Medical Gas Design Guide

Air and Vacuum Systems / Medical Gas Pipeline v1

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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Chapter 1

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.

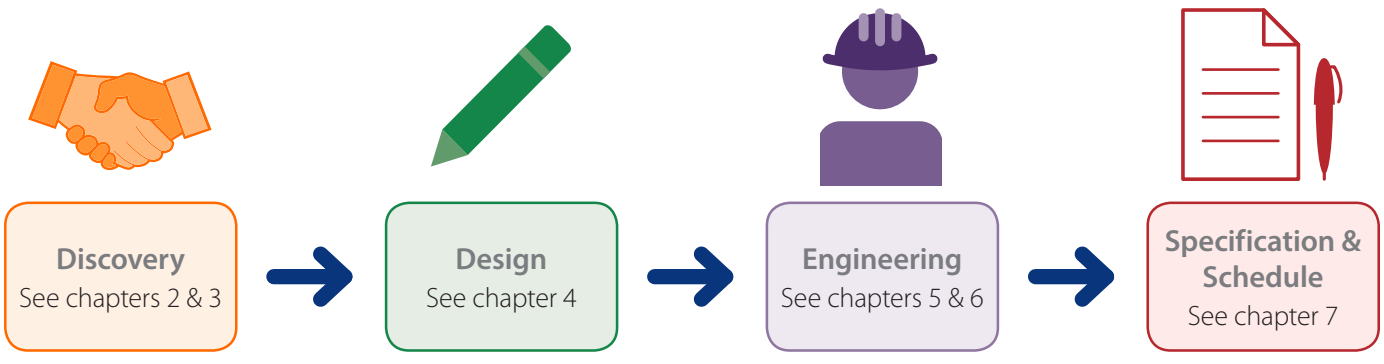
This is the first edition of this Design Guide that Amico Source Corporation has created and as such comments or suggestions for improvement are more than welcome. While we do what we can from our end, it is the knowledge that is gained from those that continually work, service and maintain our systems 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.

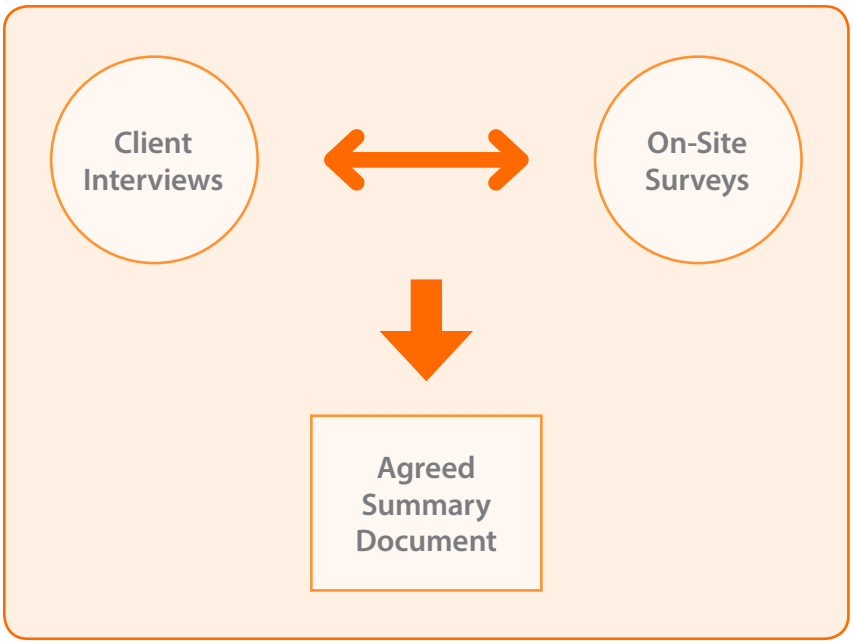
In this chapter, we have included the complete and comprehensive specifications you will need to provide for any medical compressed air, vacuum, WAGD and instrument air plant systems. This chapter will guide you through selecting the required technology and equipment and will be what ensures that the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

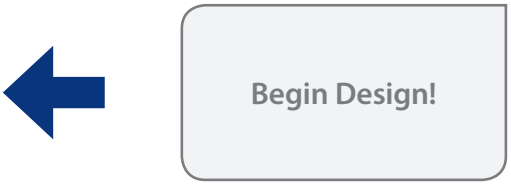
As mentioned before, done properly, your work will yield more than a simple collection of various equipment and materials. It will give you an integrated system, something that offers much more than what it appears. It is no longer a collection of components and thus you should not think of it as so. 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.

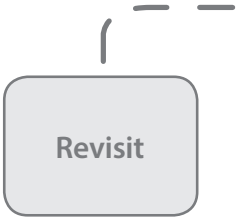
A Visual Design Map of these stages is shown on the next two pages.

VISUAL DESIGN MAP

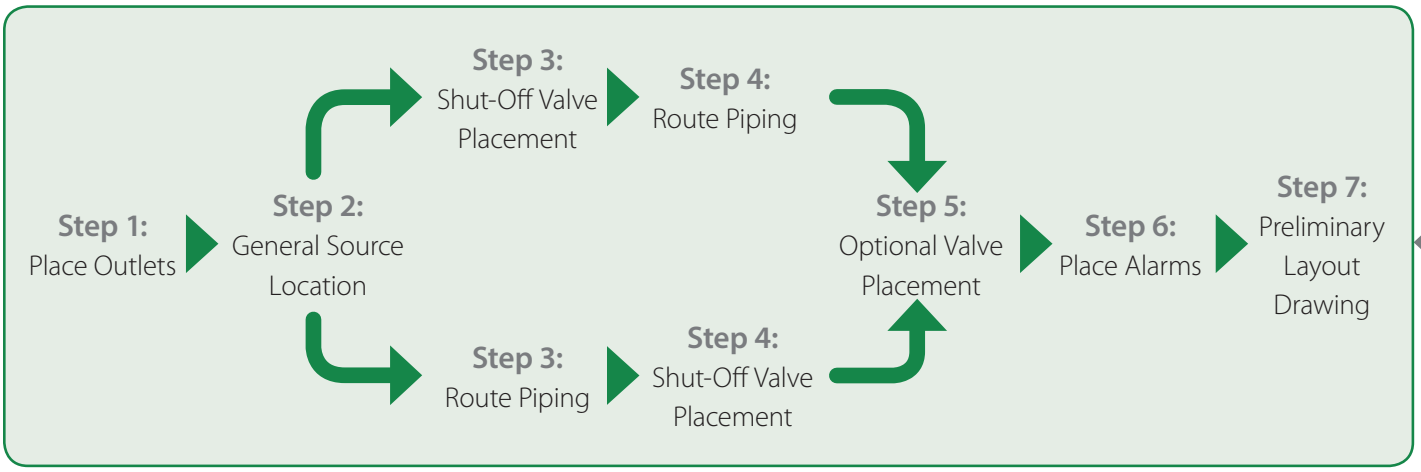
Phase 1: Discovery



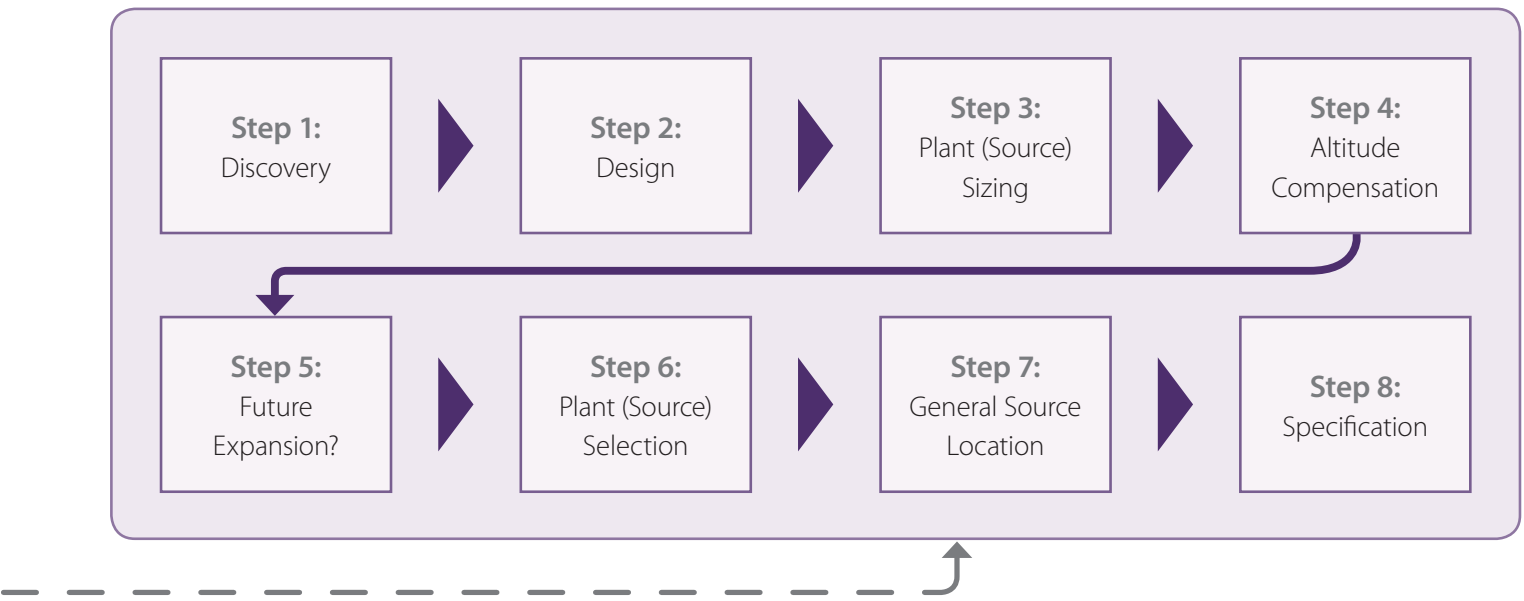




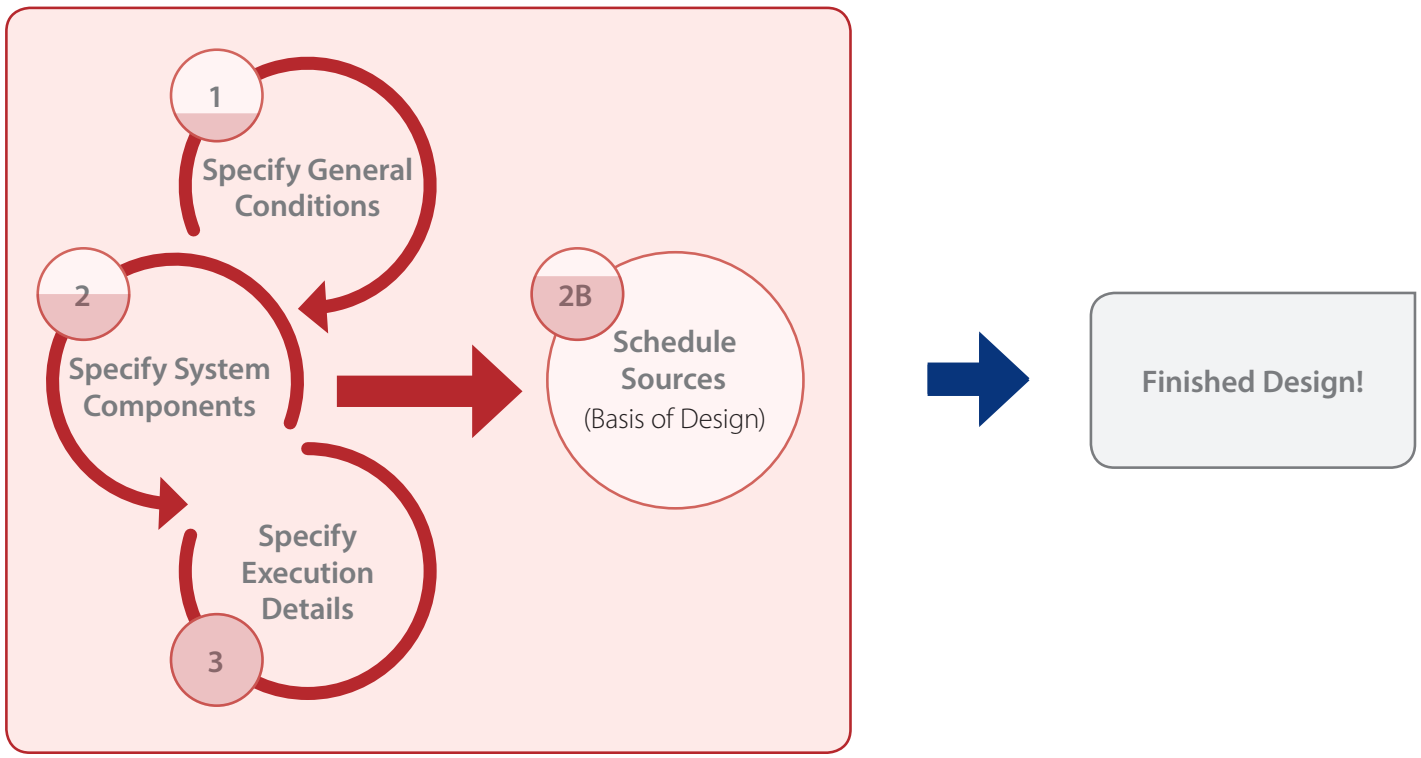
Phase 2: Design



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)
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)

Document	Description	Individual / Organization
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

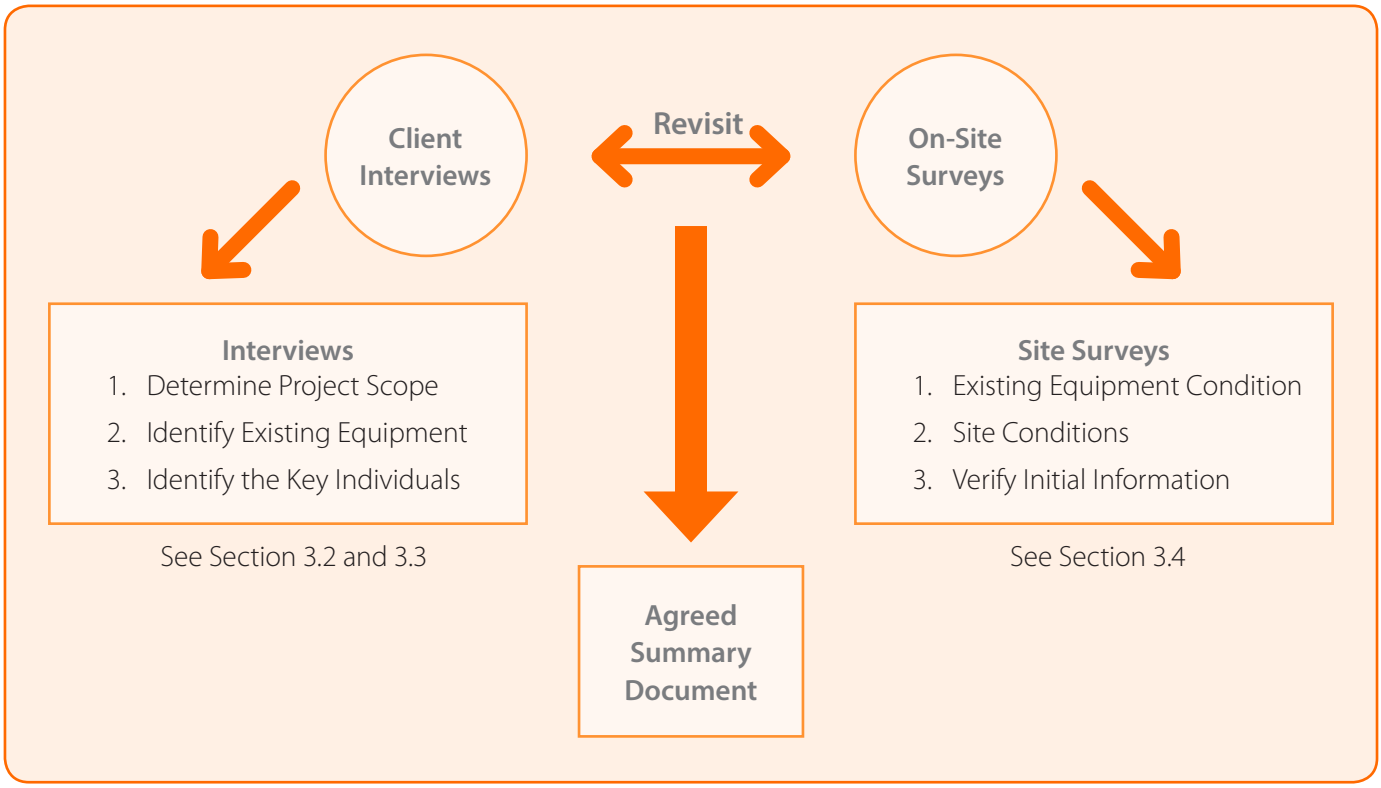
Of all the stages involved in the process of designing, manufacturing, supplying and maintaining a medical gas system, Discovery is arguably the most important phase. It is at this point where:

- ✓ 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. This conflict of interest is common within the medical gas industry and thus you must be aware of whom you are dealing with.

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: ☐ 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] ☐ Carbon Monoxide High [CO]

☐ 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] ☐ Carbon Monoxide High [CO]

☐ 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] ☐ Carbon Monoxide High [CO]

☐ 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] ☐ Carbon Monoxide High [CO]

☐ 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: ☐ Simplex ☐ 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] ☐ Dew Point High [DP] ☐ Carbon Monoxide High [CO]

☐ 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] ☐ Carbon Monoxide High [CO]

☐ 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] ☐ Dew Point High [DP] ☐ Carbon Monoxide High [CO]

☐ 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] ☐ Carbon Monoxide High [CO]

☐ 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

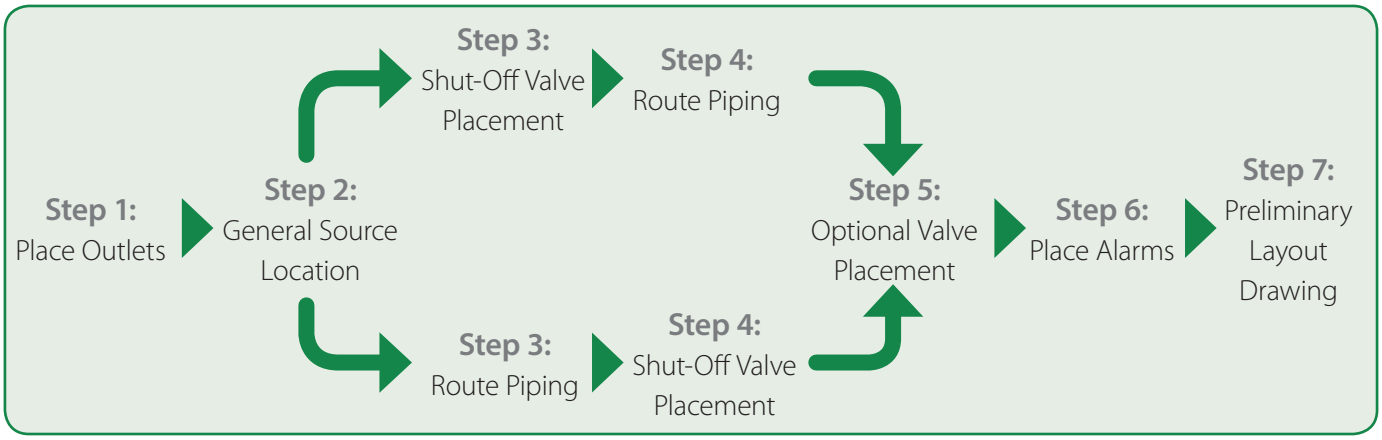
Comments on this chapter, or any other aspect of this guide, are welcome and strongly encouraged. Please send any suggestions and feedback to AS-TechSupport@amico.com

The System Design & Layout

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.

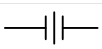
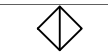
4.3 Associated Symbols

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

Proceeding room by room, outlets will now be placed in each area as required by applicable standards, or as desired by the client. Based on the occupancy, determine which outlets should be placed in each room. It is recommended to place outlets on either side of the patient bed as applicable. Where multiple outlets of a single type are required, they should be divided evenly between the two sides. Although it is possible to place outlets in fire walls, it is best to avoid doing this. Strive to place outlets in 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:

- ✓ Every source must have a source valve. The function of the source valve is to isolate the source and all of its associated equipment from the pipeline. 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 the source equipment (with its own operation characteristics) and the pipeline equipment (with its own different 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.
- ✓ For vacuum piping, please avoid creating low spots or "U" traps in the route. The ideal vacuum layout would be sloped towards the pump inlet, to allow for any liquid to run off before reaching the pump. Of course, this is just an idealization and very difficult to implement practically. However, fluid drainage is definitely a consideration to keep in mind while creating your 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. For example, an ICU which passes around a corner or a recovery room with an inpatient and outpatient section.
- ✓ 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 nurses' station however this is not often the best location. A good panel location will pass the following tests:

- ✓ Is the proposed location one where a member of the facility staff will always be in the immediate vicinity?
- ✓ Is the proposed location always visible? The alarm should never be hidden behind doors, parked equipment or any other obstacles.
- ✓ Will the alarm be loud enough to be heard over the surrounding ambient noise in the location?

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 pass the following criteria:

- ✓ Is the proposed location close to the anesthetizing locations being monitored? Please keep in mind that when the alarm goes off, someone must travel to each location and alert the staff (if each location does not have its own alarm). The larger the distance, the longer the time will be to address the issue and thus patients' wellbeing can be potentially put at risk.
- ✓ Is the proposed location one where a member of the facility staff is either stationed or in the immediate vicinity? That is, within earshot and eyesight of the alarm.
- ✓ Is the proposed location always visible? That is, the alarm should not be obstructed by any door, equipment, etc. and should be found in an area where the possibility of this happening is negligible.
- ✓ Will the alarm be audible over a large area? That is, it must be able to be heard over other nearby equipment and must not be placed in an office where the door may be closed and the alarm difficult to hear.

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.

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.

Local alarm panels are only necessary if the equipment being installed is not properly compliant with NFPA 99 as purchased. 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

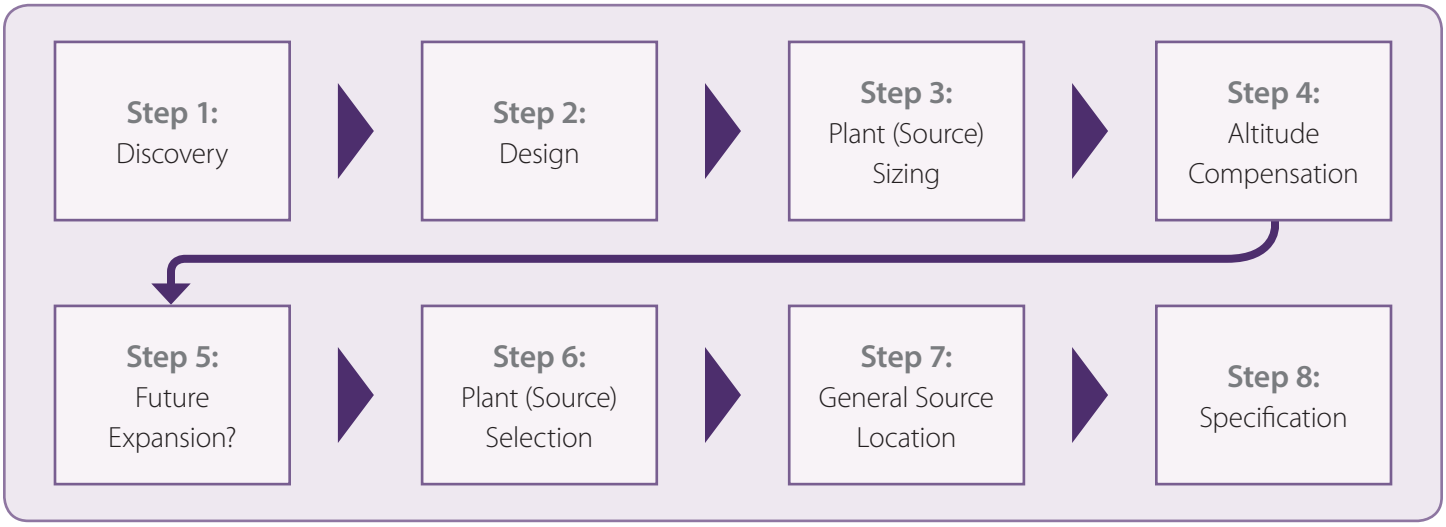
Medical Air Systems Glossary

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 and CSA standards for Medical Air Compressors define an essential foundation for Medical Air from these systems as follows: air should start clean and be kept clean. For that reason, the air inhaled by the patient should at the very least be equal to filtered local outdoor air.

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. The medical air must be available at all times, including in the event of a single fault failure.
3. The air must be dry enough to ensure no liquid water can develop under any normal operating conditions (this is not necessarily assured simply by meeting the NFPA mandated dew point).
4. Any contamination that the system can produce within itself under any operating conditions (e.g. particulates) must be removed (e.g. by filtration) before it reaches the patient.

NFPA defines various rules for the construction of the air plant and the safety devices required for each machine type. Additionally, good engineering practice defines crucial elements such as aftercoolers, drains and traps, dryers, vibration isolation and hundreds of other small but significant elements of good compressed air systems design. Amico Source Corporation has pre-engineered all medical compressed air systems in this section to warrant that they include not only the basic requirements of the aforementioned essentials, but also the many foundations behind good engineering.

This section of the Design Guide also permits the user to make selections of complete medical air packages for reasons specified hereafter. It is impractical to craft a Design Guide encompassing all the knowledge that Amico Source Corporation's engineers have applied to the design of these systems. Nevertheless, within this Design Guide, you can easily locate the necessary information to ensure you can design these systems with confidence and provide for your client a complete medical compressed air system that meets and exceeds all their requirements. Medical air in smaller systems may be provided by manifolds in lieu of compressor systems. The sizing criteria are the same for either source type.

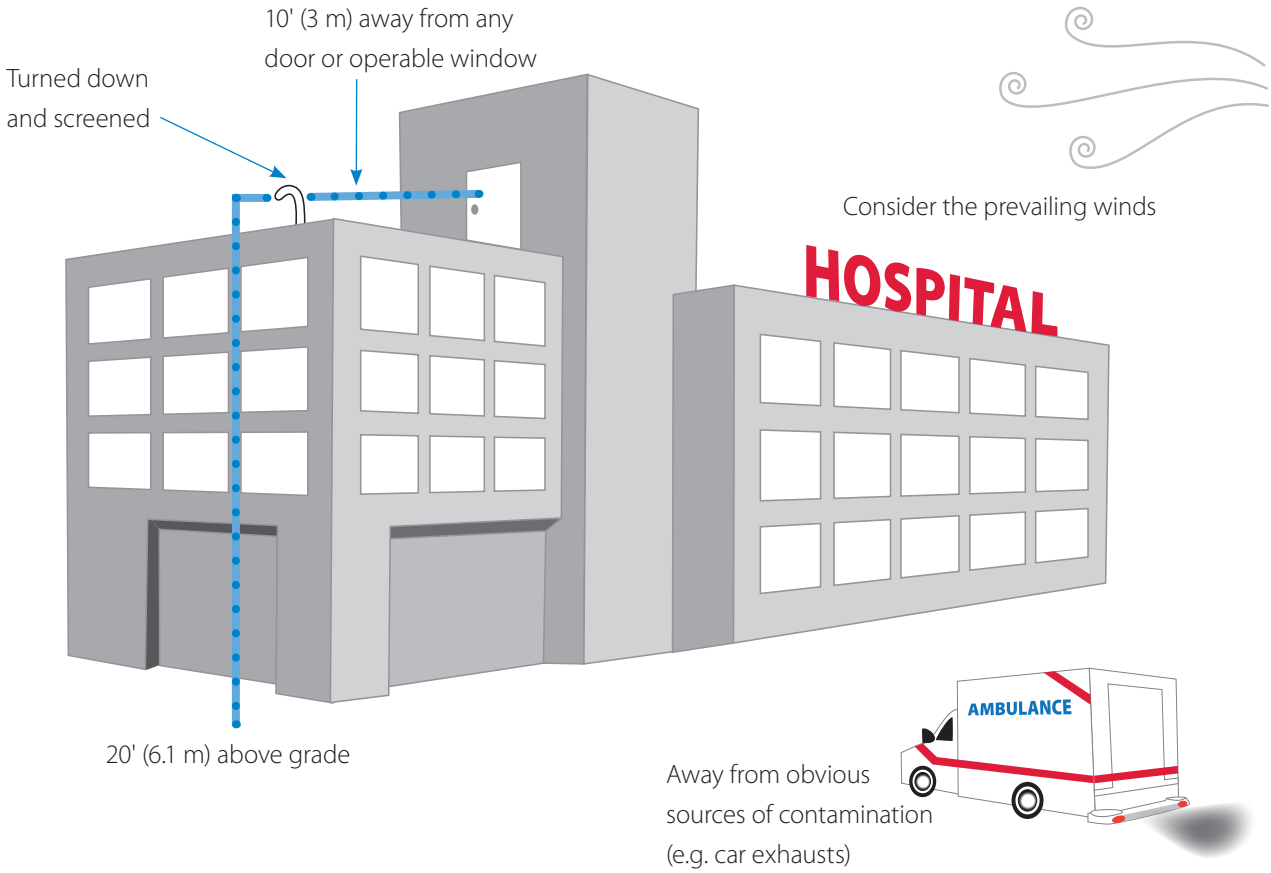
5.2 Steps to Implementing the Medical Compressed Air System

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 number of ventilators required to be in service at any one time and define their type and average inlet air requirement.
4. Examine the location intended for the air intake carefully as NFPA mandates the intake be located at a minimum of 10' (3 m) from any door or operable window; 20' (6.1 m) above grade and in a location likely to provide uncontaminated air under any conditions of wind or weather. See diagram below for an illustrated example.

   The intake opening shall be turned downward and screened. It shall be accessible to authorized personnel for cleaning, inspection and servicing. If the air intake is near a loading dock or at a location where vehicles may be present, it must be relocated. It is advisable to place the intake at a height above any other intake or vent on the same roof. For further details regarding the rules and regulation in choosing your medical air system location, please refer to the latest edition of the NFPA specification guide.

AIR INTAKE LOCATION



5. 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).
6. Ensure the intended location for the air plant is adequately ventilated, or is air conditioned at the very minimum. The plant will produce a considerable amount of heat into the surrounding area. Hence, this must be factored in when selecting a compressor site, determining the adequacy of ventilation or identifying BTU requirements for air conditioning (BTU data is provided in the equipment data sheet or system drawings).
7. Determine the availability of electrical service.
8. 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

If the compressor is to be operated at higher elevations, the peak calculated demand (from the Medical Air – SCFM Calculation Table on page 53) should be multiplied by the corresponding correction factor. It is important to keep in mind that at altitudes above sea level, all medical compressed air systems will have a reduced flow output. In such cases, the required sizing will need to be adjusted by taking the total PCL (SCFM) and multiplying it by the correction factor (see 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

Adding capacity now for any future requirements is wise, but only after being well thought out. More often than not, it is common to see oversized air plants which were initially sized to accommodate an expansion that never occurred or that was scaled back and not needed after all. In addition to the waste of money, this generates problems associated with the operation of the system. The best method in preparing for an anticipated expansion is to opt for a plant which is adequate for the present need in a duplex or triplex system, but can also be upsized for future need by simply adding additional compressors as required.

When specifying for the unit, require it be purchased in preparation for additional compressor(s), but not yet populated with those compressor(s). An example specification would read: "provide duplex medical air plant with triplex controls and air treatment subsystem ready for a future third compressor." Such a system provides an effective method of expanding the system capacity, is more capital-efficient and yields better operating characteristics and reliability when it comes to air quality control. Nevertheless, it is fundamentally important that the intake, electrical service and system piping are correctly sized for the entire expected capacity, so these larger values should be used in all calculations.

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. Choose a horsepower for the preferred technology with the capacity closest to (but normally greater than) the Peak Calculated Load (PCL). See the Visual Selection Guide on page 58 for the standard compressed air systems 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.

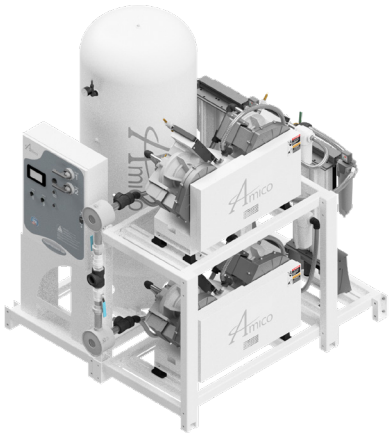
Characteristics	Scroll	Dry Reciprocating	Lubricated Reciprocating	Rotary Screw
Format	• Modular Stacking • Horizontal Tank Mount • Skid Mount	• Modular Stacking • Horizontal Tank Mount • Skid Mount	• Modular Stacking • Horizontal Tank Mount • Skid Mount	• Enclosed Unit
Lubrication	Oil Free	Oil Free	Lubricated	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	FS Curtis	FS Curtis

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

Quick Guide to Configuration

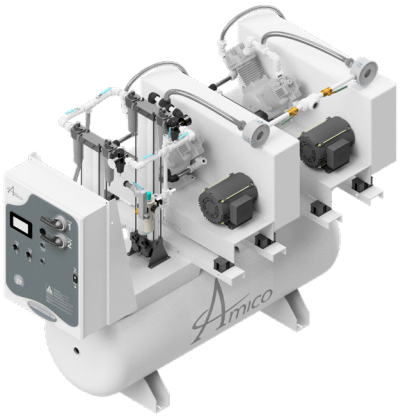
MODULAR STACKING CONFIGURATION

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.



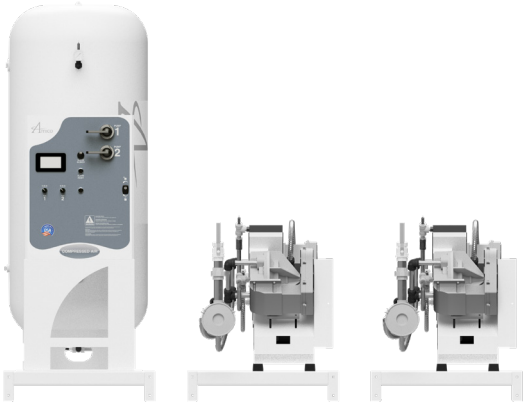
HORIZONTAL TANK MOUNT

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

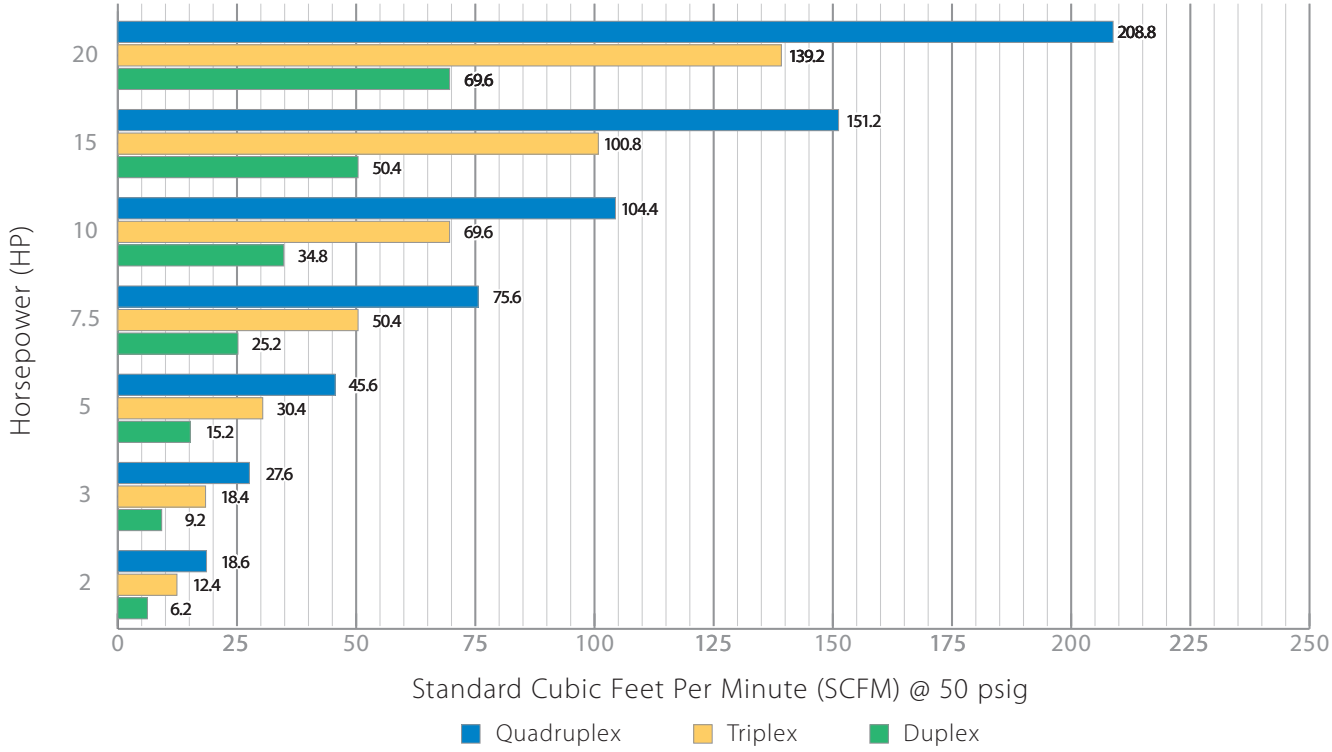
These systems are mounted on a separate skid. This configuration is suitable for larger compressors. This type of system is also designed for ease of transportation.



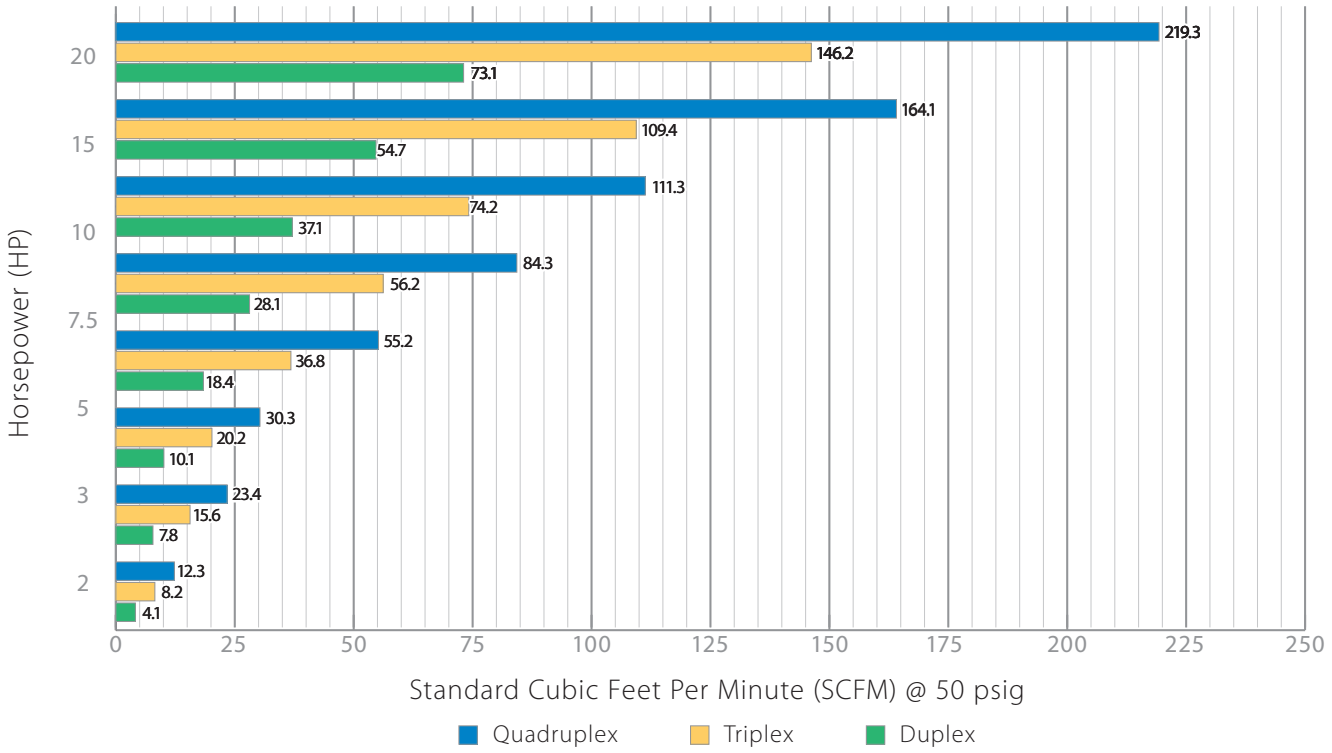
Standard Air System Visual Selection Guide

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)
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)

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-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)

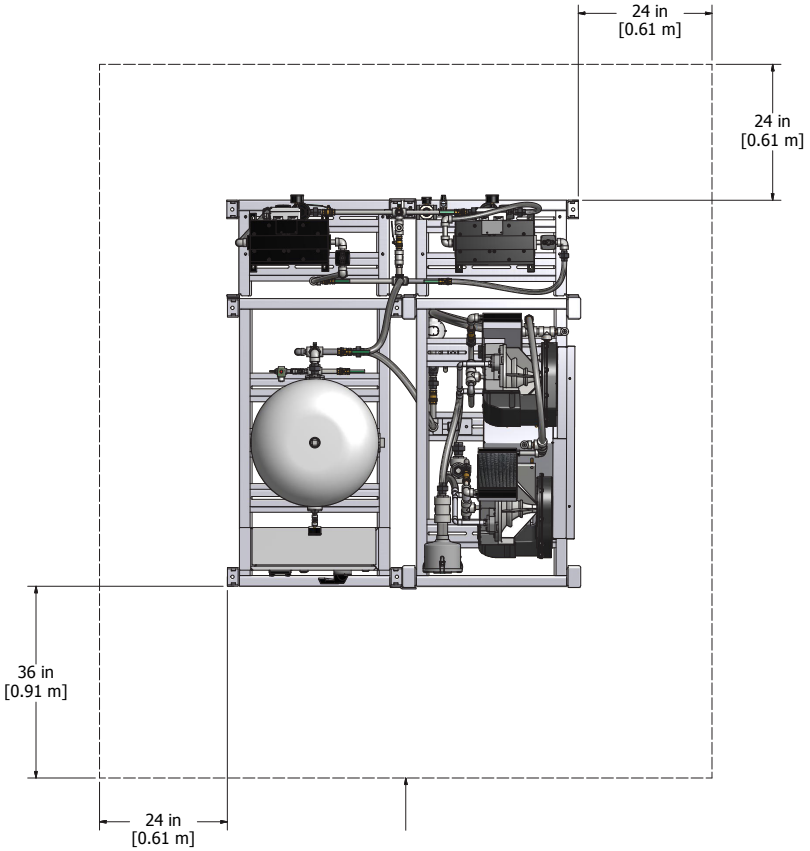
Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			at 50 psig	at 120 psig	Width	Length	Height	Total Sq. Ft. Required (M^2)
Modular Stacking (SS) Configuration								
A-RED-Q-200P-SS-N-020	Modular Stacking Quadruplex	2 (1.49)	23.4 (663)	19.8 (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

Chapter 6 – Medical Vacuum (Suction) Systems

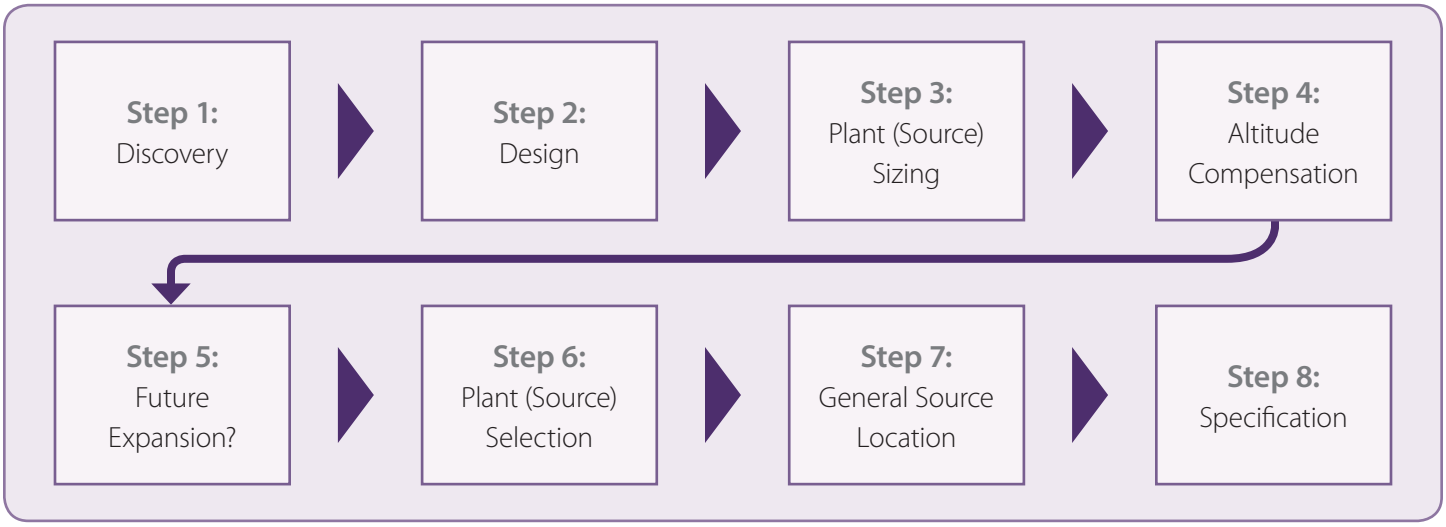
Medical Vacuum Systems Glossary

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

Medical vacuum in comparison to other medical gas source systems is quite straightforward. The most intricate part of the design process comes in the selection of the technology to be used. There are many competing technologies, each of which has their own advantages and disadvantages. NFPA standards contain requirements which are normally readily met. Thus, the decision becomes a balancing of the client's concerns for risk, initial cost versus life cycle cost and the associated maintenance requirements.

Engineers use the term "vacuum," but clinicians often refer to it as "suction." If you have the opportunity to speak with the clinicians, more than likely you will find the terminology subtly different. Furthermore, although the average clinician may not be able to articulate it very well, their major concern is flow rate. It is not uncommon to have a maintenance worker (called in because of "poor suction") plug in a vacuum gauge and quite accurately tell the complaining clinician "you're getting what I'm getting." The worker is correct in terms of vacuum level, but what the nurse is really referring to is the fact that there is a lack of flow or 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.

