PLUMBING SYSTEM

MC-02

Lecture 02

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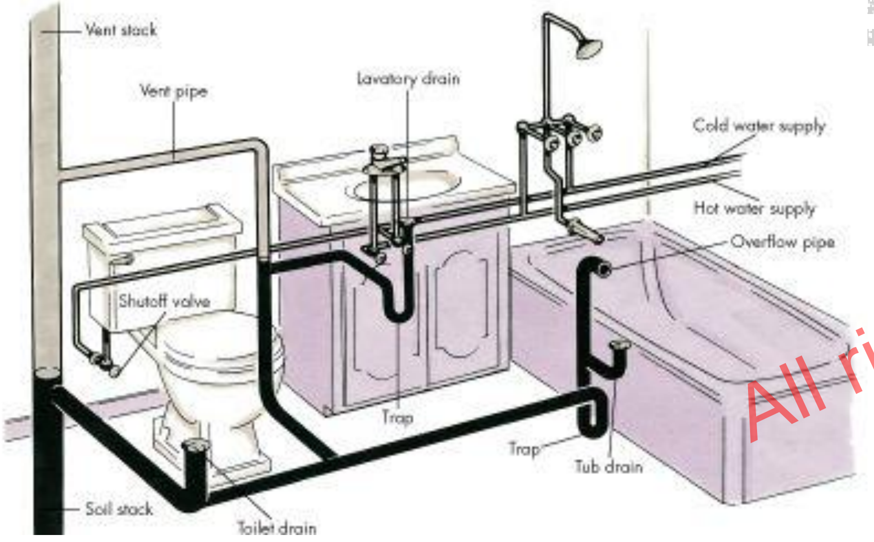

ASPE
American Society of Plumbing Engineers™

About the Lecturer:

- Bachelor's Degree in Mechanical Engineering, Helwan University, El-Mattaria, Cairo, Egypt - May 2010.
- Working as Mechanical design Engineer in "DMG" Design and Project Management MEP Consultant Group (www.dmg-eg.com) since 2010 till 2012. and Mechanical Design engineer team leader since 2012 till now.
- Working as Mechanical Design engineer Team leader in HOWEEDY Consultant office (www.howeedyconsultant.com) since Feb 2016 till now.
- Responsible for :
  - Preparing Design and work shop drawings, Bill of quantities, Technical schedule, Specifications and all calculations
  - Prepare design or workshop MEP coordination drawings, calculations, Piping and Instrumentation diagrams, technical specifications, suppliers and vendors list.
  - Review all mechanical materials and equipment submittals.
  - Participated in planning, cost development and management. In addition, prepare project schedule line and ensure that the project was completed on time

About the Lecturer:

➢ Responsible for :
  - Team leader for mechanical engineers and provide technical support to meet project goals.
  - Performed MEP commissioning visits on the site and Progress meetings to follow and solve all problems or conflicts between contractors, vendors and consultant offices and make sure that all MEP works are coordinated.
  - Prepare & submit billing breakdown for the project and manage the billing process for the project

For more information about the lecturer, Kindly visit my LinkedIn (https://eg.linkedin.com/in/nader-wadie-31834ba2)

Codes And Standards

- American society of plumbing engineers (ASPE)
- Uniform plumbing code (UPC)
- NFPA –99
- Health Technical Memorandum 2022
  - Dental compressed air and vacuum systems
  - Design, installation, validation & verification
  - Operational management
  - Guidelines for testing
  - Medical gases
- Egyptian code
  - مطابخ–غازات طبية

MEDICAL GAS PIPING SYSTEM (MGPS)

1. Pipe type will be used:

Medical Gas Piping System (MGPS)

- **Compressed air system**
- **Oxygen**
  - يُستخدم في التنفس ويخلط أحياناً مع غاز التخدير
  - لا يشتعل، ولكنه يساعد على الاشتعال
- **Nitrogen**
  - تستخدم في الأجهزة الجراحية التي تعمل بالهواء المضغوط
- **CO2**
  - يستخدم في التبريد في المعامل، ويستخدم في التخلص من الغازات المخدرة ومشاكل التنفس الناجمة من التخدير
  - لا يشتعل، ولا يساعد على الاشتعال
- **Vacuum**
- **Nitrous oxide**
  - الغاز الضاحك، وهو احد الغازات المستخدمة في التخدير
  - لا يشتعل، ولكنه يساعد على الاشتعال

Types of Medical Gas:

1.Oxygen: Oxygen is used when patients require supplemental oxygenation due to hypoxemia and hypoxia (insufficient oxygen in the blood). This system consists of a large storage system of liquid oxygen, which is then evaporated into a concentrated oxygen supply. Pressures are kept around 380 kPa or 55 psi. This arrangement is described as a vacuum insulated evaporator or VIE. For medical centers with a low patient capacity, oxygen is supplied by multiple standard cylinders, as opposed to evaporated liquid oxygen.

