw	Amico Source	V-CCD-D-120P-TH-N-100	19	87.0 (2464)	83	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
DRY ROTARY VANE SYSTEMS																
RVD Modular Stacking (SS) Configuration																
MV-1	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-012	19	5.3 (150)	67	1.2 (0.89)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-2	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-017	19	8.0 (227)	70	1.7 (1.27)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-3	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-030	19	13.5 (382)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

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			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-4	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-040	19	17.0 (481)	72	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-5	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-054	19	20.0 (566)	76	5.4 (4.03)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-6	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-064	19	35.0 (991)	77	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-7	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-074	19	28.1 (796)	77	7.4 (5.52)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-8	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-089	19	51.3 (1453)	79	8.9 (6.64)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-9	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-121	19	55.4 (1569)	79	12.1 (9.02)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-10	Medical Vacuum Pump	Modular Stacking, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-200P-SS-N-177	19	105.5 (2987)	80	17.7 (13.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-11	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-012	19	10.6 (300)	70	1.2 (0.89)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-12	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-017	19	16.0 (453)	73	1.7 (1.27)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-13	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-030	19	27.0 (765)	73	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-14	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-040	19	34.0 (963)	75	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-15	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-054	19	40.0 (1133)	79	5.4 (4.03)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-16	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-064	19	70.0 (1982)	80	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-17	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-074	19	56.2 (1591)	80	7.4 (5.52)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-18	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-089	19	102.6 (2905)	82	8.9 (6.64)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-19	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-121	19	110.8 (3138)	82	12.1 (9.02)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

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			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-20	Medical Vacuum Pump	Modular Stacking, Triplex, Rotary Vane Dry	Amico Source	V-RVD-T-200P-SS-N-177	19	211.0 (5975)	83	17.7 (13.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-21	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-012	19	15.9 (450)	72	1.2 (0.89)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-22	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-017	19	24.0 (680)	75	1.7 (1.27)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-23	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-030	19	40.5 (1147)	75	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-24	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-040	19	51.0 (1444)	77	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-25	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-054	19	60.0 (1699)	81	5.4 (4.03)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-26	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-064	19	105.0 (2973)	82	6.4 (4.77)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-27	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-074	19	84.3 (2387)	82	7.4 (5.52)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-28	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-089	19	153.9 (4358)	84	8.9 (6.64)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-29	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-121	19	166.2 (4706)	84	12.1 (9.02)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-30	Medical Vacuum Pump	Modular Stacking, Quadruplex, Rotary Vane Dry	Amico Source	V-RVD-Q-200P-SS-N-177	19	316.5 (8962)	85	17.7 (13.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
RVD Space Saver (TS) Configuration																
MV-31	Medical Vacuum Pump	Space Saver, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-080P-TS-N-012	19	5.3 (150)	67	1.2 (0.89)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-32	Medical Vacuum Pump	Space Saver, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-080P-TS-N-017	19	8.0 (227)	70	1.7 (1.27)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-33	Medical Vacuum Pump	Space Saver, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-080P-TS-N-030	19	13.5 (382)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

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			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-34	Medical Vacuum Pump	Space Saver, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-080P-TS-N-040	19	17.0 (481)	72	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-35	Medical Vacuum Pump	Space Saver, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-120P-TS-N-054	19	20.0 (566)	76	5.4 (4.03)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-36	Medical Vacuum Pump	Space Saver, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-120P-TS-N-074	19	28.1 (796)	77	7.4 (5.52)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
RVD Horizontal Tank Mount (TH) Configuration																
MV-37	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-080P-TH-N-012	19	5.3 (150)	67	1.2 (0.89)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-38	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-080P-TH-N-017	19	8.0 (227)	70	1.7 (1.27)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-39	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-080P-TH-N-030	19	13.5 (382)	70	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-40	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-080P-TH-N-040	19	17.0 (481)	72	4 (2.98)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-41	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-120P-TH-N-054	19	20.0 (566)	76	5.4 (4.03)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-42	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Rotary Vane Dry	Amico Source	V-RVD-D-120P-TH-N-074	19	28.1 (796)	77	7.4 (5.52)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
LUBRICATED ROTARY VANE SYSTEMS																
RVL Modular Stacking (SS) Configuration																
MV-1	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-010	19	4.8 (136)	72	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-2	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-015	19	7.0 (198)	63	1.5 (1.12)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-3	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-020	19	11.0 (311)	66	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-4	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-030	19	17.0 (481)	66	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-5	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-050	19	23.0 (651)	68	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-6	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-051	19	26.0 (736)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