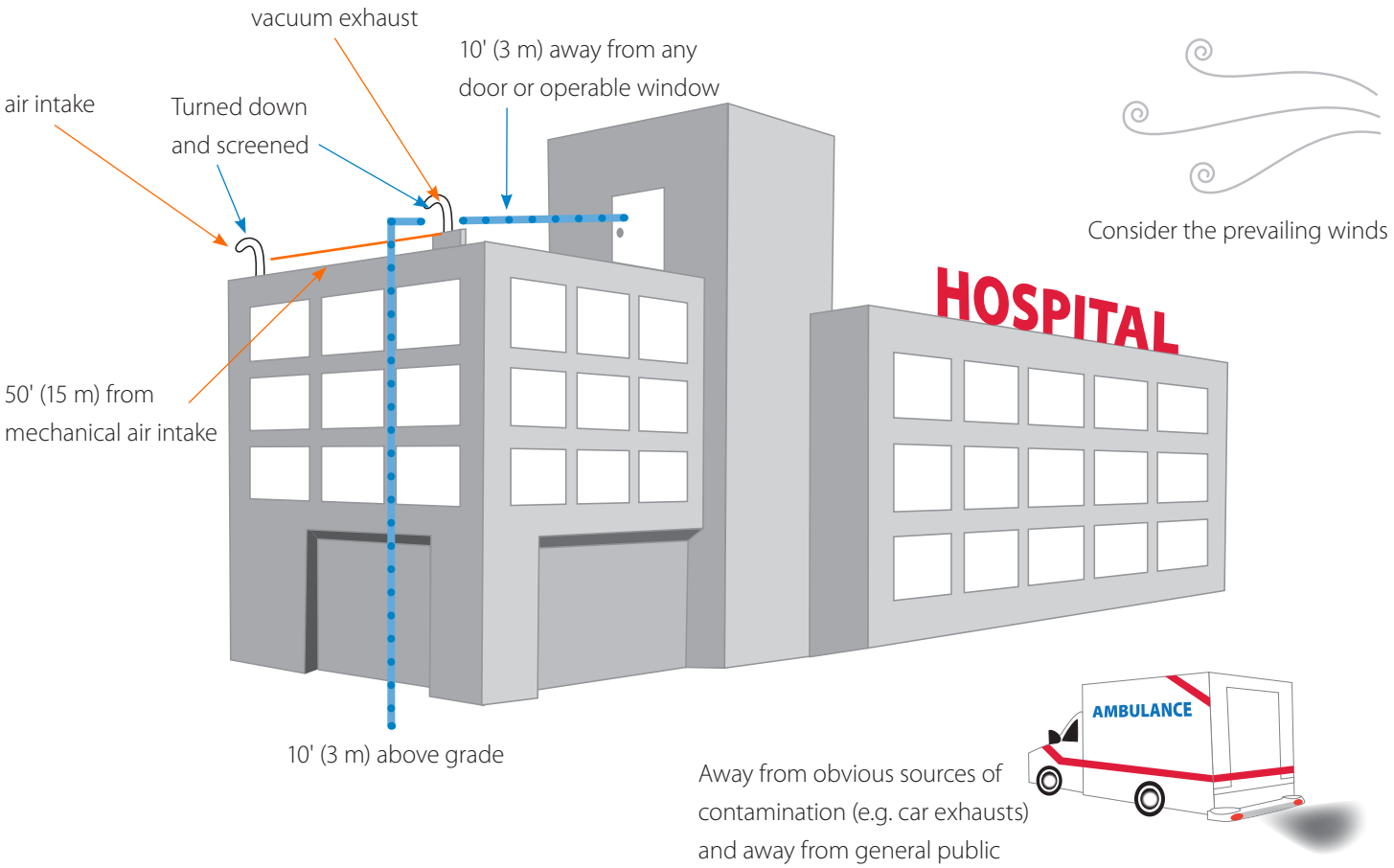
The method we will be using in this Design Guide for sizing vacuum sources will follow the latest edition of The National Fire Protection Association Standard (NFPA). This method is commonly used in the US and other countries as we understand its restrictions and from experience we know that it works 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. One classic example is within a long term care facility where wheelchair bound ventilator patients are taught to suction their own airway. Suction demand is tremendous, as they leave suction lines open constantly. A system sized using the normal criteria would wear out in a matter of months under such a load.
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. Ensure the intended location for the vacuum plant is adequately ventilated or air conditioned at the very minimum as the plant will produce a considerable amount of heat in the surrounding area. This must be factored in when selecting a pump site, determining the adequacy of ventilation or identifying BTU requirements for air conditioning. BTU data is provided in the equipment data sheet or system drawings.
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.

6.2.3 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:

All sizing methods are only approximations and should be used carefully. If an existing vacuum plant is being replaced, the operating characteristics of that vacuum pump can be an important gauge of likely future use. For example, if an existing 5 hp pump provides an ample amount of medical suction, but the sizing table yields much larger requirements, it may be suitable to use a smaller, sufficiently sized unit rather than relying on the results from the Amico Source Equipment Sizing Guide alone.

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

Adding capacity now for any future requirements is wise, but only after being well thought out. More often than not, it is common to see seriously oversized vacuum plants which were initially sized to accommodate an expansion that never occurred or was scaled back and not needed after all. In addition to the waste of money, it generates problems associated with the operation of the system. The best method in preparing for an anticipated expansion is to opt for a plant which is adequate for the present need in a duplex or triplex system, but can also be upsized for future need by simply adding additional pumps as required.

When specifying the unit, require the system to be purchased with provision for the additional pump(s), but not yet populated with those pump(s). An example specification would read: "provide duplex medical vacuum plant with triplex controls ready for a future third pump". Such a system provides an effective method of expanding the system capacity, is more capital-efficient and yields better operating characteristics and reliability. Nevertheless, it is fundamentally important that the intake, electrical service and system piping are correctly sized for the entire expected capacity, so these larger values should be used in all calculations.

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. Choose a horsepower from the preferred technology with the capacity nearest to (but typically greater than) the Peak Calculated Demand (PCD). See the Standard Vacuum System Visual Selection Guide on page 78 for the standard vacuum systems 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, Elmo Rietschle	Travaini	Becker, Busch, Elmo Rietschle	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

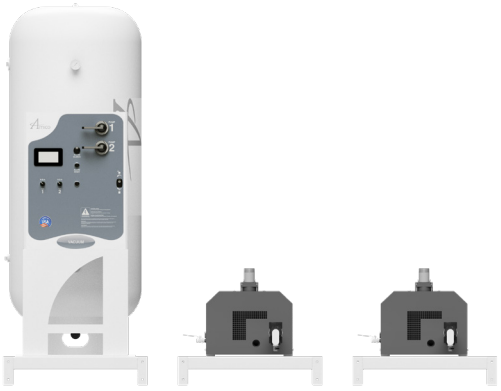
Vertical configurations have two pumps stacked on a single vertical tank. This configuration is only suitable for smaller vacuum pumps or pumps with very little inherent vibration such as Contact-less Claws. It is the most space-efficient of all medical vacuum configurations.

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

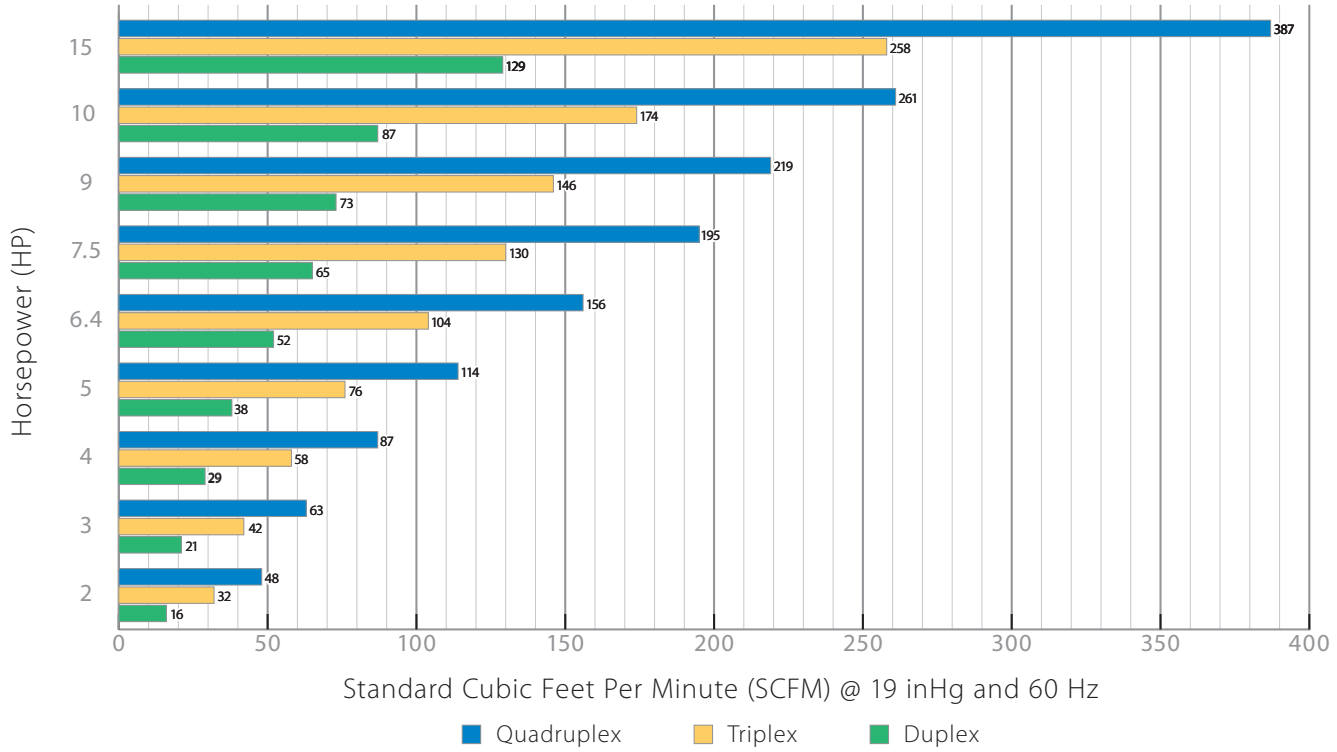
These systems are mounted on separate skids. This configuration is suitable for larger vacuum pumps. This type of vacuum system is also designed for ease of transportation.



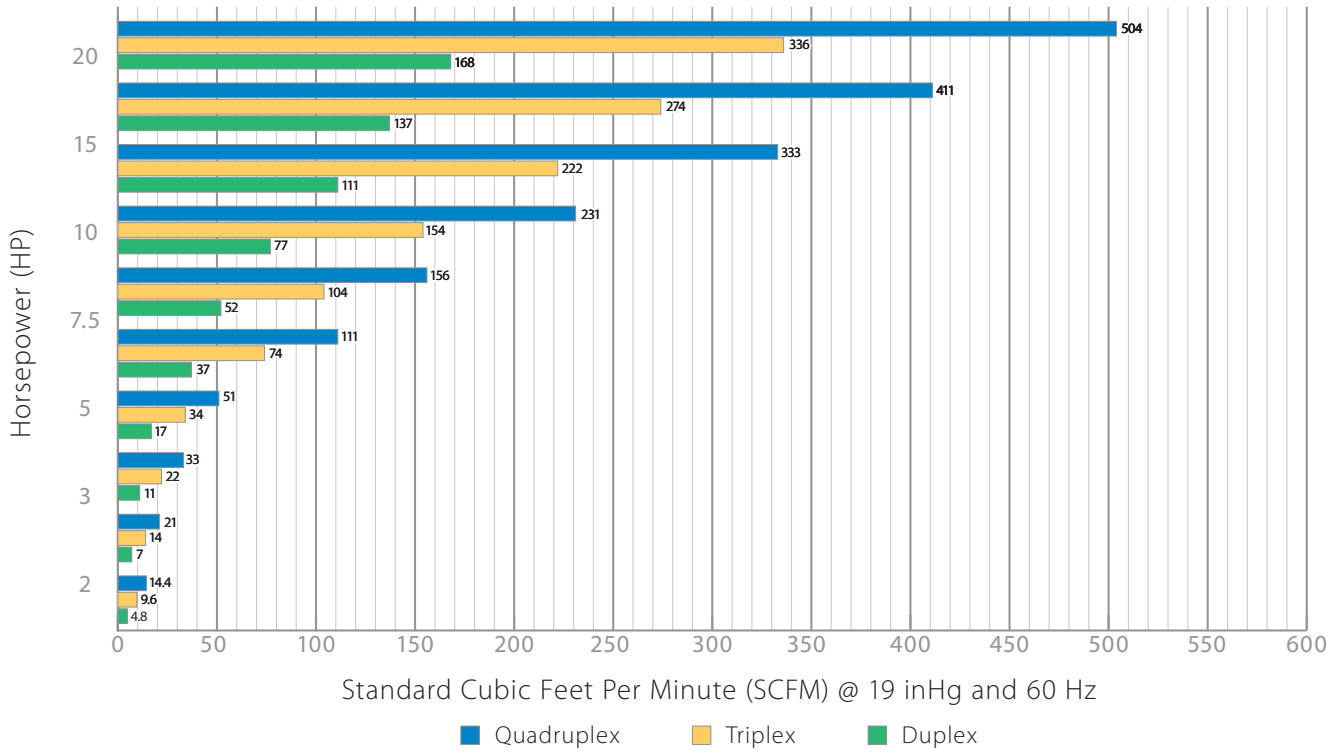
Standard Vacuum System Visual Selection Guide

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**

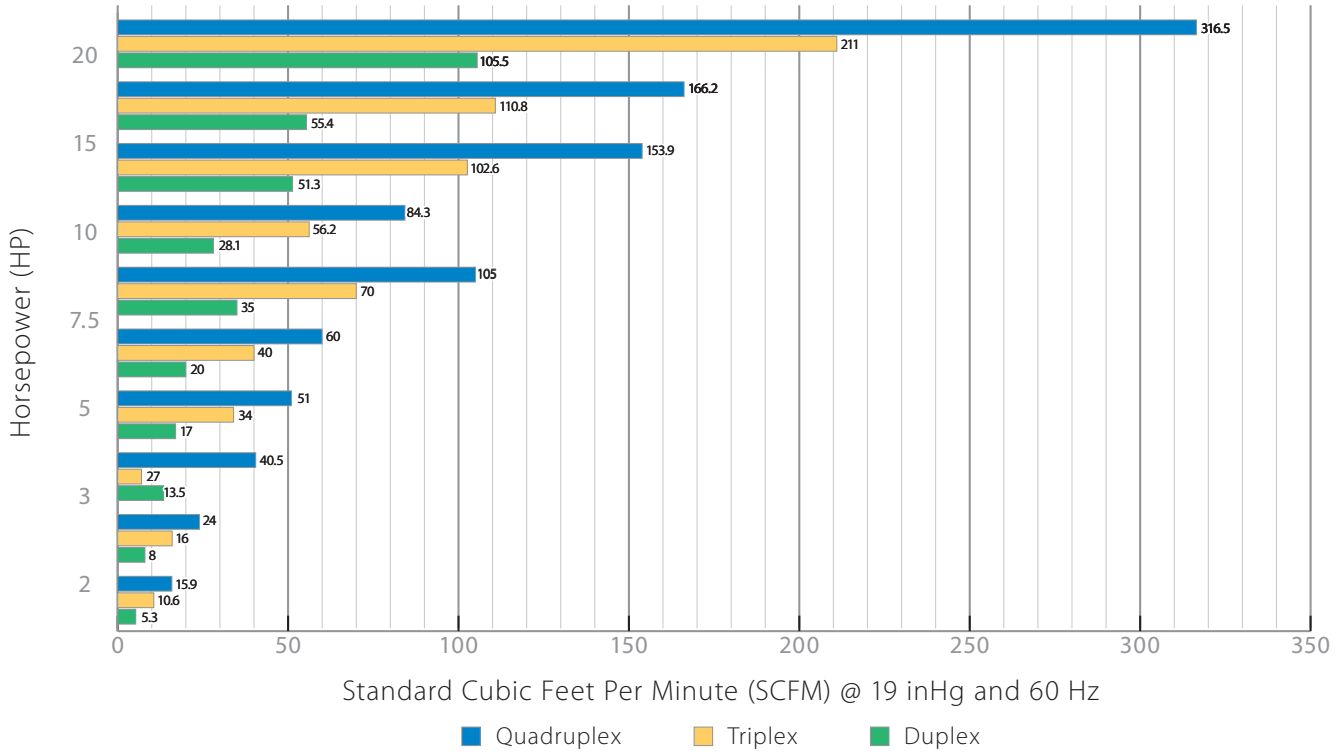
CONTACTLESS CLAW TECHNOLOGY VISUAL SELECTION GUIDE



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)

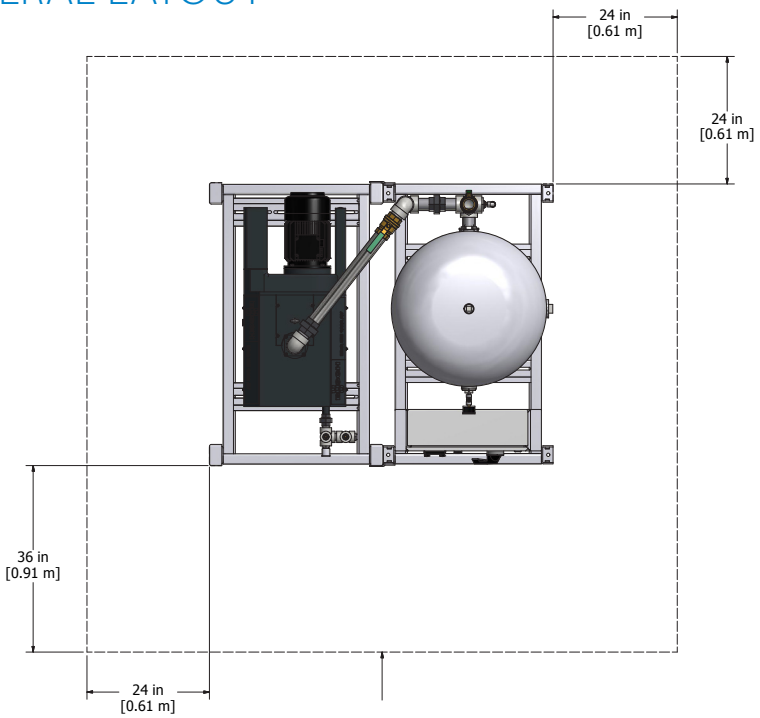
Model	System Layout	HP (kW)	NFPA SYSTEM CAPACITIES SCFM (LPM)		Complete System Dimensions* inches (metres)			
			50 Hz Motor	60 Hz Motor	Width	Length	Height	Total Sq. Ft. Required (M^2)
Horizontal Tank Mount (TH) Configuration								
V-RVL-D-080P-TH-N-010	Horizontal Tank Mount Duplex	1 (0.75)	4.0 (113)	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.

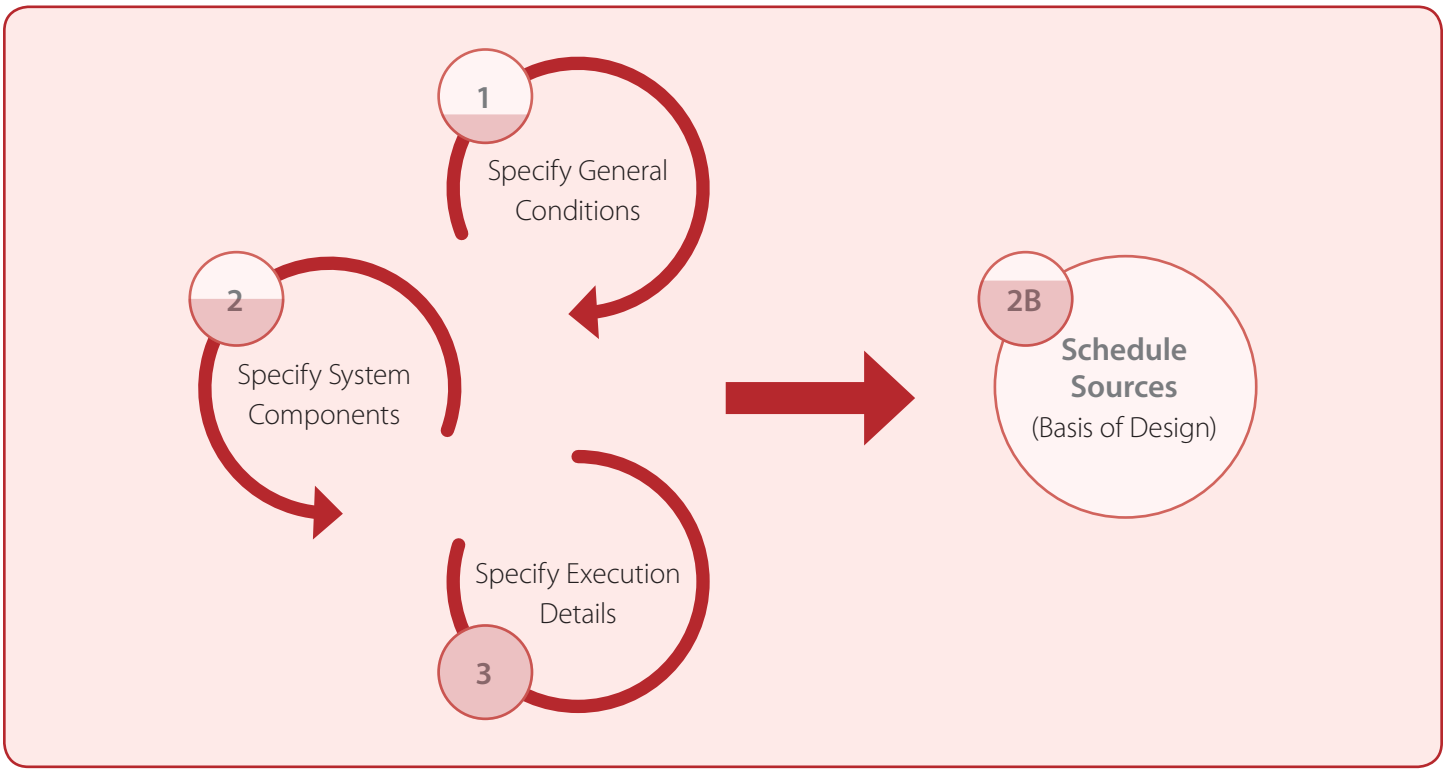
Please note that this Specification is being constantly updated and revised by Amico Source Corporation. Please ensure your copy is the most recent version available.

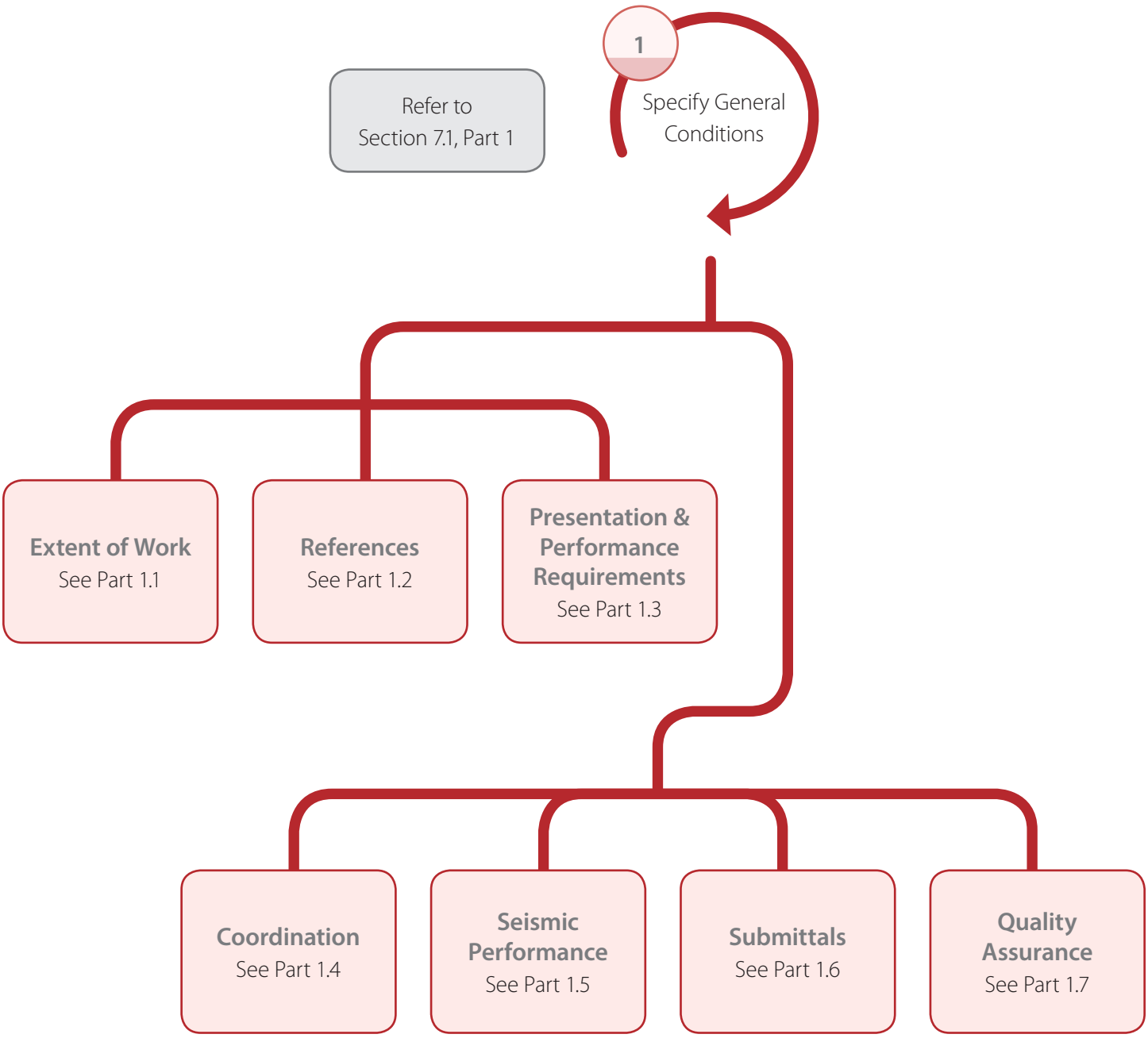
The second section contains the Schedule. For everything that is found in the Specification, you should refer to the Schedule afterwards. While the Specification is a written general document that outlines key design elements, the Schedule is what lists the specific criteria for the equipment. Thus, 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.

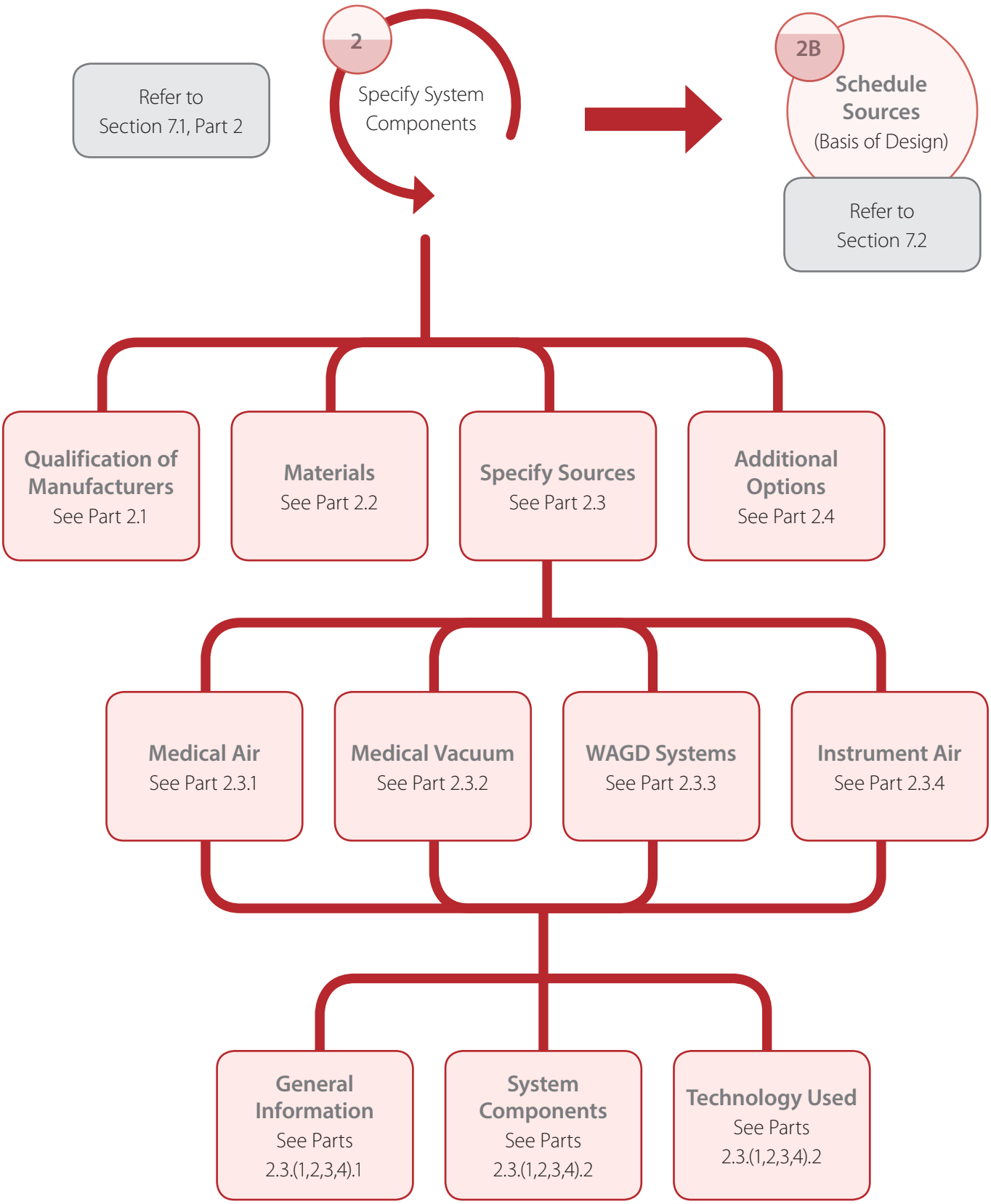
The second part of this chapter will provide the Schedule associated with all equipment from the System Selection Tables of Chapter 5 (Medical Compressed Air Systems) and 6 (Medical Vacuum [Suction] Systems). As with the Specification, this Schedule is being constantly updated by Amico Source Corporation. 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.

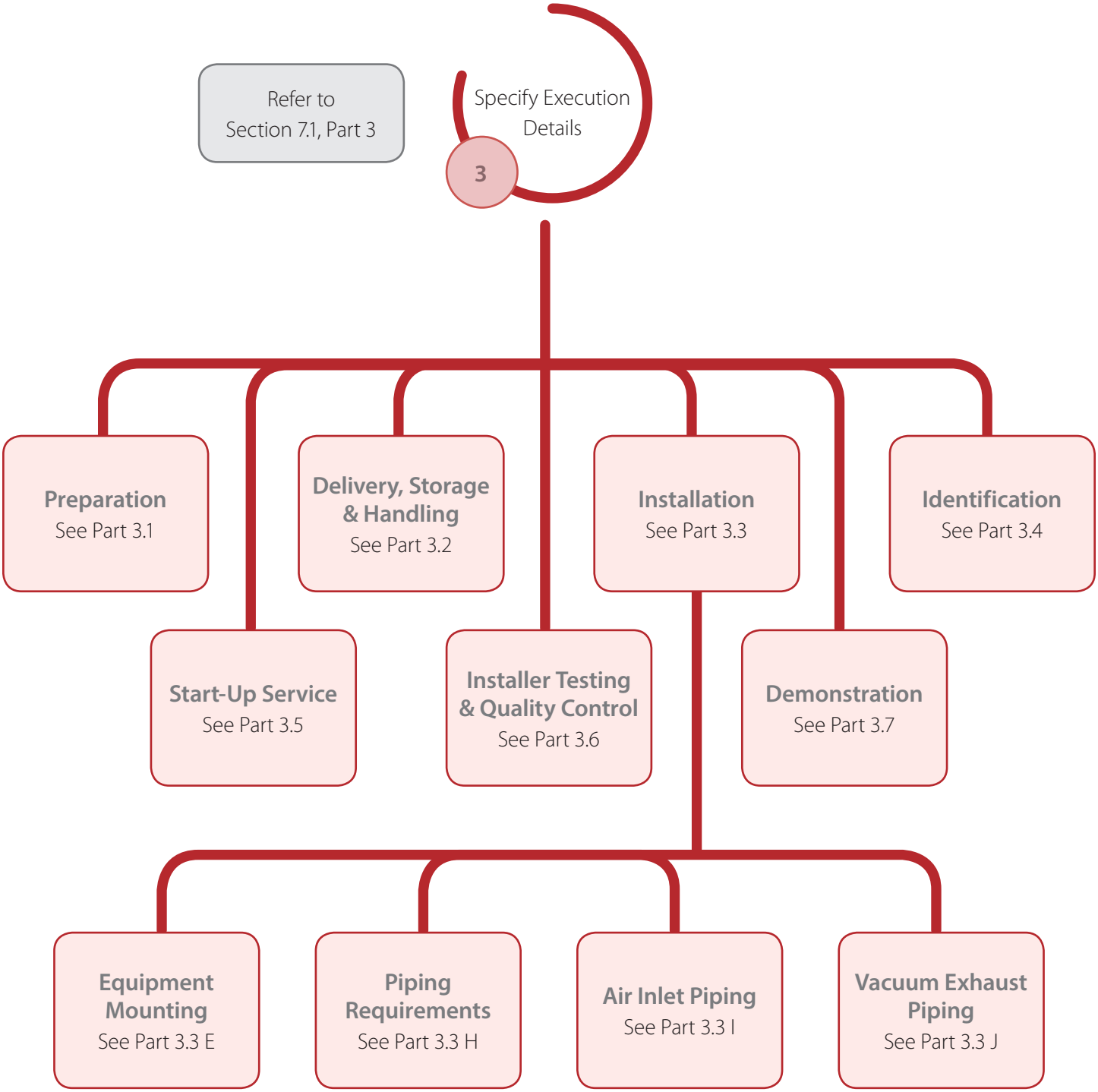
At this point, we recommend referring to Chapter 1 again for a list of the commonly used terms in the medical gas industry and their corresponding meanings, depending on their contextual use. These terms will be especially important in this Specification and Schedule chapter. The figure on the next page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

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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-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.

Chapter 9

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 9 – Medical Gas Alarm

Introduction

This chapter explains the process of selecting, configuring, placement and providing descriptions for various types of alarms. Alarms regulators and safety codes are referenced from NFPA 99 2018 edition. Specific diagrams, configurations and applications on Amico Alarm Systems will be provided. This section serves as references to your own design work.

9.1 Process Flow

Alarms are typically selected after other parts of the system are determined. Such options included number and type of signals required on the alarms and where to place the panels. Whereas area alarms can be placed before or after pipping is done. Area alarm also has to be correlated to zone valve placement. Switches and transducers must be placed after an installed valve since their placements are associated with each other.

9.2 NFPA 99 Codes and Regulations

All master, area, and local alarm systems used for medical gas and vacuum systems shall include the following:

1. Separate visual indicators for each condition monitored, except as permitted in 5.1.9.5.2 for local alarms that are displayed on master alarm panels.
2. Visual indicators that remain in alarm until the situation that has caused the alarm is resolved.
3. Cancelable audible indication of each alarm condition that produces a sound with a minimum level of 80 dBA at 0.92 m (3ft).
4. Means to indicate a lamp or LED failure and audible failure.
5. Visual and audible indication that the communication with an alarm-initiating device is disconnected.
6. Labelling of each indicator, indicating the condition monitored.
7. Labelling of each alarm panel for its area of surveillance.
8. Re-initiation of the audible signal if another alarm condition occurs while the audible alarm is silenced.
9. Power for master, area alarms, sensors and switches from the life safety branch of the essential electrical system as described in Chapter 6.
10. Power for local alarms, dew point sensors and carbon monoxide sensors permitted to be from the same essential electrical branch as is used to power the air compressor system.
11. Where used for communications, wiring from switches or sensors that is supervised or protected as required by 517.30(C)(3) of NFPA70 for life safety and critical branches circuits in which protection is any of the following types:

    a. Conduits
    b. Free air
    c. Wire
    d. Cable Tray
    e. Raceways

12. Communication devices that do not use electrical wiring for signal transmission will be supervised such that failure of communication shall initiate an alarm.

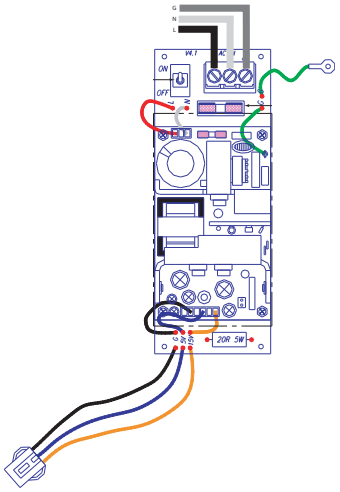
13. Assurance by the responsible authority of the facility that the labeling of alarms, where room numbers or designations are used, is accurate and up-to-date.
14. Provisions for automatic restart after a power loss of 10 seconds (e.g. during generator start-up) without giving false signals or requiring manual reset.
15. Alarm switches/sensors installed so as to be removable.

9.3 Common Feature on AMICO Modules

Amico alarms share 3 common features: System power supply, LCD module and sensor module.

SYSTEM POWER SUPPLY *AMICO ALARM MANUAL (DESCRIPTION OF MODULE)

The System Power Supply has been pre-installed into the back box assembly. The System Power Supply converts the AC voltage supply to the alarm into two voltages: 5 VDC (regulated) required by the microprocessor hardware and 15 VDC (unregulated) required by the buzzer and the LCD. This unit also contains the main ON/OFF power switch, the transformer, the heat sink, the main fuse and fuse cover, the rectifying circuitry, the terminal blocks and the low voltage DC power cable for connecting this unit to the annunciator module. The System Power Supply can be easily removed and reinstalled by unscrewing it from the back box.



LCD MODULE

The LCD Module contains the LCD screen, microprocessor, buzzer and the "MUTE" button. The function of the "MUTE" button is to silence an alarm that has occurred. By holding the "MUTE" button for 20 seconds, the module will display the high and low pressure set points. This module also contains a fail-safe relay that de-energizes when the buzzer is activated. This relay can be used with the Amico Remote Buzzer for applications requiring a remote audible alarm, master alarm or a Building Management System.

SENSOR MODULE

The Sensor Module contains the transducer which converts the source of the pressure/vacuum into a digital signal that is displayed on the LCD alarm. The sensor module shall be housed in an anodized aluminum and nickel-plated brass enclosure to act as a barrier against interference and it is temperature compensated. Each sensor is clearly labeled and color coded for the gas or vacuum being monitored. The sensor module contains a gas-specific DISS fitting to ensure correct connection of the proper sensor to the respective gas. Each sensor has been factory calibrated for the specific gas shown on the sensor housing.

9.4 Types of Alarms defined by NFPA 99

1. **Area Alarm**: Area alarm panels shall be provided to monitor all medical gas, medical-surgical vacuum, and piped WAGD systems supplying the following:
    a. Anesthetizing locations where moderate sedation, deep sedation, or general anesthesia is administered.
    b. Category 1 space *NFPA 99 Table 5.1.9.4 and (Category 1 space include post-anesthesia recovery, intensive care units and emergency departments) *NFPA 99 A.5.1.9.4(2).
2. **Master Alarm**: A master alarm system shall be provided to monitor the operation and condition of the source of supply, the reserve source (if any), and the pressure in the main lines of each medical gas and vacuum piping system *NFPA 99 5.1.9.2.
3. **Local Alarms**: Local alarms shall be installed to monitor the function of the air compressor system(s), medical-surgical vacuum pump system(s), WAGD systems, instrument air systems, and proportioning systems. *NFPA 99 5.1.9.5.

9.5 Area Alarm

REQUIRED PANEL

Area Alarm panels are necessary in patient care such as PACUs, ICUs, NICUs, emergency rooms, delivery rooms and operating rooms. The needs of an area alarm installed in any medical gas or vacuum system shall be determined by the risk towards the patient if gases can be potentially disrupted. Engineers/designers should acknowledge the dependent factors that lies on the risk of gas disruption to patient rather than merely focusing on the type of rooms.

ALARM REQUIREMENT IN TYPES OF HOSPITAL ROOMS

Intensive Care

1. Emergency Exam
2. Emergency Trauma
3. ICU/CCU
4. Labor and Delivery
5. NICU
6. PACU/Recovery
7. Psychiatric/Secure Room

Anestheitizing

1. Emergency Trauma
2. Labor and Delivery
3. NICU
4. Operating Room
5. Psychiatric/Secure Room

SELECTION OF AREA ALARM

There are two kinds of Amico's area panels. Both function and designed in the same way. However, Alert-3 alarm panels provide an LCD monitor for users, where Alert-4 panels provide an enhancement on notification by allowing users to receive alerts on their mobile devices or via Wi-Fi on a computer/laptop system.

ALERT–3 LCD ALARM

* Amico products comply with NFPA 99

*The Amico Alert-3 LCD Alarm complies with the following electromagnetic compatibility standards:

FCC Part 15 Class A and ICES-003 Class A.

Features

- LCD alarm panel incorporates the latest microprocessor based technology.
- Smallest 8 gas alarm in the industry.
- Auto detecting gas sensors.
- Digital sensors can be mounted locally or remotely utilizing a #22 gauge stranded, shielded, twisted pair cable ONLY.
- Sensors housed in a solid, tamper-proof enclosure to act as a barrier against any interference.
- LCD brightness and volume is field adjustable.
- LCD display readable in poor lighting conditions.
- Self diagnostic and error message display for ease of maintenance.
- Customizable screen text for displaying gas locations.
- High / Low alarm set points for each gas are field adjustable.
- Gas specific sensor with DISS nut and nipple.

General Specifications

- The Digital LCD Area Alarm system shall be an Amico Alert-3 series, complete with a five-year warranty.
- The LCD alarm shall be microprocessor based with a 10" [25.4 cm] screen and capable of monitoring up to 8 sensors. Sensors shall be mounted locally (in the rough-in box) by installing the copper pipe provided or mounted remotely. Sensors will be automated for gas specific detection.
- Each sensor shall be gas specific and an error message shall be displayed for an incorrect connection.
- Each specific gas service shall have a digital read-out comprising of 0-249 psi [0-1,717 kPa] for pressure and 0-30 inHg [-100-0 kPa] for vacuum. The digital read-out shall provide a continuous indication of each service being measured. A separate indicator shall be provided for each service indicating a green "NORMAL" and a red "HIGH" or "LOW" alarm condition.

- If an alarm occurs, the green indicator will change to red and a continuous audible alarm will sound. Pushing the (mute button/push to test button) will cancel the audible alarm, but the unit will remain in the alarm condition until the problem is rectified.
- The default set-points shall be +/- 20% variation from normal condition. In the calibration mode High/Low set-points shall be adjustable by on board push buttons. To view the set points and audible alarm sound level, press and hold the mute button for twenty (20) seconds.
- The box shall be fabricated from 18 gauge [1.3 mm] steel with a 3/8" [9.53 mm] O.D. type "K" copper pipe for connection to the service line. The box mounting brackets shall be adjustable to accommodate for different wall thicknesses.
- LCD Sensor operating pressure range:
  Mid-Pressure: (0 psi to 99 psi) - OXY, AIR, N2O, CO2
  High-Pressure: (0 psi to 249 psi) - NIT, IAR
  Vacuum: (0 inHg to 30 inHg) - VAC, WAGD, AGSS
- Input power to the Amico Alert-3 alarm is: 115-220 VAC, 50-60 HZ.

The Amico Alert-3 LCD Alarm is cETLus listed to UL standard 1069 and CSA standard C22.2 No. 205.
Amico products comply with NFPA 99 , CSA Z7396.1 and CSA Z305.1.
The Amico Alert-3 LCD Alarm complies with the following electromagnetic compatibility standards:
FCC Part 15 Class A and ICES-003 Class A.

ALERT–4 LCD ETHERNET AREA ALARM

*The Amico Alert-4 Series LCD Area Alarm is Ethernet ready, for use with internet Explorer, Google Chrome and Safari.
* Amico products comply with NFPA 99 and CSA Z7396.1.
* Amico Manual.

Features

- The LCD Alarm shall be capable of displaying an exact replica of the alarm on a computer screen via the facility's ethernet or internet. In addition, an exact image of the alarm can be displayed on a mobile device via wifi.
- The LCD Alarm will update its status every second.
- Self diagnostic and error message display for ease of maintenance.

General Specifications

- The Digital LCD Area Alarm system shall be an Amico Alert-4 series, complete with a five-year warranty.
- The LCD alarm shall be microprocessor based with a 10" (25.4 cm) screen and capable of monitoring up to 8 sensors. Sensors shall be mounted locally (in the rough-in box) by installing the copper pipe provided or mounted remotely. Sensors will be automated for gas specific detection.
- Each sensor unit is gas specific, with an error message display for an incorrect connection.

- Each gas service shall be provided with a digital read-out comprising of 0-249 psi (0-1,717 kPa) for pressure and 0-30"Hg (-100-0 kPa) for vacuum. The digital read-out shall provide a constant indication of each gas being measured, indicating a green "NORMAL" and a red "HIGH" or "LOW" alarm condition.
- If an alarm occurs, the green indicator will change to red and a continuous audible alarm will sound. Pushing the (mute button/push to test button) will cancel the audible alarm, but the unit will remain in the alarm condition until the problem is rectified.
- The default set-points shall be +/- 20% variation from normal condition. In the calibration mode, High/Low set points shall be adjustable by Setup button and selecting set points with up and down buttons. To view the set points, press and hold the mute button for twenty (20) seconds.

- The box shall be fabricated from 18 gauge (1.3 mm) steel with a 3/8" (9.53 mm) O.D. type "K" copper pipe for connection to the service line. The box mounting brackets shall be adjustable to accommodate for different wall thickness.
- LCD Sensor operating pressure range:
  Mid-Pressure: (0 psi to 99 psi) - OXY, AIR, N_2O, CO_2
  High Pressure: (0 psi to 249 psi) - NIT, IAR,
  Vacuum: (0 to 30 inHG) - VAC, WAGD, AGSS
- Input power to the Amico Alert-4 Series LCD Ethernet Area Alarm is: 115-220 VAC, 50-60 HZ.
- The Amico Alert-4 Series LCD Area Alarm is Ethernet ready, for use with Internet Explorer, Google Chrome and Safari.
- Amico products comply with NFPA 99, CSA Z7396.1 and CSA Z305.1.

SITING PANEL

Area alarms shall be located at a nurse's station or other similar location that will provide surveillance. *NFPA99 5.1.9.4.1 If there is no nurses' station, catergory 1 Area alarm should be placed in the following locations *NFPA 99 A.5.1.9.4 & A.5.1.9.4.1.

For each Gas Piped to the Area	
High Line Pressure	1. Near or within the location where the staff will most often be present (e.g., a staff base, a nurses' station). 2. Where audio alert will best carry throughout the unit being surveilled. 3. Where the panel is visible from the largest number of rooms, beds, or stations within the zone. 4. Where visualization of the panel will not be blocked (e.g., by cabinet doors, carts, room doors, curtains, supplies). 5. At a height above the floor at which the panel can be comfortably viewed and at which the mute button can be conveniently accessed. 6. Panel should indicate any increase or decrease by 20% from pressure line. 7. Alarm sensor should be located in an intensive/critical care area and anesthetizing location where deep to general sedation is administered. Alarm sensor should be installed on the patient or use side of each individual zone valve box assemblies.
Low line Pressure	

	If Piped to the Area
Low Medical Surgical Vacuum	1. Near or within the location where the staff will most often be present (e.g., a staff base, a nurses' station). 2. Where audio alert will best carry throughout the unit being surveilled. 3. Where the panel is visible from the largest number of rooms, beds, or stations within the zone. 4. Where visualization of the panel will not be blocked (e.g., by cabinet doors, carts, room doors, curtains, supplies). 5. At a height above the floor at which the panel can be comfortably viewed and at which the mute button can be conveniently accessed. 6. Panel should indicate any increase or decrease by 20% from pressure line 7. Alarm sensor should be located in an intensive/critical care area and anesthetizing location where deep to general sedation is administered. Alarm sensor should be installed on the patient or use side of each individual zone valve box assemblies.