2.Nitrous Oxide: Nitrous Oxide, or laughing gas, is used as an analgesic, and as an anesthetic for pre-operative procedures. Nitrous oxide is delivered to the hospital in standard tanks and is supplied through the medical gas system at around 345 kPa, or 50 psi.

3.Nitrogen: Nitrogen is often used to power up surgical equipment during various procedures, and to measure a person's response to a simulated aircraft cabin environment in pre-flight lung testing. This is known as hypoxic challenge testing. Nitrogen is also used as a cryogen to freeze and preserve blood, tissue, and other biological specimens, and to freeze and destroy diseased tissue in dermatology and cryosurgery.

4.Carbon Dioxide: Carbon dioxide is used to suspend or inflate various tissues and is used in laser surgeries. Most commonly, carbon dioxide is used in abdominal and thoracic surgeries, where the surgeon may need to move various organs to get to one particular area of the body. Carbon dioxide can also be combined with oxygen or air for respiratory simulation and treatment of various respiratory disorders. System pressures are maintained at about 345 kPa, or 50 psi.

Types of Medical Gas:

1. **Helium/Heliox:** Helium is often used to treat fixed partial upper airway obstructions or increased air resistance. This will help patients breathe easier. It is also used in liquefied form to help MRI machines to reach a superconducting state. This allows the MRI to produce high-resolution body images without exposing the patient to radiation.
2. **Carbon Monoxide:** This gas is only used in very trace amounts as an ingredient in lung diffusion testing. This test helps medical staff to determine how well a patient's lungs are exchanging gases. In addition to these main gases, there are a number of medical gas mixtures. These are often used for patient diagnostics such as lung function, or blood-gas analysis. Test gases are also used to calibrate and maintain medical devices that are employed in the delivery of anaesthetic gases. Medical gases are also used in a laboratory environment, where bacterial cultures may be grown in controlled aerobic or anaerobic incubator atmospheres. Biological cell cultures or tissue growth can be controlled by aerobic conditions that use mixtures rich in oxygen. Conversely, anaerobic conditions are created using mixtures rich in hydrogen or carbon dioxide.

MEDICAL GAS SYSTEM DESIGN CHECKLIST:

1. Determine terminals units required (Schedule of provision of terminal units – Future Extensions)
2. Design flow rates and pressure requirements at each terminal unit
3. Using diversity factor equations for piping system sizing
   - Piping design
   - Zone valves
   - Isolation valves
   - Master alarms
   - Area alarms
4. Determine the total flow (Peak load) and pressure required at plant room
5. Plant room design:
   - Select and sizing various equipment
   - Bulk oxygen (O_2)
   - High-pressure cylinder manifolds (O_2-N_2O-N_2)
   - Vacuum pumps (VAC)
   - Medical air compressor (MA)

Table 1 Quality specification for medical air
(for the requirement for dental compressed air refer to the relevant supplement)

Parameter	Specification
Oxygen	20.9 +/–1.0%
Nitrogen	78% by inference
Particulate contamination	Practically free from visible particles in a 75 *l* sample
Water content – see paragraph 2.13	115 vpm (0.095 mg/*l*) (equivalent to dewpoint –40°C at atmospheric pressure)
CO	5 ppm v/v
CO_2	500 ppm v/v
Oil content (droplet or mist)	<0.5 mg/m^3
Odour – see paragraph 2.11	none

Note: Similar values apply to other medical gases; see relevant paragraph(s) in appropriate Ph Eur monograph.

Some abbreviations:

1. MA4 (Medical air)
2. SA7 (Surgical air/Nitrogen)
3. VAC (Vacuum)
4. AGSS (??)

* Health Technical Memorandum 2022

A. Determine terminals units required (Schedule of provision of terminal units – Future Extensions):

Terminal Units عددو مواضع

قسم المستشفى

الغرف والوحدات التي بداخل القسم

Department	O_2	N_2O	N_2O/O_2	MA4	SA7	VAC	AGSS	He/O_2	AVSU	Alarm
Accident and Emergency									1 set (1)	1 set hp/lp (9)
Resuscitation room, per trolley space	2	2	–	2	–	2	2	–	2 sets*	
Note: One set either side of the trolley space, if installed in fixed location, eg trunking; or both sets in an articulated supply pendant that can be positioned either side of the bed space.										
Major treatment/plaster room per trolley space	1	1	1p	1	1p	1	1	–	1 set/8 TUs	
Post-anaesthesia recovery per trolley space	2	–	–	2	–	2	–	–	2 sets*	
Note: One set either side of the trolley space, if installed in fixed location, eg trunking; or both sets in an articulated supply pendant that can be positioned either side of the bed space.										
Treatment room/cubicle	1	–	–	–	–	1	–	–	1 set/8 TUs	
Operating department									1 set (1)	
Anaesthetic rooms (all)	1	1	–	1	–	1	1	–		
Operating room, orthopaedic:										
For anaesthetist	2	1	–	2	–	2	1	–	1 set per suite (2)(3)	1 set per suite hp/lp (10)
For surgeon	–	–	–	–	4	2	–	–	–	–
Note: Orthopaedic surgery is normally performed in operating rooms provided with ultra-clean systems. Such systems are much more effective in terms of airflow when provided with partial walls. These walls may be effectively used to include terminal units that can be supplied by rigid pipework. Such installations do not suffer from excessive pressure loss when surgical air is required at high flows.										
Operating room, neurosurgery										
Anaesthetist	2	1	–	2	–	2	1	–	1 set per suite (2)(3)	1 set per suite hp/lp (10)
Surgeon	–	–	–	–	2	2	–	–		
Note: If multi-purpose pendants are used, there may be some loss of performance of surgical tools because of bore restrictions and convolution of the flexible connecting assemblies at the articulated joints.										