SYMBOL	DESCRIPTION	CHARACTERISTICS	BASIS OF DESIGN (APPROVED MGEMs ARE LISTED IN SPECIFICATIONS)		DESIGN CAPACITY			ELECTRICAL CHARACTERISTICS					LOCAL DISCONNECT	STARTER	CONTROLS	NOTES & REMARKS
			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-7	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-052	19	37.0 (1048)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-8	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-075	19	52.0 (1472)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-9	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-100	19	65.0 (1841)	81	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-10	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-101	19	77.0 (2180)	81	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-11	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-150	19	111.0 (3143)	83	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-12	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-200	19	137.0 (3879)	84	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-13	Medical Vacuum Pump	Modular Stacking, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-200P-SS-N-250	19	168.0 (4757)	85	25 (18.6)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-14	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-010	19	9.6 (272)	75	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-15	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-015	19	14.0 (396)	66	1.5 (1.12)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-16	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-020	19	22.0 (623)	69	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-17	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-030	19	34.0 (963)	69	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-18	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-050	19	46.0 (1303)	71	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-19	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-051	19	52.0 (1472)	82	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-20	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-052	19	74.0 (2095)	82	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-21	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-075	19	104.0 (2945)	82	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-22	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-100	19	130.0 (3681)	84	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

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			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-23	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-101	19	154.0 (4361)	84	25 (18.6)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-24	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-150	19	222.0 (6286)	86	30 (22.4)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-25	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-200	19	274.0 (7759)	87	40 (29.8)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-26	Medical Vacuum Pump	Modular Stacking, Triplex, Lubricated Rotary Vane	Amico Source	V-RVL-T-200P-SS-N-250	19	336.0 (9514)	88	50 (37.3)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-27	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-010	19	14.4 (408)	77	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-28	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-015	19	21.0 (595)	68	1.5 (1.12)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-29	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-020	19	33.0 (934)	71	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-30	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-030	19	51.0 (1444)	71	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-31	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-050	19	69.0 (1954)	73	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-32	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-051	19	78.0 (2209)	84	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-33	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-052	19	111.0 (3143)	84	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-34	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-075	19	156.0 (4417)	84	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-35	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-100	19	195.0 (5522)	86	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-36	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-101	19	231.0 (6541)	86	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

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			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-37	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-150	19	333.0 (9430)	88	15 (11.2)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-38	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-200	19	411.0 (11638)	89	20 (14.9)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-39	Medical Vacuum Pump	Modular Stacking, Quadruplex, Lubricated Rotary Vane	Amico Source	V-RVL-Q-200P-SS-N-250	19	504.0 (14272)	90	25 (18.6)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
RVL Space Saver (TS) Configuration																
MV-40	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-080P-TS-N-010	19	4.8 (136)	72	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-41	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-080P-TS-N-015	19	7.0 (198)	63	1.5 (1.12)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-42	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-080P-TS-N-020	19	11.0 (311)	66	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-43	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-080P-TS-N-030	19	17.0 (481)	66	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-44	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TS-N-050	19	23.0 (651)	68	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-45	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TS-N-051	19	26.0 (736)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-46	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TS-N-052	19	37.0 (1048)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-47	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TS-N-075	19	52.0 (1472)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-48	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TS-N-100	19	65.0 (1841)	81	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-49	Medical Vacuum Pump	Space Saver, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TS-N-101	19	77.0 (2180)	81	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
RVL Horizontal Tank Mount (TH) Configuration																
MV-50	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-080P-TH-N-010	19	4.8 (136)	72	1 (0.75)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

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			MGEM	Model Number	inHg[1]	FLOW SCFM (LPM)	dB(A)	HP (kW)[2]	V AC/PH[3]	EP[4]	MCA[5] (460 V)	MOCP[6]	Type	Type	By	
MV-51	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-080P-TH-N-015	19	7.0 (198)	63	1.5 (1.12)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-52	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-080P-TH-N-020	19	11.0 (311)	66	2 (1.49)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-53	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-080P-TH-N-030	19	17.0 (481)	66	3 (2.24)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-54	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TH-N-050	19	23.0 (651)	68	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-55	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TH-N-051	19	26.0 (736)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-56	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TH-N-052	19	37.0 (1048)	79	5 (3.73)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-57	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TH-N-075	19	52.0 (1472)	79	7.5 (5.59)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-58	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TH-N-100	19	65.0 (1841)	81	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	
MV-59	Medical Vacuum Pump	Horizontal Tank Mount, Duplex, Lubricated Rotary Vane	Amico Source	V-RVL-D-120P-TH-N-101	19	77.0 (2180)	81	10 (7.46)	460/3	—	—	—	Circuit Breaker	Magnetic	Automatic PLC & Manual H-O-A	