WIRING

1. General Requirements

a. All wiring shall be protected from physical damage by raceways, cable trays or conduit in accordance with NFPA 70, National Electric Code or the Canadian Electrical Code.

b. All alarms are to be powered from the life safety branch of the emergency power system as required by applicable standards.

c. Alarm panel wires should be directly connected to switches or sensor as required by applicable standards.

d. All wire runs should be made with color coded wire. Record color, signal and source of signal for each wire lead to aid in connection of alarm finish components.

e. The alarm panel and remote sensors should not be installed near radio transmitters, electrical motors, electrical control room, switchgear, CT scanners, MRI machines or high voltage lines.

f. In the presence of any electrical, magnetic, radio frequencies, wireless or other interference, cable installation MUST be placed in metallic conduits.

g. No solid wire should be used for connecting sensors or master alarms to source equipment.

h. To protect from static electricity, ensure to discharge body static before installing the Medical Gas Alarm and Sensors.

i. Do not ground the shield drain wire at sensor or inside alarm panel back box.

j. Electrical cable should not run below sensors or behind the alarm box, to protect from radio frequencies and EMI.

2. Low Voltage Wire Type, Size and Other Requirements

All low voltage wiring must meet the following criteria:

a. #22 AWG stranded, shielded twisted pair wire ONLY must be used, rated for 300V and 60°C (140°F) minimum. (Belden 8451 or equivalent).

b. Marrette the sensor cable in a junction box (supplied by others) to the installation cable (supplied by others) to protect from physical damage, radio frequencies and EMI.

c. For multiple sensors, a multi-conductor #22 gauge stranded, shielded and twisted pair cable ONLY must be used.

The following rules along with references to this manual's schematics clarify wiring requirements. Two conductor cables (must be #22 gauge stranded, shielded and twisted part cable type) are required for each Gas Sensor module to the Gas Input board.

*Amico Manual Appendix H Alert-3 LCD Alarm.

WIRING THE PANEL

Remote Sensor

The sensor module is supplied with a 6-8", #22 gauge stranded, shielded twisted pair wire. Connect the wires to a junction box (not supplied) located near the sensor. Connect a shielded twisted part wire cable from the junction back box to back box assembly. Knockouts are provided throughout the alarm back box. Connect the red wire from the cable to the terminal display module marked "Sensor +". Connect the black wire to terminal "Sensor -".

- For Alert-4 alarm, maximum distance for wire cable is 500 – 2000 feet. Wiring process remains the same. For further technical specification, please refer to "Technical Specification" under Appendix section of Amico's Manual.

Local Sensor

The sensor module supplied with a 6-8" #22 gauge stranded, shielded and twisted pair wire which includes a red wire (positive) and a black wire (negative). Connecting the wires to the display modules as the graph shown Appendix D in Amico's Manual. After attaching the wires on the display module, take the red wire from the sensor and attach it to the terminal " Sensor +" on the display module and take the black wire from the sensor and attach it to the terminal "Sensor –". The terminal on the display module helps to clearly demonstrate a proper conncetion of the sensor wires.

LCD Display Module

If the dry contacts for a generic alarm is to be used for remote monitoring: connect the wires to the appropriate terminals COM (Common), NO (Normally Open) or NC (Normally Closed). Refer to Appendix F in Amico's Manual.

9.6 Master Alarm

PANEL LOCATION

The master alarm system shall consist of two or more alarm panels located in at least two separate locations, as follows:
*NFPA 99 5.1.9.2.1 – 5.1.9.2.2.

1. One Master alarm panel shall be located in the office or work space of the on-site individual responsible for the maintenance of the medical gas and vacuum piping systems.
2. In order to ensure continous surveillance of the medical gas and vacuum systems while the facility is in operation, the second master alarm panel shall be located in an area of continous observation (e.g., the telephone switch board, security office or other continously staffed location).
3. A centralized computer system shall be permitted to be substitued for one of the master alarms required in 5.1.9.2.1 computer system complies with 5.1.9.3.

ALERT–4 LCD ETHERNET MASTER ALARM

Features

- The LCD Alarm shall be capable of displaying an exact replica of the alarm on a computer screen via the facility's ethernet or internet. In addition, an exact image of the alarm can be displayed on a mobile device via wifi.
- The LCD Alarm will update its status every second.

General Specifications

- The Amico LCD Ethernet Master Alarm system shall be an Amico Alert-4 series, complete with a five-year warranty.
- Each LCD Alarm shall be microprocessor based and field adjustable.
- Ethernet capable for convenient viewing, remotely or wirelessly, anywhere in the building.
- Monitor up to 30 channels.
- Each channel can be labelled with up to 16 characters per line. Alarm conditions can be selected as normally open or normally closed.
- Channels can be grouped together or separated using Amico Master Configuration Software.
- When channels are in normal condition, the channel will illuminate in green.
- When a channel is in fault condition, an alarm will sound and both the channel heading and the channel in fault will illuminate in red. Heading will display channel status in fault.
- Maintenance mode for easy troubleshooting: press and hold the mute button for 20 seconds and the display will show the terminal port for each channel.
- Repeat alarm function shall be capable of turning on the buzzer again after a preset time, if the fault condition has not been rectified.
- Dry contact for remote monitoring.
- The Amico Alert-4 Series LCD Master Alarm is Ethernet ready, for use with Internet Explorer, Google Chrome and Safari.
- Amico products comply with NFPA 99, CSA Z7396.1 and CSA Z305.1.

AMICO MOBILE ECO SYSTEM APP

Amico is pleased to introduce the latest technology for monitoring the Medical Gas System of a hospital on a mobile phone. This App allows facilities to monitor the pipeline equipment in real time on an iPhone or Android phones.

The App will provide an exact and instant visual representation of the equipment in alarm condition, thereby eliminating the need for nurses to call maintenance personnel in the event of a gas outage. The App will also help maintenance personnel to localize the outage for a quicker resolution.

AMICO MOBILE ECO SYSTEM APP
Download Now!

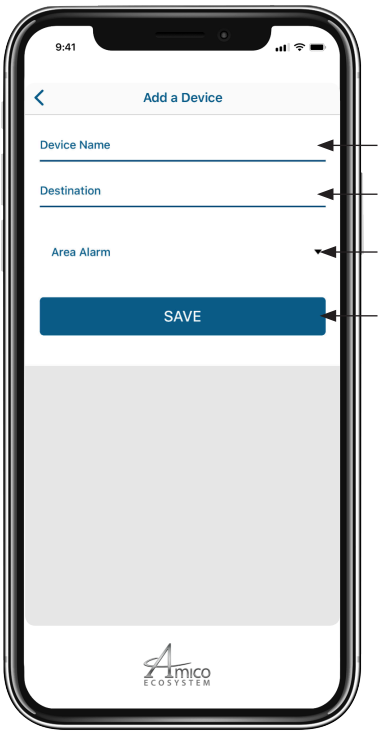
Download on the App Store

GET IT ON Google Play

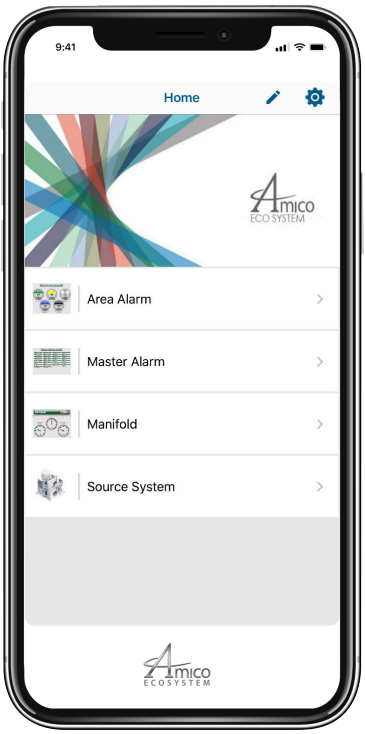
NOTE: If A4 alarm is given with local IP address, the phone must be connected to local WiFi before connecting the app to the A4 alarm. If A4 alarm is given with global IP address, connecting the phone to local WiFi is not needed.

Click and open Amico mobile eco system app on the phones

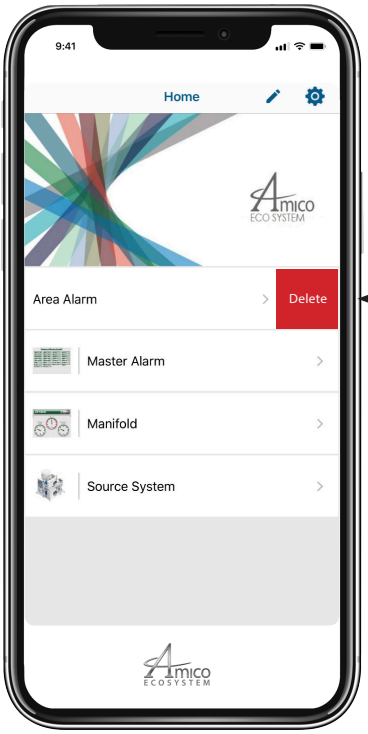
Home Screen



Add a Device Screen



Home Screen with Devices Added

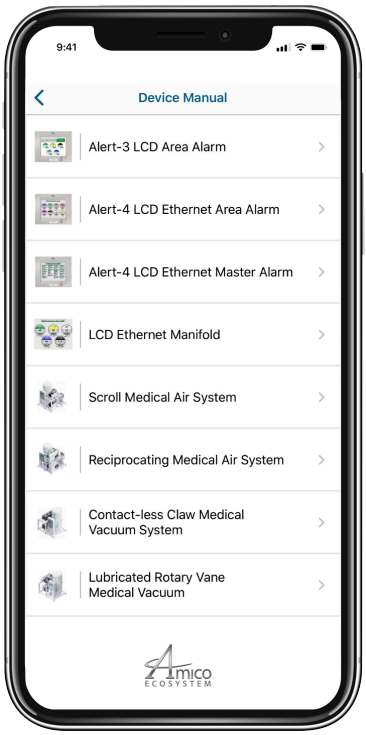


Slide Left to Delete Device

Click to Open Manuals

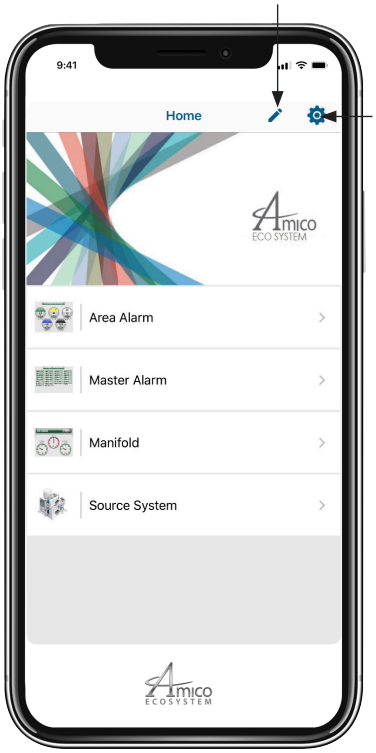
Click to Contact Amico

Display Exact Image of the Alarm



Device Manual

Re-order mode

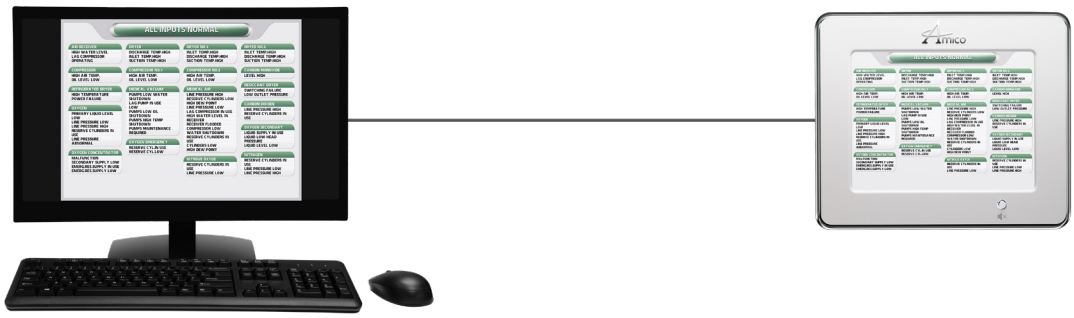


Click to add more devices

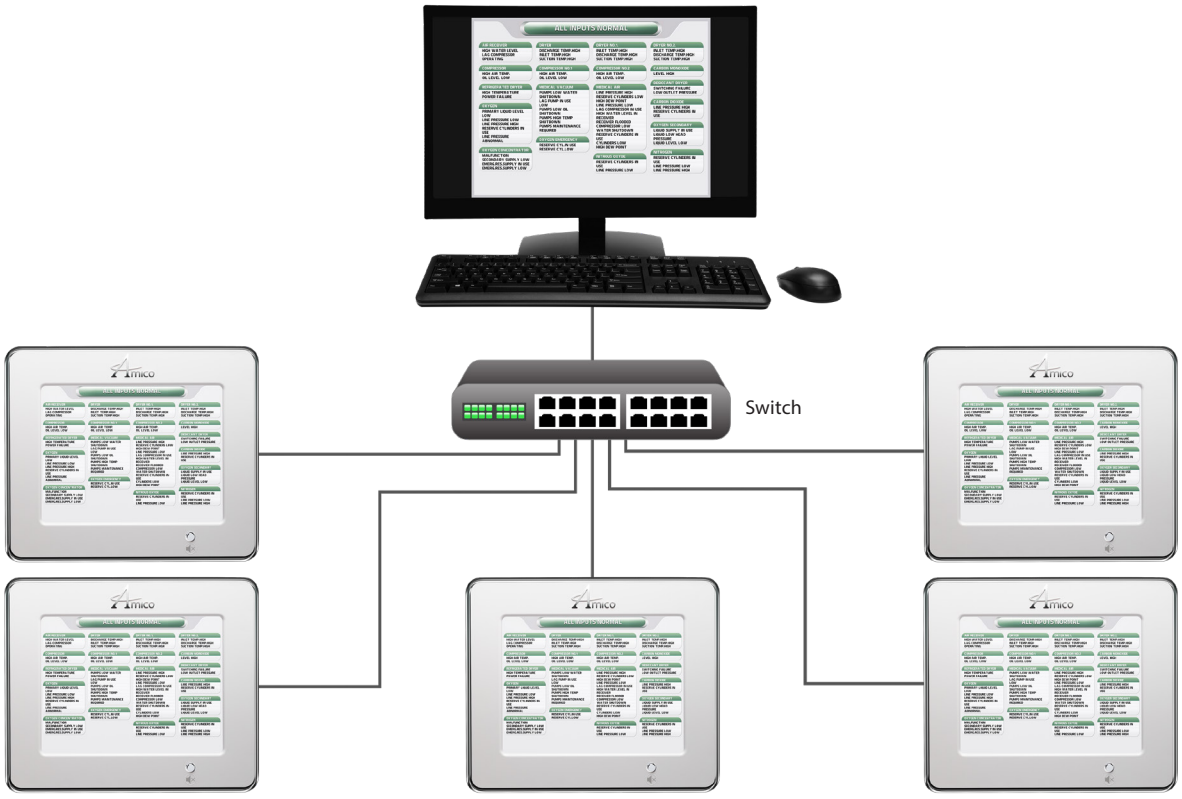
Press and hold the device screen to move the device

NETWORK DIAGRAMS

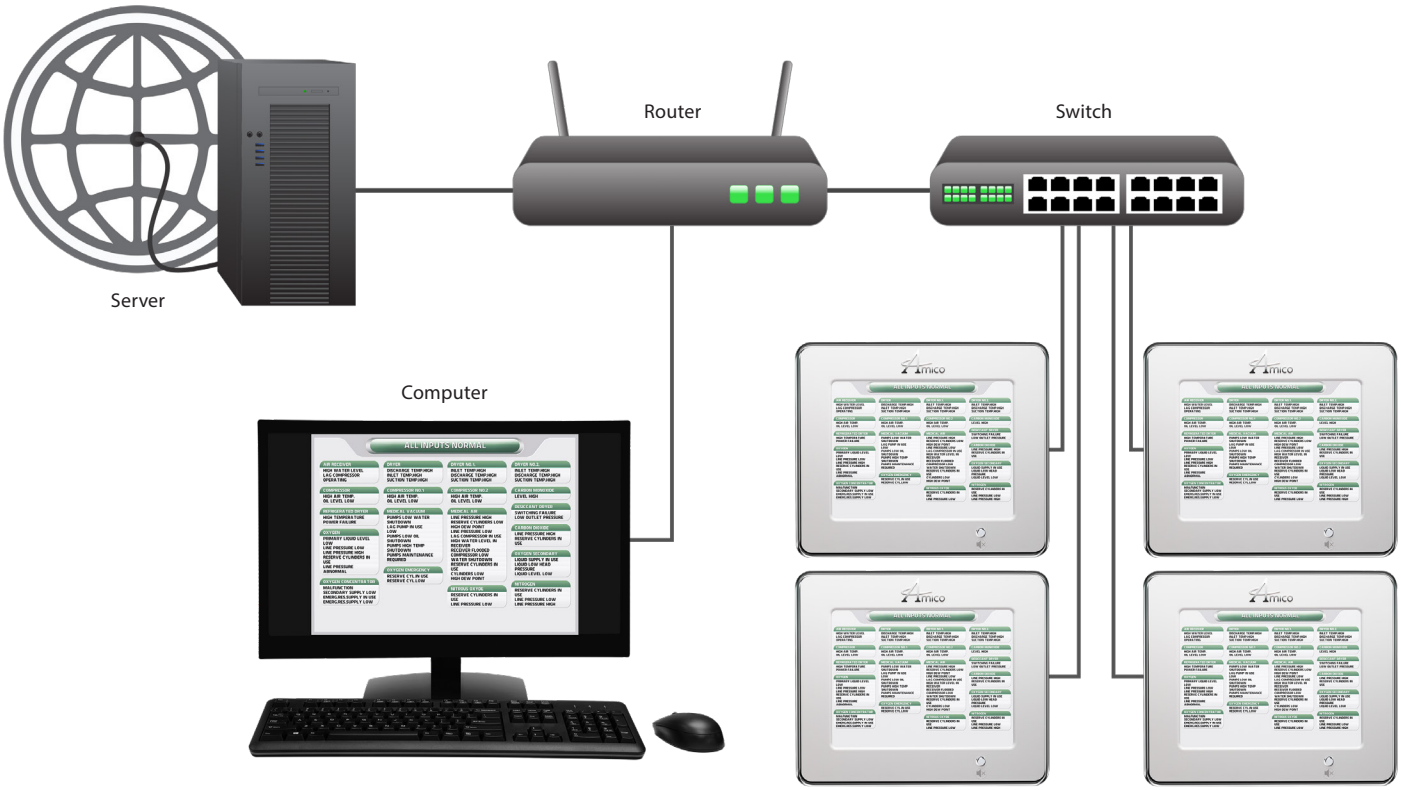
Direct Connection



Simple Unmanaged Network



Complex Managed Network



LOCAL ALARM AND MASTER ALARM SIGNAL CHART

Determine what source(s) you are planning to apply to your design, and identify the required alarm signals.

Local Alarm Signal Applications

<table>
<tr><th></th><th>Required</th><th colspan="2">Optional</th></tr>
<tr><td>Oil less Medical System</td><td>Dew Point High
CO High
Lag in Use
High temperature</td><td rowspan="5">High Water in Separator
High Water in Receiver</td><td></td></tr>
<tr><td>Oil- Free Medical Air System</td><td>Dew Point High
CO High
Lag in Use
High temperature</td><td></td></tr>
<tr><td>Simplex Hybrid Instrument Air System</td><td>Dew Point High</td><td rowspan="3">High temperature</td></tr>
<tr><td>Multiplex Instrument Air System</td><td>Dew Point High
Lag in Use</td></tr>
<tr><td>Medical Vacuum System</td><td>Lag in Use</td></tr>
<tr><td>Central WAGD System</td><td>Lag in Use</td><td></td><td></td></tr>
<tr><td colspan="4">• Apply only when water cooled aftercooler is implied.
• Apply when it is applicable to compressors or pumps.
• NFPA 99 – 5.1.9.5.4.
• Compressor or System that applies liquid ring compressor, shall include alarm signal for High Water in the Separators.
• Compressor or System that applies other than liquid ring compressor, shall include alarm signal for High Temperature.</td></tr>
</table>

Master Alarm Signal Applications

<table>
<tr><th></th><th colspan="3">Required</th><th>Optional</th></tr>
<tr><td>Oil less Medical System</td><td rowspan="3">High Pressure or Vac
Low Pressure or Vac
Dew Point High</td><td rowspan="3">CO high
Lag in use</td><td>High Temperature</td><td>High water receiver
Reserve Header in use</td></tr>
<tr><td>Oil- Free Medical Air System</td><td></td><td></td></tr>
<tr><td>Multiplex Instrument Air System</td><td>Reserve header in use
Reserve header Low</td><td rowspan="3">High Water Separator
High Water in Receiver
High Temperature</td></tr>
<tr><td>Medical Vacuum System</td><td>Low Pressure or Vac</td><td>Lag in use</td><td></td></tr>
<tr><td>Central WAGD System</td><td colspan="3"></td></tr>
</table>

- Apply only when water cooled aftercooler is implied.
- Apply when it is applicable to compressors or pumps.
- NFPA 99 – 5.1.9.5.4.
- Compressor or System that applies liquid ring compressor, shall include alarm signal for High Water in the Separators.
- Compressor or System that applies other than liquid ring compressor, shall include alarm signal for High Temperature.

Alarm on Source Types

<table>
<tr><th></th><th colspan="4">Required</th><th>Optional</th></tr>
<tr><td>Cylinder X Cylinder Manifold</td><td rowspan="4">High Pressure Low Pressure Change Over</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Cylinder X Cylinder X Cylinder Manifold</td><td rowspan="2">Secondary Header Low</td><td rowspan="3">Reserve in Use</td><td rowspan="3">Reserve Low</td><td></td></tr>
<tr><td>Container X Cylinder Manifold</td><td>Main Contents Low</td></tr>
<tr><td>Container X Container Manifold</td><td></td><td></td></tr>
<tr><td>Bulk Cryogenic System</td><td></td><td>Main Contents Low</td><td>Reserve not Functional</td><td>Reserve Low Reverse in Use</td></tr>
</table>

Siting Panel

Siting for master panel has to be highly visible at all time. Ensuring the panel is not at locations where it has the risk of being blocked by any open door, storages or other potential interferences.

The first master panel is for the pupose of allowing medical staff to have quick access and continous surveillance. The second master alarm panel needs to be monitored nonstop and is normally located in the sercuity office or any similar security level location. There are swiches for various conditions other than indication on “High” and “Low”. During the process of siting, please be reminded that swiches have to be placed on demand checks in order to conduct examination without shutting off the system.

CATEGORY 1 MASTER ALARM FOR GAS AND VACUUM SYSTEM NFPA 99 5.1.9.2

Nitrogen

<table>
<tr><th>Master Alarm Signal Nitrogen</th><th>Nitrogen Main Line Pressure High</th><th>Nitrogen Main Line Pressure Low</th><th>Nitrogen Changeover to Secondary Supply</th><th>Nitrogen Main Supply Less than 1 Day (low content)</th><th>Nitrogen Reserve in use</th><th>Nitrogen Reserve Supply Less than 1 Day (low content)</th><th>Nitrogen Reserve in use</th></tr>
<tr><td>Manifold for Gas Cylinder</td><td rowspan="4">Required</td><td rowspan="4">Required</td><td rowspan="2">Required</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Manifold for Cryogenic Liquid Cylinders with Reserve</td><td></td><td rowspan="3">Required</td><td rowspan="2">Required</td><td></td></tr>
<tr><td>Cryogenic Bulk with Cryogenic Reserve</td><td></td><td></td><td rowspan="2">Required</td><td></td></tr>
<tr><td>Cryogenic Bulk with Cylinder Reserve</td><td></td><td></td><td></td><td></td></tr>
</table>

Carbon Dioxide

Master Alarm Signal Carbon Dioxide	Carbon Dioxide Main Line Pressure High	Carbon Dioxide Main Line Pressure Low	Carbon Dioxide Changeover to Secondary Supply	Carbon Dioxide Main Supply Less than 1 Day (low content)	Carbon Dioxide Reserve in use	Carbon Dioxide Reserve Supply Less than 1 Day (low content)	Carbon Dioxide Reserve Pressure Low (not functional)
Manifold for Gas Cylinder	**Required**						
Manifold for Cryogenic Liquid Cylinders with Reserve	**Required**				**Required**	**Required**	
Cryogenic Bulk with Cryogenic Reserve	**Required**					**Required**	**Required**
Cryogenic Bulk with Cylinder Reserve					**Required**		

Medical Air

Master Alarm Medical Air	Medical Air Main Line Pressure High	Medical Air Main Line Pressure Low	Medical Air Changeover to Secondary Supply	Medical Air Dew Point	Medical Air Production Stop
Manifold for Gas Cylinder	**Required**	**Required**	**Required**		
Manifold for Cryogenic Liquid Cylinders with Reserve					
Cryogenic Bulk with Cryogenic Reserve					
Cryogenic Bulk with Cylinder Reserve					
Medical Proportioning System					**Required**
Medical Air Compressor	**Required**	**Required**		**Required**	

Oxygen

<table>
<tr><th>Master Alarm Signal Oxygen</th><th>Oxygen Main Line Pressure High</th><th>Oxygen Main Line Pressure Low</th><th>Oxygen Changeover to Secondary Supply</th><th>Oxygen Main Supply Less than 1 Day (low content)</th><th>Oxygen Reserve in use</th><th>Oxygen Reserve Supply Less than 1 Day (low content)</th><th>Oxygen Reserve Pressure Low (not functional)</th></tr>
<tr><td>Manifold for gas cylinder</td><td colspan="2" rowspan="4">Required</td><td rowspan="2">Required</td><td></td><td rowspan="4">Required</td><td></td><td></td></tr>
<tr><td>Manifold for Cryogenic Liquid Cylinders with Reserve</td><td></td><td></td><td></td></tr>
<tr><td>Cryogenic Bulk with Cryogenic Reserve</td><td></td><td rowspan="2">Required</td><td rowspan="2">Required</td><td>Required</td></tr>
<tr><td>Cryogenic Bulk with Cylinder Reserve</td><td></td><td></td></tr>
</table>

Nitrous Oxide

Master Alarm Signal Nitrous Oxide	Nitrous Oxide Main Line Pressure High	Nitrous Oxide Main Line Pressure Low	Nitrous Oxide Changeover to Secondary Supply	Nitrous Oxide Main Supply Less than 1 Day (low content)	Nitrous Oxide Reserve in use	Nitrous Oxide Reserve Supply Less than 1 Day (low content)	Nitrous Oxide Reserve Pressure Low (not functional)
Manifold for Gas Cylinder	**Required**	**Required**	**Required**				
Manifold for Cryogenic Liquid Cylinders with Reserve	**Required**	**Required**	**Required**		**Required**	**Required**	**Required**
Cryogenic Bulk with Cryogenic Reserve	**Required**	**Required**		**Required**	**Required**	**Required**	**Required**
Cryogenic Bulk with Cylinder Reserve	**Required**	**Required**		**Required**	**Required**	**Required**	**Required**

WIRING THE PANEL (MASTER ALARM MANUAL)

Display Master Module

1. Source equipment needs to be directly attached to the master alarm.
2. Pull the remote signal wires into the alarm panel. Make the connections to the terminal blocks located on the side of the status module. The wiring is fail-safe normally closed (NC) connections from the source equipment. The signal level is 5 VDC.
3. Make the appropriate wiring connections.
4. For version 3 and version 4, ensure that the unused terminals in the master module are jumpered. If this is not done, the terminals that have not been jumpered will go into alarm.

CONNECTING PROCEDURE WITH ALERT-4 MASTER ALARM SYSTEM

1. A #22 gauge stranded, shielded & twisted pair cable only must be used to connect from the junction box to the back box assembly. Knockouts are provided throughout the alarm back box. #22 gauge stranded, shielded, & twisted pair cable only must be used.
2. Connect the red wire from the terminal on the display module marked "+". Connect the black wire to terminal "-".
3. Repeat the above procedures with the remaining point modules using the wiring diagram.

NFPA 99 5.1.9.2.3.1 has specific requirements on communicating by wire:

1. Each of the 2 mandatory alarms shall be wired independently to the initiating device(s) for each signal.
2. The wiring between each mandatory alarm(s) and initiating device(s) shall not utilize common conductors that, if interrupted, would disable more than one signal.
3. Each set of wires shall run into the initiating device(s) without interruption other than in-line splices necessary to complete the necessary length of wire.
4. Where initiating devices are remote from the building and the wiring is to run under ground in compliances with NFPA70, the following exceptions shall be permitted to be used:
    a. Wiring from initiating devices and through the underground section shall be permitted to be run to a junction box located where the wiring first enters the building.
    b. A single set of wires complying with 5.1.9.2.3.1(B) and 5.1.9.2.3.1 (C) for each signal shall be permitted to connect the initiating device and the junction box.
    c. Between the junction box and the 2 mandatory alarm panels, wiring shall comply with 5.1.9.2.3.1(A) through 5.1.9.2.3.1(C), 5.1.9.2.3.4, and 5.1.9.2.3.5 in all respects.

*Wires that run in a room should use rigid conduit. Ensure alarm system is connected to an essential electrical system with protection.

FINAL PROCESS

After identifying the required number of alarms and the types of alarm applying to your plan. Verify the following areas to ensure all the requirements are met:

- Signals and gases that needs to be monitored.
- Location of alarms.
- Network building requirement.
- Necessary design and specifications, if any.
- Checklist on types of alarms required in certain types of rooms.

Please refer to Amico's medical alarm manuals for in depth explanation and elaborations of installations and configuration process. Information such as troubleshooting and maintenance are also provided in each manual for users.

9.7 Category 2 Piped Gas and Vacuum Systems

The definition of Category 2 is based on the level of reliability on medical gases during a patient treatment when a patient can tolerate a short duration of MGVS downtime without causing significant impact. A category 2 system failure is likely to cause minor injury to patient, staff, or visitor.

APPLICATION NFPA99 5.2.1.2

Category 2 piped gas or vacuum system requirements shall be permitted when all of the following criteria are met:

- Only moderate sedation: minimum sedation, as defined in 3.3.65.3 and 3.3.65.4; or no sedation is performed. Deep sedation and general anesthesia shall not be permitted.
- The lost of the piped gas or piped vacuum systems is likely to cause minor injury to patients, staff, or visitors.
- The facility piped gas or pipped vacuum systems are intended for Category 2 patient care space per 3.3.135.2.

WARNING SYSTEM NFPA 99 5.2.9

Warning systems related to Category 2 system should include the master, area and local alarm functions of a Category 1 system. However, there are exceptions:

- Warning system shall be permitted to be a single alarm panel. A Category 2 warning alarm system allows the implication of single alarm panel, also known as the combo unit alarm where the area alarm and master alarm can be monitored on one panel.
- Alarm panel should be located in an area where it is under continous surveillance while facility is in operation.
- Pressure and vacuum switches/sensors shall be mounted at the source equipment with a pressure indicator at the master alarm panel.

DEVELOPING AN EMERGENCY PLAN FOR CATEGORY 2 SYSTEM

- In a standard scenario, system alarms are installed according to NFPA 99 regulations. However, in a constant changing environment, clinical facilities have to conduct plans in order to respond to unusual situations. It is vital for you to conduct and verify the initial risk assessment in determining the category of the area.
- In deed, under the code NFPA 99 5.2.3.5(2), facility staff shall develop their emergency plan to deal with the loss of medical air in Category 2 system. Medical air is not an absolute requirement to a Category 2 system due to the use of medical gas during a patient treatment which will disqualify the facility from installing a Category 2 system alarm. Hence, there are currently no rules and regulations in regards to the installation. However, where medical gas is provided, systems are not required to be duplexed. Alternatively, the facility will need to develop plans for system failure.

MASTER ALARM BY COMPUTER SYSTEM

When a computer system is used to substitute as one of the two required alarm panels, it improves the efficiency in monitoring medical gases in different facilities. Users are now able to obtain notifications from computer systems. Therefore, computers and programs are require to follow a list of mechanical and electrical characteristics before any implication. Understanding the intention of a computer system is not to lower the security level or surveilances, but merely to provide another optiion for users to work with their design.

It is important to have the computer system and the program function as an independent panel with additional features to ensure the computer system itself is sufficient to run on its own and able to deliver significant information.

MECHANICAL AND ELECTRICAL CHARACTERISTICS NFPA 99 5.1.9.3.1

Computer systems used to substitute for alarms shall have the following mechanical and electrical characteristics:

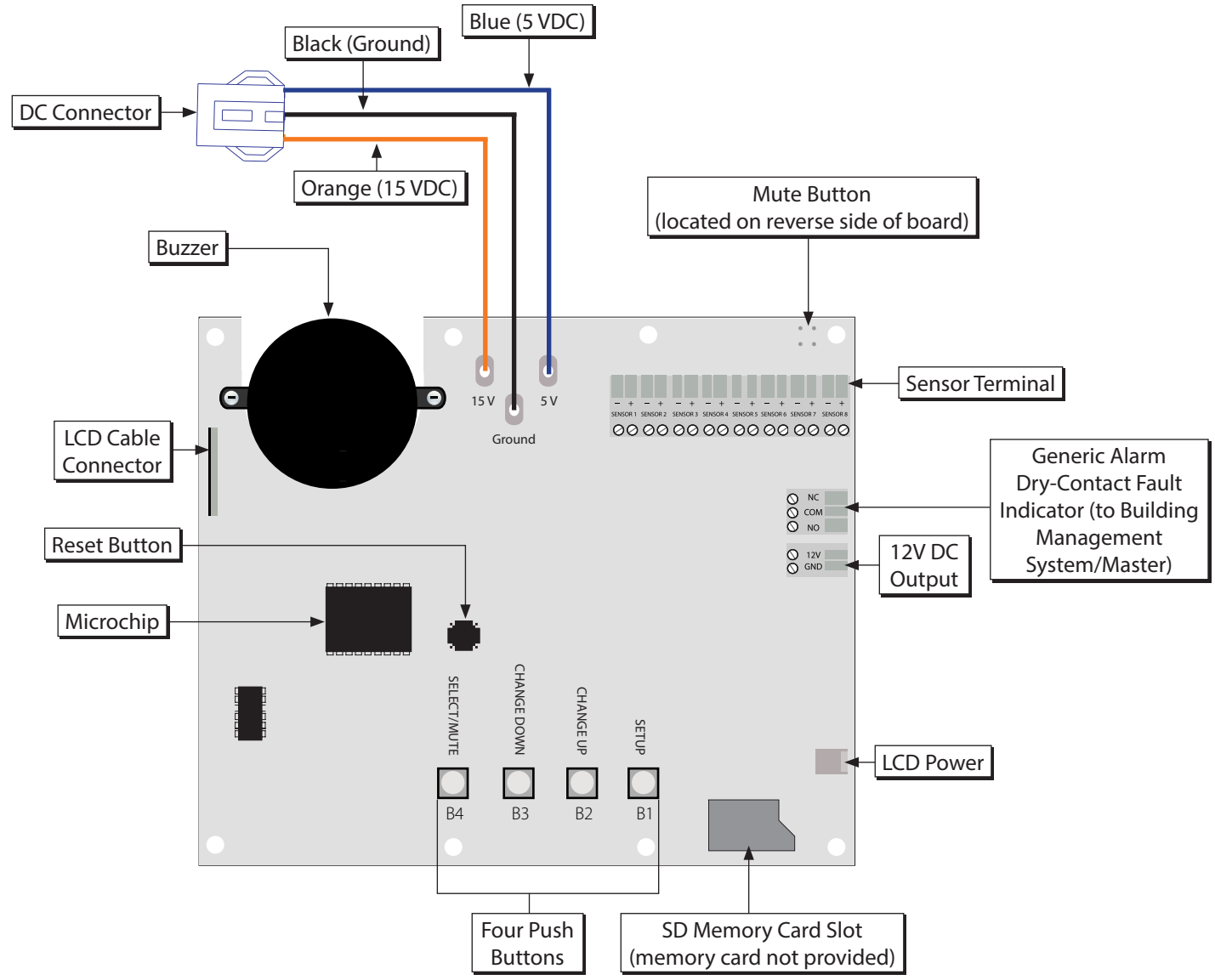
- The computer system cannot be interrupted at any time, and be provided with power supplies as needed to ensure such reliability.
- The computer system shall be continously monitored by responsible individuals or parties.
- Any signal interface devices shall be able to initiate alarms when any failure occurs.
- If the computer system doesn't power the signaling switches/sensors from the same power supply required in 5.1.9.3.1(1), then it should be powered by the life safety branch of the essential electrical system.
- The computer system shall be able to communicate directly to sensors/switches in the alarm initiating devices. Similarly to an alarm panel if operation of another alarm panel is impaired.
- Continous supervision of the signaling switches and sensors for computer system commuication. Signal an alarm when failure occurs.
- Computer system should feature an audio alert function per 5.1.9.1(3), except the audio alert shall be permitted to be only as loud as needed to alert the system operator.
- The facility shall ensure compliances with 5.1.9.1(12).

PROGRAM SYSTEM NFPA 99 5.1.9.3.2

The operating program for computer systems used to substitute for alarms shall include the following:

- The medical gas alarm shall be allocated the priority of a life safety signal.
- A medical gas alarm signal shall interrupt any other activity of lesser priority to run the alarm algorithm(s).
- The algorithm shall include activation of an audible alert, activation of any remote signaling protocol, and display of the specific condition in alarm.
- The alarm algorithm shall provide for compliance with 5.1.9.1(1) through 5.1.9.1(5) and 5.1.9.1(8).

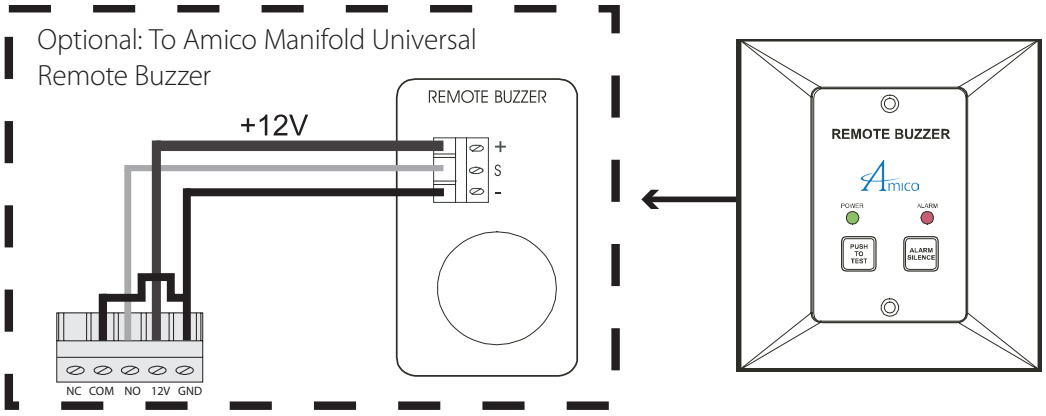
WIRING DIAGRAM: LCD BOARD



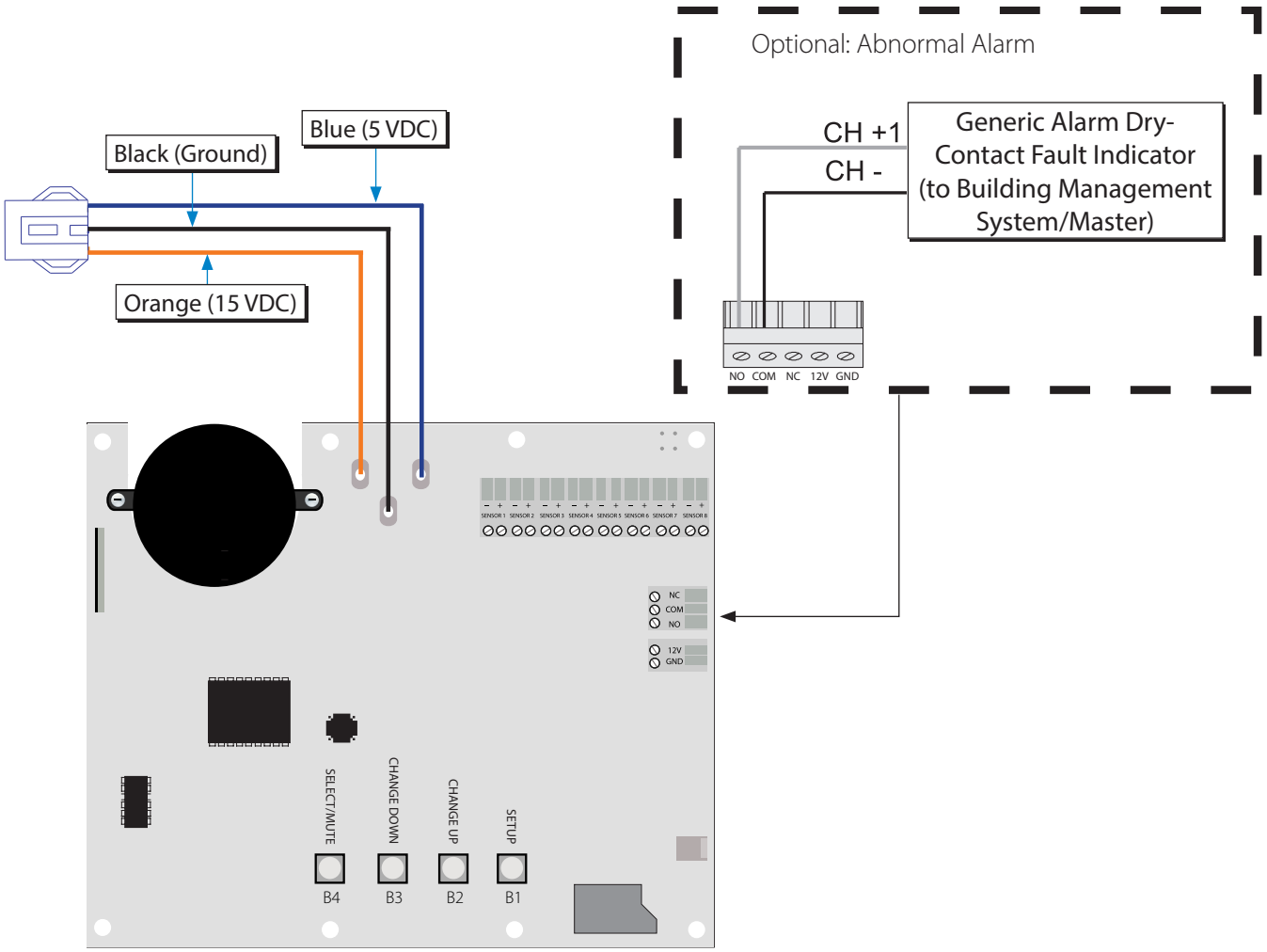
CAUTION:

1. Keep the shield drain wires as short as possible and taped to prevent from grounding, so they cannot touch the front panel circuit board when front panel is closed.
2. To protect from static electricity, ensure to discharge body static before installing the Medical Gas Alarm and Sensors.
3. Warranty void if push button is broken or if the frame assembly is disassembled.

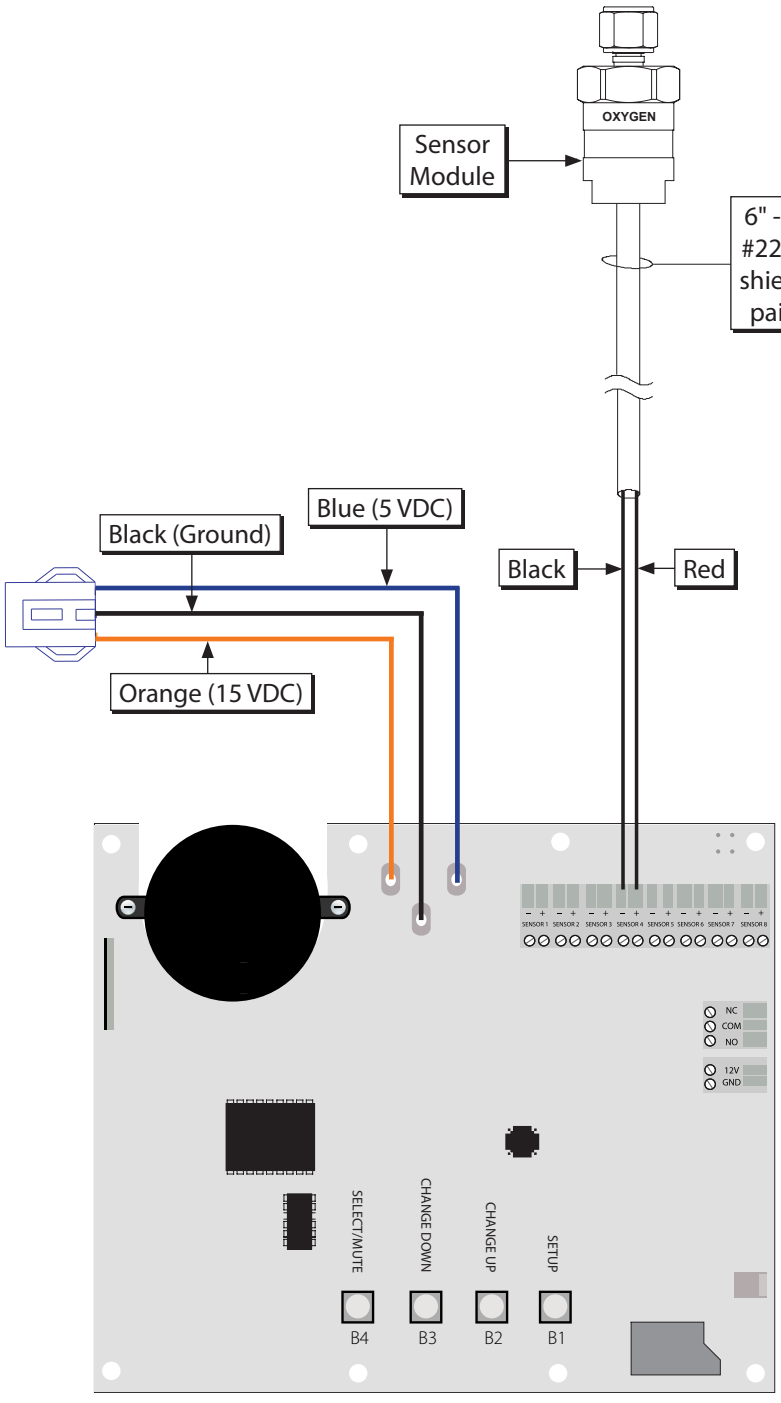
WIRING DIAGRAM: LCD DISPLAY BOARD - ALARM BUZZER



NOTE: Amico recommends max. 50 ft. to power up buzzer from alarm panel to power up the buzzer. More than 50 ft., a A3P-POWER-V4 is required to supply voltage for the alarm buzzer.