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2- Determine medical gas inlet/outlet terminals required (type, location, style and future expansion)

Table 2-4 Inlet /Outlet Station Data

Room	O_2	VAC	N_2O	Air	N_2	EVAC	Typical Uses
Anesthesia workroom	1	1	[a]	1			Equipment repair testing
Animal oper. (research surgery)	1	1	[a]				Animal anesthesia and surgery
Animal research lab	1	1		1			Routine animal care
Autopsy	1	1					Suction waste materials from body
Bed holding	1	1					Cardiac arrest, O_2 therapy
Biochemistry	[b]	1		1			Standard lab use[a]
Biochem. lab	[b]	1		1			Standard lab use[a]
Biophysics / biochemical	[b]	1		1			Standard lab use[a]
Blood processing		1		1			Standard lab use[a]
Blood receiving (blood donors)	1	1		1			Emergency use
Cardiac catheterization room	1	2					Cardiac arrest and other emergencies
Chem analysis lab (sm. lab in hosp.)		1		1			Standard lab use[a]
Chemical lab		1		1			Standard lab use[a]
Cystoscopy	1	3				1	Emergency use

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Table 2-5 Medical-Air Peak-Demand Chart

Area	Free-Air Design Flow, scfm (L/min) Per Room	Per Bed	Per Outlet	Simultaneous Use Factor (%)
Anesthetizing locations[a]				
Special surgery	0.5 (15)	—	—	100
Major surgery	0.5 (15)	—	—	100
Minor surgery	0.5 (15)	—	—	75
Emergency surgery	0.5 (15)	—	—	50
Radiology	0.5 (15)	—	—	25
Cardiac catheterization	0.5 (15)	—	—	50
Acute-care locations				
Recovery room	—	2 (60)	—	50
ICU/CCU	—	2 (60)	—	50
Emergency room	—	2 (60)	—	50
Neonatal ICU	—	1.5 (40)	—	75
Dialysis unit	—	—	0.5 (15)	10

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Table 2-6 Outlet Rating Chart for Medical-Vacuum Piping Systems

Location of Medical-Surgical Vacuum Outlets	Free-Air Allowance, cfm (L/min) at 1 atmosphere		Zone Allowances—Corridors, Risers, Main Supply Line, Valves	
	Per Room	Per Outlet	Simultaneous Usage Factor (%)	Air to Be Transported, cfm (L/min)[a]
Operating rooms:				
Major "A" (Radical, open heart; organ transplant; radical thoracic)	3.5 (100)	—	100	3.5 (100)
Major "B" (All other major ORs)	2.0 (60)	—	100	2.0 (60)
Minor	1.0 (30)	—	100	1.0 (30)
Delivery rooms	1.0 (30)	—	100	1.0 (30)
Recovery room (post anesthesia) and intensive-care units (a minimum of 2 outlets per bed in each such department):				
1st outlet at each bed	—	3 (85)	50	1.5 (40)
2nd outlet at each bed	—	1.0 (30)	50	0.5 (15)
3rd outlet at each bed	—	1.0 (30)	10	0.1 (3)
All others at each bed	—	1.0 (30)	10	0.1 (3)

* **ASPE code "health care facilities and medical gas and vacuum systems"**

Table 2-7 Medical-Vacuum Peak-Demands Chart (Medical-Surgical Vacuum System)

Area	Free-Air Design Flow, scfm (L/min) Per Room	Per Bed	Per Outlet	Simultaneous Use Factor (%)
Anesthetizing locations:				
Specialized surgeries (open heart, organ transplant, etc.)	4 (115)	—	1.5 (40)	100
Major operating rooms	3.5 (100)	—	—	100
Cystoscopy	2 (60)	—	—	100
Delivery room	1 (30)	—	—	100
Emergency operating room	3 (85)	—	—	100
Other anesthetizing areas (minor O.R., orthopedic O.R., cardiac catheterization, radiology, induction rooms, etc.)	1 (30)	—	—	50
Waste anesthetic gas evacuation	1 (30)	—	—	100
Acute care (non-anesthetizing locations):				
Post-operative recovery room	—	3 (85)	—	50
O.B. recovery room	—	2 (60)	—	50
Intensive care units (except cardiac)	—	2 (60)	—	75
Emergency room	—	1 (30)	—	100
Cardiac intensive care	—	2 (60)	—	50