VACUUM SCHEDULE NOTES:

- ✓ [1] Standard systems are designed to be used for a discharge pressure of 50 psi. Higher pressure systems are available, contact your local Amico Source Corporation representative for more information.
- ✓ [2] hp per compressor.
- ✓ [3] Systems listed operate at 60 Hz; additional voltage, frequency and phase options are available. Please contact your local Amico Source Corporation representative for more information.
- ✓ [4] Expandable System. Replace "—" with "Y" or "N" depending on whether or not the system is sized for future expansion.
- ✓ [5] Minimum Circuit Ampacity (MCA). Can be provided during submittal stage.
- ✓ [6] Maximum Over Current Protection (MOCP). Can be provided during submittal stage.

Chapter 8

Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

Conclusion

Chapter 8 – Conclusion

Final Thoughts

What we here at Amico Source Corporation have hoped to provide for you, the reader, is a logical and step-by-step guide for the design of medical gas equipment – namely medical compressed air systems and medical vacuum systems. We recognize however, that there is often not one singular method for achieving the best design of the best possible product.

While we have created this Design Guide for the viewing pleasure of anyone interested in the Medical Gas Industry (particularly source systems), our hope is that this Design Guide will ultimately end up in the hands of the engineer tasked with creating a medical gas system for a facility. Thus, we hope that this will serve you, the Engineer, as a suitable reference so that you may have all your bases covered, so to speak, when embarking on the process you have been tasked to do. Not only have we provided our thought process we have developed through our years of experience in this industry, but we have also included our own products as the basis of design throughout this Design Guide. Naturally, while we will stand by our product as the best in its class when compared to anyone else's on the market, we have also done this to provide the freedom to the engineer to choose whichever product he or she thinks is best for the facility. By having a basis of design, the engineer will have an idea of what to look for and thus a frame of reference for their design.

Nevertheless, if there can only be one thing that you as the reader should take away from the entirety of this Design Guide, it is the following fundamental statement regarding medical gas equipment:

Properly done, a medical gas system design should produce an integrated system, not simply a collection of components.

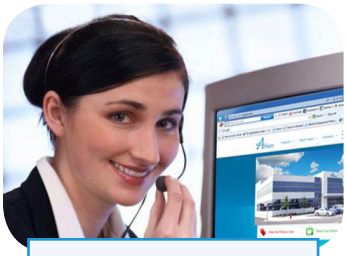
While there are certainly many parts that go into the ensuring whether a compressor or pump operates optimally, a dryer is able to remove moisture well and an impressive amount of pipe fittings to link everything together with the receiver, it is the combination of all of these parts working together in harmony that yields a successful medical gas system.

Theory, knowledge, and experience are three fundamental aspects in any engineering application. Knowledge is gained from what is observed and theories are based on this knowledge. It is experience that tests these theories, and in doing so turns knowledge into wisdom. Although we have many theories that have gone into the design of our product throughout the years, the knowledge we have gained in this industry is only as good as what we have seen so far. This guide is a way for us to give back to you, the engineer. Although it represents the cumulative knowledge of Amico Source Corporation into a single tool, it is important to remember that a tool is only as good as the person that is using it. Someone who knows both the extent of its applications and limitations, and can tell the difference between the blurred lines that lie between them.

We wish you continued success in the design of these medical gas systems. Regardless of experience level or stage in the design process, you can rest assured that Amico Source Corporation will be there for you – every step of the way.

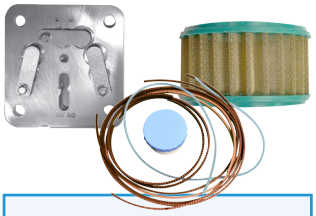
Engineering
& Design

Technical Expertise
& Support



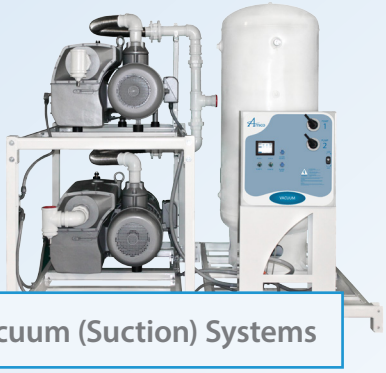
Customer Service

Amico



Replacement Parts

Compressed Air Systems



Vacuum (Suction) Systems

One Point of Contact | One Total Solution

NFPA osHpd 2YEAR warranty MADE IN NORTH AMERICA

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