WIRING DIAGRAM: LCD DISPLAY BOARD - LOCAL SENSOR



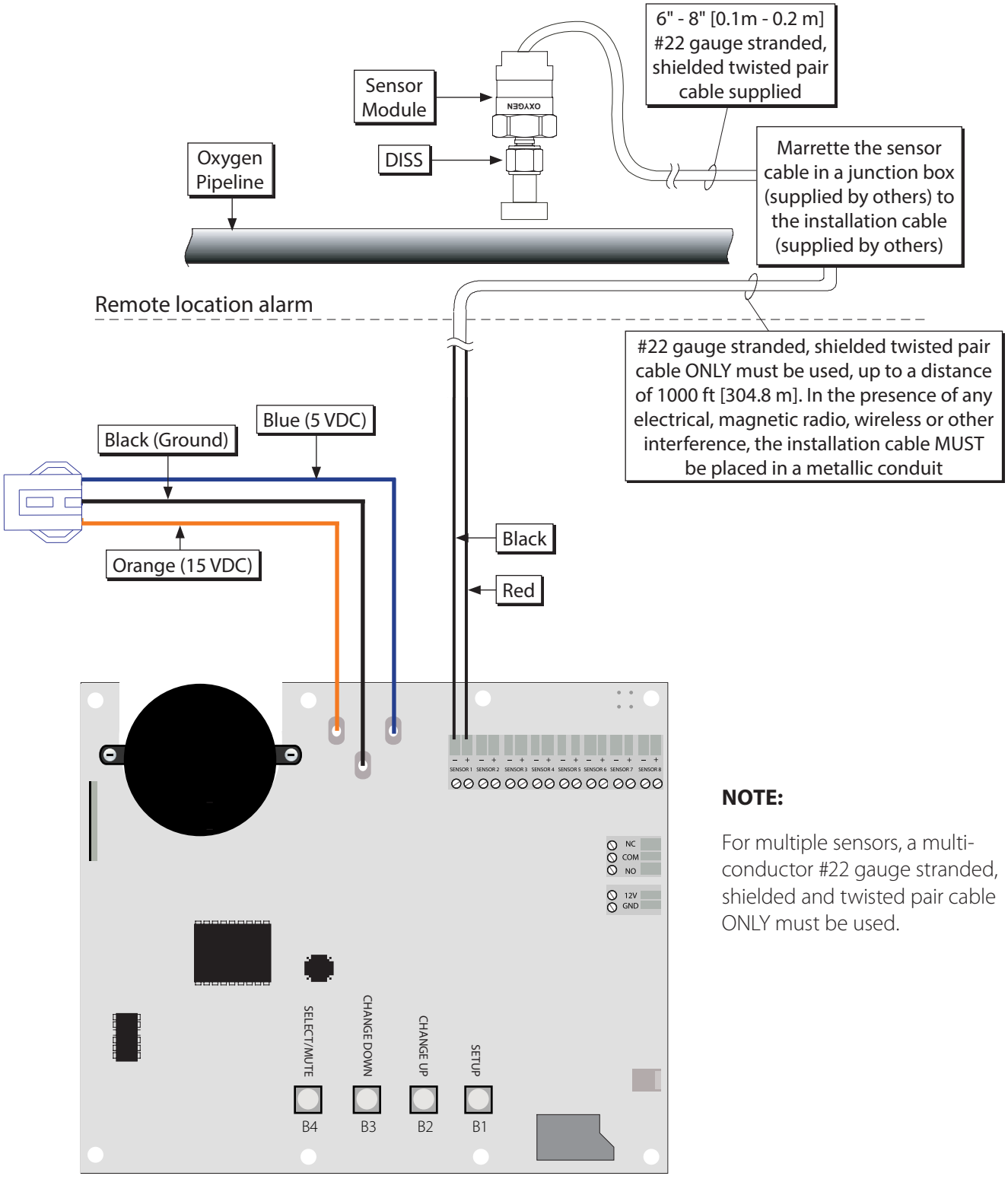
NOTE:

Do not ground the shield drain wire at sensor or inside alarm panel back box.

CAUTION:

To protect from static electricity, ensure to discharge body static before installing the Medical Gas Alarm and sensors.

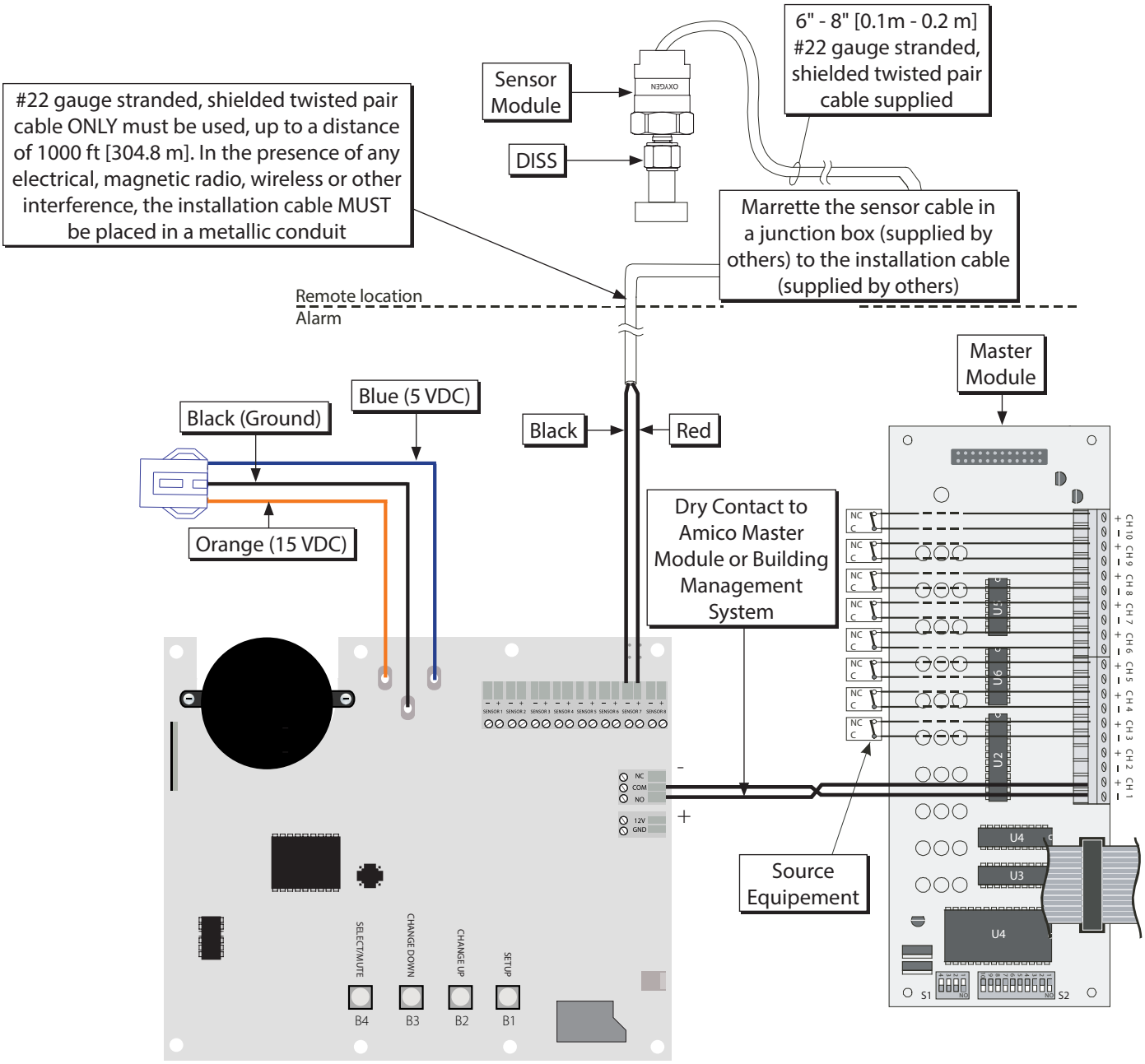
WIRING DIAGRAM: LCD DISPLAY BOARD - REMOTE SENSOR



NOTE:

For multiple sensors, a multi-conductor #22 gauge stranded, shielded and twisted pair cable ONLY must be used.

WIRING DIAGRAM: LCD DISPLAY BOARD - MASTER MODULE



NOTE:

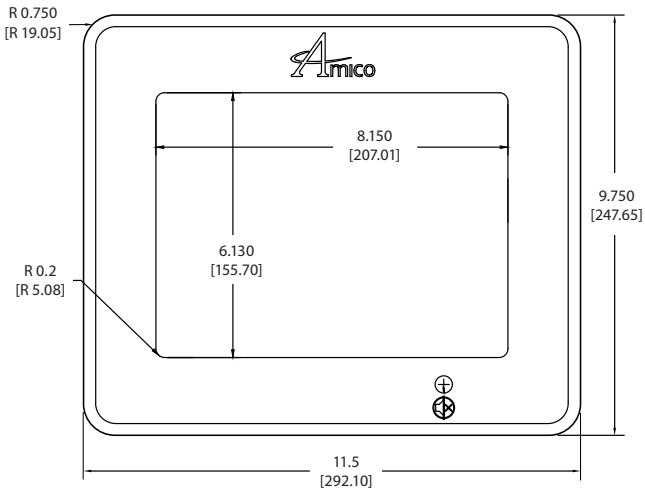
Jumper any unused points on the Master module. Turn OFF dip-switches for any unused points (Location SW-2).

CAUTION:

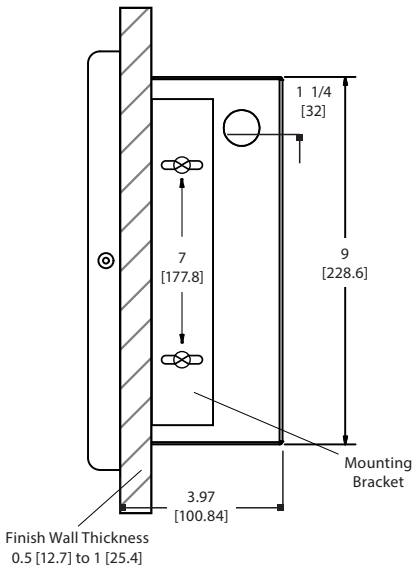
For Master Alarm, source equipment signal wires must be connected to normally-closed dry contacts. No electrical voltage can be present and contacts must be closed during normal equipment operation. When contacts are open; an alarm condition will be activated.

TECHNICAL SPECIFICATIONS AND MODEL NUMBER

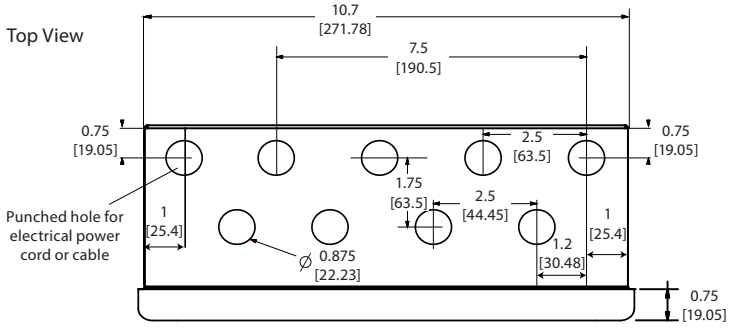
Front View



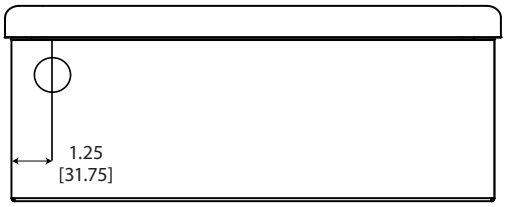
Side View



Top View



Bottom View



NOTE: LCD Alarm itself is 8 lbs. Each sensor is 1 lb.

Model Number:

A4M-E-XX

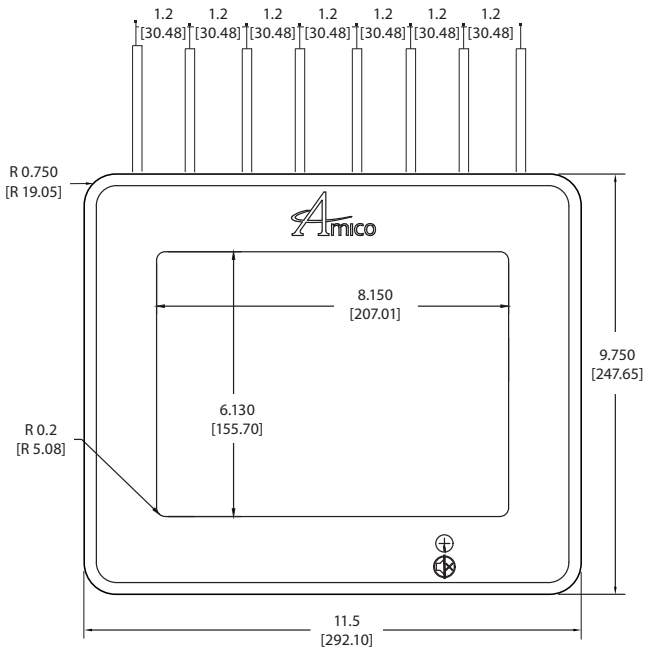
The "XX" Represents the Number of Points:

1 to 10 Points	=	10
1 to 20 Points	=	20
1 to 30 Points	=	30

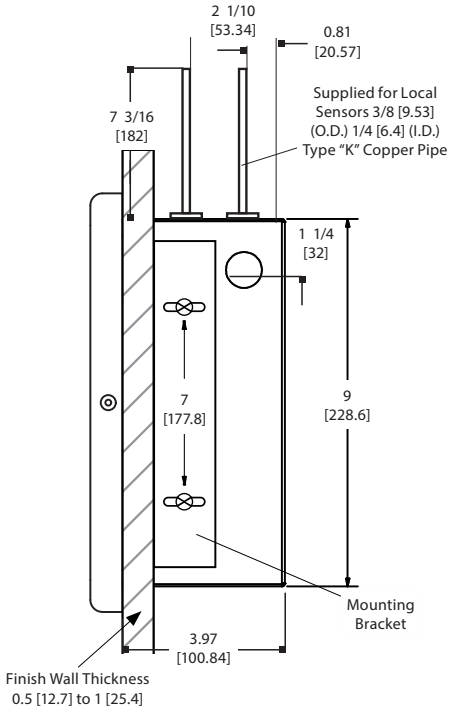
ALARM ALERT-3 LCD TECHNICAL SPECIFICATIONS AND MODEL NUMBERS

Inch
[mm]

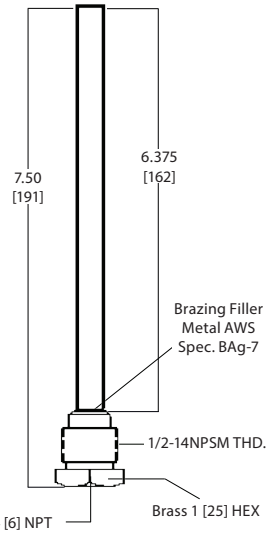
Front View



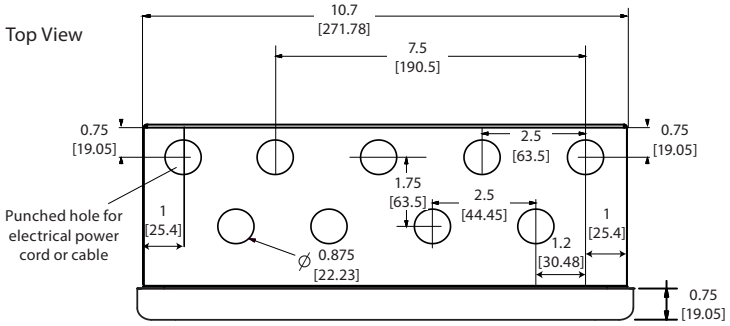
Side View



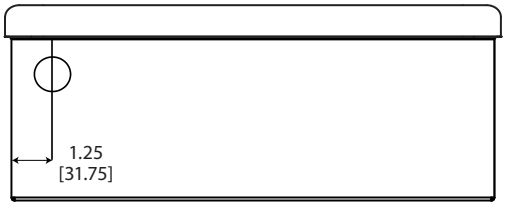
NOTE: DISS demand check valves by 1/4 [6] NPT, supplied with each sensor



Top View



Bottom View



NOTE: LCD Alarm itself is 8 lbs. Each sensor is 1 lb.

Model Numbers:

A3AR-L-XXXXXXXX

Remote/ Local Sensors	=	R
Conversion	=	C

The Letter "L" Defines the Language:

English (NFPA)	=	U
English (CSA)	=	E
French (CSA)	=	F
Spanish (NFPA)	=	S

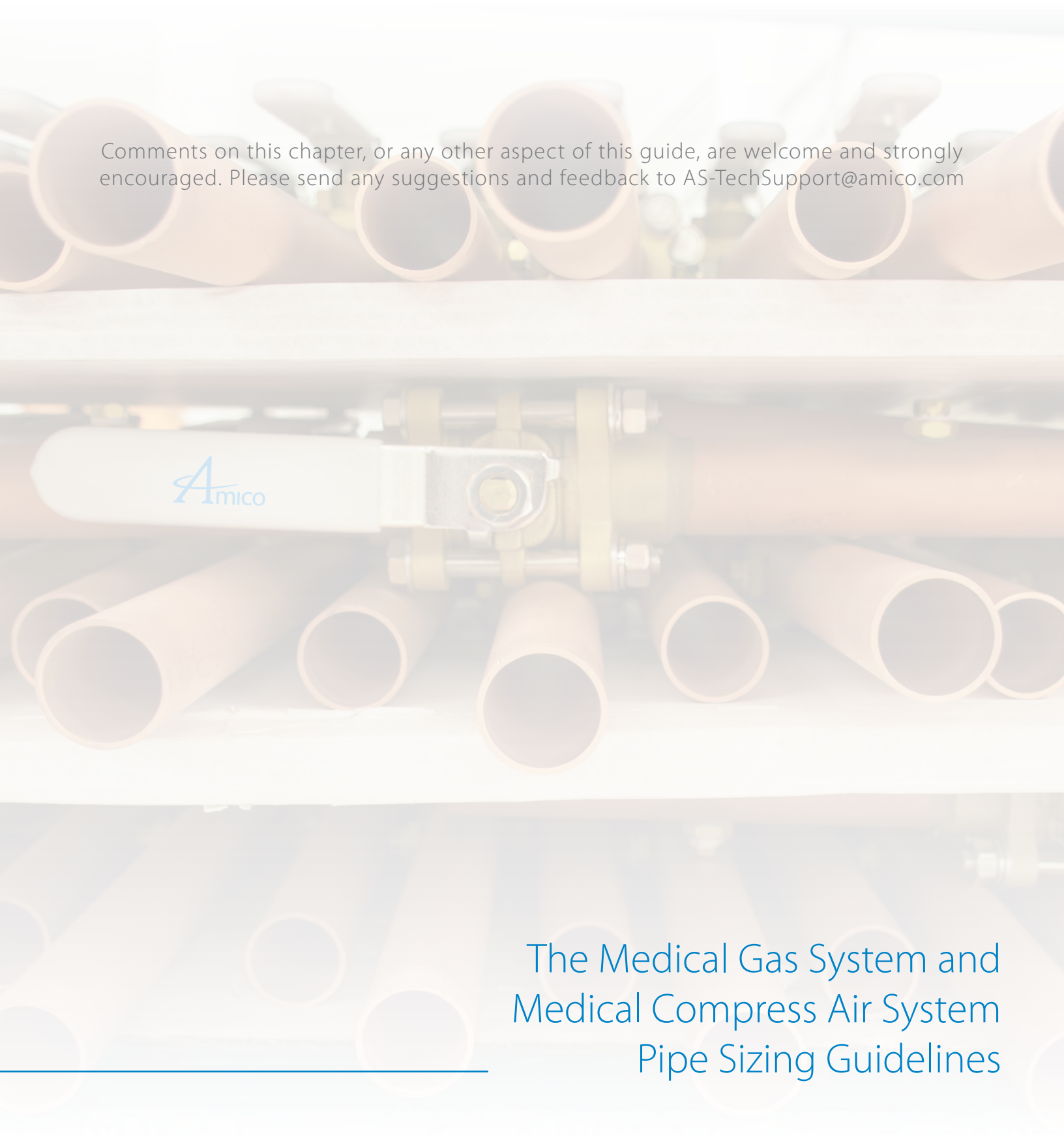
The Letter "X" Defines the Type of Gas:

Oxygen	=	O
Medical Air	=	A
MedVac	=	V
Nitrous Oxide	=	2
Nitrogen	=	N
Carbon Dioxide	=	C
WAGD (NFPA)	=	W
AGSS (ISO)	=	E
Instrument Air	=	I

Example: 3 Gas LCD Alarm Consisting of Oxygen, Medical Air & Vacuum = **A3AR-U-OAV**

Chapter 10

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 Medical Gas System and Medical Compress Air System Pipe Sizing Guidelines

Chapter 10 – The Medical Gas System and Medical Compress Air System Pipe Sizing Guidelines

How to Use this Section

This section provides step-by-step instruction of pipeline installation throughout the medical gas system and the medical compressor gas system. You will be able to find specifications on product sizes and types, along with suggested references that will help to provide a general idea on installing NFPA 99 qualified pipe systems. However, sizing methods are all approximate and are not definite.

10.1 Introduction

Before starting any pipeline sizing, all the requirements of the piping have to be finalized. The systems have to be effectively mapped out to scale. From chapter 4 (System Design and Layout), the required elements of pipeline have already been determined, including the following:

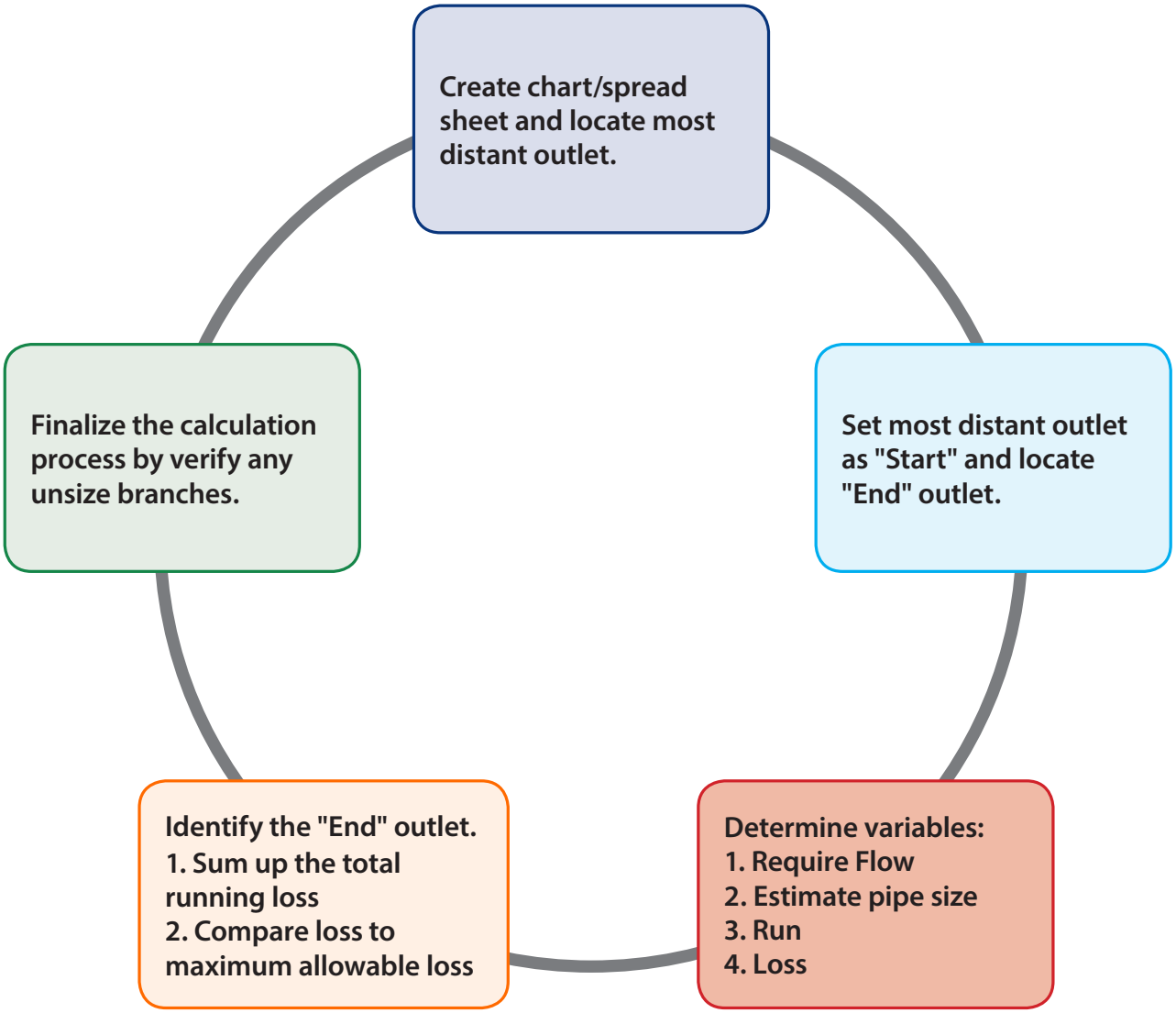
- Outlets locations
- Valve location
- Optional Valve Placement
- General Source Location
- Route Piping
- Placing Alarms

1. At this stage, the layout work and design have been determined or completed. Every element should be met and pipes are clearly mapped out. The only missing information are the pipe sizes.
2. If any of the above items have not been confirmed, it is crucial to re-adjust your sources and equipment now. Once that is obtained, complete the connection of the piping. Map out the intake and exhaust for the Medical Compressed Air System.

10.1.1 PROCESS FLOW CHART

The following flow chart provides a general idea of a sizing process. There are various methods to achieve the same result with minimal differentiation, given if all the same variables are included. With more advanced and complex method, results might slightly vary, yet the difference will be insignificant. It is **never** recommend to apply one pipe size to all systems. Each system's pipes should be sized individually even when outlets and end locations are all the same. Pay attention to the density of different gases as it does influence the sizing of the pipe.

Figure 1: Flow Chart for Medical Gas Pipeline



10.1.2 THIRD PARTY LOGISTICS

1. In a generic scenario, clients (hospitals or large scale clinical facilities) that require installing of medical air systems / compressed gas systems / vacuum systems, a third party engineering firm is usually hired to provide measurements on the total length of actual main piping and number of outlets and floors. Proper sizing of pipe will allow the systems to perform properly. Therefore the components are critical for the calculation of estimated pipe size as it generates the numbers that determine the potential air losses and if any branches are needed. Calculation of these processes will be elaborated in depth, in **chapter 10.6**.
2. After generating main lengths and losses in air flow and pressure, clients then combine information and request on specific plant size with required horsepower (hp) and flow (lpm).

10.2 NFPA Regulation and Size Charts

TABLE 1: NFPA 99 2018 EDITION; MINIMUM OUTLET/INLET FLOW FOR TESTING

System	Rate
50 psi gases (e.g. O2, Med Air, N2O, CO2, Mixtures)	3.5 SCFM (100 lpm)
80 and 100 psi gases (e.g. O2, Med Air, N2O, CO2)	As required by the equipment to be used
160 - 185 psi gases (e.g. Inst. Air, N2)	5 SCFM (140 lpm)
Vacuum	3 SCFM (85 lpm)
WAGD	1.8 SCFM (50 lpm)

TABLE 2: ALLOWABLE PRESSURE / VACUUM LOSSES ACROSS PIPELINE

System	Loss
50 psi gases (e.g. O2, Med Air, N2O, CO2, Mixtures)	5 psi (35 kPa)
80 psi gases (e.g. O2, Med Air, CO2)	5 psi (35 kPa)
100 psi gases (e.g. O2, Med Air, CO2)	8 psi (55 kPa)
160 - 185 psi gases (e.g. Inst. Air, N2)	10 psi (69 kPa)
Vacuum	4 inHg (101 mmHg)
WAGD (>=12 inHg (>=305 mmHg) Vacuum)	4 inHg (101 mmHg)
WAGD (<=5 inHg (<=127 mmHg))	N/A

TABLE 3: WAGD INLET FLOW

System	Occupancy	Flow(lpm/ ft3)	Notes
WAGD	All	50/1.8	If sizing for a BS 6834 system, use 120 lpm

TABLE 4: NOMINAL FLOW FOR PRESSURE GAS

System	Occupancy	Flow(lpm/ ft3)	Notes
Oxygen	All	10 / 0.36	Numbers indicate the lpm uses in actual scenario. For Min. testing outlet/inlet flow, refer to NFPA 99 Min/Max flow for testing.
Medical Air	All	25 / 0.88	
Nitrous Oxide	All	5 / 0.18	
Carbon Dioxide	General Medical	5 / 0.18	If specialty equipment will be connected, or the CO2 is for laboratory use, the actual demand should be substituted.
Carbon Dioxide	Insufflation	40 / 1.4	Most common in O.R. and typically involved a 100 psi system.
Nitrogen / Instrument Air	Surgical Tool use	300 / 10.6	If the gas is for other than surgical tool use, the actual demand should be substituted.
Other Gases		Use actual demand of equipment to be applied.	

*Number can used in the calculation of estimating pipe size because it doesn't influence the actual use of flow from medical staff.

10.3 Outlet

The Amico Medical Gas outlet is composed of two separate modules: the “Rough-in assembly” and the “Latch-valve assembly”. The “Rough-in assembly” is the same for all types (DISS, Ohmeda, Chemetron, Puritan-Bennett or Oxequip/ MedStar), while the “Latch-valve assembly” determines what type of adapter the outlet will accept.

Outlets shall be manufactured with a 7-3/4" (197 mm) length type ”K” 1/2" (12.7 mm) outside diameter (3/8" [9.5 mm] nominal) size copper inlet pipe stub, which is silver brazed to the outlet body. The body shall be of 1-5/16" (33 mm) diameter, one piece brass construction. For positive pressure gas services, the outlet shall be equipped with a primary and secondary check valve and the secondary check valve shall be rated at a maximum of 200 psi (1,379 kPa) in the event the primary check valve is removed for maintenance. Outlet bodies shall be gas specific by indexing each gas service to a gas specific dual pin indexing arrangement on the respective identification module.

The back pipes of the rough-ins are connected to main pipes to obtain gas supply from the gas system.

Note: Different types of copper have different thickness that affect the pressure tolerance. Yet, it does not affect air loss.

Ohmeda Compatible Wall Outlet

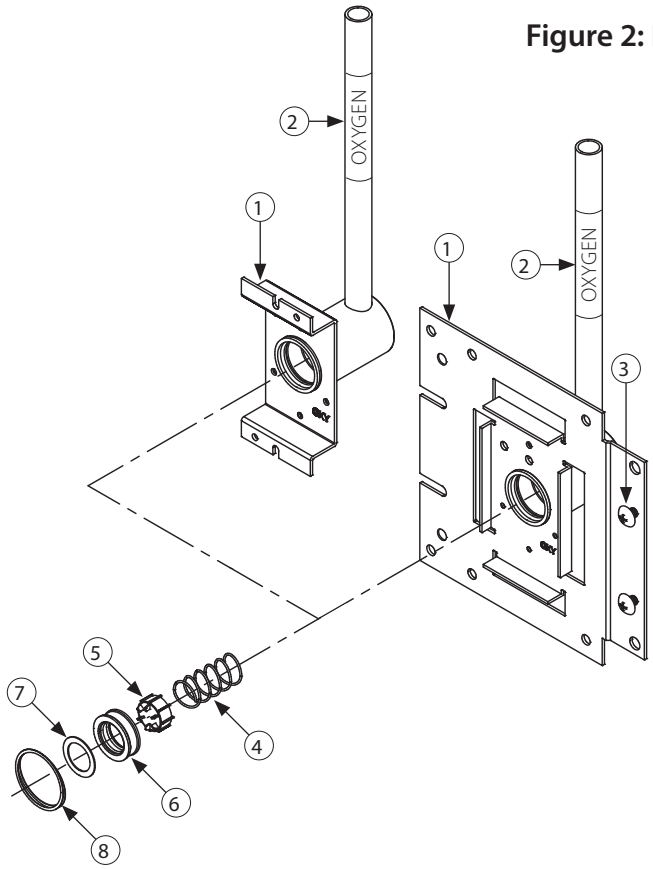


Figure 2: Rough-In Assembly

1	Rough-In Assembly
2	Gas Label
3	Screw (2 Required)
4	Secondary Check Valve Spring
5	Secondary Check Valve
6	Seat/Seal
7	Washer
8	Retaining Ring

*Amico Manual. Amico products comply with NFPA 99 and CSA Z7396.1. Outlets are UL listed and ETL listed

10.4 Manifold

The Manifold is designed to provide reliable and fully automatic uninterrupted gas flow for clinical and healthcare facilities. The manifold uses multiple high-pressure cylinders divided into two equal banks. One bank is dedicated as a primary source of gas while the other bank acts as reserve or secondary source.

Process:

1. Determining the number of cylinders and manifolds
2. Connecting cylinders with specific header bars
3. Connecting header bars to manifold on both sides

Get flows from cylinder and enters the manifold while regulator decrease pressure from:

1. All gases other than NIT; From 2000psi to 150psi then to 50psi.
2. NIT (high pressure gas); From 2500psi to 250psi then to 170psi.

TABLE 5: HEADER BAR TYPES

Header Bars		
Types	**Straight**	**Staggered**
Connections to Cylinder	Single sided	Double Sided
Pipe Size		
Length	Standard	10.5"
	Custom	8.5", 6", 3"
Width	All Diameter = 0.5"	

Pressure Straight

Pressure Staggered

*Amico Manual

1. Elements such as the length of pipes, use of header bars, number of cylinders and number of manifolds are determined by the requirement of gas supplies, number type and layout of rooms. Engineers/ designers are responsible to provide finalized drawings after verifying the requirements.
2. Keep in mind that manifolds are connected using a standardized ¾" isolation valve with locking handle supplied with the manifold. This is to be installed and connected the main supply line.
3. The following table provides general estimations on correclation of the number of operating rooms, number "H" cylinder of gases (Nitrogen, Nitrous Oxide, Carbon Dioxide) and the medical oxygen system.

TABLE 6: REFERENCE ON NUMBER OF CYLINDERS FOR GAS SYSTEMS

Medical Oxygen System	**Operating Rooms**	**Patient Rooms**
	500 cubic feet will last approx. 2 weeks **assuming:** 3 - 4 L/m per bed 8 hours of use per day (3 L/m) (60 min / hour) (8 hours) /28.8 liters per ft^3 = 50 ft^3 per OR per day 10 days = 500 cubic feet of oxygen	3 - 4 L/m per room (time will vary depending on care area) If ventilators are run off oxygen, approx. 3 to 7.0 SCFM each (check with ventilator manufacturer)
	Recovery: allow an additional 7.0 ft^3 per recovery position per patient (10 L/m)(20 minutes per patient) / 28.8 liters per ft^3 = 7.0	**Long Term Care:** 3 - 4 L/m per bed for continuous usage: (3 L/m)(60 minutes / hour) (24 hours a day) / 28.8 liters per ft3 = 150 cubic feet per day
	Notes: Oxygen will expand 860 times its liquid volume, approx. 251 cubic feet per "H" Cylinder, some freezing of bulk lines (by the vaporizer) is normal	

Nitrogen	**Number of Operating Rooms**	**Total Number of "H" Cylinder**
	1 - 2	4 (2 x 2)
	3 - 4	8 (4 x 4)
	5 - 6	12 (6 x 6)
	7 - 8	16 (8 x 8)
	9 -10	20 (10 x 10)
	11 - 12	24 (12 x 12)
	13 - 14	28 (14 x 14)
	Notes: "standard" OR typically needs approx. 8.0 SCFM orthopedic, or thoracic OR needs approx. 15 SCFM, Nitrogen regulators will typically flow a maximum of 70 SCFM, size so that each OR can use tools simultaneously approx. 230 cubic feet per "H" cylinder	

Nitrous Oxide	**Number of Operating Rooms**	**Total Number of "H" Cylinder**
	1 - 4	4 (2 x 2)
	5 - 8	8 (4 x 4)
	9 - 12	12 (6 x 6)
	13 - 16	16 (8 x 8)
	17 - 20	20 (10 x 10)
	Notes: 1 cylinder per anesthetizing room, check with anesthesia machine manufacturer for flow (most use approx. 0.2 SCFM per machine) approx. 560 cubic feet per "H" cylinder	

Carbon Dioxide	**Number of Operating Rooms**	**Total Number of "H" Cylinder**
	1 - 8	4 (2 x 2)
	9 - 16	8 (4 x 4)
	17 - 32	12 (6 x 6)
	Notes: approx. ¼ of an "H" cylinder per OR approximately 560 cubic feet per "H" cylinder, special procedure rooms/ labs may require more CO2.	

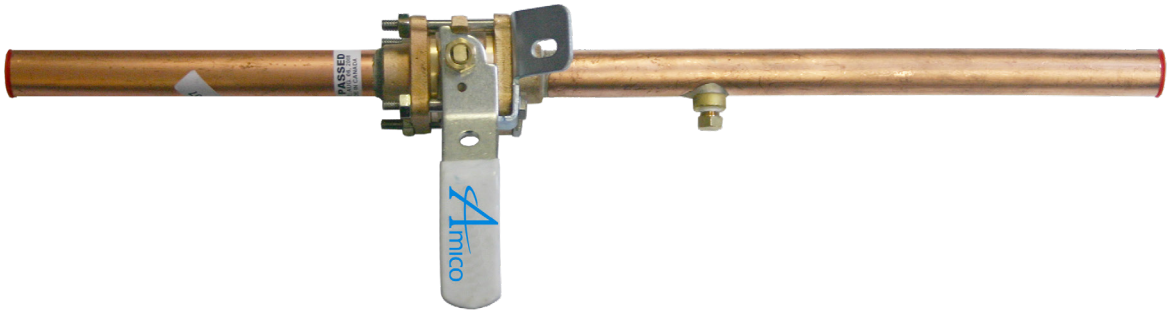
10.5 Gas and Vacuum Shutoff Valves/ Zone Valve Indicator Panels

Shutoff Valves shall be provided to isolate sections or portions of the piped distribution system for maintenance, repair, or planned future expansion need and to facilitate periodic testing. * NFPA 99 5.1.4.1.1.

Amico's valve boxes and valves can be categorized into two main applications: zone valves and isolation valves.

Zone Valves

Isolation Valves with Locking Device



The Zone Valve Shut-offs shall be 3 peice, ball-type design with a brass forging body and a chrome plated, brass ball for sizes ½" to 2". Ball seats, stem seals and stem washer shall be reinforced Teflon (PTFE), with Viton stem and flange O-rings.
A blow-out proof stem shall be used and the zone shut-off shall have a maximun rating of 600psi (4,137 kPa).
All zone shut-offs shall be compatible with pressure medical gases or vacuum service to 29" Hg (98.205 kPa).

All Zone Shut-offs shall be equipped with a type "K" washed and degreased copper pipe stub extensions of sufficient length to protrude beyond the sides of the box.

Valves shall be designed in such a manner that it can be "swung out" during installation so as to prevent damage due to heat transfer during the brazing operation.

Amico products comply with NFPA 99 and CSA Z7396.1. *Amico manual.

Refer to Table 7 for the range of pipe and valve box sizes available in different scenarios and Table 8 for variations on isolation sizing from 0.5" to 4".

TABLE 7: RANGE OF PIPE SIZE AND VALVE BOX

Valve Box	Zone	Sensor Valve (SVC)	Alarm Valve (AVC)	Note
3" 7/8 Deep Box Size				
A. With Multiple pipes	.05" - 1.25" - 1.5"	.05" - 1.25" - 1.5"	.05" - 1.25" - 1.5"	>1.5" pipe requires 2 slot spaces for handles
B. With only 1 pipe	2"	2"	2"	2" is the max. for this box size
6.5" Deep Box Size				
A. Single Valves	2", 2.5", 3"	2", 2.5", 3"	2", 2.5", 3"	
B. Multiple Valves	.05"- 2"	.05"- 2"	.05"- 2"	

TABLE 8: RANGE OF PIPE SIZE AND ISOLATIONS

Type	Valve (VV)	Isolation (ISO)	Gauge Port (G)	Note	Pipe Size (S)
1	Types of Valve Box	Monitor (M)	G	Gauge Port	sizes from .05" - 4"
2			GL	Gauge w/ Lock	
3			G2L	2 Gauges with Lock	
4			G2	2 Gauges w/o Lock	

* NFPA 99 5.1.4.1.2 Security. All valves, except valves in zone valve box assemblies, shall be secured by any of the following means:

1. Located in secured areas
2. Locked or latched in their operating position
3. Located above ceilings, but remaining accessible and not obstructed

10.6 Calculation Process

The pipe sizing calculation involves all factors from the previous sections. It requires working from a start point to and end point. And calculating total losses of air pressure and flow yet meeting NFPA 99 regulations and satisfies its safety standards. Refer to the following table and example for calculation tool.

10.6.1 STEP 1: CREATING AN EXCEL SPREAD SHEET

TABLE 9: CALCULATION CHART (SPREAD SHEET) FOR SIZING

Start	End	Run (feet)	Flow (lpm)	Pipe Size	Loss per 100'	Loss	Running Sub-total
Rm A	Rm B	27	20 (step3)	½"	0.011	0.00297	0.00297

10.6.2 STEP 2: LOCATE THE MOST DISTANT OUTLET

After pipe routing, identify the most distant outlet among all outlets and establish that outlet as the "Start". In some cases, there might be more than one outlet that share a similar distance, it is unnecessary to be overly precise on which to use. Once it is selected as the distance outlet from the source, it should be mark down on the chart / spread sheet in the "Start" column.

10.6.3 STEP 3: IDENTIFYING FLOW (LPM)

Refer to Table 4 (Page 4), apply the nominal flow used for different outlets in the gas system. Take the applicable numbers and multiply by the number of outlets. For instance, 2 Oxygen Outlet = 2 (# of outlets) X 10 (Oxygen System flow (lpm/ ft3)) = 20. Enter 20 in the "Flow" column.

10.6.4 STEP 4: WORKING ONTO THE NEXT BRANCH

Follow along the pipe route from your "Start" point as you will be able to locate the next connected outlet. In most cases, the first outlet will be joined by the second outlet. As the journey continues, it is possible to encounter branches of multiples outlets. Mark the furthest outlet as your "End" and enter into the "End" column.

10.6.5 STEP 5: TOTAL DISTANCE FROM START TO END

Calculate the distance from the "Start" point to the "End" point. The route should consider calculations that involves additional runs. Refer to figures in Chapter 10.3 (the Outlets), 10.4 (the Manifold's header bars), and 10.5 (the Valves) for your selected measurements; preferably substitute with actual numbers, if not, estimation is acceptable. And enter the figure into "Run" column.

10.6.6 STEP 6: ESTIMATION OF OUTLET PIPE SIZE

Few rules that should always be followed:

1. Main and branches pressure gas pipeline to the end of the hard pipe can never be smaller than ½" (13mm) nominal size.
2. Main and branches vacuum and high vacuum WAGD piping to the end of the hard pipe can never be smaller than ¾" (19mm) nominal size.
3. Drops to individual station outlets and inlets can never be smaller than ½" (13mm) nominal size.

Above rules applied to the inlet/outlet or the end point of the hard pipe from manufactured assemblies. The process of pipe sizing is more or less an estimation based on experiences and compliance of the NFPA 99 codes. It is recommended to first reference the medical air piping pressure loss in relation to the use of nominal size pipe under different pressures. Based on the required air flow from the outlets, estimate the nominal pipe size and size up or size down the pipes accordingly.
It is important to always avoid accommodating air losses by using a larger pipe size to compensate in the last few sections. Despite it is being theoretically achievable, it is not in practical applications. Finalize pipe size and input under "Size".

10.6.7 STEP 7: CALCULATE THE LOSS TO THIS POINT

After inputting the "Size", refer to the Oxygen Piping Pressure Lost Data (table 10) to obtain the potential air loss per 100' in the selected size of pipe and place the number under "Loss". Continue with previous example (in Step 3) Oxygen at 55psi has of 0.011 Loss per 100' under a 1/2" nominal pipe size with a flow of 20 lpm.

TABLE 10: OXYGEN (55PSI) PIPING LOSS DATA (*APPENDIX P19)

Oxygen Flow			Pressure Drop for Oxygen in PSI per 100 feet of Type L Copper Pipe for Oxygen at 55 psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)	
Liters per Minute (lpm)	Standard CFM	Actual CFM		
at 68°F & 14.7 psia		at 68°F & 55 psig		
			1/2"	
10	.35	.07	.003	3/4"
20	.71	.15	.011	.002

Input the number under Loss per 100' and generate "Loss". After determining the "Loss", insert the number to the "Section Loss" formula = (Run/100)* **Value from Pipping Pressure Loss Data**. Compare to the number from Allowable Pressure Losses across the Pipeline; Loss = .00297 < Allowable Pressure Losses 5psi @ 50psi gases. If the number seems comparatively large to the allowable loss, upsize the pipes and reevaluate your calculations. For instant, if the run is 1/3 of the total, and the loss is 1/2 of allowed loss from Table 2, the two numbers are not proportional, thus the pipe size should be one size up.

10.6.8. STEP 8 ACCUMULATE THE SUB TOTAL

Add up the "Loss" column or review the running subtotal on your chart / spread sheet. Compare the total loss to the Allowable Pressure Losses, in Table 2. If the number is approaching the maximum amount of psi, it is recommend assessing previous sections and reevaluate the variables.

10.6.9. STEP 9 PROCEED TO ANOTHER SECTION

The previous "End" becomes the "Start" for the next section. Repeat the previous steps. Such method as mentioned earlier in this chapter is not a standard, therefore there are different ways that engineers can approach and obtain sizes. The chart / spread sheet is for guiding purposes and for easy-to-manage.

10.6.10 STEP 10 VERIFICATION

After completing the sum of "Loss" column, the total amount of losses must be smaller than the Allowable Pressure Losses shown in the table 2. If exceeded, upsize the section until the total loss is within the Maximum Allowable range.

Besides comparing Aggregated Loss and Allowable Pressure Losses; upsizing should also be considered if the Running Sub Total is taking up a high proportion of the Maximum Allowable Losses. For instance, if your Sub Total loss at this stage is 3/4 of the allowed loss, yet you already at 1/2 the pipeline, you should revise and reevaluate the previous section and make adjustments accordingly.

On the contrary, you should consider downsizing a pipe size if the Running Sub Total is only a small portion of the Maximum Allowable. Such action will result in greater loss, which is still acceptable as far as it is within the Maximum Allowable index.

10.6.11 STEP 11 BRANCH SIZING

At this point, the main pipes should have been sized. You should return to ensure the branches are also been sized if not already done so. The steps for sizing each branch is same as the main pipe. Starting with locating the most distant outlet from the source and work through your calculation per section.

Branch joints to the main pipe section can be added to the main pipe sections from the branch to the source and calculate the total of loss considering the newly added branches are now the main line. Compare the Losses to the Maximum Allowable Losses and ensure it is within or equal to the required numbers.