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Table 4 Gas flow – flows required at terminal units

Service	Location	Nominal pressure kPa [e]	Flows litres/min Design flow	Typical flow required
Oxygen	Theatres All other areas	400 400	100 [a] 10 [c]	20 6
Nitrous oxide	All areas	400	15	6
Nitrous oxide/ oxygen mixture	Delivery rooms All other areas	min 310 [b] 400	275 20	20 15
Medical air 400 kPa	Theatres ITU/neonatal CCU Other	400 400 400 400	40 [c] 80 [c] 80 [c] 20	40 80 80 10 [c]
Surgical air/ nitrogen	Theatres	700	350 [d]	350
Vacuum	Theatres Recovery CCU Ward areas	40 (300 mm Hg) below atmospheric	40 40 40 40	40 40 40 40
Nitric oxide	ITU, neonatal theatres	400	15	6
Oxygen/carbon dioxide mixture	Cardio-thoracic theatres, oncology	400	100	40

a. During oxygen flush in operating and anaesthetic rooms.
b. Minimum pressure at 275 *l*/min.
c. These flows are for certain types of gas-driven ventilators under specific operating conditions, and nebulisers etc.
d. Surgical tools/tourniquets.
e. Pressure required at terminal unit, not in pipeline.

B. Design flow rates and pressure requirements at each terminal unit

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C. Using diversity factor equations for piping system sizing

Table 6 Oxygen diversified flows

Department	Design flow for each terminal unit *l*/min	Diversified flow Q *l*/min
In-patient acute		
Ward units – single and multi-bedrooms	10	$QW = 10 + \frac{(n-1)6}{3}$
Treatment rooms		
Each ward unit		
Departments comprising several ward units	10	$QD = QW \left\{1 + \frac{(w-1)}{2}\right\}$
ITU and CCU	10	$QI = 10 + (nB-1)6$
Adult acute day care		
Major treatment room	100	$QT = 100 + 20(T-1)$
Endoscopy room	10	$QR = 10 + (n-1)6$
Recovery room	10	$QR = 10 + (n-1)6$
Maternity department		
Delivery suite	10	$QM = 10 + \frac{(n-1)6}{2}$
Normal delivery room	100	$QM = 100 + \frac{(n-1)6}{2}$
Abnormal delivery room		
Neonatal unit	10	$QN = 10 + (n-1)6$
Operating department		
Operating room	100	$QT = 100 + 20(T-1)$
Anaesthetic room	10	$QA = 10 + (A-1)6$

Legend for all tables

n	= number of terminal units
nB	= number of bed spaces
W	= number of ward units
T	= number of operating rooms or major treatment rooms
A	= number of anaesthetic rooms
S	= number of operating suites (1 operating room + 1 anaesthetic room)
Q	= diversified flow
QW	= diversified flow to ward units
QD	= diversified flow to a department
QI	= diversified flow to ITU or CCU
QT	= diversified flow to operating room or major treatment room
QA	= diversified flow to anaesthetic rooms
QR	= diversified flow to recovery rooms
QM	= diversified flow to maternity suite
QN	= diversified flow to neonatal unit
QB	= diversified flow to baby bed space
QDent	= diversified flow to dental department
QWS	= diversified flow to equipment workshop
QP	= diversified flow to plaster room

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Nitrous oxide

4.40 Nitrous oxide is provided mainly for anaesthetic purposes and may be provided occasionally for analgesic purposes. In all cases each terminal unit should be capable of passing 15 *l*/min, but in practice the flow is unlikely to exceed 6 *l*/min.

4.41 Therefore, for operating rooms and anaesthetic rooms allow 15 *l*/min for the first room and 6 *l*/min for the remainder.

4.42 It must be assumed that where nitrous oxide terminal units are provided, they may all be in use simultaneously. Design and diversified flows for nitrous oxide are given in Table 7.

Table 7 Nitrous oxide diversified flows

Department	Design flow for each terminal unit *l*/min	Diversified flow Q *l*/min
All departments	15	Q = 15 + (nB–1)6

nB = number of bed spaces or number of rooms as appropriate

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Nitrous oxide/oxygen mixture

4.43 All terminal units should be capable of passing 275 *l*/min for a very short period to supply inhalationary gasps by the patient, and a continuous flow of 20 *l*/min. The actual flow would not normally exceed 20 *l*/min.

4.44 The diversified flow in intensive therapy units and coronary care units is based on 20 *l*/min for the first bed space and 15 *l*/min for each of the remainder, since it is possible that nitrous oxide/oxygen mixtures could be administered at all bed spaces where provided.

4.45 The diversified flow in delivery rooms is based on 275 *l*/min for the first bed space and 20 *l*/min for each of the remainder, of which only 50% will be in use simultaneously.