10.6.12 STEP 12 COMPENSATE IF FITTINGS ARE INVOLVED

Listed or approved metallic gas tube fittings that, when made up, provided a permanent joint having the mechanical, thermal, and sealing integrity of a brazed joint shall be permitted to be used. *NFPA 99 5.1.10.9.1 and 5.1.10.9.2: Dielectric fittings that comply with the following shall be permitted only where required by the manufacturer of special medical equipment to electrically isolate the equipment from the system distribution piping:

1. They shall be of brass or copper construction with an appropriate dielectric
2. They shall be permitted to be a union
3. They shall be clean for oxygen where used for medical gases and medical support gases

Whenever fittings are used, ensure the total loss is less than 3/4 of the total allowed loss. Refer to table 11 for pressure loss in fittings.

TABLE 11: PRESSURE LOSS IN FITTINGS AND VALVES EXPRESSED AS EQUIVALENT LENGTH OF TUBE, FEET

Nominal or Standard Size, Inches	Fittings				Valves				
	Standard ell		90° tee		Coupling	Ball	Gate	Btfly	Check
	90°	45°	Side Branch	Straight Run					
3/8	0.5	-	1.5	-	-	-	-	-	1.5
½	1	0.5	2	-	-	-	-	-	2
5/8	1.5	0.5	2	-	-	-	-	-	2.5
¾	2	0.5	3	-	-	-	-	-	3
1	2.5	1	4.5	-	-	0.5	-	-	4.5
1¼	3	1	5.5	0.5	0.5	0.5	-	-	5.5
1½	4	1.5	7	0.5	0.5	0.5	-	-	6.5
2	5.5	2	9	0.5	0.5	0.5	0.5	7.5	9
2½	7	2.5	12	0.5	0.5	-	1	10	11.5
3	9	3.5	15	1	1	-	1.5	15.5	14.5
3½	9	3.5	14	1	1	-	2	-	12.5
4	12.5	5	21	1	1	-	2	16	18.5
5	16	6	27	1.5	1.5	-	3	11.5	23.5
6	19	7	34	2	2	-	3.5	13.5	26.5
8	29	11	50	3	3	-	5	12.5	39

Notes: Allowances are for streamlined soldered fittings and recessed threaded fittings. For threaded fittings, double the allowances shown in the table. The equivalent lengths presented above are based upon a C factor of 150 in the Hazen-Williams friction loss formula. The lengths shown are rounded.

* "14. Technical Data" copper.org: Copper Tube Handbook. References: CDA Publication A4015-14/17 Page 80

10.6.13 STEP 13 STATIC LINE

Static line is not required to be sized as it does not carry any flow.

10.6.14 COMMON SIZING ISSUES

Below are some issues one might encounter when working on sizing:

1. Allowable Pressure / Vacuum Losses across the Pipeline in NFPA 99 is an outlet test that is usually used for safety reference purposes. It is uncommon to use as design guideline while building the system.
2. Uncertainty on the 1/2" and 3/4"minimums outlet connection. The greatest losses usually occur at the last 5 feet to the outlet if the pipeline is undersized.
3. The ineffective assumption on placing excessive fittings (elbows and tees) causes inaccurate estimations on sizing main pipelines, resulting in undersized or oversized systems.

10.6.15 PROFESSIONALISM

SIZING METHODS IN THIS CHAPTER ARE APPROXIMATIONS. IT IS ACCPETABLE TO BE IMPRECISE, USERS ARE RESPONSIBLE TO PROVIDE THE BEST ESTIMATION USING PROVIDED INDEXES AND ESTABLISH A PRACTICAL AND NFPA 99 QUALIFIED SYSTEM.

Appendix

MEDICAL AIR (55 PSI) PIPING PRESSURE LOSS DATA

Air Flow			Pressure Drop of Air in PSI per 100ft of Type L Copper Pipe for Air at 55psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Liters per Minute	Standard CFM	Actual CFM					
@ 68°F & 14.7 psia		@ 68°F & 55 psig	1/2"				
10	0.35	0.07	0.003	**3/4"**			
20	0.71	0.15	0.006	0.002			
30	1.06	0.22	0.020	0.004			
40	1.41	0.30	0.032	0.006			
50	1.77	0.37	0.047	0.008			
60	2.12	0.45	0.064	0.011			
70	2.47	0.52	0.083	0.015			
80	2.83	0.60	0.105	0.019			
90	3.18	0.67	0.129	0.023	**1"**		
100	3.53	0.74	0.155	0.028	0.008		
120	4.24	0.89	0.213	0.038	0.011		
140	4.94	1.04	0.279	0.049	0.014		
160	5.65	1.19	0.352	0.062	0.018		
180	6.36	1.34	0.433	0.076	0.022		
200	7.06	1.49	0.521	0.092	0.026		
220	7.77	1.64	0.616	0.108	0.031		
240	8.48	1.79	0.719	0.126	0.036		
260	9.18	1.94	0.828	0.145	0.041		
280	9.89	2.08	0.944	0.165	0.046		
300	10.59	2.23	1.067	0.187	0.052		
320	11.3	2.38	1.196	0.209	0.059		
340	12.01	2.53	1.332	0.233	0.065		
360	12.71	2.68	1.475	0.258	0.072		
380	13.42	2.83	1.624	0.283	0.079	**1 1/4"**	
400	14.13	2.98	1.780	0.310	0.087	0.032	
450	15.89	3.35	2.196	0.382	0.107	0.039	
500	17.66	3.72	2.652	0.461	0.129	0.047	
550	19.42	4.01	3.146	0.546	0.152	0.056	
600	21.19	4.47	3.677	0.637	0.178	0.065	
650	22.95	4.84	4.247	0.735	0.205	0.075	
700	24.72	5.21	4.853	0.839	0.234	0.086	
750	26.49	5.58		0.949	0.264	0.097	**1 1/2"**
800	28.25	5.96		1.065	0.296	0.108	0.047
850	30.02	6.33		1.187	0.330	0.121	0.053
900	31.78	6.70		1.315	0.365	0.134	0.058
950	33.55	7.07		1.449	0.402	0.147	0.064
1000	35.31	7.45		1.589	0.441	0.161	0.070

MEDICAL AIR (55 PSI) PIPING PRESSURE LOSS DATA

Air Flow			Pressure Drop of Air in PSI per 100ft of Type L Copper Pipe for Air at 55psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)						
Liters per Minute	Standard CFM	Actual CFM							
@ 68°F & 14.7 psia		@ 68°F & 55 psig		**3/4"**	**1"**	**1 1/4"**	**1 1/2"**		
1100	38.85	8.19		1.886	0.523	0.191	0.083		
1200	42.38	8.94		2.206	0.611	0.223	0.097		
1300	45.91	9.68		2.548	0.705	0.257	0.112		
1400	49.44	10.42		2.913	0.806	0.293	0.128		
1500	52.97	11.17		3.300	0.912	0.332	0.144	**2"**	
1600	56.5	11.91		3.709	1.024	0.373	0.162	0.043	
1700	60.03	12.66		4.140	1.142	0.415	0.180	0.048	
1800	63.57	13.40		4.592	1.266	0.460	0.200	0.053	
1900	67.01	14.15		5.066	1.396	0.507	0.220	0.058	**2 1/2"**
2000	70.63	14.89			1.532	0.556	0.241	0.064	0.023
2250	79.46	16.75			1.895	0.687	0.298	0.079	0.028
2500	88.29	18.62			2.293	0.831	0.360	0.095	0.034
2750	97.12	20.48			2.726	0.987	0.428	0.113	0.040
3000	105.9	22.34			3.193	1.155	0.500	0.132	0.047
3250	114.8	24.20			3.694	1.335	0.578	0.153	0.054
3500	123.6	26.06			4.228	1.527	0.660	0.174	0.062
3750	132.4	27.92			4.796	1.731	0.748	0.197	0.070
4000	141.3	29.79				1.946	0.841	0.222	0.078
4250	150.1	31.65				2.173	0.938	0.247	0.087
4500	158.9	33.51				2.411	1.041	0.274	0.097
4750	167.7	35.37				2.661	1.148	0.302	0.107
5000	176.6	37.23				2.922	1.260	0.331	0.117
5500	194.2	40.96	**3"**			3.477	1.499	0.394	0.139
6000	211.9	44.68	0.069			4.077	1.756	0.461	0.162
6500	229.6	48.40	0.080			4.721	2.032	0.533	0.188
7000	247.2	52.12	0.091				2.326	0.609	0.214
7500	264.9	55.85	0.103				2.638	0.691	0.243
8000	282.5	59.57	0.116	**4"**			2.969	0.777	0.273
8500	300.2	63.29	0.129	0.033			3.318	0.867	0.305
9000	317.8	67.02	0.143	0.037			3.684	0.962	0.338
9500	335.5	70.74	0.158	0.041			4.069	1.062	0.373
10000	353.2	74.46	0.173	0.045			4.471	1.166	0.409
10500	370.8	78.19	0.189	0.049			4.890	1.275	0.447
11000	388.5	81.91	0.206	0.053				1.388	0.486
11500	406.1	85.63	0.223	0.057				1.505	0.527
12000	423.8	89.36	0.241	0.062				1.627	0.570
13000	459.1	96.80	0.279	0.072				1.884	0.659

MEDICAL AIR (80 PSI) PIPING PRESSURE LOSS DATA

Air Flow			Pressure Drop of Air in PSI per 100ft of Type L Copper Pipe for Air at 80psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Liters per Minute	Standard CFM	Actual CFM					
@ 68°F & 14.7 psia		@ 68°F & 80 psig	**1/2"**				
10	0.35	0.05	0.002	**3/4"**			
20	0.71	0.11	0.005	0.001			
30	1.06	0.16	0.014	0.003			
40	1.41	0.22	0.024	0.004			
50	1.77	0.27	0.034	0.006			
60	2.12	0.33	0.047	0.008			
70	2.47	0.38	0.061	0.011			
80	2.83	0.44	0.077	0.014			
90	3.18	0.49	0.095	0.017	**1"**		
100	3.53	0.55	0.114	0.020	0.006		
120	4.24	0.66	0.157	0.028	0.008		
140	4.94	0.77	0.205	0.036	0.010		
160	5.65	0.88	0.259	0.046	0.013		
180	6.36	0.99	0.319	0.056	0.016		
200	7.06	1.01	0.383	0.067	0.019		
220	7.77	1.21	0.454	0.080	0.022		
240	8.48	1.32	0.529	0.093	0.026		
260	9.18	1.42	0.609	0.107	0.030		
280	9.89	1.53	0.695	0.122	0.034		
300	10.6	1.64	0.785	0.137	0.039		
320	11.3	1.75	0.881	0.154	0.043		
340	12	1.86	0.981	0.171	0.048		
360	12.7	1.97	1.086	0.190	0.053		
380	13.4	2.08	1.195	0.209	0.058	**1 1/4"**	
400	14.1	2.19	1.310	0.228	0.064	0.023	
450	15.9	2.47	1.616	0.281	0.079	0.029	
500	17.7	2.74	1.952	0.339	0.095	0.035	
550	19.4	3.01	2.315	0.402	0.112	0.041	
600	21.2	3.29	2.707	0.469	0.131	0.048	
650	23	3.56	3.126	0.541	0.151	0.055	
700	24.7	3.84	3.572	0.617	0.172	0.063	
750	26.5	4.11	4.045	0.698	0.194	0.071	**1 1/2"**
800	28.3	4.38	4.545	0.784	0.218	0.080	0.035
850	30	4.66	5.071	0.874	0.243	0.089	0.039
900	31.8	4.93	5.624	0.968	0.269	0.098	0.043
950	33.6	5.21	6.202	1.067	0.296	0.108	0.047
1000	35.3	5.48	6.807	1.169	0.325	0.118	0.052

MEDICAL AIR (80 PSI) PIPING PRESSURE LOSS DATA

Air Flow			Pressure Drop of Air in PSI per 100ft of Type L Copper Pipe for Air at 80psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 80 psig	**1/2"**	**3/4"**	**1"**	**1 1/4"**	**1 1/2"**	
1100	38.85	6.03	8.093	1.388	0.385	0.140	0.061	
1200	42.38	6.58		1.623	0.450	0.164	0.071	
1300	45.91	7.12		1.876	0.519	0.189	0.082	
1400	49.44	7.67		2.144	0.593	0.216	0.094	
1500	52.97	8.22		2.429	0.671	0.244	0.106	**2"**
1600	56.5	8.77		2.730	0.754	0.274	0.119	0.032
1700	60.03	9.32		3.047	0.841	0.306	0.133	0.035
1800	63.57	9.86		3.380	0.932	0.339	0.147	0.039
1900	67.01	10.40	**2 1/2"**	3.729	1.028	0.373	0.162	0.043
2000	70.63	10.96	0.017	4.093	1.127	0.409	0.178	0.047
2250	79.46	12.30	0.021	5.072	1.395	0.506	0.219	0.058
2500	88.29	13.70	0.025	6.147	1.688	0.612	0.265	0.070
2750	97.12	15.10	0.029	7.317	2.007	0.726	0.315	0.083
3000	105.9	16.40	0.034	8.581	2.350	0.850	0.368	0.097
3250	114.8	17.80	0.040		2.719	0.983	0.425	0.112
3500	123.6	19.20	0.045		3.112	1.124	0.486	0.128
3750	132.4	20.60	0.051		3.529	1.274	0.551	0.145
4000	141.3	21.90	0.058		3.971	1.432	0.619	0.163
4250	150.1	23.30	0.064		4.437	1.599	0.691	0.182
4500	158.9	24.70	0.071		4.926	1.775	0.766	0.202
4750	167.7	26.00	0.078		5.440	1.958	0.845	0.222
5000	176.6	27.40	0.086		5.976	2.151	0.927	0.244
5500	194.2	30.10	0.102	**3"**		2.559	1.103	0.290
6000	211.9	32.90	0.119	0.051		3.001	1.292	0.339
6500	229.6	35.60	0.138	0.059		3.475	1.495	0.392
7000	247.2	38.40	0.158	0.067		3.981	1.712	0.448
7500	264.9	41.10	0.179	0.076		4.518	1.942	0.508
8000	282.5	43.80	0.201	0.085	**4"**	5.088	2.185	0.572
8500	300.2	46.60	0.224	0.095	0.024	5.688	2.442	0.638
9000	317.8	49.30	0.249	0.105	0.027	6.320	2.712	0.708
9500	335.5	52.10	0.274	0.116	0.030	6.984	2.995	0.782
10000	353.2	54.80	0.301	0.128	0.033	7.678	3.290	0.858
10500	370.8	57.60	0.329	0.139	0.036	8.402	3.599	0.938
11000	388.5	60.30	0.358	0.152	0.039		3.921	1.021
11500	406.1	63.00	0.388	0.164	0.042		4.256	1.108
12000	423.8	65.80	0.419	0.178	0.046		4.603	1.197
13000	459.1	71.30	0.485	0.205	0.053		5.336	1.386

OXYGEN (55 PSI) PIPING PRESSURE LOSS DATA

Oxygen Flow			Pressure Drop of Oxygen in PSI per 100ft of Type L Copper Pipe for Oxygen at 55psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Liters per Minute	Standard CFM	Actual CFM					
@ 68°F & 14.7 psia		@ 68°F & 55 psig					
			1/2"				
10	0.35	0.07	0.003	**3/4"**			
20	0.71	0.15	0.011	0.002			
30	1.06	0.22	0.021	0.004			
40	1.41	0.30	0.035	0.006			
50	1.77	0.37	0.051	0.009			
60	2.12	0.45	0.070	0.013			
70	2.47	0.52	0.092	0.016			
80	2.83	0.60	0.115	0.021			
90	3.18	0.67	0.142	0.025	**1"**		
100	3.53	0.74	0.170	0.030	0.009		
120	4.24	0.89	0.234	0.041	0.012		
140	4.94	1.04	0.306	0.054	0.015		
160	5.65	1.19	0.387	0.068	0.019		
180	6.36	1.34	0.476	0.084	0.024		
200	7.06	1.49	0.572	0.101	0.028		
220	7.77	1.64	0.677	0.119	0.034		
240	8.48	1.79	0.790	0.139	0.039		
260	9.18	1.94	0.910	0.160	0.045		
280	9.89	2.08	1.037	0.182	0.051		
300	10.6	2.23	1.173	0.205	0.058		
320	11.3	2.38	1.315	0.230	0.065		
340	12	2.53	1.465	0.256	0.072		
360	12.7	2.68	1.621	0.283	0.079		
380	13.4	2.83	1.785	0.311	0.087	**1 1/4"**	
400	14.1	2.98	1.956	0.341	0.095	0.035	
450	15.9	3.35	2.414	0.420	0.117	0.043	
500	17.7	3.72	2.915	0.506	0.142	0.052	
550	19.4	4.01	3.459	0.600	0.167	0.061	
600	21.2	4.47	4.044	0.700	0.195	0.072	
650	23	4.84	4.670	0.808	0.225	0.082	
700	24.7	5.21	5.337	0.922	0.257	0.094	
750	26.5	5.58		1.043	0.290	0.106	**1 1/2"**
800	28.3	5.96		1.171	0.326	0.119	0.052
850	30	6.33		1.305	0.363	0.133	0.058
900	31.8	6.70		1.446	0.402	0.147	0.064
950	33.6	7.07		1.593	0.442	0.162	0.070
1000	35.3	7.45		1.747	0.485	0.177	0.077

OXYGEN (55 PSI) PIPING PRESSURE LOSS DATA

Oxygen Flow			Pressure Drop of Oxygen in PSI per 100ft of Type L Copper Pipe for Oxygen at 55psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 55 psig		3/4"	1"	1 1/4"	1 1/2"	
1100	38.9	8.19		2.074	0.575	0.210	0.091	
1200	42.4	8.94		2.426	0.672	0.245	0.107	
1300	45.9	9.68		2.802	0.776	0.282	0.123	
1400	49.4	10.42		3.204	0.886	0.323	0.140	
1500	53	11.17		3.630	1.003	0.365	0.159	**2"**
1600	56.5	11.91		4.080	1.126	0.410	0.178	0.047
1700	60	12.66		4.554	1.256	0.457	0.198	0.053
1800	63.6	13.40		5.051	1.393	0.506	0.220	0.058
1900	67	14.15	**2 1/2"**		1.535	0.558	0.242	0.064
2000	70.6	14.89	0.025		1.684	0.611	0.265	0.070
2250	79.5	16.75	0.031		2.084	0.756	0.328	0.087
2500	88.3	18.62	0.037		2.523	0.914	0.396	0.105
2750	97.1	20.48	0.044		2.999	1.086	0.470	0.124
3000	105.9	22.34	0.051		3.513	1.271	0.550	0.145
3250	114.8	24.20	0.059		4.064	1.469	0.635	0.168
3500	123.6	26.06	0.068		4.652	1.680	0.726	0.192
3750	132.4	27.92	0.077		5.276	1.904	0.823	0.217
4000	141.3	29.79	0.086			2.141	0.925	0.244
4250	150	31.65	0.096			2.391	1.032	0.272
4500	159	33.51	0.106			2.653	1.145	0.301
4750	168	35.37	0.117			2.928	1.263	0.332
5000	177	37.23	0.129			3.215	1.386	0.364
5500	194	40.96	0.153	**3"**		3.826	1.649	0.433
6000	212	44.68	0.178	0.076		4.486	1.932	0.507
6500	230	48.40	0.206	0.088		5.195	2.235	0.586
7000	247	52.12	0.236	0.100			2.559	0.670
7500	265	55.85	0.267	0.113			2.903	0.760
8000	283	59.57	0.300	0.127	**4"**		3.267	0.854
8500	300	63.29	0.335	0.142	0.037		3.651	0.954
9000	318	67.02	0.372	0.158	0.041		4.055	1.059
9500	335	70.74	0.410	0.174	0.045		4.478	1.168
10000	353	74.46	0.450	0.191	0.049		4.920	1.283
10500	371	78.19	0.492	0.208	0.054		5.382	1.402
11000	388	81.91	0.535	0.227	0.058			1.527
11500	406	85.63	0.580	0.246	0.063			1.656
12000	424	89.36	0.627	0.265	0.068			1.790
13000	459	96.80	0.725	0.307	0.079			2.073

OXYGEN (80 PSI) PIPING PRESSURE LOSS DATA

Oxygen Flow			Pressure Drop for Oxygen in PSI per 100ft of Type L Copper Pipe for Oxygen at 80psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 80 psig	**1/2"**	**3/4"**	**1"**	**1 1/4"**		
400	14.13	2.19	1.440	0.251	0.070	0.026		
450	15.89	2.47	1.777	0.309	0.086	0.032		
500	17.66	2.74	2.146	0.373	0.104	0.038		
550	19.42	3.01	2.546	0.442	0.123	0.045		
600	21.19	3.29	2.976	0.515	0.144	0.053		
650	22.95	3.56	3.437	0.595	0.166	0.061		
700	24.72	3.84	3.928	0.679	0.189	0.069		
750	26.49	4.11	4.448	0.768	0.214	0.078	**1 1/2"**	
800	28.25	4.38	4.998	0.862	0.240	0.088	0.038	
850	30.02	4.66	5.577	0.961	0.267	0.098	0.043	
900	31.78	4.93	6.185	1.064	0.296	0.108	0.047	
950	33.55	5.21	6.822	1.173	0.326	0.119	0.052	
1000	35.31	5.48	7.488	1.286	0.357	0.130	0.057	
1100	38.85	6.03		1.526	0.423	0.154	0.067	
1200	42.38	6.58		1.785	0.495	0.180	0.078	
1300	45.91	7.12		2.063	0.571	0.208	0.090	
1400	49.44	7.67		2.358	0.652	0.237	0.103	
1500	52.97	8.22		2.671	0.738	0.269	0.117	**2"**
1600	56.5	8.77		3.003	0.829	0.301	0.131	0.035
1700	60.03	9.32		3.352	0.925	0.336	0.146	0.039
1800	63.57	9.86		3.718	1.025	0.372	0.162	0.043
1900	67.01	10.41	**2 1/2"**	4.102	1.130	0.410	0.178	0.047
2000	70.63	10.96	0.018	4.503	1.240	0.450	0.195	0.052
2250	79.46	12.33	0.023	5.580	1.534	0.556	0.241	0.064
2500	88.29	13.7	0.027	6.764	1.857	0.673	0.291	0.077
2750	97.12	15.07	0.032	8.052	2.207	0.799	0.346	0.091
3000	105.94	16.44	0.038		2.586	0.935	0.405	0.107
3250	114.77	17.81	0.044		2.991	1.081	0.468	0.123
3500	123.6	19.18	0.050		3.424	1.236	0.535	0.141
3750	132.43	20.55	0.056		3.883	1.401	0.606	0.160
4000	141.26	21.92	0.063		4.369	1.576	0.681	0.179
4250	150.09	23.29	0.071		4.882	1.759	0.760	0.200
4500	158.92	24.66	0.078		5.421	1.952	0.843	0.222
4750	167.74	26.03	0.086		5.986	2.155	0.929	0.244
5000	176.57	27.4	0.095		6.577	2.366	1.020	0.268
5500	194.23	30.14	0.112	**3"**		2.816	1.213	0.319
6000	211.89	32.88	0.131	0.056		3.302	1.422	0.373

OXYGEN (80 PSI) PIPING PRESSURE LOSS DATA

Oxygen Flow			Pressure Drop for Oxygen in PSI per 100ft of Type L Copper Pipe for Oxygen at 80psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 80 psig	**2 1/2"**	**3"**		**1 1/4"**	**1 1/2"**	**2"**
6500	229.55	35.62	0.152	0.064		3.824	1.645	0.431
7000	247.2	38.36	0.174	0.074		4.380	1.883	0.493
7500	264.86	41.1	0.197	0.083		4.972	2.137	0.559
8000	282.52	43.84	0.221	0.094	**4"**	5.599	2.405	0.629
8500	300.17	46.58	0.247	0.105	0.027	6.261	2.687	0.702
9000	317.83	49.32	0.274	0.116	0.030	6.957	2.984	0.779
9500	335.49	52.07	0.302	0.128	0.033	7.687	3.296	0.860
10000	535.15	54.81	0.331	0.140	0.036	8.451	3.621	0.944
10500	370.8	57.55	0.362	0.153	0.039		3.961	1.032
11000	388.46	60.29	0.394	0.167	0.043		4.316	1.124
11500	406.12	63.03	0.427	0.181	0.046		4.684	1.219
12000	423.78	65.77	0.461	0.195	0.050		5.066	1.318
13000	459.09	71.25	0.534	0.226	0.058		5.873	1.526
14000	494.41	76.73	0.611	0.259	0.066	**6"**	6.736	1.748
15000	529.72	82.21	0.693	0.293	0.075	0.011	7.654	1.984
16000	565.03	87.69	0.780	0.330	0.084	0.012		2.234
17000	600.35	93.17	0.872	0.368	0.094	0.013		2.497
18000	635.66	98.65	0.968	0.409	0.105	0.015		2.775
19000	670.98	104.13	1.069	0.451	0.155	0.016		3.065
20000	706.29	109.61	1.174	0.495	0.127	0.018		3.370
21000	741.61	115.09	1.284	0.542	0.138	0.020		3.688
22000	776.92	120.57	1.399	0.590	0.151	0.021		4.019
23000	812.24	126.05	1.518	0.640	0.163	0.023		4.363
24000	847.55	131.53	1.642	0.692	0.176	0.025		4.721
25000	882.87	137.01	1.770	0.745	0.190	0.027	**8"**	5.092
26000	918.18	142.49	1.903	0.801	0.204	0.029	0.008	5.476
27000	953.5	147.97	2.040	0.858	0.219	0.031	0.008	5.874
28000	988.81	153.45	2.181	0.918	0.234	0.033	0.009	6.284
29000	1024.13	158.94	2.327	0.979	0.249	0.035	0.009	6.708
30000	1059.44	164.42	2.478	1.042	0.265	0.037	0.001	7.145
35000	1236.01	191.82	3.295	1.384	0.351	0.050	0.013	
40000	1412.59	219.22	4.222	1.770	0.499	0.063	0.017	
45000	1589.16	246.62	5.256	2.201	0.557	0.078	0.021	
50000	1765.73	274.03	6.396	2.676	0.676	0.095	0.025	
55000	1942.31	301.43	7.642	3.194	0.806	0.113	0.030	
60000	2118.88	328.83		3.755	0.947	0.133	0.035	
65000	2295.45	356.23		4.358	1.098	0.154	0.040	

NITROUS OXIDE (55 PSI) PIPING PRESSURE LOSS DATA

Nitrous Oxide Flow			Pressure Drop of Nitrous Oxide in PSI per 100ft of Type L Copper Pipe for Nitrous Oxide at 55psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Liters per Minute	Standard CFM	Actual CFM					
@ 68°F & 14.7 psia		@ 68°F & 55 psig	**1/2"**				
10	0.35	0.07	0.003	**3/4"**			
20	0.71	0.15	0.013	0.002			
30	1.06	0.22	0.026	0.005			
40	1.41	0.30	0.043	0.008			
50	1.77	0.37	0.063	0.011			
60	2.12	0.45	0.087	0.015			
70	2.47	0.52	0.114	0.020			
80	2.83	0.60	0.144	0.025			
90	3.18	0.67	0.176	0.031	**1"**		
100	3.53	0.74	0.212	0.037	0.011		
120	4.24	0.89	0.292	0.051	0.015		
140	4.94	1.04	0.383	0.067	0.019		
160	5.65	1.19	0.485	0.085	0.024		
180	6.36	1.34	0.597	0.105	0.029		
200	7.06	1.49	0.720	0.126	0.035		
220	7.77	1.64	0.853	0.149	0.042		
240	8.48	1.79	0.996	0.174	0.049		
260	9.18	1.94	1.148	0.200	0.056		
280	9.89	2.08	1.310	0.228	0.064		
300	10.59	2.23	1.482	0.258	0.072		
320	11.30	2.38	1.664	0.289	0.081		
340	12.01	2.53	1.854	0.322	0.090		
360	12.71	2.68	2.054	0.357	0.010		
380	13.42	2.83	2.264	0.393	0.110	**1 1/4"**	
400	14.13	2.98	2.482	0.430	0.120	0.044	
450	15.89	3.35	3.068	0.531	0.148	0.054	
500	17.66	3.72	3.709	0.640	0.178	0.065	
550	19.42	4.01	4.406	0.759	0.211	0.077	
600	21.19	4.47	5.157	0.888	0.247	0.090	
650	22.95	4.84		1.025	0.258	0.104	
700	24.72	5.21		1.171	0.325	0.119	
750	26.49	5.58		1.325	0.367	0.134	**1 1/2"**
800	28.25	5.96		1.489	0.412	0.150	0.065
850	30.02	6.33		1.661	0.460	0.168	0.073
900	31.78	6.70		1.841	0.509	0.186	0.081
950	33.55	7.07		2.030	0.561	0.204	0.089
1000	35.31	7.45		2.227	0.616	0.224	0.097

NITROUS OXIDE (55 PSI) PIPING PRESSURE LOSS DATA

Nitrous Oxide Flow			Pressure Drop of Nitrous Oxide in PSI per 100ft of Type L Copper Pipe for Nitrous Oxide at 55psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 55 psig		3/4"	1"	1 1/4"	1 1/2"	
1100	38.85	8.19		2.647	0.731	0.266	0.115	
1200	42.38	8.94		3.099	0.855	0.311	0.135	
1300	45.91	9.68		3.585	0.988	0.359	0.156	
1400	49.44	10.42		4.102	1.129	0.410	0.178	
1500	52.97	11.17		4.651	1.279	0.464	0.201	**2"**
1600	56.50	11.91		5.232	1.438	0.521	0.226	0.060
1700	60.03	12.66			1.605	0.581	0.252	0.067
1800	63.57	13.40			1.780	0.644	0.279	0.074
1900	67.01	14.15	**2 1/2"**		1.963	0.711	0.308	0.081
2000	70.63	14.89	0.032		2.155	0.780	0.337	0.089
2250	79.46	16.75	0.039		2.671	0.965	0.417	0.110
2500	88.29	18.62	0.047		3.237	1.168	0.505	0.133
2750	97.12	20.48	0.056		3.853	1.389	0.600	0.158
3000	105.94	22.34	0.065		4.518	1.628	0.702	0.185
3250	114.77	24.20	0.075		5.232	1.883	0.812	0.214
3500	123.60	26.06	0.086			2.156	0.929	0.244
3750	132.43	27.92	0.098			2.445	1.054	0.277
4000	141.26	29.79	0.110			2.752	1.185	0.311
4250	150.09	31.65	0.122			3.075	1.323	0.347
4500	158.92	33.51	0.135			3.415	1.469	0.385
4750	167.74	35.37	0.149			3.771	1.621	0.425
5000	176.57	37.23	0.164			4.144	1.781	0.466
5500	194.23	40.96	0.195	**3"**		4.938	2.120	0.554
6000	211.89	44.68	0.228	0.097		5.796	2.487	0.649
6500	229.55	48.40	0.264	0.112			2.880	0.751
7000	247.20	52.12	0.302	0.128			3.301	0.860
7500	264.86	55.85	0.342	0.145			3.748	0.976
8000	282.52	59.57	0.385	0.163	**4"**		4.221	1.098
8500	300.17	63.29	0.430	0.182	0.047		4.721	1.227
9000	317.83	67.02	0.477	0.202	0.052		5.247	1.363
9500	335.49	70.74	0.526	0.223	0.057			1.505
10000	353.15	74.46	0.578	0.244	0.063			1.653
10500	370.80	78.19	0.632	0.267	0.068			1.808
11000	388.46	81.91	0.688	0.291	0.074			1.970
11500	406.12	85.63	0.746	0.315	0.081			2.138
12000	423.78	89.36	0.807	0.341	0.087			2.312
13000	459.09	96.80	0.934	0.394	0.101			2.679

CARBON DIOXIDE (55 PSI) PIPING PRESSURE LOSS DATA

Carbon Dioxide Flow			Pressure Drop for Carbon Dioxide in PSI per 100 feet of Type L Copper Pipe for Carbon Dioxide at 55 psi Gauge Pressure 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Liters per Minute	Standard CFM	Actual CFM					
@ 68°F & 14.7 psia		@ 68°F & 55 psig	**1/2"**				
10	0.35	0.07	0.003	**3/4"**			
20	0.71	0.15	0.012	0.002			
30	1.06	0.22	0.025	0.004			
40	1.41	0.30	0.040	0.007			
50	1.77	0.37	0.059	0.011			
60	2.12	0.45	0.082	0.014			
70	2.47	0.52	0.107	0.019			
80	2.83	0.60	0.135	0.024			
90	3.18	0.67	0.166	0.029	**1"**		
100	3.53	0.74	0.200	0.035	0.001		
120	4.24	0.89	0.275	0.048	0.014		
140	4.94	1.04	0.362	0.063	0.018		
160	5.65	1.19	0.458	0.080	0.023		
180	6.36	1.34	0.565	0.099	0.028		
200	7.06	1.49	0.681	0.119	0.033		
220	7.77	1.64	0.808	0.141	0.039		
240	8.48	1.79	0.944	0.164	0.046		
260	9.18	1.94	1.089	0.189	0.053		
280	9.89	2.08	1.244	0.216	0.060		
300	10.59	2.23	1.407	0.244	0.068		
320	11.30	2.38	1.580	0.274	0.076		
340	12.01	2.53	1.763	0.305	0.085		
360	12.71	2.68	1.954	0.338	0.094		
380	13.42	2.83	2.154	0.372	0.104	**1 1/4"**	
400	14.13	2.98	2.362	0.408	0.113	0.041	
450	15.89	3.35	2.923	0.503	0.140	0.051	
500	17.66	3.72	3.537	0.608	0.169	0.062	
550	19.42	4.01	4.205	0.722	0.200	0.073	
600	21.19	4.47	4.926	0.844	0.234	0.085	
650	22.95	4.84		0.975	0.270	0.098	
700	24.72	5.21		1.114	0.308	0.112	
750	26.49	5.58		1.262	0.349	0.127	**1 1/2"**
800	28.25	5.96		1.419	0.392	0.143	0.062
850	30.02	6.33		1.583	0.437	0.159	0.069
900	31.78	6.70		1.756	0.485	0.176	0.077
950	33.55	7.07		1.937	0.534	0.194	0.084
1000	35.31	7.45		2.127	0.586	0.213	0.092

CARBON DIOXIDE (55 PSI) PIPING PRESSURE LOSS DATA

Carbon Dioxide Flow			Pressure Drop for Carbon Dioxide in PSI per 100 feet of Type L Copper Pipe for Carbon Dioxide at 55 psi Gauge Pressure 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 55 psig		3/4"	1"	1 1/4"	1 1/2"	
1100	38.85	8.19		2.529	0.696	0.253	0.110	
1200	42.38	8.94		2.964	0.815	0.295	0.128	
1300	45.91	9.68		3.430	0.942	0.341	0.148	
1400	49.44	10.42		3.928	1.077	0.390	0.169	
1500	52.97	11.17		4.456	1.221	0.442	0.191	**2"**
1600	56.50	11.91		5.016	1.373	0.497	0.215	0.057
1700	60.03	12.66			1.533	0.554	0.240	0.063
1800	63.57	13.40			1.702	0.615	0.266	0.070
1900	67.01	14.15	**2 1/2"**		1.878	0.678	0.293	0.077
2000	70.63	14.89	0.030		2.063	0.744	0.322	0.085
2250	79.46	16.75	0.037		2.558	0.922	0.398	0.105
2500	88.29	18.62	0.045		3.103	1.117	0.482	0.127
2750	97.12	20.48	0.053		3.697	1.329	0.573	0.151
3000	105.94	22.34	0.062		4.338	1.558	0.671	0.176
3250	114.77	24.20	0.072		5.028	1.804	0.777	0.204
3500	123.60	26.06	0.082			2.067	0.889	0.233
3750	132.43	27.92	0.093			2.346	1.009	0.264
4000	141.26	29.79	0.104			2.641	1.135	0.297
4250	150.09	31.65	0.117			2.953	1.268	0.332
4500	158.92	33.51	0.129			3.281	1.408	0.368
4750	167.74	35.37	0.143			3.625	1.555	0.406
5000	176.57	37.23	0.156			3.984	1.708	0.446
5500	194.23	40.96	0.186	**3"**		4.752	2.035	0.530
6000	211.89	44.68	0.218	0.092		5.583	2.389	0.622
6500	229.55	48.40	0.252	0.107			2.769	0.720
7000	247.20	52.12	0.289	0.122			3.175	0.825
7500	264.86	55.85	0.327	0.138			3.608	0.936
8000	282.52	59.57	0.368	0.156	**4"**		4.066	1.054
8500	300.17	63.29	0.411	0.174	0.045		4.549	1.178
9000	317.83	67.02	0.457	0.193	0.049		5.058	1.309
9500	335.49	70.74	0.504	0.213	0.054			1.446
10000	353.15	74.46	0.554	0.234	0.060			1.589
10500	370.80	78.19	0.606	0.256	0.065			1.739
11000	388.46	81.91	0.660	0.278	0.071			1.895
11500	406.12	85.63	0.716	0.302	0.077			2.057
12000	423.78	89.36	0.774	0.326	0.083			2.225
13000	459.09	96.80	0.897	0.378	0.096			2.581

CARBON DIOXIDE (100 PSI) PIPING PRESSURE LOSS DATA

Carbon Dioxide Flow			Pressure Drop of Carbon Dioxide in PSI per 100ft of Type L Copper Pipe for Carbon Dioxide at 100psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Liters per Minute	Standard CFM	Actual CFM					
@ 68°F & 14.7 psia		@ 68°F & 100 psig	**1/2"**				
10	0.35	0.05	0.002	**3/4"**			
20	0.71	0.09	0.007	0.001			
30	1.06	0.14	0.015	0.003			
40	1.41	0.18	0.025	0.004			
50	1.77	0.23	0.036	0.006			
60	2.12	0.27	0.050	0.009			
70	2.47	0.32	0.065	0.011			
80	2.83	0.36	0.082	0.014			
90	3.18	0.41	0.101	0.018	**1"**		
100	3.53	0.45	0.121	0.021	0.006		
120	4.24	0.54	0.167	0.029	0.008		
140	4.94	0.63	0.220	0.039	0.011		
160	5.65	0.72	0.278	0.049	0.014		
180	6.36	0.81	0.343	0.060	0.017		
200	7.06	0.90	0.414	0.072	0.020		
220	7.77	1.00	0.491	0.085	0.024		
240	8.48	1.09	0.573	0.010	0.028		
260	9.18	1.18	0.662	0.115	0.032		
280	9.89	1.27	0.756	0.131	0.037		
300	10.59	1.36	0.855	0.148	0.041		
320	11.30	1.45	0.960	0.166	0.046		
340	12.01	1.54	1.071	0.185	0.052		
360	12.71	1.63	1.187	0.205	0.057		
380	13.42	1.72	1.309	0.226	0.063	**1 1/4"**	
400	14.13	1.81	1.436	0.248	0.069	0.025	
450	15.89	2.04	1.776	0.306	0.085	0.031	
500	17.66	2.26	2.149	0.370	0.103	0.037	
550	19.42	2.49	2.555	0.439	0.122	0.044	
600	21.19	2.71	2.993	0.513	0.142	0.052	
650	22.95	2.94	3.463	0.592	0.164	0.060	
700	24.72	3.17	3.964	0.677	0.187	0.068	
750	26.49	3.39	4.497	0.767	0.212	0.077	**1 1/2"**
800	28.25	3.62	5.061	0.862	0.238	0.087	0.038
850	30.02	3.85	5.655	0.962	0.266	0.097	0.042
900	31.78	4.07	6.281	1.067	0.294	0.107	0.046
950	33.55	4.30	6.936	1.177	0.325	0.118	0.051
1000	35.31	4.52	7.622	1.292	0.356	0.129	0.056

CARBON DIOXIDE (100 PSI) PIPING PRESSURE LOSS DATA

Carbon Dioxide Flow			Pressure Drop of Carbon Dioxide in PSI per 100ft of Type L Copper Pipe for Carbon Dioxide at 100psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 100 psig		3/4"	1"	1 1/4"	1 1/2"	
1100	38.85	4.98		1.537	0.423	0.153	0.067	
1200	42.38	5.43		1.801	0.495	0.180	0.078	
1300	45.91	5.88		2.084	0.572	0.207	0.090	
1400	49.44	6.33		2.387	0.655	0.237	0.103	
1500	52.97	6.79		2.708	0.742	2.690	0.116	**2"**
1600	56.50	7.24		3.048	0.834	0.302	0.131	0.035
1700	60.03	7.69		3.407	0.932	0.337	0.146	0.038
1800	63.57	8.14		3.784	1.034	0.374	0.162	0.043
1900	67.01	8.60	**2 1/2"**	4.180	1.141	0.412	0.178	0.047
2000	70.63	9.05	0.018	4.594	1.253	0.452	0.195	0.052
2250	79.46	10.18	0.022	5.709	1.555	0.560	0.242	0.064
2500	88.29	11.31	0.027	6.938	1.886	0.679	0.293	0.077
2750	97.12	12.44	0.032	8.278	2.246	0.808	0.348	0.092
3000	105.94	13.57	0.038		2.636	0.947	0.408	0.107
3250	114.77	14.71	0.044		3.055	1.096	0.472	0.124
3500	123.60	15.84	0.050		3.503	1.256	0.540	0.142
3750	132.43	16.97	0.056		3.979	1.425	0.613	0.160
4000	141.26	18.01	0.063		4.484	1.605	0.690	0.180
4250	150.09	19.23	0.071		5.017	1.794	0.771	0.201
4500	158.92	20.36	0.079		5.579	1.993	0.856	0.224
4750	167.74	21.49	0.087		6.168	2.202	0.945	0.247
5000	176.57	22.62	0.095		6.786	2.421	1.038	0.271
5500	194.23	24.89	0.113	**3"**		2.888	1.237	0.322
6000	211.89	27.15	0.132	0.056		3.393	1.452	0.378
6500	229.55	29.41	0.153	0.065		3.936	1.683	0.437
7000	247.20	31.67	0.175	0.074		4.517	1.930	0.501
7500	264.86	33.94	0.199	0.084		5.136	2.192	0.569
8000	282.52	36.20	0.224	0.095	**4"**	5.792	2.470	0.640
8500	300.17	38.46	0.250	0.106	0.027	6.486	2.764	0.716
9000	317.83	40.72	0.278	0.117	0.030	7.217	3.074	0.795
9500	335.49	42.99	0.306	0.129	0.033	7.985	3.399	0.878
10000	353.15	45.25	0.337	0.142	0.036	8.791	3.739	0.966
10500	370.80	47.51	0.368	0.155	0.040	9.633	4.095	1.056
11000	388.46	49.77	0.401	0.169	0.043		4.466	1.151
11500	406.12	52.04	0.435	0.183	0.047		4.852	1.250
12000	423.78	54.30	0.471	0.198	0.051		5.254	1.352
13000	459.09	58.82	0.545	0.230	0.059		6.102	1.568

NITROGEN (185 PSI) PIPING PRESSURE LOSS DATA

Nitrogen Flow			Pressure Drop of Nitrogen in PSI per 100ft of Type L Copper Pipe for Nitrogen at 185 psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 185 psig	**1/2"**					
100	3.53	0.26	0.061	**3/4"**				
150	5.30	0.39	0.123	0.024				
200	7.06	0.52	0.205	0.039				
250	8.83	0.65	0.303	0.058				
300	10.59	0.78	0.419	0.080				
350	12.36	0.91	0.552	0.105				
400	14.13	1.04	0.700	0.133				
450	15.89	1.17	0.864	0.164				
500	17.66	1.30	1.044	0.198	**1"**			
600	21.19	1.56	1.448	0.274	0.069			
700	24.72	1.82	1.912	0.361	0.090			
800	28.25	2.08	2.434	0.458	0.114			
900	31.78	2.34	3.012	0.566	0.141			
1000	35.31	2.60	3.648	0.685	0.170	**1 1/4"**		
1100	38.85	2.86	4.338	0.813	0.202	0.069		
1200	42.38	3.12	5.084	0.951	0.236	0.080		
1300	45.91	3.38	5.884	1.099	0.272	0.093		
1400	49.44	3.64	6.739	1.257	0.311	0.106	**1 1/2"**	
1500	52.97	3.90	7.647	1.424	0.352	0.120	0.052	
1600	56.50	4.16	8.608	1.601	0.396	0.135	0.059	
1700	60.03	4.42	9.623	1.787	0.442	0.150	0.065	
1800	63.57	4.68	10.690	1.983	0.490	0.166	0.072	
1900	67.01	4.94	11.810	2.188	0.540	0.183	0.080	**2"**
2000	70.63	5.20	12.982	2.402	0.592	0.201	0.087	0.025
2100	74.16	5.46	14.206	2.626	0.647	0.220	0.095	0.027
2200	77.69	5.72	15.482	2.859	0.704	0.239	0.104	0.029
2300	81.22	5.98	16.810	3.100	0.763	0.259	0.112	0.032
2400	84.76	6.24	18.190	3.351	0.824	0.279	0.121	0.034
2500	88.29	6.50	19.620	3.611	0.887	0.301	0.130	0.040
2750	97.12	7.15		4.301	1.055	0.357	0.155	0.047
3000	105.94	7.80		5.046	1.236	0.418	0.181	0.054
3250	114.77	8.45	**2 1/2"**	5.846	1.430	0.483	0.209	0.062
3500	123.60	9.01	0.025	6.702	1.637	0.553	0.239	0.070
3750	132.43	9.75	0.028	7.612	1.857	0.627	0.271	0.079
4000	141.26	10.40	0.031	8.576	2.090	0.705	0.304	0.088
4250	150.09	11.05	0.034	9.594	2.336	0.787	0.340	0.098
4500	158.92	11.69	0.038	10.667	2.594	0.873	0.377	0.108

NITROGEN (185 PSI) PIPING PRESSURE LOSS DATA

Nitrogen Flow			Pressure Drop of Nitrogen in PSI per 100ft of Type L Copper Pipe for Nitrogen at 185 psi Gauge Pressure and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Liters per Minute	Standard CFM	Actual CFM						
@ 68°F & 14.7 psia		@ 68°F & 185 psig	**2 1/2"**	**3/4"**	**1"**	**1 1/4"**	**1 1/2"**	**2"**
4750	167.74	12.34	0.042	11.792	2.864	0.964	0.416	0.118
5000	176.57	12.99	0.049	12.971	3.148	1.058	0.456	0.141
6000	211.89	15.59	0.058	15.489	3.751	1.260	0.543	0.165
6500	229.55	16.89	0.067	18.219	4.404	1.477	0.636	0.190
7000	247.20	18.19	0.076		5.106	1.711	0.736	0.218
7500	264.86	19.49	0.086		5.857	1.960	0.843	0.247
8000	282.52	20.79	0.097		6.655	2.225	0.956	0.277
8500	300.17	22.09	0.108		7.502	2.506	1.077	0.310
9000	317.83	23.39	0.120		8.397	2.803	1.203	0.344
9500	335.49	24.69	0.133		9.339	3.114	1.336	0.379
10000	353.15	25.99	0.145		10.329	3.441	1.476	0.417
10500	370.80	27.29	0.159	**3"**	11.366	3.784	1.622	0.456
11000	388.46	28.59	0.173	0.074	12.451	4.142	1.774	0.496
11500	406.12	29.89	0.188	0.080	13.582	4.515	1.993	0.538
12000	423.78	31.19	0.203	0.086	14.761	4.903	2.098	0.582
13000	459.09	33.79	0.235	0.010	15.986	5.306	2.269	0.674
14000	494.41	36.38	0.269	0.114	18.577	6.157	2.631	0.772
15000	529.72	38.98	0.305	0.129	21.354	7.068	3.018	0.876
16000	565.03	41.58	0.343	0.145		8.039	3.430	0.986
17000	600.35	44.18	0.383	0.162		9.069	3.866	1.103
18000	635.66	46.78	0.425	0.180		10.158	4.327	1.225
19000	670.98	49.38	0.470	0.199		11.306	4.812	1.354
20000	706.29	51.98	0.516	0.218		13.778	5.856	1.488
21000	741.61	54.58	0.564	0.239		15.102	6.415	1.629
22000	776.92	57.18	0.615	0.260		16.484	6.997	1.775
23000	812.24	59.77	0.667	0.282	**4"**	17.924	7.604	1.928
24000	847.55	62.37	0.722	0.305	0.078	19.422	8.235	2.086
26000	918.18	67.57	0.836	0.353	0.090		9.568	2.420
28000	988.81	72.77	0.959	0.405	0.103		10.997	2.777
30000	1059.44	77.97	1.089	0.460	0.117		12.521	3.157
32000	1130.07	83.16	1.227	0.518	0.131		14.140	3.561
34000	1200.70	88.36	1.373	0.579	0.147		15.853	3.987
36000	1271.33	93.56	1.527	0.643	0.163		17.661	4.436
38000	1341.96	98.76	1.688	0.711	0.180		19.563	4.908
40000	1412.59	103.95	1.857	0.781	0.197		21.559	5.403
42000	1483.22	109.15	2.033	0.855	0.216			5.921
44000	1553.85	114.35	2.217	0.932	0.235			6.461

VACUUM (19 inHgV) PIPING PRESSURE LOSS DATA

Air Flow			Pressure Drop for Air in inHg per 100ft of Type L Copper Pipe for under vacuum at 19inHgV gauge vacuum and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Actual CFM	Actual LPM	SCFM					
@ 68°F & 19 inHgV		@ 68°F & 29.9 inHgA	**3/4"**				
1	28.32	0.36	0.021				
2	56.63	0.73	0.041				
3	84.95	1.09	0.099				
4	113.27	1.46	0.161	**1"**			
5	141.58	1.82	0.235	0.067			
6	169.90	2.19	0.320	0.091			
7	198.22	2.55	0.417	0.119			
8	226.53	2.92	0.525	0.149			
9	254.85	3.28	0.642	0.182	**1 1/4"**		
10	283.17	3.65	0.770	0.218	0.081		
11	311.49	4.01	0.908	0.257	0.095		
12	339.80	4.38	1.056	0.299	0.111		
13	368.12	4.74	1.213	0.343	0.127		
14	396.44	5.11	1.380	0.390	0.144	**1 1/2"**	
15	424.75	5.47	1.556	0.439	0.163	0.072	
16	453.07	5.84	1.741	0.491	0.182	0.080	
17	481.39	6.20	1.935	0.546	0.202	0.089	
18	509.70	6.57	2.138	0.603	0.223	0.098	
19	538.02	6.93	2.349	0.662	0.244	0.107	
20	566.34	7.30	2.570	0.724	0.267	0.117	
21	594.65	7.66	2.799	0.788	0.291	0.128	
22	622.97	8.03	3.036	0.855	0.315	0.138	
23	651.29	8.39	3.282	0.924	0.340	0.150	
24	679.60	8.76	3.537	0.995	0.367	0.161	
25	707.92	9.12	3.799	1.068	0.394	0.173	
26	736.24	9.49		1.144	0.421	0.185	
27	764.55	9.85		1.222	0.450	0.197	
28	792.87	10.22		1.302	0.479	0.210	
29	821.19	10.58		1.385	0.510	0.224	
30	849.51	10.95		1.470	0.541	0.237	
31	877.82	11.31		1.557	0.573	0.251	
32	906.14	11.68		1.646	0.605	0.265	
33	934.46	12.04		1.737	0.639	0.280	
34	962.77	12.41		1.831	0.673	0.295	**2"**
35	991.09	12.77		1.926	0.708	0.310	0.083
36	1019.41	13.14		2.024	0.744	0.326	0.088
37	1047.72	13.50		2.124	0.780	0.342	0.092
38	1076.04	13.87		2.226	0.818	0.358	0.096

VACUUM (19 inHgV) PIPING PRESSURE LOSS DATA

Air Flow			Pressure Drop for Air in inHgV per 100ft of Type L Copper Pipe for under vacuum at 19inHgV gauge vacuum and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)					
Actual CFM	Actual LPM	SCFM						
@ 68°F & 19 inHgV		@ 68°F & 29.9 inHgA		1"	1 1/4"	1 1/2"	2"	
39	1104.36	14.23		2.330	0.856	0.375	0.101	
40	1132.67	14.60		2.436	0.895	0.392	0.105	
41	1160.99	14.96		2.544	0.934	0.409	0.110	
42	1189.31	15.33		2.655	0.975	0.427	0.115	
43	1217.62	15.69		2.767	1.016	0.445	0.119	
44	1245.94	16.06		2.882	1.058	0.463	0.124	
45	1274.26	16.42		2.998	1.100	0.481	0.129	
46	1302.58	16.79		3.117	1.143	0.500	0.134	
47	1330.89	17.15		3.237	1.188	0.519	0.139	
48	1359.21	17.52		3.360	1.232	0.539	0.145	
49	1387.53	17.88		3.485	1.278	0.559	0.150	
50	1415.84	18.25		3.611	1.324	0.579	0.155	
55	1557.43	20.07			1.566	0.685	0.183	**2 1/2"**
60	1699.01	21.90			1.826	0.798	0.214	0.076
65	1840.60	23.72			2.104	0.919	0.246	0.088
70	1982.18	25.55			2.398	1.047	0.280	0.100
75	2123.76	27.37			2.710	1.182	0.316	0.113
80	2265.35	29.20			3.038	1.325	0.354	0.126
85	2406.93	31.02			3.383	1.475	0.394	0.141
90	2548.52	32.85			3.745	1.632	0.436	0.155
95	2690.10	34.67				1.797	0.479	0.171
100	2831.68	36.50	**3"**				0.525	0.187
110	3114.85	40.15	0.080				0.621	0.221
120	3398.02	43.80	0.095				0.724	0.258
130	3681.19	47.45	0.110				0.835	0.297
140	3964.36	51.01	0.127				0.952	0.338
150	4247.53	54.75	0.145				1.076	0.382
160	4530.70	58.40	0.164					0.429
170	4813.86	62.05	0.183					0.477
180	5097.03	65.70	0.204					0.528
190	5380.20	69.35	0.226	**4"**				0.582
200	5663.37	73.00	0.249	0.071				0.637
210	5946.54	76.65	0.272	0.077				0.695
220	6229.71	80.30	0.297	0.084				0.755
230	6512.88	83.95	0.322	0.091				0.817
240	6796.04	87.60	0.349	0.098				0.881
250	7079.21	91.25	0.376	0.105				0.948
275	7787.13	100.37	0.405	0.124				1.123

VACUUM (19 inHgV) PIPING PRESSURE LOSS DATA

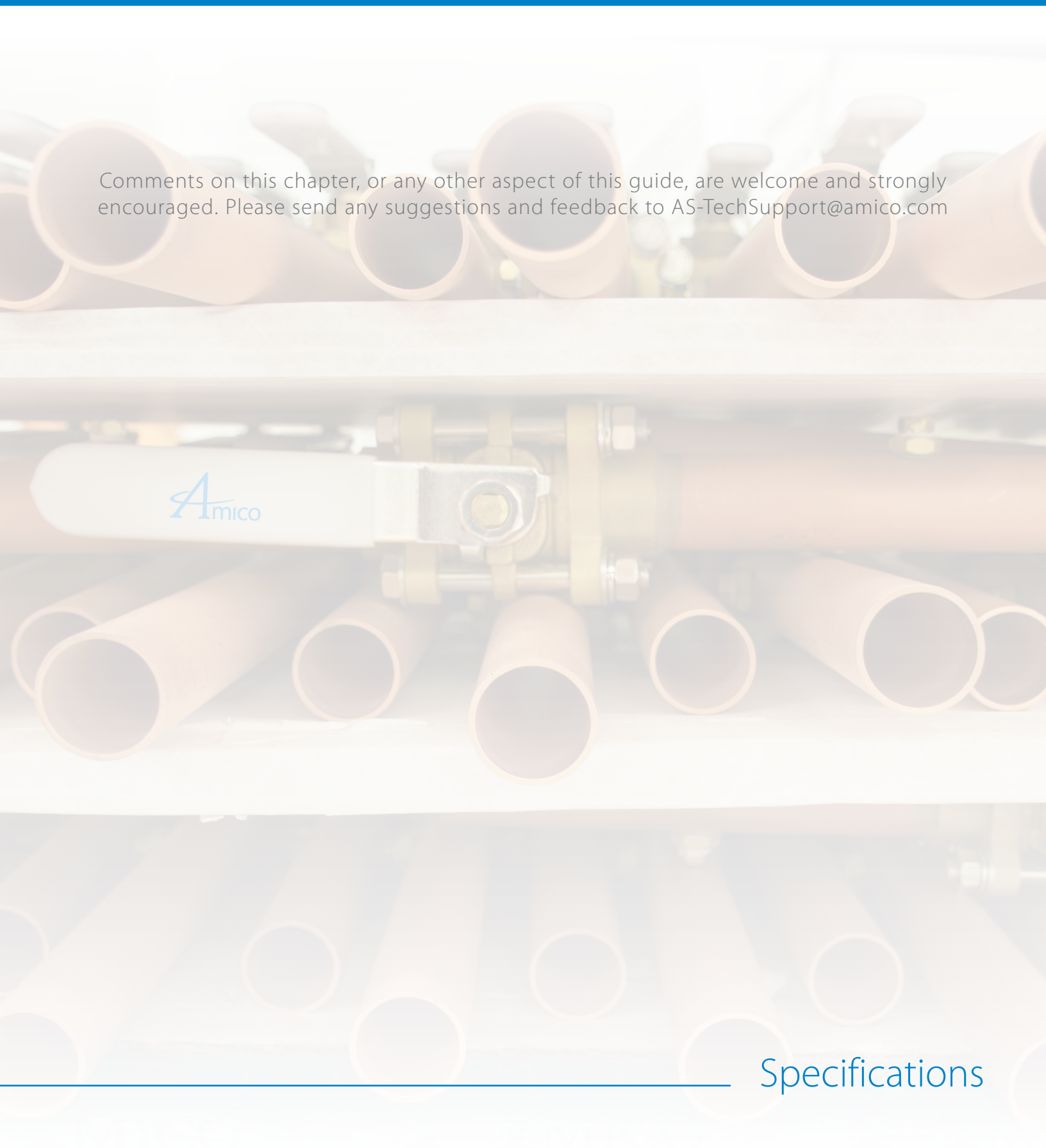
Air Flow			Pressure Drop for Air in inHg per 100ft of Type L Copper Pipe for under vacuum at 19inHgV gauge vacuum and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Actual CFM	Actual LPM	SCFM					
@ 68°F & 19 inHgV		@ 68°F & 29.9 inHgA	3"	4"			2 1/2"
300	8495	109	0.479	0.145			1.312
325	9203	118	0.560	0.167			1.514
350	9911	127	0.646	0.191			1.729
375	10619	136	0.737	0.216			1.957
400	11327	146	0.834	0.242			2.197
425	12034	155	0.936	0.270			2.450
450	12742	164	1.043	0.299			2.715
475	13450	173	1.155	0.329			2.992
500	14158	182	1.273	0.361			3.281
550	15574	200	1.396	0.428	6"		
600	16990	218	1.656	0.500	0.072		
650	18406	237	1.937	0.577	0.083		
700	19822	255	2.237	0.659	0.095		
750	21238	273	2.556	0.746	0.107		
800	22653	292	2.895	0.838	0.120		
850	24069	310	3.253	0.934	0.134		
900	25485	328	3.629	1.035	0.148		
950	26901	346		1.141	0.163		
1000	28317	364		1.252	0.179		
1050	29733	383		1.367	0.196		
1100	31148	401		1.487	0.213		
1150	32564	419		1.611	0.230		
1200	33980	437		1.740	0.249	8"	
1300	36812	474		2.011	0.287	0.076	
1400	39643	511		2.299	0.328	0.087	
1500	42475	547		2.605	0.371	0.098	
1600	45307	584		2.928	0.417	0.110	
1700	48139	620		3.269	0.465	0.123	
1800	50970	657			0.516	0.136	
1900	53802	693			0.569	0.150	
2000	56634	730			0.624	0.164	
2100	59465	766			0.681	0.180	
2200	62297	803			0.741	0.195	
2300	65129	839			0.803	0.212	
2400	67960	876			0.868	0.228	
2500	70792	912			0.934	0.246	
3000	84950	1095			1.300	0.342	
3500	99109	1277			1.721	0.452	

VACUUM (19 inHgV) PIPING PRESSURE LOSS DATA

Air Flow			Pressure Drop for Air in inHg per 100ft of Type L Copper Pipe for under vacuum at 19inHgV gauge vacuum and 68°F Temperature (Nominal Pipe Diameters are shown in Bold)				
Actual CFM	Actual LPM	SCFM					
@ 68°F & 19 inHgV		@ 68°F & 29.9 inHgA					
				6"	**8"**		
4000	113267	1459		2.194	0.576		
4500	127425	1642		2.720	0.713		
5000	141584	1824		3.297	0.863		
5500	155742	2007			1.027		

Chapter 11

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



Specifications

Chapter 11 – Specifications

This is a final stage of the design work. All required equipment should have been sized, chosen and placed in the drawings and plans. This chapter ties all the necessary design steps and processes together and transformed into an essential legal document.

Below forma is followed from AIA Guidespec master format.

PART 1: GENERAL

1.1 RELATED DOCUMENTS

- Drawings and general provisions of the Contact, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes all labor, equipment and services for the purpose of installation of piped medical gas and vacuum systems which include Oxygen, Medical Air, Medical Vacuum, WAGD, Nitrogen, Instrument Air, Nitrous Oxide, Helium, Carbon Dioxide, Argon, Dental Air, Dental Vacuum, Laboratory Air and Mixed Gases systems as presented on drawings and/specified herein.

- Oxygen systems shall be complete to the source valve and ready to connect to the gas supply system,
- Medical Vacuum, WAGD and Medical Air systems shall be completed, tested, started and all ready to be used.
- Nitrogen, Nitrous Oxide, Carbon Dioxide, Argon, Helium and Mixed Gas Systems shall be completed, tested and ready to be used.

B. Owner Furnished Materials for installation under this section

- Supply of gases in cylinders or containers as appropriate for manifolds.
- Initial supply of liquid (Nitrogen, Oxygen)

1.3 DEFINITIONS AND REFERENCES

All references related to the latest edition.

- National Fire Protection Association (NFPA), NFPA 99 Health Care Facilities Code.
- Copper Development Association Inc. Copper Tube Handbook.
- AIA Guidespec Master Format

1.4 PERFORMANCE REQUIREMENTS

- Contractor/installer shall make required connections to owner completed equipment
- Given all elements and accessories required for complete systems as per NFPA 99 latest edition
- All materials, devices, equipment used shall be new and of the best quality and workmanship shall be first class in every aspect. Contractor/installer shall be responsible for compliance with all Local, State or Federal codes.
- Install all pipping as shown on drawings, using methods of cleaning, testing and procedures described in this guide.

- Electrical power wiring for alarms, vacuum pumps, medical air compressors and modular accessories associated with the systems shall be part of the electrical contract.
- Perform Installer pressure testing and all other related testing shall be as per NFPA 99 latest edition.

1.5 COORDINATION

- Coordinate with owner to verify medical gas outlets (whether it is supplied by owner or installer) are in walls, in ceiling and that all required equipment is provided by the same medical gas equipment manufacturer.
- Medical Gas Contractor/Installer shall work with related trades to ensure installations are on reasonable time and to avoid conflicts and other interference.
- Coordinate with gas supplier for installation and connection of gas supply systems.
- Medical gas contractor or installer shall supply and install master alarm system, including the signal wiring and for proper termination, testing of alarm panel. While the electrical contractor shall provide power wiring to each alarm panel.
- Coordinate with Medical Gas Verifier to perform tests and ready for owner to use.

1.6 SUBMITTALS

A. Medical Gas Equipment Manufacturer (MGEM) submittals shall include:

- Complete specifications for the parts chosen to be installed: for instance, dimensional drawings and wiring schematics where applicable.
- Complete installation instructions for use of the installer
- Maintenance schedules
- Warranty statements
- Statement of compliance with NFPA 99 latest edition
- For Medical Air, Medical Vacuum and WAGD plants include:
    - Package drawing specifying style, measurement when it is done, method of disassembly and sizes of subsections for rigging and installation.
    - Compressor and package capacity in required unit of measure
    - Types and replacement of air filters
    - Types and manufacturer of air dryer
    - Types and manufacturer of pressure regulators
    - Dew point monitor including technology employed , calibration interval and annual drift in ppm
    - Carbon monoxide monitor including technology employed, calibration interval, and annual drift in ppm
    - Sound pressure in dBa when operated at NFPA capacity
    - BTU output for the equipment

B. Pre-approval:

- Written pre-approval is required for equipment not exactly as per specifications.
- A request for pre-approval of equipment must be received by the Engineer at a given time frame

1.7 QUALITY ASSURANCE

A. Regulatory Requirements:

- Medical Air, Instrument Air, WAGD and Medical Vacuum controls are to be wired in according with NEC.
- The contractor or installer shall furnish documentation stating that all installing pipping materials were bought cleaned and compliance with NFPA 99 5.1.10.1 and 5.1.10.2

B. Installation and starting up:

The Medical Gas Equipment Manufacturer (MGEM) may provide factory authorized representatives to review the installation or perform the initial starting up.

C. Warranty

- Warranty shall include on site repairs including travel, labor and parts.
- All medical gas pipeline components shall be warranted by the Medical Gas Equipment Manufacturer.
- Warranty include all components of the system and be responsibility of the Medical Gas Equipment Manufacturer of record only. Warranties limiting the responsibility of the Medical Gas Equipment Manufacturer for any system component or which through the Medical Gas Equipment Manufacturer to another manufacturer are not acceptable.

D. Maintenance

- MGEM shall offer factory direct preventative maintenance contract for the owner's consideration
- MGEM may offer formal maintenance training courses for owners review

PART 2: PRODUCTS

2.1 QUALIFICATION OF MANUFACTURER

- Approved MGEM: Piping Systems Components and Medical Gas Alarms:
  - Amico Corporation
  - Alternate by _____ with pre approval.
- Written Pre-approval is required for all equipment from other manufactures
- MGEM shall provide a list of approved contractors during the installation and service support around or within the hospital area after turnover.

2.2 MATERIALS

A. All pressurized medical gas piping shall be as follow:

- Valves, pipe, fittings and other components shall be cleaned for oxygen service in a facility equipped to clean, rinse and purge the material in compliance with NFPA 5.1.10.1.1 and received on job site cleaned and capped.
- Fittings shall be wrought copper, brass or bronze designed for brazed connection compliant with ANSI B16.22
- Seamless ASTM B-819, type K or L hard medical gas copper tubing
- Brazing alloy shall be BCup-5

2.3 SUBSYSTEMS

A. Medical Gas Outlet Stations:

- Amico's Medical gas outlet stations include: Ohmeda Compatible-quick-disconnect recessed type, DISS screw thread. Threaded DISS connector shall be per CGA standards. Puritan Bennett, Oxequip/Medstar, Chemetron compatible type and Dual Connect type.
- The designed on the latching mechanism shall be for one handed, single thrust mounting and one handed fingertip release of secondary equipment or DISS thread type.
- Latch-valve assembly shall be up to 1" (25 mm) for variation of wall thickness.
- Complete outlet station shall be cleaned and packaged to NFPA 99 standards, CSA certified, ETL and UL listed. Outlets shall be cleaned for Oxygen services as per CGA Pamphlet G-4.1. The complete assembly shall be capped and poly bagged for shipment.
- Outlet assembly shall be color coded and indexed to eliminate interchangeability of gas services.
- The rough-in assembly shall be modular designed and including a gas specific steel mounting plate designed for ganging of multiple outlets on 5" center line spacing. A machined brass outlet block shall be permanently attached to the mounting bracket to permit the ½" O.D., type "K" copper inlet pipe to swivel 360° for easy installation.
- Furnish hose assemblies for all ceiling outlets are provided with hose with heavy-duty retractor for pressure gases and vacuum.
- Dual Connect Outlet is in various combinations using Ohmeda, Chemetron and DISS connections. Note: Dual outlet is recommended to be used with 3/8" (10mm) ID (nominal) rough-ins.

B. Medical Gas Alarm systems:

- Amico's Alarm systems include Area Alarms – Alert-4 LCD Ethernet Area, Alert-3 LCD Alarm and Compact Alarm Systems. Master Alarms – Alert-4 Ethernet Master Alarm, Master Alarm systems. And Combination Alarms-Alarm Valve Combo Unit, Single Alarm Valve Combo Unit and Combination Alarm Systems-Compact/Master.
- LCD alarm panel incorporates the latest microprocessor based technology, with smallest 8 gas alarm in the industry. LCD panel auto detecting gas sensors. Sensors housed in a solid, tamper-proof enclosure to act as barrier against any interference. Each sensor shall be gas specific and an error message shall be displayed for incorrect connection.
- Medical alarm panels are UL listed, comply with NFPA 99, CSA standard and ETL listed. Assembly shall include factory wiring, transformers, power supply and input power 115-220 VAC, 50-60 HZ.
- The alarm box shall be steel with a 3/8" (9.53mm) O.D. type "K" copper pipe for connecting to the service line. The box mounting brackets shall be adjustable to accommodate for different wall thicknesses.

- The Alert-4 Series Ethernet LCD alarm shall be capable of displaying an exact replica of the alarm on a computer screen via the facility's Ethernet or internet and an exact image of the alarm can be displayed on a mobile device via WIFI. The LCD alarm will update its status every second. And it is self-diagnostic and error message display for ease of maintenance.
- The Alarm Valve Combo Unit combines 2 in 1 design the Area Alarm and Zone Valve Box to compensate for space restrictions. Individual microprocessor for each display and sensor module: digital sensor is mounted locally. And Pre-mounted pull-out ring allows for ease of maintenance.

C. Medical Gas Valves

- Amico's Zone Indicator Control System shall consist of an alarm display gauge for the zone and a control function. It shall be 3 piece ball-type design with a brass forging body and a chrome-plated brass ball. Ball seats, stem seals and stem washer shall be Reinforced Teflon (PTFE), with Viton stem and Flange O-rings. A blow-out proof stem shall be used and the zone indicator shall have a maximum pressure rating of 600 psi (4,137 kPa).
- The display shall indicate the status, RED for alarm condition and GREEN for normal condition. It shall be equipped with a type "K", full port copper pipe stub extensions at both the inlet and outlet sides of the zone indicator port to facilitate installation.
- It shall be designed in such manner that it can be "swung out" during installation so as to prevent damage due to heat transfer during the brazing operation.
- Each Zone indicator assembly shall be washed and degreased for medical gas service. Pipe stub extensions shall be capped at both ends and in sealed plastic bag to prevent contamination prior to installation. And is comply with NFPA 99 and CSA.
- Zone indicator panel boxes shall be Alert-1 series. Each recessed zone indicator panel box shall consist of steel box, which can house two to seven zone shut-offs with tube extensions, a frame and a pull-out removable window. Gauges are included.
- It shall be constructed of 18 gauge steel complete with a baked white enamel finish. Affixed to the opposite sides of the box will be two adjustable steel brackets for the purpose of mounting the box to the structural support. The steel brackets shall accommodate various finished wall thicknesses between 3/8" (9.5mm) and 1-3/16" (30mm) and shall be field adjustable.
- The window shall be marked to prohibit unauthorized people from tampering with the zone indicator panel with silkscreen caution: "MEDICAL GAS CONTROL VALVES CLOSE ONLY IN EMERGENCY".
- Each shut-off shall be supplied with an identification bracket which shall be riveted to the zone indicator panel box for the purpose of applying an approved medical gas identification label. A package of labels shall be supplied with each Zone Indicator Panel box assembly for application by the installer.

D. Gas Control Panels

- Amico's Gas control Panels include Alert-1 series Control Panel, Alert-2 series Compact Gas Control Panel and Laboratory Compact Control Panel with back box. They are designed to deliver variable pressures to power pneumatic surgical tools. Maximum supply pressure is 250 psi and maximum delivery of pressure:
    - Carbon Dioxide = 80 psi (551 kPa)
    - Nitrogen = 200 psi (1,379 kPa)
    - Instrument Air = 200 psi (1,379 kPa)
    - HP (High Pressure) with Safety Swing Coupling = 250 psi (1,724 kPa)

- The Gas Panel meets CSA and NFPA requirements.
- The Alert-1 series control panel shall be supplied with a quarter turn shut-off ball valve, rated at no less than 300 psi (2,069 kPa). It shall have an inlet pressure indicator valve that indicates the inlet supply pressure from 0-400 psi (0-2,750 kPa). The pressure regulator shall be adjustable between 0-250 psi (0-1,724 kPa).
- The DISS outlet shall be a Diameter Index Safety System (D.I.S.S.) for Air or Nitrogen Service Outlet or "Safety Swing Coupling" for pressures above 200 psi. The outlets shall be used for connection to pneumatic surgical tools.
- The controls shall be mounted in #18 gauge (1.3mm) galvanized steel enclosure, with adjustable bracket for different wall thicknesses.
- Alert-2 series shall consist of carbon steel coated plate, pressure regulator, inlet pressure indicator, DISS outlet adapter, gas specific lamacoid and internal copper tubing sizes 1/8" (3.175mm) and ¼" (6.5mm). The plate should include a color coded label to indicate which gas the control panel was designed for.
- Maximum supply pressure is 250 psi (1,724 kPa) and DISS maximum delivery of pressure:
    - Laboratory Air = 80 psi (551 kPa)
    - Carbon Dioxide = 80 psi (551 kPa)
    - Instrument Air = 200 psi (1,379 kPa)
    - Nitrogen = 200 psi (1,379 kPa)
- The Compact Gas Control Panel's pressure regulator shall be adjustable between 0-250psi (0-1724 kPa). With Maximum delivery pressure:
    - Laboratory Air = 80 psi (551 kPa)
    - Carbon Dioxide = 80 psi (551 kPa)
    - Nitrogen = 200 psi (1,379 kPa)

E. Amico's Dome Loaded Manifold

- The automatic dome loaded manifold has been designed to provide reliable and fully automatic uninterrupted gas flow regardless of the size of the facility. With the best flow rates in the industry, the manifold provide years of hassle-free service. Dome loading technology allows to eliminate the shuttle valve, and provides the ability to switch from the bank in use to the reserve bank without a fluctuation in flow pressure. The Manifold is comply with NFPA 99
- The manifold is fully automatic with dual line regulators. Its input power is 110 VAC to 240 VAC, 50 to 60 HZ.
- The unit shall be compact, measuring 19" high x 17" wide x 9" deep.
- The Manifold shall be equipped with the following features:
    - A 3/4" outlet shutoff valve. The valve comes complete with a ¾" type "K" 6-3/4" (172mm) long pipe extensions and 1/8" port for an optional pressure switch.
    - High pressure shutoff valves outside the cabinet to allow for emergency isolation of the header bars. They shall incorporate integral check valves for each station.
    - Pressure transducers, which sends information to the main circuit board for operation of the fail-safe relay which transmits a remote signal to the master alarm or buzzer.
- The Manifold cabinet has a NEMA-1 rating for general purpose use.

- Optional heaters are available for Nitrous Oxide and Carbon Dioxide manifolds.
- The display of LED's on the front of the manifold indicates the status of the gas supply. Each bank has a green "in Use", yellow "Ready" and red "Empty" LED. When the primary bank of cylinders is depleted, the manifold will automatically switch to the secondary bank of cylinders without interruption of gas flow to the facility. The red LED will illuminate when a bank is depleted and two normally closed dry contacts for Reserve In-Use Alarm will open. One or both sets of contacts may be wired to an external alarm, remote buzzer and/or a building management system.

PART 3: EXECUTION

3.1 INSTALLATION

A. Pipe work

- All installations shall be performed in according to NFPA 99 5.1.10. Brazing procedures shall be according to NFPA 99 5.1.10.5.
- Piping underground within buildings should be according to NFPA 99 5.1.10.11.2.2.
- Piping underground, the outdoor end of the sleeve shall be according to NFPA 99 5.1.10.11.5.10.
- Buried piping shall be at a depth that will protect the piping or its enclosure from excessive stresses as per NFPA 99 5.1.10.11.5.4.
- Fittings, valves, copper, tubing shall be pre-cleaned and Oxygen serviced by the manufacturer and received sealed on the job.
- Pipe expose to physical damage shall be well protected.
- During the brazing process, the joints shall be purged with oil-free, dry nitrogen NF according to NFPA 99 5.1.10.4.5.1.
- During or after the installation of piping, before the installation of Outlet valves, the pipes should be kept sealed to maintain a nitrogen atmosphere within the pipes in order to keep them debris or contaminant free.
- Alarms and valves shall be labelled for gas services and areas monitored or controlled. Label valves with name and identification color of the gas and direction of flow with supplied arrow labels.

B. Labeling

- Label the medical gas pipelines per NFPA 99 5.1.11 TABLE 5.1.11 and 5.1.11.1.
- Zone valve boxes shall be labeled with room, areas or spaces as per NFPA 99 5.1.11.2.7.

3.2 INSTALLER TESTING

Before declaring for final verification, the installing contractor shall follow procedures for verification as per NFPA 99 5.1.12.2. The installing contractor shall provide in writing over the notarized signature of an officer of the installing company stating that the following:

- The systems have been checked for no cross-connections exist among different medical gas systems. (NFPA 99 5.1.12.4.3)
- All brazing process was nitrogen purge as per NFPA 99 5.1.10.4.5.
- The initial piping in the system has been blown clear by means of oil-free, dry nitrogen NF after installation of the distribution piping. (NFPA 99 5.1.12.2.2)

- That the brazers are qualified to ASSE 6010 and holding current medical gas endorsement.
- Initial pressure tests have been conducted as per steps in NFPA 99 5.1.12.2.3.2.
- After installation of devices, the pipeline shall be proven to be leak free for 24 hours at pressure of 20% above standard system operating line pressure. (NFPA 5.1.12.2.6.4 & 5.1.12.2.6.5)

3.3 VERIFIER TESTING

A. Before the hand over the system to the owner, contractor/installer shall save a Verifier acceptable to the engineer and owner who shall follow the procedures for verification detailing in NFPA 99 5.1.12.3 and present a written report and certificate bearing the notarized signature of an officer of the verification company stating at least the following:

- Statements clarifying that the verification company is not the supplier of the equipment used in the project and that the verification contractor has no interest of conflict with the manufacturer, the seller, or the installer of the equipment used in the project.
- A list of all the tests performed on each source, valve, alarm and outlets.
- An affirmation stating tests were performed by Certified Medical Gas Verifier or by qualified personnel to perform the work and holding legitimate qualifications to ASSE 6030.
- Document to prove that the equipment used was calibrated at least within the last six months which could be traced to a National Bureau of Standard Reference and enclosing certificates of the calibrations.
- Document stating that the systems were tested and no cross-connections found as per NFPA 99 5.1.12.4.3.
- Document stating that the systems were tested and found to be free of contaminants as per NFPA 99 5.1.12.4.8.
    - A document stating that all valves and alarms are accurately labeled as to zone of control.
    - A document stating that sources including all alarms required by NFPA 99 table A5.1.9.5.
    - A listing of area alarms' function and activation as per NFPA 99 5.1.12.4.5.3.
    - A listing of master alarms' function and activation as per NFPA 99 5.1.12.4.5.2.
    - A list of medical gas concentrations as per NFPA 99 Table 5.1.12.4.11.
    - A document stating medical gas concentration test as per NFPA 99 5.1.12.4.11.

B. Provide original of this affidavit, and report, distributed 1 to the engineer, 1 owner's representative, 1 to the general contractor and 1 for installer.

Chapter 12

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

Patient Medical Gas Sources

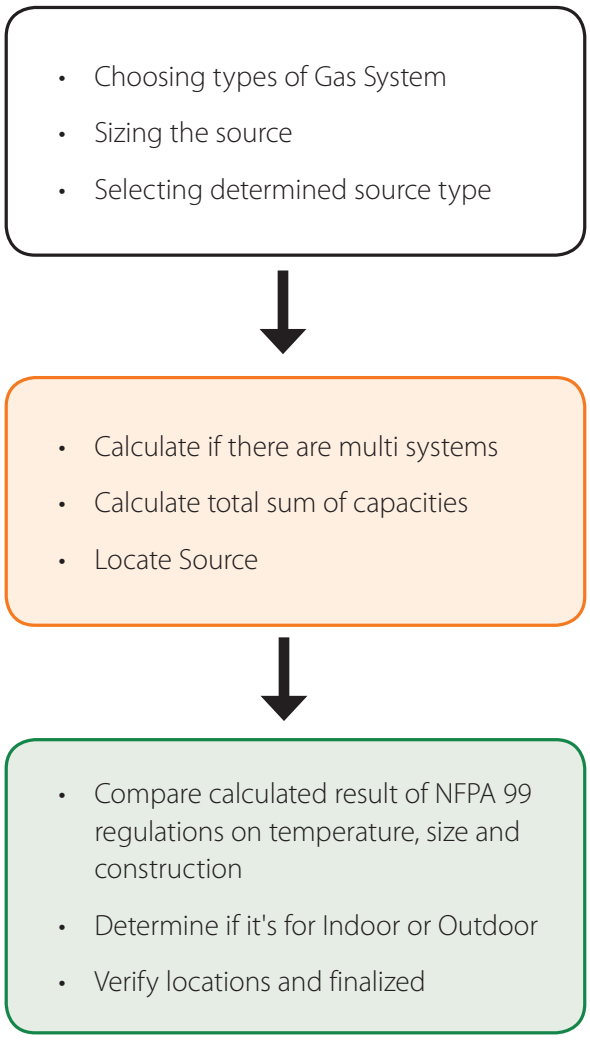
Chapter 12 – Patient Medical Gas Sources

Introduction

This chapter provides general process on how to size, select and plan for source equipment for gases of Oxygen, Nitrous Oxide, Carbon Dioxide and Exotic gases such as Helium, Argon and mixtures. This chapter will also covers the selections of Manifold and the requirements in NFPA 99 standards.

Process Map

A process map is provided to illustrate the steps and crucial elements to take in consideration when you are sizing, selecting and locating your source system.



Source Types

CHOOSING SOURCE TYPE

There are 3 important elements that has to be taken into consideration when selecting on what type of source a facility should be using:

- Practicality and Requirements
- Economical Cost
- Accessibility

It is important to choose the most suitable source type in order to maximize the usage of the system so no resources nor money wasted.

PRACTICALITY AND REQUIREMENTS

It is vital to consider the practicality when selecting a source system for a medical facility. Practicality and Requirement involve matching cylinders that fulfills the demand for different scale of facilities. For instance, a dental clinic that implied cylinders as its source type: the capacity of cylinders will be able to provide sufficient amount of gas supply. In addition, cylinders can also provide flexibility to the clinic when demand is low, as it is able to hold up content indefinitely. Basically, the goal is to provide sufficient amount of gas to supply the practical usage. For instance, it is not practical to have use a bulk oxygen in such small facility.

ECONOMICAL COST

Cylinder is capable to hold content indefinitely and comes in different capacity. The cost of a cylinder is significantly lower than a cryogenic container. Facilities that implied cylinder as their source type can be greatly benefit by achieving a lower fix cost. It is recommended to perform site examination before any implications.

ACCESSIBILITY

When choosing source type, it is recommended to evaluate the facility's location for delivering supplies. Cylinder is easy to store, relocate, and deliver. Hence, it is commonly used among facilities due to its convenience and easy to transport for suppliers. Table 1 provides medical gas cylinder's volume and weight of available content.

TABLE 1: ** NFPA99 TABLE A.11.3.4 TYPICAL MEDICAL GAS CYLINDERS VOLUME AND WEIGHT OF AVAILABLE CONTENT [ALL VOLUMES AT 21.1˚C (70˚F) AND 101.325KPA (14.696 PSI)

Cylinder Style and Dimensions	Nominal Volume [L(in³)]	Contents	Air	Carbon Dioxide	Helium	Nitrogen	Nitrous Oxide	Oxygen	Mixtures of Oxygen	
									Helium	CO2
B 8.89 x 33cm (3 1/2 in. O.D. x 13 in.)	1.43 (87)	kPa (psig) L (ft³) kg (lb-oz)		5778 (838) 370 (13) 0.68 (1-8)				13100 (1900) 200 (7) -		
D 10.8 x 43 cm (4 1/4 in. O.D. x 17 in.)	2.88 (176)	kPa (psig) L (ft³) kg (lb-oz)	13100 (1900) 375 (13) -	5778 (838) 940 (33) 1.73 (3-13)	11032 (1600) 300 (11) -	13100 (1900) 370 (13) -	5137 (745) 940 (33) 1.73 (3-13)	13100 (1900) 400 (14) -	* 300 (11) *	* 400 (14) *
E 10.8 x 66 cm (4 1/4 in. O.D. x 26 in.)	4.80 (293)	kPa (psig) L (ft³) kg (lb-oz)	13100 (1900) 625 (22) -	5778 (838) 1590 (56) 2.92 (6-7)	11032 (1600) 500 (18) -	13100 (1900) 610 (22) -	5137 (745) 1590 (56) 2.92 (6-7)	13100 (1900) 660 (23) -	* 500 (18) *	* 660 (23) *
M 17.8 x 109cm (7 in. O.D. x 43 in.)	21.9 (1337)	kPa (psig) L (ft³) kg (lb-oz)	13100 (1900) 2850 (101) -	5778 (838) 7570 (267) 13.9 (30-10)	11032 (1600) 2260 (80) -	15169 (2200) 3200 (113) -	5137 (745) 7570 (267) 13.9 (30-10)	15169 (2200) 3450 (122) -	* 2260 (80) *	* 3000 (106) *
G 21.6 x 130 cm (8 1/2 in. O.D. x 51 in)	38.8 (2370)	kPa (psig) L (ft³) kg (lb-oz)	13100 (1900) 5050 (178) -	5778 (838) 12300 (434) 22.7 (50-0)	11032 (1600) 4000 (141) -	15169 (2200) 5000 (176) -	5137 (745) 13800 (487) 25.4 (56-0)	15169 (2200) 6000(211) -	* 4000 (141) *	* 5330 (188) *
H or K 23.5 x 130 cm (9 1/4 in. O.D. x 51 in.)	43.6 (2660)	kPa (psig) L (ft³) kg (lb-oz)	15169 (2200) 6550 (231) -	5778 (838) 15840 (559) 29.1 (64)	15169 (2200) 6000 (212) -	15169 (2200) 6400 (226) -	5137 (745) 15800 (558) 29.1 (64)	15169** 2200** 6900 (244) -	* 6000 (212) *	* 15840 (559) *

Note: There are computed contents based on nominal cylinder volumes and rounded to no greater variance than ±1 percent.
* The pressure and weight of mixed gases will vary according to the composition of the mixtures.
**275 ft³ /7800 L cylinder at 2490 psig are available on request.
Source: Compressed Gas Association, Inc.

Oxygen

TABLE 2: SIZING SOURCE

It is important to estimate the size of source required in the design plan. The source sizing table 2 below summarizes the primary and secondary source sizing calculation and requirements:

Sourcing Size Guide - Oxygen			
Primary Source Sizing	1. Total bed counts (+)	Number:	
	2. Total Anesthetizing Bed Counts	Number:	
	Total Sum of Bed counts Multiply 400 - 1000 cubic feet/Month/Bed	Est. Number	
	*Numbers should be determined by the size of the facility.		= ( )
Manifold Source	Divided the result by 4 to obtain Weekly usage.		
*Generate an estimated number and refer to Table 3 to select a size			
Types	Secondary/Reserve		
Cylinder Manifold	Primary Source Size = Secondary Source Size		

STEPS FOR SOURCE SIZING:

- Determine bed count,
- Add the bed count to the number of anesthetizing bed count,
- Multiply the total by 400-1,000 cubic feet per month per bed
- If using manifold source, divide the amount by 4 to obtain weekly usage
- Refer to table 3 to select appropriate source options for estimated consumption

Note: the consideration of exact number to use in such wide range depends on a judgement call based on understanding of the facility's needs and its intended use.

TABLE 3: OXYGEN SOURCE RANGE

Gas	Configuration (Primary x Secondary)	Cylinder Manifold (Ft^3/L)
Oxygen	2 x 2	1800L
	3 x 3	2700L
	4 x 4	3600L
	5 x 5	4600L
	6 x 6	5500L
	7 x 7	6400L
	8 x 8	7300L
	9 x 9	8200L
	10 x 10	9200L
	11 x 11	10000L
	12 x 12	11000L
	13 x 13	11900L
	14 x 14	12800L

Nitrous Oxide

SIZING SOURCE

A gas cylinder manifold that holds nitrous oxide will be stored as liquid form. The source sizing table 4 below summarizes the Primary and Secondary source sizing calculations and requirements:

TABLE 4: SOURCING SIZING GUIDE - NITROUS OXIDE

Source Sizing Guide - Nitrous Oxide			
Primary Source Sizing			
Standard Method	Total # of Anesthetizing locations with Nitrous Oxide	# of location x 0.5 = number of Primary source cylinder use per week	Note* 1. Areas have to be piped with Nitrous Oxide 2. Containers/cylinders should be sized at minimum of 1 week supply
Generate an estimate number and refer to table 5 to select a size			
Calculation Method	Obtain data on daily equipment utilization	Multiply number by 7. Result in a weekly usage.	Note* 1. Equipment utilization index is hard to be accurate, therefore its safer to use a higher number 2. Containers/cylinders should be sized at minimum of 1 week supply
Generate an estimated number and refer to table 5 to select a size			
Sizing Secondary and Reserves			
Cylinder Manifold	Cylinder has to be sized as the Primary		Note* 1. A separate manifold is mandatory with at least 24 hours of supply

TABLE 5: ANESTHETIZING LOCATION PIPED WITH NITROUS OXIDE

Gas	Configuration (Primary x Secondary)	Anesthetizing Location
Nitrous Oxide	2 x 2	4
	3 x 3	6
	4 x 4	8
	5 x 5	10
	6 x 6	12
	7 x 7	14
	8 x 8	16
	9 x 9	18
	10 x 10	20
	11 x 11	22
	12 x 12	24
	13 x 13	26
	14 x 14	28

STEPS:

- Determine # of anesthetizing locations
- # Locations X ½ = estimated # of cylinder used per week
- Use table 5 to select appropriate source types

CALCULATION METHOD

Get data on daily use and multiply by 7 to get a weekly usage (Note: change of cylinder not more than once a week) use table 5 to select appropriate source.

Carbon Dioxide

Carbon Dioxide is typically drawn from a Gas Cylinder Manifold. In some cases, it is possible to drawn from container. This could be found in facility whose demand of CO2 is in a large quantity. In such case, facility must request assistance from engineer or technician.

Carbon Dioxide is also in a liquid form in the cylinder. It might not be always piped at 55 psi (345kPa). It is recommended to check required pressure because some medical devices required to elevate pressure of 100 psi (690kPa).

TABLE 6: SIZING SOURCE - CARBON DIOXIDE

Primary Source Sizing				
Standard Method	Identify the # of locations piped with CO2	# of location x 0.5 = number of Primary source cylinders used per week	Select the higher number between Est. Cylinder # per side, or 2 cylinders per side	Note* 1. Containers/cylinders should be sized at a minimum of 1 week supply
Choose the appropriate manifold cylinder according to the generated number				
Calculation Method	Obtain daily equipment utilization	Select the smallest applicable size from consumption chart (Table7)		Note* 1. Equipment utilization index is hard to be accurate, therefore its safer to use a higher number 2. Chart indexes are all calculated in advance
Secondary Source Sizing				
Cylinder Manifold	Cylinder has to be sized exactly the same as the Primary Source			

TABLE 7: CO2 CONSUMPTION IN MANIFOLD CYLINDER

Gas	Location	Configuration (Primary x Secondary)	Daily Consumption (Ft^3/L)
Carbon Oxide	2	2 x 2	3400L
	4	3 x 3	5300L
	6	4 x 4	7000L
	8	5 x 5	8700L
	10	6 x 6	11000L
	12	7 x 7	12000L
	14	8 x 8	14000L
	16	9 x 9	16000L
	18	10 x 10	18000L
	20	11 x 11	19000L
	22	12 x 12	21000L
	24	13 x 13	23000L
	26	14 x 14	24000L

Medical Air Manifolds

With a smaller scale of installation, it is easier to achieve the 2 elements in both being practical and meeting requirement, and at the same time, being cost efficient and economical. Refer to Chapter 5 in this Guide for detailed information on Medical Compressed Air system.

TABLE 8: SOURCE SIZING

Primary Source Sizing
Sizing for Medical Air is fairly straightforward. The most important variable is to verify with facility on the require use of medical air. From there, matches the requirement with provided chart to determine the source size and the appropriate manifold.
Second Source Sizing
Secondary source is the same as primary.

TABLE 9: MEDICAL AIR MANIFOLD CONSUMPTION

Size	Air Consumed Per Minute	
Configuration	Cylinder Manifold	
	(Ft^3/L)	L
2 x 2	0.3	9
3 x 3	0.5	14
4 x 4	0.6	18
5 x 5	0.8	24
6 x 6	1	28
7 x 7	1.2	34
8 x 8	1.4	37
9 x 9	1.5	39
10 x 10	1.6	45
11 x 11	1.8	50
12 x 12	1.9	54
13 x 13	2.1	59
14 x 14	2.3	65

Exotics

Exotic gases generally used in specialist facilities. They are Helium, Helium-Oxygen mixtures, Argon, Carbon Dioxide – Oxygen mixtures, Nitrous Oxide, special respiratory mixtures etc. Due to its special application used, pipe sizing is as follow:

TABLE 10: SOURCE SIZING

Exotic Air Source Sizing		
Obtaining Data	Obtain daily Equipment usage from medical staff:	**Note*** 1. Equipment utilization index is hard to be accurate, therefore its safer to use a higher number 2. Containers/cylinders should be sized at minimum of 1 week supply 3. Content of the cylinder can be obtain from Typical Medical Gas Cylinders' Volume and Weight of Available Contents
Calculations	1. Daily Equipment usage x 7 to obtain equipment usage per week 2. Weekly Equipment usage/content of the Cylinder (L ft^3) = Cylinder weekly require	
Compare generated numbers with 2 Cylinders in which greater, that number shall be used as minimum number of cylinder on the reserves.		