4.46 Design and diversified flows for nitrous oxide/oxygen mixtures are given in Table 8.

Table 8 Nitrous oxide/oxygen mixtures design and diversified flows

Department	Design flow for each terminal unit *l*/min	Diversified flow Q *l*/min
Delivery rooms	275	$Q_M = 275 + \frac{20(n_B-1)}{2}$
Other areas	20	$Q_I = 20 + 15(n_B-1)$

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Medical air

General

4.47 Medical air is used to provide power for several types of equipment including surgical tools, ventilators and nebulisers. Oxygen should be avoided as a power source because of fire risk and cost, and should not be used where medical air is available, unless specifically recommended by the device manufacturer.

BS 4272:Pt 3:1988 provides for auxiliary outlets on anaesthetic machines for both air and oxygen

4.48 Medical air should be provided at two different pressures:

a. a pressure of 400 kPa is required to drive ventilators and for other respiratory applications;

b. a higher pressure of 700 kPa is required to drive surgical tools. In this document, medical air at 700 kPa is referred to as surgical air to avoid confusion.

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- The supply system for medical air 400 kPa may be a manifold system, a compressor system or a proportioning system (synthetic air) and includes an emergency/reserve manifold. A compressor plant should always be specified where air-powered ventilators are to be used.

- One of the major uses of medical air is for patient ventilators. Patient ventilators fall into two main categories – those used during an aesthesia and those used during intensive therapy. Pneumatically powered ventilators can use up to 80 l/min free air continuously. The exact flow requirements will depend on the design of the ventilator. The flow and pressure requirements for some typical ventilators are given in Table 9.

- 4.53 Current models of an aesthetic ventilators are very similar to intensive therapy models, and may require peak flows of up to 80 l/min and average flows of 20 l/min. Almost all such units are pneumatically driven and electronically controlled.

- Medical air 400 kPa is also used for other equipment such as an aesthetic gas mixers, humidifiers and nebulisers. The flow rates normally required would not exceed 10 l/min, and this flow is always in excess of the actual volume respired.

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- **The minimum pressure required at terminal units for respiratory use is 355 kPa and all terminal units should be tested to ensure that the pressure does not fall below 355 kPa at flows of: 80 l/min in intensive therapy units and coronary care units; 40 l/min in special care bay units and operating suites; 20 l/min in ward areas.**

Table 9 Typical pressure and flow requirements for ventilators and nebulisers

Ventilator type	Pressure kPa	Flow *l*/min free air
Anaesthesia, typically gas driven, electronically controlled	300–700 [1] nominal 400	Pneumatically driven ventilators use up to 80 *l*/min 20 *l*/min continuous
Intensive therapy Electronically controlled Gas powered	300–700 [1] nominal 400	180 peak [2] 80 continuous
Neonatal – electronically controlled Gas driven	300–700 [1] nominal 400	80 peak [2] 40 continuous
Nebulisers	400	10

Notes:

1. It is strongly recommended that ventilators are not connected to the 700 kPa system since the blenders only work satisfactorily with a tolerance of about 10% on the differential pressure for air and oxygen, and incorrect mixtures could be obtained.
2. These flows can be achieved under certain clinical conditions. The peak flows are usually of very short duration.

* **Health Technical Memorandum 2022**

Table 10 Medical air 400 kPa design and diversified flows

Department	Design flow for each terminal unit *l*/min	Diversified flow Q *l*/min
In-patient acute		
Ward units – single and multi-bedrooms Treatment rooms	20	$QW = 20 + \frac{(n-1)10}{3}$
Each ward unit Departments comprising several ward units	20	$QD = QW \left\{1 + \frac{(w-1)}{2}\right\}$
ITU and CCU	80	$QI = nB - 1 * \frac{80}{2}$
Adult acute day care		
Major treatment room Endoscopy room	40	$QT = 40 + (T-1) * \frac{40}{4}$

* **Health Technical Memorandum 2022**

Table 11 Typical pressure and flow requirements for surgical tools

Type of tool	Pressure kPa	Flow *l*/min
Small air drill	600–700	200
Medullary reaming machine	600–700	350
Oscillating bone saw	600–700	300
Universal drill	600–700	300
Craniotome	620–750	300

Table 12 Surgical air 700 kPa design and diversified flows

Department	Design flow for each terminal unit *l*/min	Diversified flow Q *l*/min
Operating room	350	$QT = 350 + \frac{(T-1)350}{4}$
SDU, ODA workshop etc	350	QWS = 350

* **Health Technical Memorandum 2022**

Table 13 Vacuum design and diversified flow

Department	Design flow for each terminal unit *l*/min	Diversified flow Q *l*/min
In-patient acute		
Ward units – single and multi-bedrooms	40	QW = 40
Treatment rooms	40	$OT = 40 + (nB-1)*\frac{40}{4}$
Departments – ward areas	40	$QD = 80 + (nB-1)*1$
Operating department		
Operating room	40	QT = 80
Anaesthetic room	40	QA = 40
Operating suite 1 operating room	40	$QS = (120*2) + \frac{(S-2)*120}{2}$
Recovery room	40	$QR = 40 + (nB-1)*\frac{40}{4}$
ITU and CCU	40	$QI = 40 + (nB-1)*\frac{40}{4}$