TABLE 11: EXAMPLE OF SOURCE SIZING CALCULATION - HELIUM SYSTEM

A facility obtained a gas daily usage to be 100L in Helium. 100L x 7 days = 700L/weekly. If a container of a gas cylinder is equal to 6000L ft^3; 700/6000 = 0.1	Typical Content for H or K Cylinders	
Conclusion: 0.1 is small than 2 Cylinders, hence the size of the Helium source for the facility would be manifold with 2 Cylinders on each side.	**Gas**	**Cylinder**
	Oxygen	6900L (244 ft^3)
	Nitrous Oxide	15800L (558 ft^3)
	Carbon Dioxide	15840L (559 ft^3)
	Air	6550L (231 ft^3)
	Nitrogen	6400L (226 ft^3)
	Helium	6000L (212 ft^3)

TABLE 12: REFERENCE ON NUMBER OF CYLINDERS FOR GAS SYSTEMS

Medical Oxygen System	**Operating Rooms**	**Patient Rooms**
	500 cubic feet will last approx. 2 weeks **assuming:** 3-4 L/m per bed 8 hours of use per day (3 L/m) (60 min/hour) (8 hours) /28.8 liters per ft^3 = 50 ft^3 per OR per day 10 days = 500 cubic feet of oxygen	3 - 4 L/m per room (time will vary depending on care area) If ventilators are run off oxygen, approx. 3 to 7.0 SCFM each (check with ventilator manufacturer)
	Recovery: allow an additional 7.0 ft^3 per recovery position per patient (10 L/m) (20 minutes per patient) /28.8 liters per ft^3 = 7.0	**Long Term Care:** 3 - 4 L/m per bed for continuous usage: (3 L/m) (60 minutes / hour) (24 hours a day) /28.8 liters per ft^3 = 150 cubic feet per day
	Notes: Oxygen will expand 860 times its liquid volume, approx. 251 cubic feet per "H" Cylinder, some freezing of bulk lines (by the vaporizer) is normal.	
Nitrogen	**Number of Operating Room**	**Total # of "H" Cylinder**
	1-2	4 (2 x 2)
	3-4	8 (4 x 4)
	5-6	12 (6 x 6)
	7-8	16 (8 x 8)
	9-10	20 (10 x 10)
	11-12	24 (12 x 12)
	13-14	28 (14 x 14)
	Notes: "standard" OR typically needs approx. 8.0 SCFM orthopedic, or thoracic OR needs approx. 15 SCFM, nitrogen regulators will typically flow a maximum of 70 SCFM, size so that each OR can use tools simultaneously approx. 230 cubic feet per "H" cylinder.	
Nitrous Oxide	**Number of Operating Rooms**	**Total # of "H" Cylinder**
	1-4	4 (2 x 2)
	5-8	8 (4 x 4)
	9-12	12 (6 x 6)
	13-16	16 (8 x 8)
	17-20	20 (10 x 10)
	Notes: 1 cylinder per anesthetizing room, check with anesthesia machine manufacturer for flow (most use approx. 0.2 SCFM per machine) approx. 560 cubic feet per "H" cylinder.	
Carbon Dioxide	**Number of Operating Room**	**Total # of "H" Cylinder**
	1-8	4 (2 x2)
	9-16	8 (4 x 4)
	17-32	12 (6 x 6)
	Notes: approx. ¼ of an "H" cylinder per OR approx. 560 cubic feet per "H" cylinder, specialprocedure rooms / labs may require more CO2.	

Locating Source

The most direct way to locate a source system is to first locate manifolds indoor, and locate bulk system outdoor. By separating the 2 source types, it immediately dividing the total capacity and simplifies further process.

SUM OF GAS TYPE IN SPECIFIC LOCATION

Step 1:

Add the total volumes of gas for each systems, also adding all the different gases you picked, including nitrogen and instrument air if they are piped. Multiply the number of cylinders on each manifold by the typical Content for H or K Cylinders in Table 1. Hence if you know specific size of cylinder or container the facility is using, use the actual figures.

Step 2:

Obtain the number of stored cylinders, if the facility choose to store full cylinders in the same area, add those in as well.

If obtaining data is not possible, estimate the stored cylinder from multiplying the numbers of primary header to the type of gases it's indicating.

Step 1 and 2 calculations should be able to provide a total stored capacity of each gas and types by its locations.

EVALUATION ON SOURCE LOCATIONS:

Compare estimated number of total capacities of each gas type numbers with NFPA 99 safety regulations on temperature, construction and storage requirement.

For instance, to evaluate the source size for Oxygen in a single storage room: if total capacity exceeded the recommended capacity of 566,335 L (20,000 ft^3), it has to be relocate to other locations. Within the single storage, Oxidizing gas such as Oxygen should be distanced with flammable material with required distance and should be within the 52 °C (125 °F).

TABLE 13: NFPA 99 ON CYLINDER AND STORAGE REQUIREMENTS

NFPA 99 5.1.3.3.2 Design and Construction	NFPA 99 5.1.3.2.12 & 5.1.3.2.13 Temperature	NFPA 99 5.1.3.3.1.6 and 11.3 Storage Requirement
Cylinders and Containers should be able to transport easily. Locks and gates shall be provided or otherwise able to be secured. If outdoor, they should provided with an enclosure constructed of noncombustible materials. If outdoor and greater than 18.6 m2 (200 ft^3), they shall be provided with a minimum of two entry/exits.	Cylinders in use and in storage shall be prevented from reaching temperatures in excess of 52 °C (125 °F). Central supply systems for N2O and CO2 using cylinders or portable containers shall be prevented from reaching temperatures lower than the recommendations of the central supply system's manufacturer, but shall never be lower than -7 (20 °F) or greater than 52 °C (125 °F).	Central supply system for Oxygen with a total capacity connected in storage of 566,335 L (20,000 ft^3) or more outside of the facility at standard temperature and pressure shall complied with NFPA 55. Storage for nonflammable gases with greater than 85m3 (3000 ft^3) should complied with 5.1.3.3.2 - 5.1.3.3.3. When determining the volume of storage, don't consider in use cylinders, but only in stored. Only if it exceeded 3000 ft^3, then is required to locate in an enclosure. Oxidizing gas shall not be stored with any flammable gas/liquid/vapor.

STORAGE REQUIREMENT:

*NFPA 99 11.3.5.3

Oxidizing gases such as oxygen and nitrous oxide shall be separated from combustibles or flammable materials by one of the following:

- Minimum distance of 6.1 m (20 ft).
- Minimum distance of 1.5 m (5 ft) if the entire storage location is protected by an automatic sprinkler system designed in accordance with NFPA 13.
- A gas cabinet constructed per NFPA 30 or NFPA 55, if the entire storage location is protected by an automatic sprinkler system designed in accordance with NFPA 13.

*NFPA 99 11.3.5.6

Smoking, open flames, electric heating elements, and other sources of ignition shall be prohibited within storage locations and within 6.1 m (20 ft) of outside storage locations.

Ventilation

Initially, NFPA 99 had stated that ventilation for medical gas storage room and manifold areas was 85 m^3 (3000 ft^3). But beginning with the 2012 edition, the ventilation requirement is based on the ventilation rate needed in the consideration of potential escape in gas or fluids. Ventilation requirements then divided into 2 categories: Natural and Mechanical.

NATURAL VENTILATION *NFPA 99 9.3.6.5.2

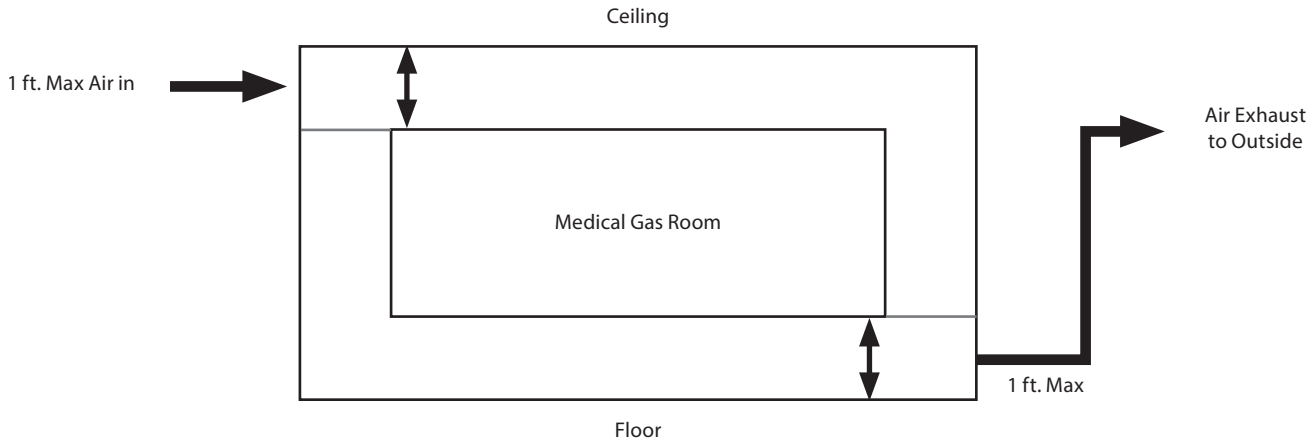
- Shall consist of two non-closable louvered openings, each having an aggregate free opening area of at least 155 cm^2 /35 L (24 in^2 /1000 ft^3) of the fluid designed to be stored in the space and in no case less than 465 cm^2 (72 in^2).
- Two openings required: one opening shall be located within 30 cm (1 ft) of the floor, and one shall be located within 30 cm (1 ft) of the ceiling.
- Openings shall be located to ensure cross ventilation.
- Openings shall be directly to the outside atmosphere without ductwork.

MECHANICAL VENTILATION *NFPA 99 9.3.6.5.3

Mechanical ventilation is meant to ensure ventilations requirements are met if natural ventilation cannot be met.

- Mechanical exhaust to maintain a negative pressure in the space shall be provided continuously, unless an alternative design is approved by the authority having jurisdiction.
- Mechanical exhaust shall be at a rate of 1 L/sec of airflow for each 300 L (1 cfm per 5 ft^3 of fluid) designed to be stored in the space and not less than 24 L/sec (50 cfm) nor more than 235 L/sec (500 cfm).
- Mechanical exhaust inlets shall be unobstructed and shall draw air from within 300 mm (1 ft.) of the floor and adjacent to the cylinder or containers.
- Mechanical exhaust air fans shall be supplied with electrical power from the essential electrical system. Where an essential electrical system is not provided, a risk assessment shall be conducted to determine if continuous ventilation shall be provided by alternate means.

DIAGRAM 1: VENTILATION FLOW MODULE



Completion

Source locations should be determined, after evaluating the source total capacity and potential locations. Ensure gases are set to pressure (50 psi, 100psi, 170 psi) as required.

There are three categories of Amico manifolds depending upon the delivery pressure. The following gas types are available for each delivery pressure:

- 55 psi Delivery Pressure – Oxygen, Nitrous Oxide, Medical Air, Carbon Dioxide, Helium, Argon
- 100 psi Delivery Pressure – Oxygen, Medical Air, Carbon Dioxide
- 170 psi Delivery Pressure – Nitrogen, Instrument Air

DIAGRAM 2: GAS STANDARD PRESSURE

	55 psi	100 psi	170 psi
Intermediate Pressure - Ready Bank	100 psi	200 psi	200 psi
Dome Bias Pressure	50 psi**	50 psi	50 psi
Intermediate Pressure In-Use Bank	150 ± 10 psi*	250 ± 10 psi	250 ± 10 psi
Intermediate Relief Valve	350 psi	350 psi	350 psi
Line Regulator Relief Valve	75 psi	150 psi	225 psi
Maximum Inlet Pressure	3000 psi	3000 psi	3000 psi

*The intermediate pressure valve of the "In Use" bank is dependent upon the dome bias pressure.
Variations from the 55 psi delivery pressure will affect the intermediate pressure reading.
**Same as delivery pressure

DIAGRAM 3: AMICO GAS MANIFOLD FLOW CAPACITY:

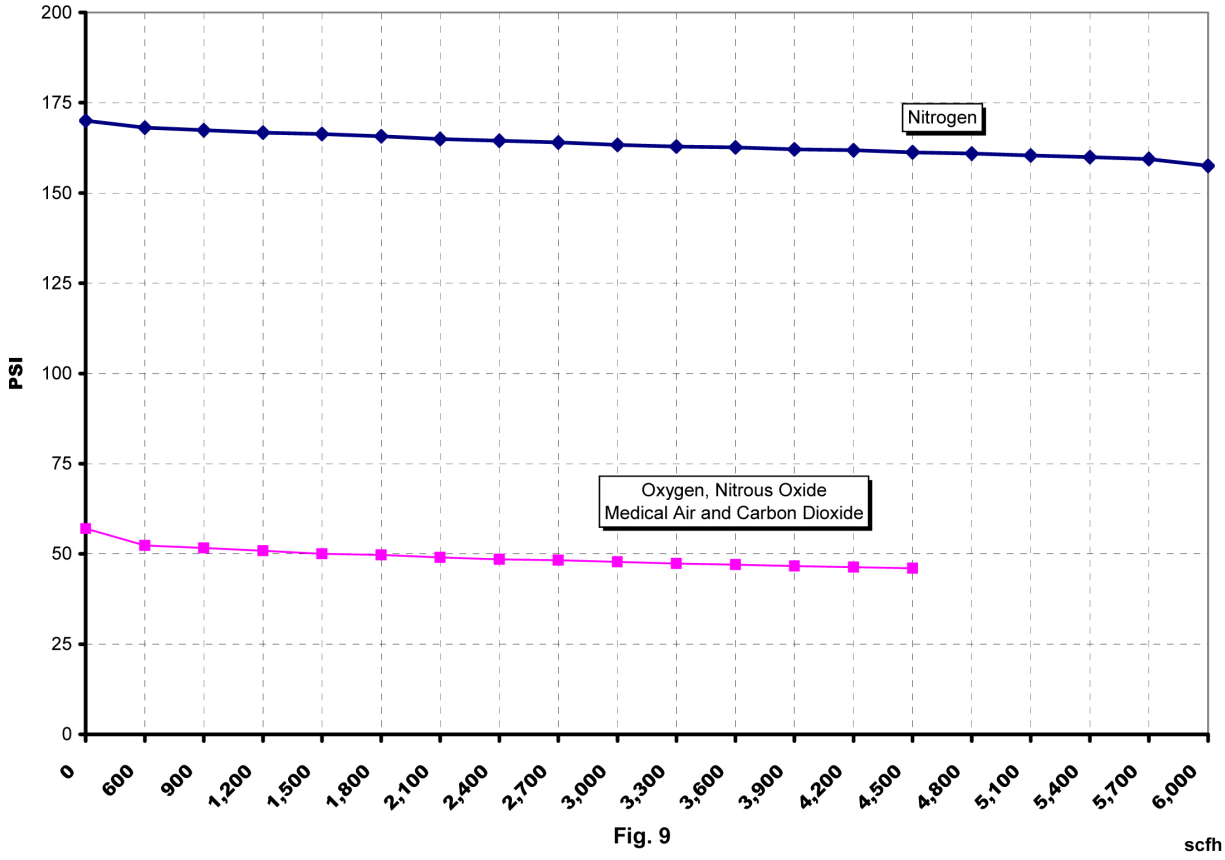


Fig. 9

DOME LOADED MANIFOLD NFPA

General Specifications

The Manifold shall be a fully automatic type and shall switch from "Bank in Use" to "Reserve Bank" without fluctuation in the final line pressure.

After the switchover, the "Reserve Bank" shall then become the "Bank in Use" and the "Bank in Use" shall become the "Reserve Bank." The control panel includes a line gauge, two bank gauges and incorporates six LED's: two green for "Bank in Use," two yellow for "Bank Ready" and two red for "Bank Empty" on the front of the cabinet. The manifold consists of two bank regulators (dome –bias) used to reduce the cylinder pressure to the two line regulators which in turn controls the final line pressure. The manifold has an intermediate and line relief valve that is internally connected to a common vent port, terminating into a 1/2" FNPT pipe.

The unit shall be compact, measuring 19" high x 17" wide x 9" deep.

PLEASE NOTES:

- The manifold shall be equipped with a 3/4" outlet shutoff valve. The valve comes complete with a 3/4" type "K" 6-3/4" [172mm] long pipe extensions and 1/8" port for an optional pressure switch.
- The header bars shall be equipped with high pressure shutoff valves outside the cabinet to allow for emergency isolation of the header bars. The header bar shall incorporate integral check valves for each station.
- The manifold is equipped with pressure transducers, which sends information to the main circuit board for operation of the fail-safe relay which transmits a remote signal to the master alarm or buzzer.
- The header bar mounting brackets are only supplied with more than 10 cylinders, for a staggered header bar, and more than 4 cylinders for a straight header bar.
- The Manifold cabinet has a NEMA-1 rating for general purpose use.
- Optional heaters are available for Nitrous Oxide and Carbon Dioxide manifolds.
- **The flow capacity of a nitrous oxide and carbon dioxide manifold depends upon the environmental conditions at the installation site and the number of cylinders in service. Installing them in a location that exposes it to an ambient temperature below 32°F (0°C) is not recommended.**
- The manifold shall be installed in accordance with the requirements stated by NFPA 99, CGA, and all applicable local codes. Amico recommends the control cabinet be located at an installation site protected from rain, snow and direct sunlight.
- CGA gas specific header bar with integral check valves and cylinder pigtail assemblies (to be ordered separately)

FLOW CAPACITY

Oxygen, Medical Air, Nitrous Oxide and Carbon Dioxide:
4,500 SCFH [2,123 L/min]
Nitrogen and Instrument Air:
6,000 SCFH [2,831 L/min]

Features

- Fully automatic with dual line regulators
- Input power 110 VAC to 240 VAC, 50 to 60 HZ
- Digital display noticeable even in poorest of lighting conditions
- 3/4" isolation valve for supply line
- Includes wall mounting bracket
- Removable cabinet enclosure made easy for easy installation and service
- Manifold complies with NFPA 99

DOME LOADED MANIFOLD NFPA MODEL NUMBERS

Manifold Cabinet: **M4D-DL-HH(H)-L-XXX**

Dome Loaded (NFPA) = DL

Digital = D

High Pressure = HH
Heaters = HHH

The Letter "L" Defines the Language
English (NFPA) = U
Spanish (NFPA) = S

The Letters "XXX" Define the Type of Gas:

Oxygen	=	OXY
Nitrogen	=	NIT
Medical Air	=	AIR
Carbon Dioxide	=	CO2
Nitrous Oxide	=	N2O
Argon	=	ARG
Helium	=	HEL
Heliox	=	HELIOX
Instrument Air	=	IAR

Header-Bar Assembly: **M2-HBYY-XXL-XXX**

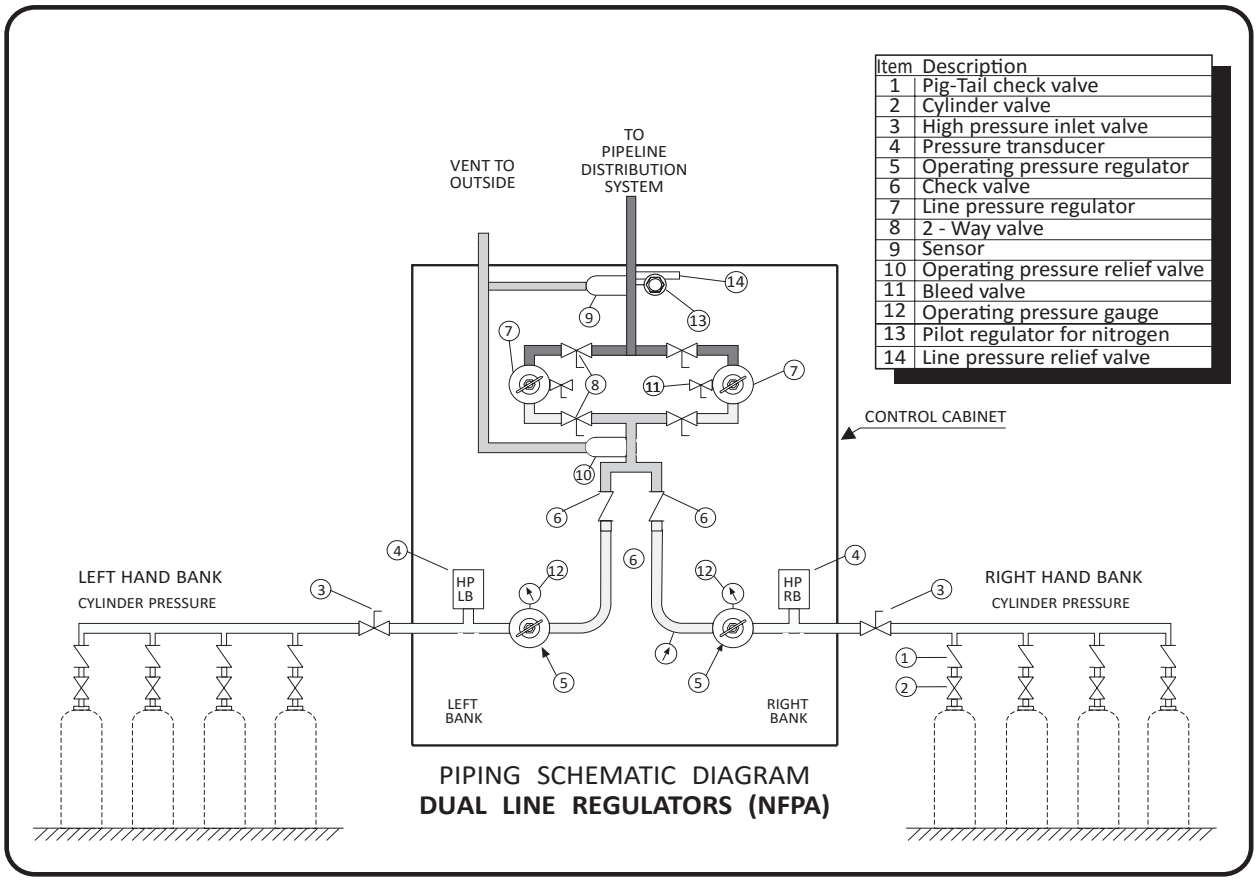
The Letters "YY" Define the Type of Header-Bar Assembly:

Straight c/w Stainless Pigtails	=	TS
Straight c/w Copper Pigtails	=	TC
Staggered c/w Stainless Pigtails	=	XS
Staggered c/w Copper Pigtails	=	XC

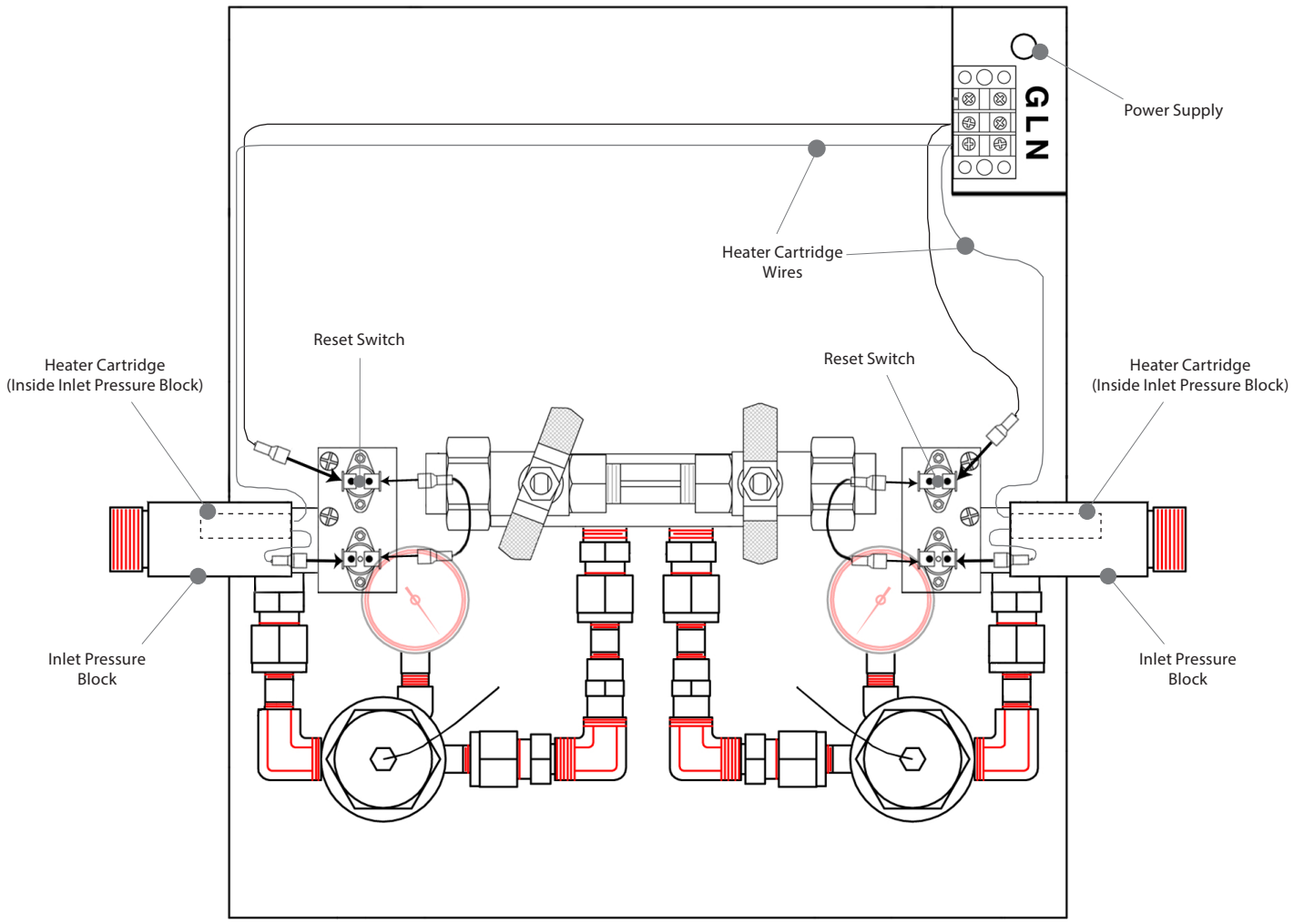
The Letters "XX" Define the Number of Cylinders:
2 x 2 use 04
4 x 4 use 08

Wall Bracket for Header-Bar Assembly: **M-X-HB-WLBRKIT**

MANIFOLD PIPING SCHEMATIC DIAGRAM:

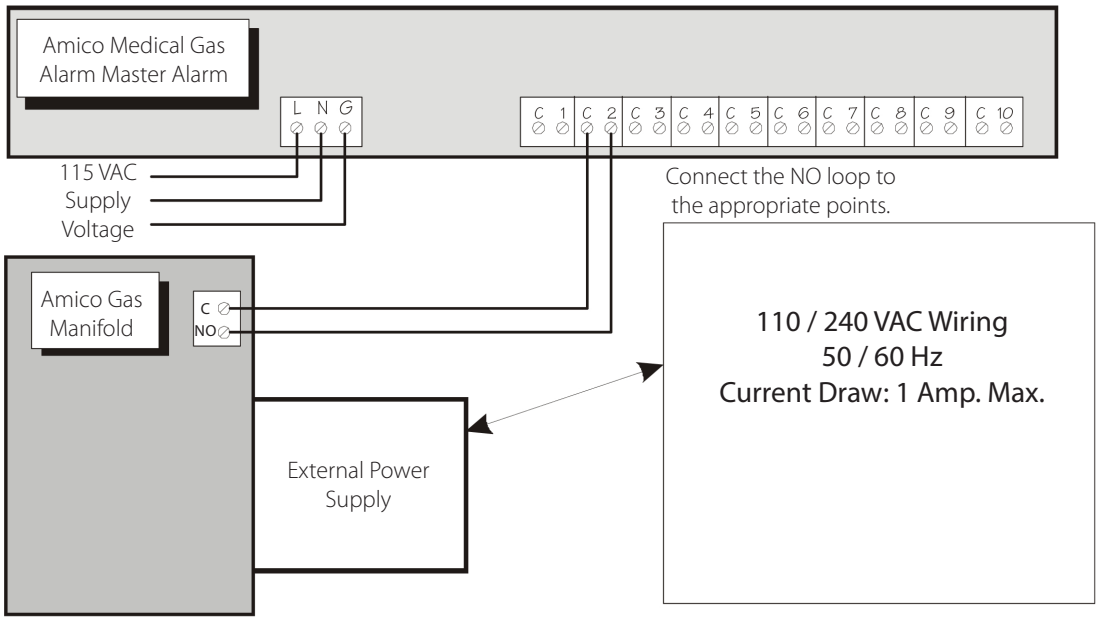


WIRING SCHEMATIC HEATER UNITS

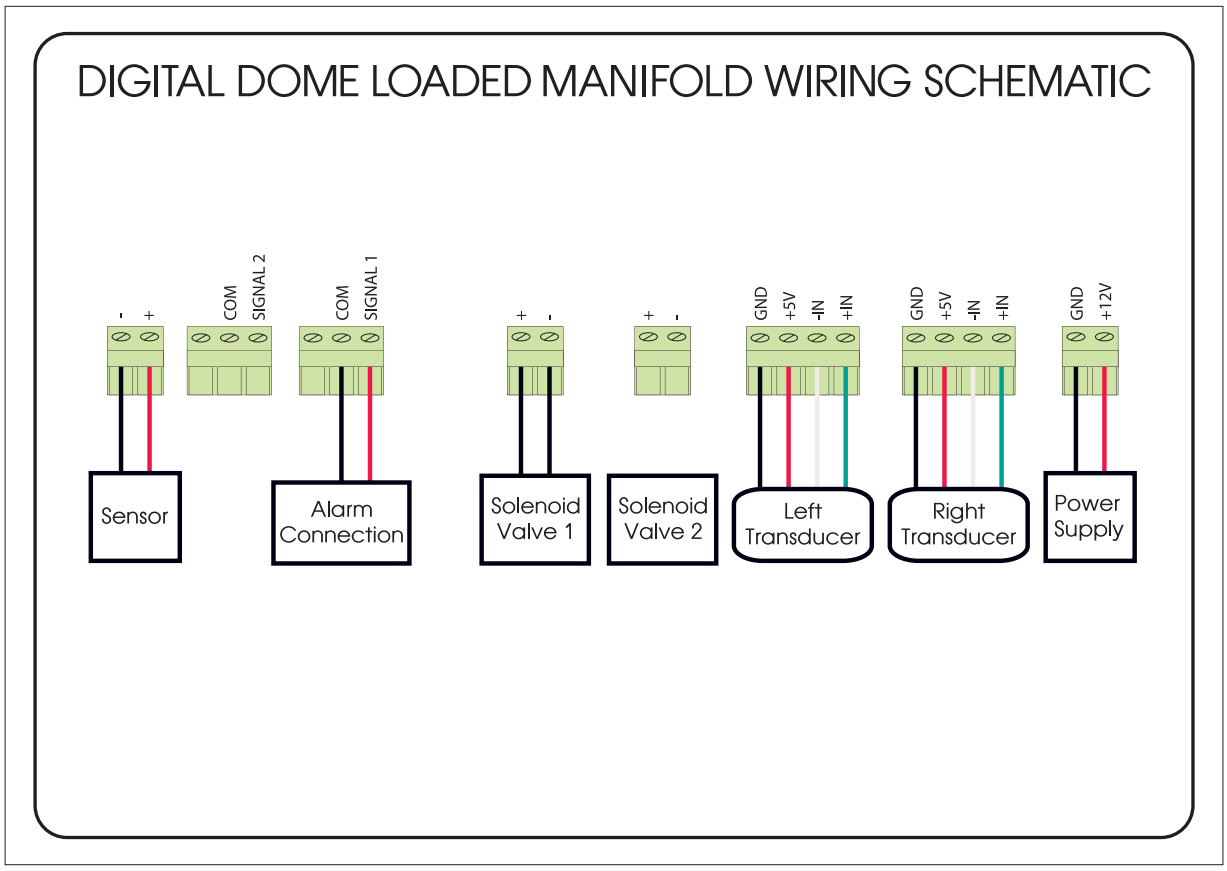


The heaters normally switch on when the temperature drops below 24°C or 75°F. If the temperature exceeds 65-75°C or 160-175°F, the Heater reset switch will trip and the heaters will automatically switch off. To reset the heaters, remove the heater covers and press the red button on the reset switch to activate. When the heaters are "In Use" or switched on, it will draw up to 3 amps of current. The heater cartridge is 200 watts (each side). Normally both sides do not switch on together, it depends on the flow of gas or climate conditions.

ELECTRICAL WIRING DIAGRAM

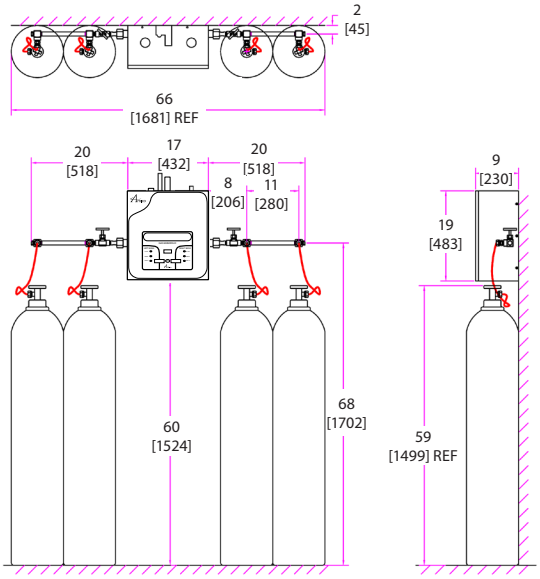


CONTROL CABINET WIRING DIAGRAM



TECHNICAL SPECIFICATIONS

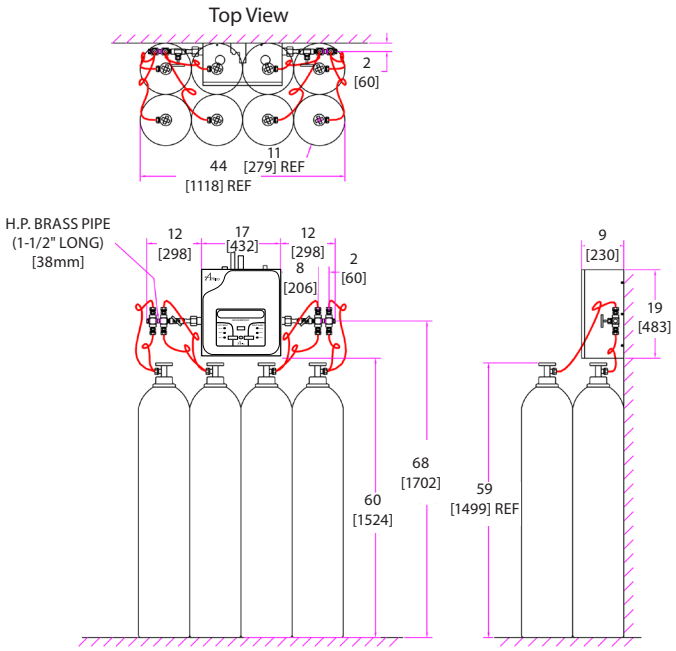
Figure 1: Standard Set-up



Standard 2x2 Dome Loaded Manifold with Straight Header Bars Layout

Figure 2: Optional Set-up

Inch
[mm]



Front View

Side View

Standard Setup Overall Length

Approximate length of a standard header bar with the manifold.

No. of Cylinders	StaggeredOverall Length Inch [mm]	Straight Overall Length Inch [mm]
2	38 [965]	38 [965]
4	40 [1016]	62 [1575]
6	40 [1016]	62 [1575]
8	62 [1575]	104 [2642]
10	62 [1575]	104 [2642]
12	80 [2032]	126 [3200]
14	80 [2032]	126 [3200]
16	104 [2642]	148 [3759]
18	104 [2642]	148 [3759]
20	126 [3200]	170 [4318]

TESTING FOR LEAKAGE

The following instructions apply for performing a leak test on the joints made during assembly and connection of the Amico manifold.

The connections inside the Amico control cabinet have been inspected at the manufacturing plant and DO NOT require leak testing. In order to determine whether any leaks exist between cylinder header bar sections or at the pipeline connections, the systems must be pressurized using either oil-free dry air or oil-free dry nitrogen.

In the case of Medical Oxygen, Nitrous Oxide, or Carbon Dioxide Amico Manifolds, the actual service gases ARE NOT suitable for leak testing due to their inherent dangerous properties. Leak testing must be performed using either oil-free dry air or oil-free dry nitrogen. In the case of either Medical Air or a Nitrogen Amico manifold, the actual service gas may be used to perform the leak tests as follows:

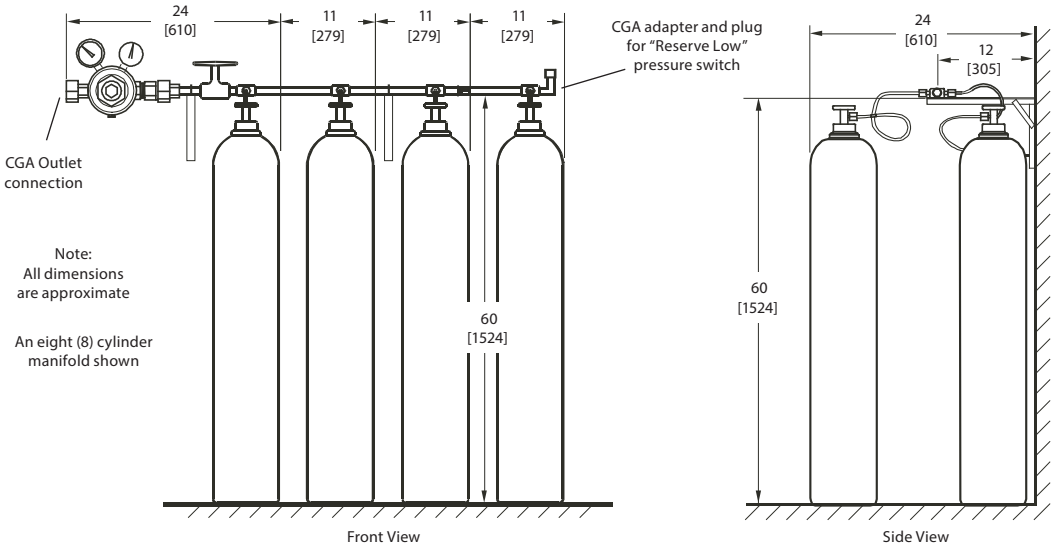
1. Connect a cylinder of the manifold service gas to each side of the header bar using the proper cylinder connection hose assemblies (pigtails) supplied.
2. Make sure all other outlets are capped with the plug and chain assemblies supplied.
3. Make sure that the high pressure inlet valves of each bank are fully OPEN.
4. S-L-O-W-L-Y open the two cylinder valves on each side of the cabinet, one at a time, to pressurize the header bar and pipeline.
5. All outlets from the pipeline, downstream of the manifold, should be closed and thus there should be no flow from the manifold.
6. Check for leaks at all cylinder extension joints and at the joints where the pipes are connected to the pipeline, using a commercial leak detector which is compatible with oxygen.
7. If any leaks are found, the system must be depressurized by bleeding through a convenient pipeline outlet and the faulty connections must be repaired.
8. The header bar connections may be tightened one more turn to maintain the horizontal location of the cylinder adapters or a further application of an oxygen service threaded sealant may be required.
9. If the brazed pipeline connections leak they must be removed, cleaned and then re-brazed following the proper technique. All repaired joints must be pressure tested as above.

SIMPLEX MANIFOLD (RESERVE MANIFOLD)

Features

- Rigid copper pigtails with check valve
- 3000 psi working pressure
- CGA adapter port for pressure switch installation
- Wall mounted bracket included
- Staggered type for maximizing wall space
- High pressure master isolation valve
- High flow capacity regulator
- Cleaned for oxygen service
- Optional stainless steel pigtails available
- Simplex Manifold complies with NFPA-99

Inch
[mm]



Model Numbers:

M-SIMP-L-XX-GAS

The Letter "L" Defines the Language:

English (NFPA)	=	U
English (CSA/ISO)	=	E
Spanish (NFPA)	=	S

"XX" Defines the Number of Cylinders:

	# of Cylinders	Overall Manifold Length
02	2	26 (660)
04	4	39 (991)
06	6	52 (1321)
08	8	65 (1651)
10	10	78 (1981)
12	12	91 (2311)
14	14	104 (2642)
16	16	117 (2972)
18	18	130 (3302)
20	20	143 (3632)

The "GAS" Defines the Type of Gas:

Oxygen	=	OXY
Medical Air	=	AIR
Nitrous Oxide	=	N2O
Nitrogen	=	NIT
Carbon Dioxide	=	CO2

P-PRSW-RES

Pressure Switch set @ 1,100 psi decreasing pressure.

EMERGENCY OXYGEN INLET STATION: RECESSED MOUNT LOW PRESSURE

Features

- Low pressure 1" female npt connection for high flow
- Lockable weather tight enclosure, for outside mounting
- Gauge for display of supply pressure
- Box can be mounted horizontally or vertically by changing front label
- Box available in recessed or surface mounting
- 3-Piece check valves and brass body relief valves available for installation (must be ordered separately)

General Specifications

The "Emergency Gaseous Oxygen Inlet Station" shall be an Amico Alert-1 series.

As required by NFPA 99 and CSA Z7396.1, oxygen systems having the source of supply outside the building shall have an inlet to connect a temporary, auxiliary source of supply for emergency or maintenance situations. This connection shall include necessary valves and to allow for an emergency supply of oxygen and isolation of the normal source of supply. The inlet connection shall be a 1" female npt connection and be provided with a plug to prevent entry of foreign matter into the oxygen system when not in use.

A 1" brass ball valve controls access to the emergency supply, and the gauge indicates the pressure being introduced into the oxygen pipeline. Maximum input pressure of 100 psi.

The Emergency Gaseous Oxygen Inlet shall be housed in a weather tight recessed enclosure.

The enclosure door shall be labelled "Emergency Low Pressure Gaseous Oxygen Inlet" and shall be equipped with a staple for padlocking to allow entry only by authorized personnel. A mounting frame shall extend completely around the enclosure to trim recessed mounting on an exterior wall.

The interior of the enclosure shall be clearly labelled with instructions for connection and operation of the emergency oxygen inlet.

The check valves shall be a 3-Piece design, with a removable body for servicing without cutting or disassembling of lines. Valves are to be provided with type-K copper extensions for connections on the pipeline. Required for installation in the main and emergency supply pipeline, in accordance with NFPA 99.

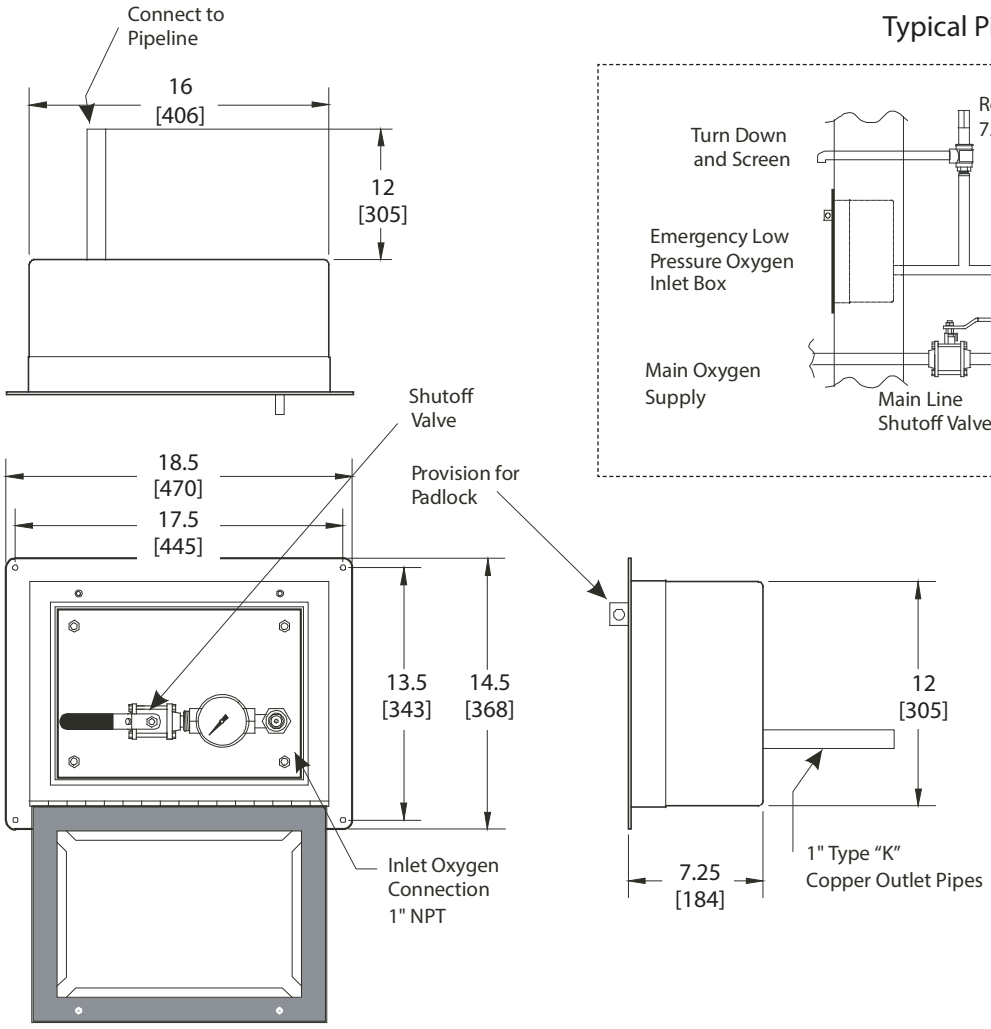
A brass body relief valve with the relief pressure set @75 psi is required for installation in the emergency supply line. The relief valve shall be supplied factory cleaned for oxygen service and shall automatically reset after discharging to provide a positive seal.

All components will be sourced and cleaned for medical gas service. The sealing compound used will be compatible for medical gas service.

Amico products comply with NFPA 99 and CSA Z7396.1.

TECHNICAL SPECIFICATIONS:

Inch
[mm]



Typical Piping

Model Numbers:

Emergency Low Pressure Oxygen Inlet Station Recessed Wall Mounting:	**M-FILL-OXY-LP**
Optional Check and Relief Valves (to be ordered separately):	
Check Valve 1"	**VV-CHK3-EXT10**
Check Valve 1-1/2"	**VV-CHK3-EXT15**
Check Valve 2"	**VV-CHK3-EXT20**
Relief Valve Pipe Away Adapter 1/2" NPT (NFPA)	**M-X-PIPEAWAY-05**
Relief Valve (NFPA)	**M-X-MAN-72W-075**
Relief Valve (CSA)	**M2-X-MAN-73-075**

EMERGENCY OXYGEN INLET STATION: RECESSED MOUNT HIGH PRESSURE

Features

- High pressure CGA 540 cylinder connection
- Lockable weather tight enclosure, for outside mounting
- Dual gauges for display of supply and delivery pressures
- Bronze body check valves and brass body relief valves available for installation (must be ordered separately)

General Specifications

The "Emergency Gaseous Oxygen Inlet Station" shall be an Amico Alert-1 series.

As required by NFPA 99 and CSA Z7396.1, oxygen systems having the source of supply outside the building shall have an inlet to connect a temporary, auxiliary source of supply for emergency or maintenance situations. This connection shall include necessary valves and a high pressure regulator to allow for an emergency supply of oxygen and isolation of the normal source of supply. The inlet connection shall only accept a CGA 540 connection and be provided with a nut to prevent entry of foreign matter into the oxygen system when not in use.

A 1" brass ball valve and a high pressure regulator controls access to the emergency supply and indicates the supply pressure and the pressure being introduced into the oxygen pipeline. Maximum input pressure of 3,000 psi.

The Emergency Gaseous Oxygen Inlet shall be housed in a weather tight recessed enclosure.

The enclosure door shall be labelled "Emergency High Pressure Gaseous Oxygen Inlet" and shall be equipped with a staple for padlocking to allow entry only by authorized personnel. A mounting frame shall extend completely around the enclosure to trim recessed mounting on an exterior wall.

The interior of the enclosure shall be clearly labelled with instructions for connection and operation of the emergency oxygen inlet.

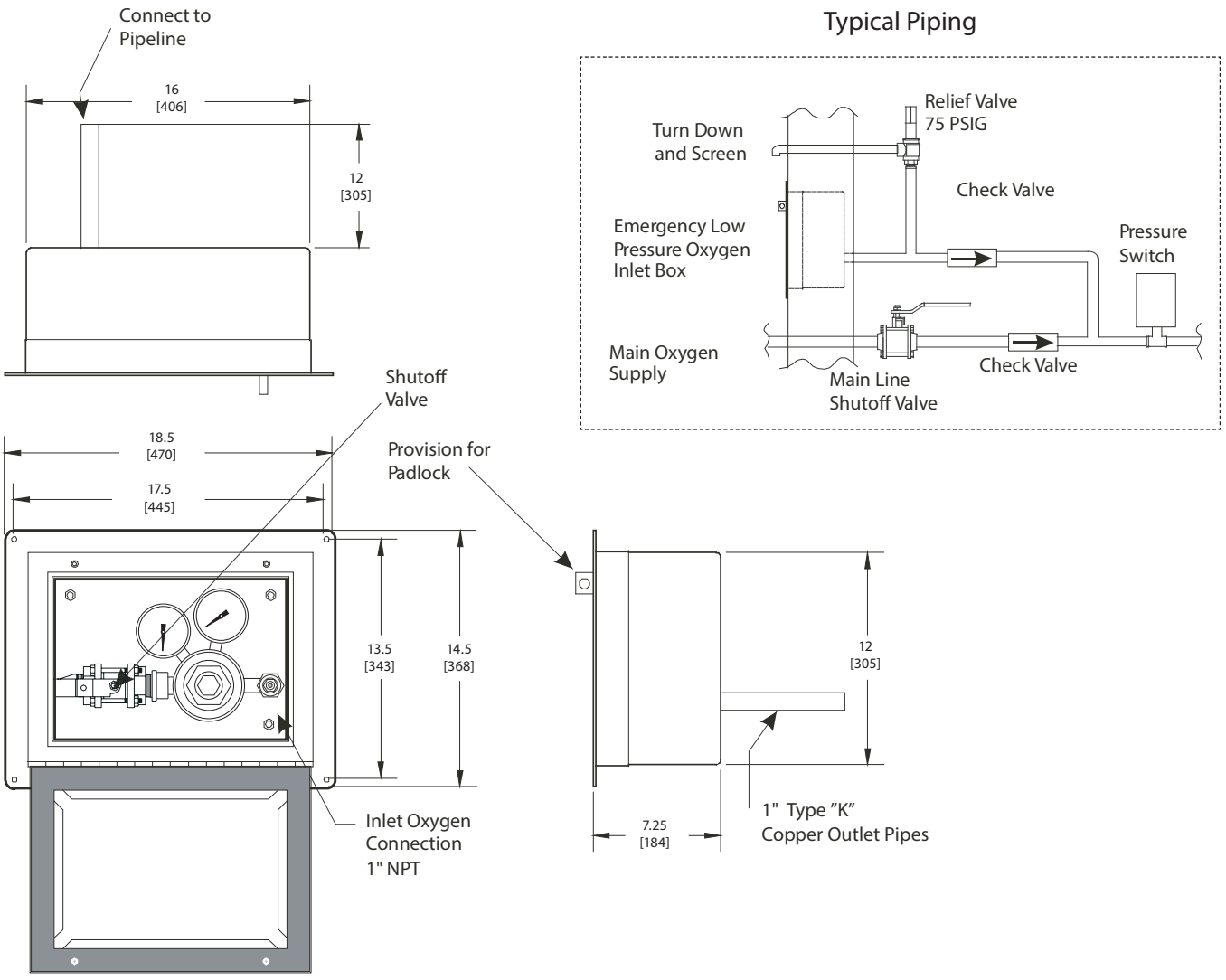
Bronze body check valves with female pipe threads on each end shall be provided for installation in the main and emergency supply pipeline in accordance with NFPA 99 and CSA Z7396.1.

A brass body relief valve with the relief pressure set @75 psi shall be provided for installation in the emergency supply line. The relief valve shall be supplied factory cleaned for oxygen service and shall automatically reset after discharging to provide a positive seal.

Amico products comply with NFPA 99 and CSA Z7396.1.

TECHNICAL SPECIFICATIONS

Inch
[mm]



Model Numbers:

Emergency High Pressure Oxygen Inlet Station Recessed Wall Mounting:	**M-FILL-OXY-HP**
Optional Check and Relief Valves (to be ordered separately):	
Check Valve 1"	**VV-CHK3-EXT10**
Check Valve 1-1/2"	**VV-CHK3-EXT15**
Check Valve 2"	**VV-CHK3-EXT20**
Relief Valve Pipe Away Adapter 1/2" NPT (NFPA)	**M-X-PIPEAWAY-05**
Relief Valve (NFPA)	**M-X-MAN-72W-075**
Relief Valve (CSA)	**M2-X-MAN-73-075**

EMERGENCY OXYGEN INLET STATION – 2" RECESSED MOUNT LOW PRESSURE

Features

- Low pressure 2" female NPT connection for high flow
- Lockable, weather-tight enclosure, for outside mounting
- Gauge for display of supply pressure
- Box can be mounted horizontally or vertically by changing front label
- Box available in recessed or surface mounting
- 3-Piece check valves and brass body relief valves available for installation (must be ordered separately)

General Specifications

The "Emergency Gaseous Oxygen Inlet Station" shall be an Amico Alert-1 series.

As required by NFPA 99 and CSA Z7396.1, oxygen systems having the source of supply outside the building shall have an inlet to connect a temporary, auxiliary source of supply for emergency or maintenance situations. This connection shall include necessary valves and allows for an emergency supply of oxygen and isolation of the normal source of supply. The inlet connection shall be a 2" female NPT connection and be provided with a plug to prevent entry of foreign matter into the oxygen system when not in use.

A 3-piece, threaded 2" bronze ball valve controls access to the emergency supply and the gauge indicates the pressure being introduced into the oxygen pipeline. Maximum input pressure of 100 psi.

The Emergency Gaseous Oxygen Inlet shall be housed in a weather-tight recessed enclosure.

The enclosure door shall be labeled "Emergency Low Pressure Gaseous Oxygen Inlet" and shall be equipped with a staple for padlocking to allow entry only by authorized personnel. A mounting frame shall extend completely around the enclosure to trim recessed mounting on an exterior wall.

The interior of the enclosure shall be clearly labeled with instructions for connection and operation of the emergency oxygen inlet.

The brass check valves shall be a 3-piece design, with a removable body for servicing without cutting or disassembling of lines. Valves are to be provided with type-K copper extensions for connections on the pipeline, as required for installation in the main and emergency supply pipeline, in accordance with NFPA 99.

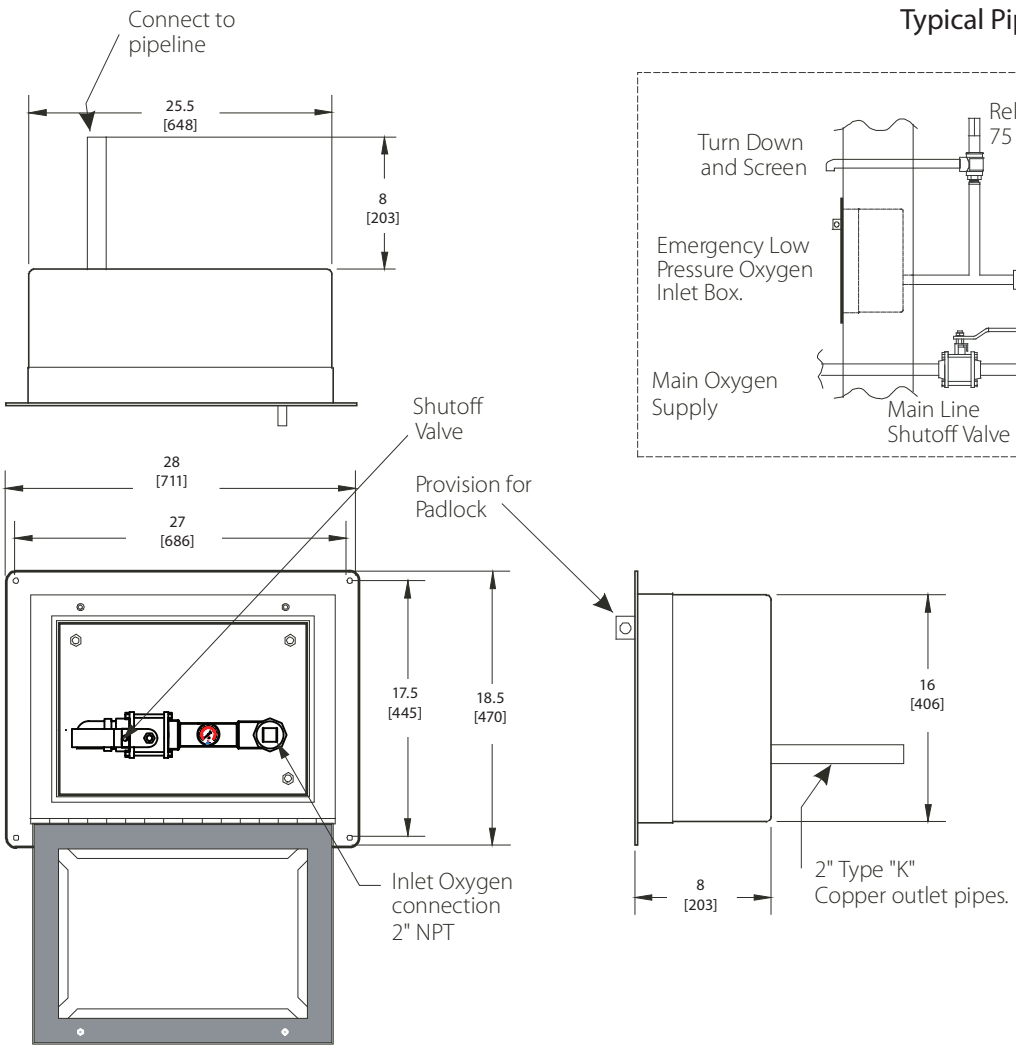
A brass body relief valve with the relief pressure set at 75 psi is required for installation in the emergency supply line. The relief valve shall be supplied factory cleaned for oxygen service and shall automatically reset after discharging to provide a positive seal.

All components will be sourced and cleaned for medical gas service. The sealing compound used will be compatible with medical gas service.

Amico products comply with NFPA 99 and CSA Z7396.1.

TECHNICAL SPECIFICATIONS

Inch
[mm]



Typical Piping

Model Numbers:

Emergency Low Pressure Oxygen Inlet Station Recessed Wall Mounting:	**M-FILL-OXY-LP2**
Optional Check and Relief Valves (to be ordered separately):	
Check Valve 1"	**VV-CHK3-EXT10**
Check Valve 1-1/2"	**VV-CHK3-EXT15**
Check Valve 2"	**VV-CHK3-EXT20**
Relief Valve Pipe Away Adapter 1/2" NPT (NFPA)	**M-X-PIPEAWAY-05**
Relief Valve (NFPA)	**M-X-MAN-72W-075**
Relief Valve (CSA)	**M2-X-MAN-73-075**

Chapter 13

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 13 – Medical Support Gas Sources – Nitrogen

Introduction

This chapter focusing on providing a process on how to size, select and plan for source equipment for Nitrogen. Nitrogen systems are primary function as operating driving tools.

Process

Nitrogen systems are as important as all other gases. Any implications on selecting source types and sizing should be done relating to chapter 12 Patient Medical Gas Sources.

Nitrogen Implication

Nitrogen is one of the three sources that supply a Category 3 drive gas system. Cylinders with Nitrogen are used primarily to drive gas-powered devices. For instance, dental equipment that is powered by air for drilling teeth, drying teeth and gums. Other applications include working as a reserve supply or alternate supply to a compressor system.

Source Types

There are few types:

- **Gas Cylinder Manifold** – Obtaining gas from a high pressure cylinder at 2200 psi.
- **Liquid Container Manifold** – Portable container, containing nitrogen as cryogenic liquid form.
- **Bulk Cryogenic Station** – Large permanently mounted container, containing nitrogen as cryogenic liquid form.

TABLE 1: CONTAINERS SPECIFICATIONS

System Type	Holding Contents Efficiency
Gas Cylinder	Can hold content indefinitely
Liquid Container	Cannot hold content overtime

Identifying Source Type

Three important elements to consider when selecting source type for facility to use:

- Practicality and Requirements
- Economical cost
- Accessibility

These elements are used to select the most suitable source type in order to maximize the utility of the system and to ensure that no money is wasted.

Practicality and Requirement

It is important to consider the practicality when selecting a source system for a medical facility. This involves matching cylinders that fulfill demands for different scale facilities. For instance, a dental clinic that implied cylinders as its source type: the capacity should provide sufficient amount of gas supply for the clinic. In addition, cylinders can also provide flexibility to the clinic when demand is low, as it is able to hold the content indefinitely.

ECONOMICAL

During the process of choosing source types, the primary consideration is to determine the financial ability for the facility in supporting the source type they have selected. Cost for different source types vary according to the duration it stores the content, gas lost over time and maintenance. For instance, a cylinder is significantly lower than cryogenic container. Facilities using cylinders as their source types can benefit lower fixed cost. It is recommended to perform site examination before any implications.

ACCESSIBILITY

It is recommended when determining source type to evaluate the facility's location for delivering supplies. Cylinders are easy to store, relocate and deliver. Hence, it is commonly used among facilities due to its convenience and ease of transport for suppliers.

Below table summarize the primary source sizing, secondary source sizing, calculation and requirements:

TABLE 2: SOURCE SIZING – NITROGEN

<table>
<tr><th colspan="4">Primary Source Sizing</th></tr>
<tr><td rowspan="2">Standard Method</td><td>1. Identify # of operating room that piped with Nitrogen.</td><td>Number:</td><td rowspan="2">Note*
1. Equipment utilization index is hard to be accurate, therefore it's safer to use a higher number</td></tr>
<tr><td>2. Identify # of Cylinder use in * 1 cylinder / week use for standard O.R. + * 2 cylinders / week for major O.R.</td><td>Number:
(1)
(2)</td></tr>
<tr><td colspan="4">Sum the 2 numbers and select appropriate source type</td></tr>
<tr><td>Calculation Method</td><td colspan="2">Obtain equipment utilization per day from medical staffs</td><td rowspan="2">Note*
1. Equipment utilization index is hard to be accurate, therefore it's recommend to use a higher number.
2. Tools can be estimated to run for 45-60 mins per week each, therefore a minimum requirement of 13,600L (477 ft^3) per week.</td></tr>
<tr><td>If actual tool usage Is unknown</td><td colspan="2"></td></tr>
<tr><td colspan="4">Based on the obtained number in table 3 and select appropriate source type</td></tr>
<tr><td colspan="4">Secondary Source Sizing</td></tr>
<tr><td>Cylinder Manifold</td><td colspan="3">Secondary manifold is always the same size as Primary.</td></tr>
</table>

STEPS: STANDARD METHOD

1. Determine the number of operating rooms (piped with Nitrogen)
2. Calculate 1 cylinder per week, for regular O.R. and 2 for heavy use O.R.
3. Sum the number of cylinders per week
4. Use Table 3 to select desired source types

CALCULATIONS METHOD

Estimate daily usage of each equipment used with the system (estimate at a higher number). For tools, where actually usage is unknown, a rough estimate is to run 45-60 minutes per week. Each tool can be estimated to require at least 13,600 L (477 ft^3) per week.

Use Table 3 to select desired source types

TABLE 3 NITROGEN SOURCE RANGES

Gas	Configuration (Primary x Secondary)	Cylinder Manifold (# location piped with Nitrogen)
Nitrogen	2x2	1-2
	3x3	1-3
	4x4	2-4
	5x5	2-5
	6x6	3-6
	7x7	3-7
	8x8	4-8
	9x9	4-9
	10x10	5-10
	11x11	5-11
	12x12	6-12
	13x13	6-13
	14x14	7-14

Proceed to Locating Source on page 252, Storage Requirements and Ventilation on page 253 of Chapter 12 Patient Medical Gas Sources.

COMPLETION

Verification on

1. Source Type
   - Ensure it considers the three elements: Requirements, Economical & Accessibility
2. Source Size
   - Ensure it fulfills the regulations on both primary and secondary sources
3. Refers to Medical Alarm Chapter, apply Medical alarms where required.

AMICO GAS CONTROL PANEL

General Specifications

The Gas Control panel shall be an Amico Alert-1 series.

The control panel shall be supplied with a quarter turn shutoff ball valve, rated at no less than 300 psi (2,069 kPa).

The unit shall have an inlet pressure indicator valve that indicates the inlet supply pressure from 0 - 400 psi (0 - 2,750 kPa).

The pressure regulator shall be adjustable between 0 - 250 psi (0 - 1,724 kPa).

The outlet controlled pressure shall be monitored by a pressure indicator with a range of 0 - 400 psi (0 - 2,750 kPa).

The DISS outlet shall be a Diameter Index Safety System (D.I.S.S.) For Air or Nitrogen Service Outlet or "Safety Swing Coupling" for pressures above 200 psi. The outlets shall be used for connection to pneumatic surgical tools.

The controls shall be mounted in an 1.3 mm (#18 gauge) galvanized steel enclosure, with adjustable bracket for different wall thicknesses.

The unit shall be factory tested for intended gas service.

The Gas Control Panel meets CSA and NFPA requirements.

Amico products comply with NFPA-99.

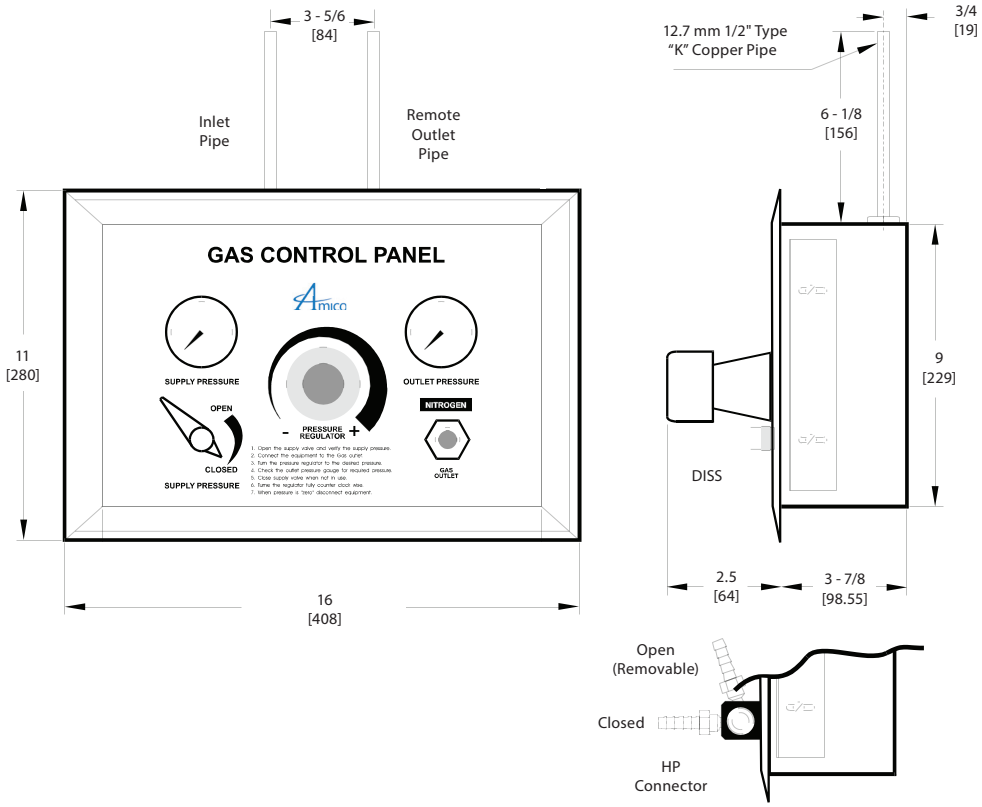
Features

- Inlet and outlet pressure display gauges in psi/kPa
- Manual shut-off valve
- Outlet supply pipe for remote mounted outlets
- 3/8" (9.5 mm) internal tubing for high flow
- High flow capacity regulator
- Wall mount with adjustable brackets for different wall thicknesses
- Aluminum front simplifies cleaning
- Maximum supply pressure 250 psi (1,724 kPa)
- DISS maximum delivery pressure:

Carbon Dioxide	=	80 psi (551 kPa)
Nitrogen	=	200 psi (1,379 kPa)
Instrument Air	=	200 psi (1,379 kPa)
HP (High Pressure) Safety Swing Coupling	=	250 psi (1,723 kPa)

TECHNICAL SPECIFICATIONS

Inch
[mm]



Model Numbers:

N-CONP-E-REL	=	Nitrogen - Gas Control Panel - NFPA, relieving
N-CONP-E-HP-REL	=	Nitrogen - Gas Control Panel High Pressure - NFPA, relieving
N-CONP-E-REL-C	=	Carbon Dioxide - Gas Control Panel - NFPA, relieving
N-CONP-U-REL-I	=	Instrument Air - Gas Control Panel - NFPA, relieving
N-CONS-E-REL	=	Nitrogen - Gas Control Panel Schraeder - NFPA, relieving

NOTE:

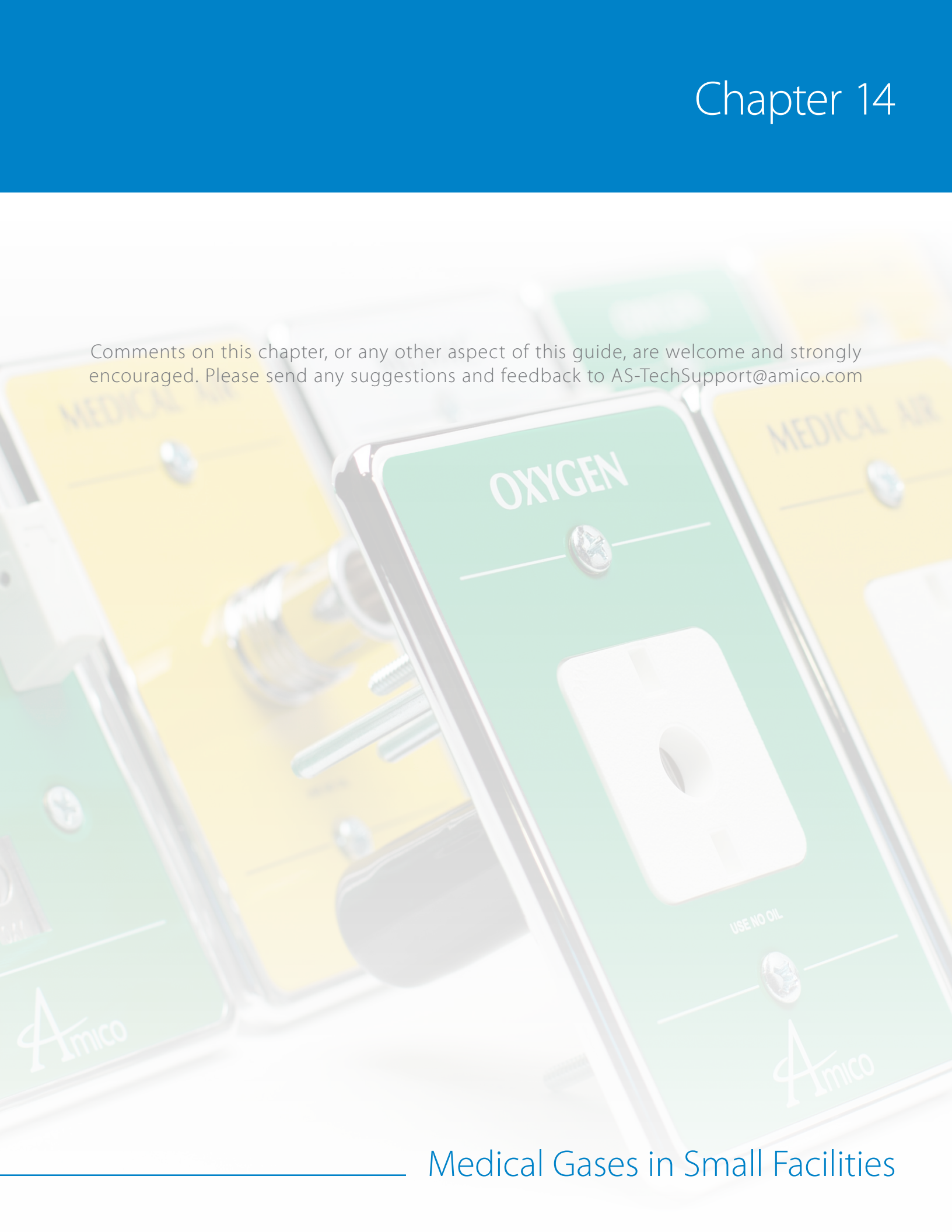
N-X-CON-ADA-B25	=	High pressure adaptor with 1/4" hose barb (supplied with HP Gas Control Panel)

REFERENCE

Reference Source	Page	Medical Support Gas Sources
Control Panel Spec.	Page 1 & 2	Pages 5 & 6

Chapter 14

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 14 – Medical Gases in Small Facilities

Introduction

This Chapter is focusing on Pipeline Medical Gases used in smaller facilities. With today's advanced technologies, some surgeries can be performed under local anesthesia on patients who could leave the facility almost on the same day. Such surgeries can save money and time on both the patients and healthcare providers. With such trends, the standards are included in the NFPA 99 codes.

14.1 SYSTEMS' CATEGORIES

*NFPA 99 A.4.1 Four levels of systems categories are defined in this code, based on the risks to patients and caregivers in the facilities. The categories are as follows:

1. Category 1: Systems are expected to work or be available at all times to support patient needs.
2. Category 2: Systems are expected to provide a high level of reliability; however, limited short durations of equipment downtime can be tolerated without significant impact on patient care. Category 2 systems support patient needs but are not critical for life support.
3. Category 3: Normal building system reliabilities are expected. Such systems support patient needs, but failure of such equipment would not immediately affect patient care. Such equipment is not critical for life support.
4. Category 4: Such systems have no impact on patient care and would not be noticeable to patients in the event of failure.

14.2 CRITERIA FOR EACH CATEGORY

Category 1: Any systems, equipment or activities' failures resulting major injury or death of staffs, patients or visitors. Injuries include loss of eyesight, cut of limb, unconsciousness due to absorbing of chemical or electric shock.

Category 2: Any systems, equipment or activities' failures resulting minor injury of staffs, patients or visitors. Such injuries are not serious nor life threatening. Minor injuries include task or procedure lighting in patient rooms or procedures that can be done without medical gases

Category 3: Any systems, equipment or activities' failures not likely in result injury to staffs, patients or visitors but only result in discomfort. Such examples include heating system, humidity control in non-operating area or dental drill.

Category 4: Any systems, equipment, or activities' failures resulting no impact on patient care. For instance, gray water lawn sprinkler systems or seasonal lighting systems *NFPA 99 4.1.1 - 4.1.4.

14.3 APPLYING THE CATEGORIES

In category 1, these facilities depending solely on medical treatment whose patients may be dependent on the gas for life. These facilities include general hospitals, outpatient surgery centers involving the use of anesthesia.

In addition, category 1 provides alarms and warning systems suggesting the facility to take actions on two levels: the immediate staff and maintenance. It also provides gases of purity in a level that they are delivered through cleaned pipelines so that gases are be breathed and relied to sustain life.

Category 2, facilities sometimes use gas to treat their patients but not solely depending on the use of gas. Examples are clinics, outpatient surgery centers involving low intensity surgeries. Their patients will not be at high risk if the gases malfunction.

In the event of single faults, category 2 systems are expected to handle risk by taking action by medical staff or the patient will survive unharmed without gas or vacuum. This category provides warning systems to facility's immediate staff that problem has taken place. Facility provides gases of purity in a level that they are delivered through cleaned pipelines so that gases are be breathed and relied to sustain life.

Category 3, these facilities could be office based. If gases in these facilities failed, the patients will not be affected. For instance, a dental office, a gas failure would likely be interrupted but not life threatening. Note: oral surgeon does not qualify in category 3.

In the event of single faults, it is assumed that gas and vacuum are not available. The facility would qualified for category 3, if the process of losing gas or vacuum would only create inconvenience, not life threatening. This category provides alarms only signaling the doctor that Oxygen and Nitrous Oxide systems needed attention. And only the Oxygen and Nitrous Oxide are delivered through cleaned pipelines and all other gases are dangerous to be breathed in, they are used on utility tools only.

Category 4 may not applied in this article.

14.4 CATEGORIZE FACILITY

Factors to consider when deciding what category the facility should fall into:

- The likely the patient is depending on the gas and vacuum, the higher category the facility should built upon on.
- Will the patient's life be affected if gas and vacuum suddenly not available? If the answer is "yes", the facility should be built as category 1.
- Facility's specifications: if a facility has Operating Rooms, Endoscopy, Emergency Treatment, etc. it should be in a category 1.
- If bulk oxygen tanks are included in the design, then it is category 1.

The categories are established as category 1 as superior to category 2 which is superior to category 3.

As per NFPA 99, it is possible to have category 1, 2, and 3 systems coexisting in a facility. For instance, a sleep lab inside a hospital can operate as standalone category 3 where oxygen system is feasible. Each system in category must standalone and could not be served by a category 1 source or vice versa.

14.5 SYSTEMS AND THEIR CHARACTERISTICS

A category 1 facility may have any gases. Oxygen, Medical Air, Medical Vacuum, Nitrous Oxide, Nitrogen and WAGD. CO2, Helium and mixture are rarely seen.

A category 2 facility may have Oxygen and Medical Vacuum, Medical Air and Nitrous Oxide. Nitrogen or Instrument air in an Operating Room would be rarely seen.

A category 3 facility will have piped with Oxygen, an Air system for tools use only, Vacuum may be for 'wet' system if use for dental purposes, and Nitrous Oxide. Both Nitrous Oxide and Oxygen are considered "Medical gases" and air in the use as driving tools considered as a separate category. This air is not suitable for breathing. Category 3 facility does not require Medical Air.

14.6 APPLYING VALVES, ALARMS AND MONITORS IN THE CATEGORY

Category 1 warning systems, NFPA 99 5.1.9.1: All master, area and local alarm systems used for medical gas vacuum systems shall include the following:

- Separate visual indicators for each condition monitored, except as permitted in 5.1.9.5.2 for local alarms that are displayed on master alarm panels
- Visual indicators that remain in alarm until the situation that has caused the alarm is resolved
- Cancelable audible indication of each alarm condition that produces a sound with a minimum level of 80 dBA at .092 m (3ft)

Master alarm system in category 1 consist of two or more alarm panels. They should be located in at least two different locations:

- One master alarm should be in the office where the individual is responsible for maintaining of the medical gas and vacuum piping systems.
- The other master alarm should be located in the facility where the medical gas and vacuum is continuously being monitored (for instance, security office, telephone switchboard, etc.)

NFPA 99 5.2.9: Warning Systems associated with category 2 systems shall provide the master, area, and local alarm functions of a Category 1 system as required in 5.1.9, except as follows:

- Warning systems shall be permitted to be a single alarm panel
- The alarm panel shall be located in an area of continuous surveillance while the facility is in operation.
- Pressure and vacuum switches/sensors shall be mounted at the source equipment with a pressure indicator at the master alarm panel.

To accommodate small facilities, the alarm is of a special type, it is called combination alarm systems. See below Compact/ Master alarm:

A master alarm system is needed to monitor the operation and condition of source supply. See table 1 from NFPA 99 A.5.1.9.2 for requirements for category 1 master alarm for gas and vacuum system on pages 286 to 289.

Requirements of valves in the category 1 to 3 facilities are exactly the same. This is an issue in very small facilities where space is limited. Deciding what constitutes a critical care or anesthetizing location becoming difficult. As per NFPA 99, shut off valves are provided to isolate section or portions of the piped distribution system for maintenance, repair etc. Pipes should be located in above ceilings but remaining accessible and not obstructed and in secured area. They should be in locked or latched when in operating position.

14.7 LAYOUT AND STORAGE AREA FOR SMALL FACILITIES

Small facilities are usually tight in all aspects in their facility layout, from space for systems inside the facility to space for equipment outside the facility, (excluding direct impact to the patients).

Below are basic rules to follow when installing Manifold and storage of cylinders for category 1, 2 or 3:

- Manifolds and cylinder storage may be placed together or may be separated
- Manifolds and cylinder storage must be stored away from compressors and vacuum while pumps and compressor may be placed together
- Manifold, cylinder and compressor storage must be in ventilated area
- Suitable location to store manifold and cylinder is on outside walls with easy access

14.8 STATION OUTLETS IN SMALL FACILITIES

Placing outlets is mainly up to the clients' preferences. However, there are some minimum number of outlets required as stated in FGI Guidelines for Design and Construction of Hospitals and Outpatient Facilities. See table 2 extracted from Table 2.1-4 Station Outlets for Oxygen. Vacuum (Suction), and Medical Air Systems in Hospitals.

Location	Oxygen	Vacuum	Medical Air	WAGD
Critical care (general)	3/bed	3/bed	1/bed	
Coronary critical care	3/bed	2/bed	1/bed	
Operating Room	2/room	5/room	1/room	1/room
NICU	3/infant care bed	3/infant care bed	3/infant care bed	
Cesarean Delivery Room	2/room	4/room	1/room	1/room

Outlets should be placed at a reasonable height above the floor to avoid physical damage to the equipment attached to the outlets and they should be gas-specific.

The following recommendation applies to category 2: When possible, the outlets should be on the door side of the bed for better clinical access and the clinical staff should not have to reach over a patient to access the medical gas outlets.

14.9 PIPED GAS AND VACUUM SYSTEMS FOR CATEGORY 1, 2 & 3

*NFPA 99 5.1.1.2: Category 1 piped gas or piped vacuum system requirement shall be applied where any of the following criteria is met:

- General anesthesia or deep sedation is performed as defined in 3.3.65.1 and 3.3.65.2.
- The loss of the piped gas or piped vacuum systems is likely to cause major injury or death of patients, staff, or visitors
- The facility piped gas or piped vacuum systems are intended for Category 1 patient care space per 3.3.135.1.

*NFPA 99 5.2.1.2: Category 2 piped gas or piped vacuum system requirements shall be permitted when all of the following criteria are met:

- Only moderate sedation; minimal sedation, as defined in 3.3.65.3 and 3.3.65.4; or no sedation is performed. Deep sedation and general anesthesia shall not be permitted.
- The loss of the piped gas or piped vacuum systems is likely to cause minor injury to patients, staff, or visitors.
- The facility piped gas or piped vacuum systems are intended for Category 2 patient care space per 3.3.135.2.

*NFPA 99 5.3.1.2: Category 3 piped gas and vacuum systems shall be permitted when all of the following criteria are met:

- Only moderate sedation; minimal sedation, as defined in 3.3.65.3 and 3.3.65.4; or no sedation is performed. Deep sedation and general anesthesia are not be performed.
- The loss of the piped gas and vacuum systems is not likely to cause injury to patients, staff, or visitors but can cause discomfort.
- The facility piped gas or piped vacuum systems are intended for Category 3 or Category 4 patient care rooms per 3.3.135.3 and 3.3135.4.

14.10 MAINTENANCE AND OPERATION

Small facilities usually have one thing in common; they do not have permanent maintenance staff. Maintenance are usually done by nurse, doctor or facility administrator. This is a factor client must considered when choosing source equipment. For instance, it may be cheaper to use a manifold air system but the manifold requires frequent changing of cylinders, in which there might not be staff to change. A quality compressor in this case may be a better choice since it requires maintenance once every few months or so, in which it can be performed by a contracted service personnel. Such decisions should be included when designing small facilities.

14.11 FINAL THOUGHTS

Small facilities signifies the ability to provide healthcare economically. Experienced design engineers can help their clients meet the goal without compromising patient or staff's safety. By following NFPA 99 standards on the categories required in the medical gases. And applying the categories with careful thoughts, combine with good judgments in planning and most importantly communication between the owners and medical staffs, things can be reached to satisfactory results!

REQUIREMENTS FOR CATEGORY 1 MASTER ALARMS FOR GAS AND VACUUM SYSTEMS

Table 1 **NFPA 99 2018 P203 -206 table A.5.1.9.2

Alarm Condition	Manifold for Gas Cylinders (5.1.3.5.12)	Manifold for Cryogenic Liquid Cylinders with Reserve (5.1.3.5.13)	Cryogenic Bulk with Cryogenic Reserve (5.1.3.5.14)	Cryogenic Bulk with Cylinder Reserve (5.1.3.5.15)	Medical Air Proportioning System (5.1.3.6.3.13)	Medical Air Compressors (5.1.3.6)	Instrument Air Compressors (5.1.13.3.5)	Medical – Surgical Vacuum Pumps (5.1.3.7)	WAGD Producers (5.1.3.8)	Oxygen Concentrator (5.1.3.9)
Nitrogen Main Line Pressure High	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)						
Nitrogen Main Line Pressure Low	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)						
Nitrogen Changeover to Secondary Supply	5.1.3.5.12.6, 5.1.9.2.4(1)	5.1.3.5.13.9(1), 5.1.9.2.4(1)	5.1.3.14.4(5)							
Nitrogen Main Supply less than 1 Day (Low Contents)			5.1.9.2.4(2), 5.1.3.5.14.4(1)	5.1.9.2.4(2), 5.1.3.5.14.4(1)						
Nitrogen Reserve In Use		5.1.3.5.13.9(3), 5.1.9.2.4(3)	5.1.9.2.4(3), 5.1.3.5.14.4(2)	5.1.9.2.4(3), 5.1.3.5.14.4(2)						
Nitrogen Reserve Supply less than 1 Day (Low Contents)		5.1.9.2.4(4), 5.1.3.5.13.9(4)	5.1.9.2.4(5), 5.1.3.5.14.4(3)	5.1.9.2.4(4), 5.1.3.5.14.4(3)						
Nitrogen Reserve Pressure Low (Not Functional)			5.1.9.2.4(6), 5.1.3.5.14.4(4)							
Carbon Dioxide Main Line Pressure High	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)						
Carbon Dioxide Main Line Pressure Low	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)						
Carbon Dioxide Changeover to Secondary Supply	5.1.3.5.12.6, 5.1.9.2.4(1)	5.1.3.5.13.9(1), 5.1.9.2.4(1)								
Carbon Dioxide Main Supply less than 1 Day (Low Contents)			5.1.9.2.4(2), 5.1.3.5.14.4(1)	5.1.9.2.4(2), 5.1.3.5.14.4(1)						
Carbon Dioxide Reserve In Use		5.1.3.5.13.9(3), 5.1.9.2.4(3)	5.1.9.2.4(3), 5.1.3.5.14.4(2)	5.1.9.2.4(3), 5.1.3.5.14.4(2)						
Carbon Dioxide Reserve Supply less than 1 Day (Low Contents)		5.1.3.5.13.9(4)	5.1.9.2.4(5), 5.1.3.5.14.4(3)	5.1.9.2.4(5), 5.1.3.5.14.4(3)						
Carbon Dioxide Reserve Pressure Low (Not Functional)			5.1.9.2.4(6), 5.1.3.5.14.4(3)							
Medical Air Main Line Pressure High	5.1.9.2.4(7)					5.1.9.2.4(7)				

Alarm Condition	Manifold for Gas Cylinders (5.1.3.5.12)	Manifold for Cryogenic Liquid Cylinders with Reserve (5.1.3.5.13)	Cryogenic Bulk with Cryogenic Reserve (5.1.3.5.14)	Cryogenic Bulk with Cylinder Reserve (5.1.3.5.15)	Medical Air Proportioning System (5.1.3.6.3.13)	Medical Air Compressors (5.1.3.6)	Instrument Air Compressors (5.1.13.3.5)	Medical – Surgical Vacuum Pumps (5.1.3.7)	WAGD Producers (5.1.3.8)	Oxygen Concentrator (5.1.3.9)
Medical Air Main Line Pressure Low	5.1.9.2.4(7)					5.1.9.2.4(7)				
Medical Air Changeover to Secondary Supply	5.1.3.5.12.6, 5.1.9.2.4(1)									
Medical Air Dew Point High						5.1.3.6.3.13.(1), 5.1.9.2.4(10)				
Medical Air Production Stop					5.1.9.2.4(13)					
Oxygen Main Line Pressure High	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)						
Oxygen Main Line Pressure Low	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)						
Oxygen Changeover to Secondary Supply	5.1.3.5.12.6, 5.1.9.2.4(1)	5.1.3.5.13.9(1), 5.1.9.2.4(1)								
Oxygen Main Supply less than 1 Day (Low Contents)			5.1.9.2.4(2), 5.1.3.5.14.4(1)	5.1.9.2.4(2), 5.1.3.5.14.4(1)						
Oxygen Reserve In Use		5.1.3.5.13.9(3), 5.1.9.2.4(3)	5.1.9.2.4(3), 5.1.3.5.14.4(2)	5.1.9.2.4(3), 5.1.3.5.13.9(4), 5.1.3.5.14.4(2)						
Oxygen Reserve Supply less than 1 Day (Low Contents)		5.1.9.2.4(5)	5.1.3.5.14.4(3)	5.1.3.5.14.4(3)						
Oxygen Reserve Pressure Low (Not Functional)			5.1.9.2.4(6), 5.1.3.5.14.4(3)							

Alarm Condition	Manifold for Gas Cylinders (5.1.3.5.12)	Manifold for Cryogenic Liquid Cylinders with Reserve (5.1.3.5.13)	Cryogenic Bulk with Cryogenic Reserve (5.1.3.5.14)	Cryogenic Bulk with Cylinder Reserve (5.1.3.5.15)	Medical Air Proportioning System (5.1.3.6.3.13)	Medical Air Compressors (5.1.3.6)	Instrument Air Compressors (5.1.13.3.5)	Medical – Surgical Vacuum Pumps (5.1.3.7)	WAGD Producers (5.1.3.8)	Oxygen Concentrator (5.1.3.9)
Nitrous Oxide Main Line Pressure High	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)						
Nitrous Oxide Main Line Pressure Low	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)	5.1.9.2.4(7)						
Nitrous Oxide Changeover To Secondary Supply	5.1.3.5.12.6, 5.1.9.2.4(1)	5.1.3.5.13.9(1), 5.1.9.2.4(1)								
Nitrous Oxide Main Supply less than 1 Day (Low Contents)			5.1.9.2.4(2), 5.1.3.5.14.4(1)	5.1.9.2.4(2), 5.1.3.5.14.4(1)						
Nitrous Oxide Reserve In Use		5.1.9.2.4(3), 5.1.3.5.13.9(3)	5.1.9.2.4(3), 5.1.3.5.14.4(2)	5.1.9.2.4(3), 5.1.3.5.14.4(2)						
Nitrous Oxide Reserve Supply less than 1 Day (Low Contents)		5.1.3.5.13.9(4)	5.1.9.2.4(5), 5.1.3.5.14.4(3)	5.1.9.2.4(5), 5.1.3.5.14.4(2)						
Nitrous Oxide Reserve Pressure Low (Not Functional)			5.1.9.2.4(6), 5.1.3.5.14.4(4)							
Medical–Surgical Main Line Vacuum Low								5.1.9.2.4(8)		
WAGD Main Line Vacuum Low									5.1.9.2.4(11)	
Local Alarm					5.1.9.2.4(9), 5.1.9.5.2, 5.1.3.6.3.14(C)(9)	5.1.3.6.3.12, 5.1.9.2.4(9), 5.1.9.5.2	5.1.13.3.4.11, 5.1.9.2.4(9), 5.1.9.5.2	5.1.3.7.8, 5.1.9.2.4(9), 5.1.9.5.2	5.1.3.8.3.2, 5.1.9.2.4(9), 5.1.9.5.2	

Alarm Condition	Manifold for Gas Cylinders (5.1.3.5.12)	Manifold for Cryogenic Liquid Cylinders with Reserve (5.1.3.5.13)	Cryogenic Bulk with Cryogenic Reserve (5.1.3.5.14)	Cryogenic Bulk with Cylinder Reserve (5.1.3.5.15)	Medical Air Proportioning System (5.1.3.6.3.13)	Medical Air Compressors (5.1.3.6)	Instrument Air Compressors (5.1.13.3.5)	Medical – Surgical Vacuum Pumps (5.1.3.7)	WAGD Producers (5.1.3.8)	Oxygen Concentrator (5.1.3.9)
Instrument Air Main Line Pressure High							5.1.9.2.4(7)			
Instrument Air Main Line Pressure Low							5.1.9.2.4(7)			
Instrument Air Dew Point High							5.1.13.3.4.11(A)(2), 5.1.9.2.4(12)			
Instrument Air Cylinder Reserve In Use (If Provided)							5.1.13.3.4.11(B)(1)			
Instrument Air Cylinder Reserve less than 1 hour Supply							5.1.13.3.4.11(B)(2)		5.1.3.5.11.13(12)	
Oxygen Concentrator Low Concentration									5.1.3.9.2.(10)(c), 5.1.3.9.4.1(5), 5.1.9.2.4(14)(b)	
Oxygen Concentrator Offline									5.1.3.5.11.12(5), 5.1.3.9.4.1(5), 5.1.9.2.4(14)(b)	
Oxygen Reserve In Use									5.1.3.9.4.3(2), 5.1.9.2.4(3), 5.1.9.2.4(14)(c)	
Oxygen Reserve Supply less than 1 Day (Low Contents)									5.1.3.9.4.3(3) 5.1.9.2.4(4) 5.1.9.2.4(14)(d)	
Oxygen Main Line Low Concentration									5.1.3.9.4.2(4) 5.1.9.2.4(14)(g)	
Oxygen Main Line High Concentration									5.1.3.9.4.2(5) 5.1.9.2.4(14)(h)	
Oxygen Main Line Pressure High									5.1.9.2.4(7)	
Oxygen Main Line Pressure Low									5.1.9.2.4(7)	
Oxygen Change of Source									5.1.3.9.4.4(1)(a)	
Oxygen Concentrator Internal Pressure Low									5.1.3.9.4.4(2), 5.1.9.2.4(14)(f)	
Oxygen Concentrator Local Alarm									5.1.9.2.4(9)	

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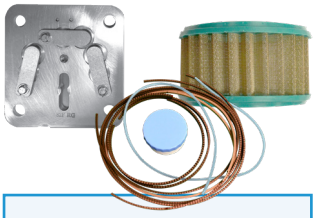

Replacement Parts

Compressed Air Systems

Vacuum (Suction) Systems

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