* Health Technical Memorandum 2022

جدول رقم (٤-٥)

الحد الادنى لكمية الهواء طبقا لعدد المخارج ومعامل الاستخدام النسبى

عدد المخارج	معامل الإستخدام النسبى	أدنى حد لكمية الهواء قدم مكعب / الدقيقة
١-٢	١٠٠	١
٣-١٢	٨٠	٣
١٣-٣٨	٦٠	١٠
٣٩-١١٥	٤٠	٢٥
١١٦-٣١٦	٣٠	٥٠
٣١٧-٧٠٠	٢٠	٩٥
٧٠١-١٨٨٠	١٥	١٤٥
١٨٨١-٤٤٠٠	١٠	٢٨٥
٤٤٠١-١٦٠٠٠	٥	٤٤٥

التصرفات المطلوبة لأماكن إمداد مخارج أكسيد النتروز

الموقع	التصرف (الحجم) Volume, Lpm لتر / دقيقة
غرفة العمليات الأولى (أبعد ماسورة من غرف العمليات)	٣٠ لكل غرفة عمليات
غرفة العمليات الثانية (فى قطاع الماسورة)	٢٠ لكل غرفة عمليات
لكل غرفة عمليات إضافية (فى قطاع بالماسورة)	١٥ لكل غرفة
غرف الولادة	٢٠ لكل غرفة
غرف الطوارئ	٢٠ لكل غرفة
غرف التجبيس (الكسر)	١٥ لكل غرفة
غرف الأسنان	١٥ لكل غرفة

المواقع المختلفة المطلوب إمداد الإكسجين لها

ومعامل الإستخدام وحجم الهواء

الموقع	معامل الإستخدام Simultaneous	معدل امداد الهواء L / min
غرفة عمليات أولى (الأبعد من المواسير)	١٠٠	٥٠ للغرفة
غرفة عمليات ثانية (فى مسار المواسير)	١٠٠	(عدد ٢ مخرج لكل غرفة عمليات)
كل غرفة عمليات إضافية (فى مسار المواسير)	١٠٠	٣٠ للغرفة
غرف الطوارى - غرف الولادة -	١٠٠	(عدد ٢ مخرج لكل غرفة عمليات)
غرف الإنعاش (مخرج واحد لكل سرير) Recover rooms		٢٠ للغرفة
من ١ - ٨ مخارج	١٠٠	(عدد ٢ مخرج لكل غرفة عمليات)
+ ٩ - ١٢ مخرج	٦٠	مماثلة لغرف العمليات
+ ١٣ - ١٦ مخرج	٥٠	٢٠ لكل مخرج
+ مخارج إضافية	٤٥	
غرفة العناية المركزه CCV & ICV (مخرجين لكل سرير)	١٠٠	
أماكن أخرى مثل :		٢٠ لكل مخرج
غرف المرضى جراحه ، باطنه		
(أحياناً مخرج لكل سرير وأحياناً مخرج لكل سريرين)		
الحضانات		
الكشف والعلاج		على الأقل ٤٥
غرف تحضير للعمليات		على الأقل ١١٥
غرف التبرع بالدم		على الأقل ١٢٥
غرف التجبيس		على الأقل ١٥٥
غرف الأسنان		
غرف القسطره للقلب والصدر		
غرف الأشعه - غرف رسم القلب		
المخارج من ١ - ٣	١٠٠	
من ٤ - ١٢	٧٥	
من ١٣ - ٢٠	٥٠	
من ٢١ - ٤٠	٣٣	
من ٤١ فأكثر	٢٥	

جدول رقم (٤-٦)

الموقع	معدل الهواء قدم مكعب / دقيقة	معامل الإستخدام
غرفة عمليات كبرى (مخرجين للحجرة)	٢	١٠٠
غرفة عمليات صغرى	٢	١٠٠
غرفة طوارئ	[illegible]	١٠٠
غرفة تجبيس	١	٥٠
غرفة إنعاش (مخرج لكل سرير)	٢	٥٠
عناية مركزه CCV - ICV	٢	٥٠
غرفة مرضى	١	١٠
حضانات (عدد ١ مخرج لكل ٤ حضانات)	١	٢٠

١/٢/٨/٤ نظم الهواء الطبى للمستشفيات

جدول رقم (٤-٧)

نظم الشفط

Vacuum air Systems

الموقـــــــــع	التصرف لكل مدخل بالقدم مكعب / دقيقة cpm perinlet at 15 - in Hg	معامل الإستخدام simultaneous use factor
غرفة عمليات للقلب المفتوح (عدد ٢ لكل غرفة)	٣,٥	١٠٠
غرفة عمليات كبرى (عدد ٢ لكل غرفة)	٢	١٠٠
غرفة عمليات صغرى (عدد ٢ لكل غرفة)	٢	١٠٠
غرفة طوارئ (عدد ٢ لكل غرفة)	٢	١٠٠
غرفة تجبيس	١	١٠٠
غرفة الولادة (عدد ٢ لكل غرفة)	٢	١٠٠
غرفة الإنعاش المدخل الأول للسرير	٣	٥٠
غرفة الانعاش المدخل الثانى للسرير	١	٥٠
غرفة الانعاش مداخل إضافية للسرير	١	١٠
غرفة العناية المركزة Icu & ccu المدخل الأول للسرير	٣	٥٠
غرفة العناية المركزة Icu & ccu المدخل الثانى للسرير	١	٥٠
غرفة العناية المركزة Icu & ccu مداخل إضافية للسرير	١	١٠
غرف المرضى (جراحة)		
فى بعض الأحيان مدخل واحد للسرير	١	١٠
فى بعض الأحيان مدخل واحد للسريرين	١	١٠
غرف المرضى (باطنه)		
فى بعض الأحيان مدخل واحد للسرير	١	١٠
فى بعض الأحيان مدخل واحد للسريرين	١	١٠
حضانات الأطفال (مدخل واحد لكل ٤ حضانات)	١	١٠
غرف تحضير العمليات – غرف الكشف – غرف التبرع بالدم –	١	١٠
غرف القسطرة – EEG - ECG - EMG غرف الاشعه السينيه		
الصيدلية	١	٤٠

١٢٨

جدول رقم (٤-٨)

عدد المداخل No of inlets	معامل الإستخدام Use factor	أقل تصرف قدم مكعب / دقيقة Minimum cfm
١ إلى ٤	١٠٠	
٦ إلى ١٢	[illegible]	٥
١٣ إلى ٣٣	٦٠	١٠
٣٤ إلى ٨٠	٥٠	٢١
٨١ إلى ١٥٠	٤٠	٤٠
١٥١ إلى ٣١٥	٣٥	٦١
٣١٦ إلى ٥٦٥	٣٠	١١١
٥٦٦ إلى ١٠٠٠	٢٥	١٧١
١٠٠١ إلى ٢١٧٥	٢٠	٢٥١
٢١٧٦ إلى ٤٦٧٠	١٥	٤٣٦
٤٦٧١ إلى	١٠	٧٠١

Table 2-22 Data for Sizing Oxygen and Nitrous Oxide Supply Piping

O_2 and N_2O, cfm (L/min)	Nominal Pipe Size, in. (mm)								
	½ (12.7)	¾ (19.1)	1 (25.4)	1¼ (31.8)	1½ (38.1)	2 (50.8)	2½ (63.5)	3 (76.2)	4 (101.6)
	Pressure Drop per 100 Ft (30.48 m) of Pipe, psi (kPa)								
1.76 (50)	0.04 (0.28)								
3.53 (100)	0.16 (1.1)								
4.41 (125)	0.25 (1.72)								
5.3 (150)	0.33 (2.27)	0.04 (0.28)							
6.18 (175)	0.48 (3.31)	0.06 (0.41)							
7.06 (200)	0.63 (4.34)	0.07 (0.48)							
8.83 (250)	0.99 (6.83)	0.11 (0.76)							
10.89 (300)	1.41 (9.72)	0.16 (1.1)	0.04 (0.28)						
14.12 (400)	2.51 (17.31)	0.29 (2.0)	0.07 (0.48)						
17.66 (500)	3.92 (27.03)	0.45 (3.1)	0.11 (0.76)						
26.48 (750)		1.02 (7.03)	0.24 (1.65)						

Table 2-23 Data for Sizing Nitrogen Supply Piping

cfm	(L/min)	½ (12.7)	¾ (19.1)	1 (25.4)	1¼ (31.8)	1½ (38.1)	2 (50.8)
		Pressure Loss, psi per 100 ft (kPa per 3.48 m) of 160 psi (1103.2 kPa) Piping					
5	(145)	0.11 (0.76)	0.01 (0.07)				
10	(284)	0.43 (2.96)	0.07 (0.48)	0.02 (0.14)	0.01 (0.07)		
15	(425)	0.96 (6.62)	0.12 (0.83)	0.04 (0.28)	0.01 (0.07)		
20	(567)	1.70 (11.72)	0.26 (1.79)	0.07 (0.48)	0.02 (0.14)	0.01 (0.07)	
25	(708)	2.66 (18.34)	0.42 (2.90)	0.11 (0.76)	0.03 (0.21)	0.01 (0.07)	
30	(850)		0.59 (4.07)	0.17 (1.17)	0.04 (0.28)	0.02 (0.14)	
35	(992)		0.81 (5.58)	0.22 (1.52)	0.05 (0.34)	0.02 (0.14)	
40	(1133)		1.06 (7.31)	0.29 (2.00)	0.07 (0.48)	0.03 (0.21)	
45	(1275)		1.34 (9.24)	0.37 (2.55)	0.09 (0.62)	0.04 (0.28)	0.01 (0.07)
50	(1416)		1.65 (11.38)	0.46 (3.17)	0.11 (0.76)	0.05 (0.34)	0.01 (0.07)
60	(1700)		2.37 (16.34)	0.66 (4.55)	0.15 (1.03)	0.07 (0.48)	0.02 (0.14)
70	(1984)			0.90 (6.21)	0.21 (1.45)	0.09 (0.62)	0.02 (0.14)

Column group heading: Nominal Pipe Size, in. (mm)

Table 2-24 Pressure Loss, psi per 100 ft (kPa per 30.48 m) in 50 psi (344.74 kPa) Compressed-Air Piping

		Nominal Pipe Size, in. (mm)								
cfm	(L/s)	½ (12.7)	¾ (19.1)	1 (25.4)	1¼ (31.8)	1½ (38.1)	2 (50.8)	2½ (63.5)	3 (76.2)	4 (101.6)
5	(2.36)	0.30 (2.07)	0.03 (0.21)	0.01 (0.07)						
10	(4.72)	1.15 (7.93)	0.18 (1.24)	0.05 (0.34)	0.01 (0.07)					
15	(7.08)		0.40 (2.76)	0.11 (0.76)	0.03 (0.21)					
20	(9.44)		0.69 (4.76)	0.20 (1.38)	0.05 (0.34)	0.02 (0.14)				
25	(11.80)		1.14 (7.86)	0.31 (2.14)	0.07 (0.48)	0.03 (0.21)				
30	(14.16)			0.44 (3.03	0.10 (0.69)	0.05 (0.34)				
35	(16.52)			0.61 (4.21)	0.14 (0.97)	0.06 (0.41)				
40	(18.88)			0.80 (5.52)	0.18 (1.24)	0.08 (0.55)				
45	(21.24)			1.00 (6.89)	0.23 (1.59)	0.10 (0.69)	0.03 (0.21)			
50	(23.60)				0.29 (2.00)	0.13 (0.90)	0.04 (0.28)			
60	(28.32)				0.42 (2.90)	0.18 (1.24)	0.05 (0.34)			
70	(33.04)				0.56 (3.86)	0.25 (1.72)	0.07 (0.48)	0.03 (0.21)		
80	(37.76)				0.74 (5.10)	0.33 (2.28)	0.09 (0.62)	0.03 (0.21)		
90	(42.48)				0.93 (6.41)	0.41 (2.83)	0.11 (0.76)	0.04 (0.28)		
100	(47.20)				1.15 (7.93)	0.51 (3.52)	0.14 (0.97)	0.05 (0.34)		
110	(51.92)					0.62 (4.27)	0.17 (1.17)	0.06 (0.41)		

Table 2-25 Data for Sizing Vacuum Piping Systems

Air Flow, cfm (L/s)	Nominal Pipe Size, inches (mm)							
	¾ (19.1)	1 (25.4)	1¼ (31.8)	1½ (38.1)	2 (50.8)	2½ (63.5)	3 (76.2)	4 (101.6)
	Pressure Drop per 100 Ft (30.48 m) of Pipe, in. Hg (kPa)							
1 (0.5)	0.15 (0.51)							
2 (0.9)	0.39 (1.32)	0.10 (0.34)						
3 (1.4)	0.77 (2.60)	0.19 (0.64)						
4 (1.9)	1.24 (4.19)	0.31 (1.05)	0.10 (0.34)					
5 (2.4)	1.78 (6.01)	0.44 (1.49)	0.14 (0.47)					
6 (2.8)	2.40 (8.10)	0.60 (2.03)	0.19 (0.64)					
7 (3.3)		0.77 (2.60)	0.24 (0.81)	0.12 (0.41)				

Minimum recommended pipe sizes, in. (mm)

Service	O_2	N_2O	N_2	MA	MV
Minimum system pipe/tube size	½ (12.5)	½ (12.7)	½ (12.7)	½ (12.7)	¾ (19.1)
Minimum riser size	¾ (19.1)	¾ (19.1)	1 (25.4)	¾ (19.1)	1 (25.4)
Minimum branch size	½ (12.7)	½ (12.7)	½ (12.7)	½ (12.7)	¾ (19.1)
Minimum single outlet supply size	⅜ (9.5)	⅜ (9.5)	⅜ (9.5)	⅜ (9.5)	⅜ (9.5)

جدول رقم (٤-١٠)

القطر الأدنى لماسورة طلمبة الشفط الى السطح

القطر بالبوصة	التصرف قدم مكعب / دقيقة No of inlets
١ ١/٤	١٢
١ ١/٢	٢٣
٢	٤٠
٢ ١/٢	٧٢
٣	١٣٠
٤	١٦٠
٤	١٩٠
٥	٣٥٠
٥	٥٢٥

٢/٦/٢ – تحديد أقطار المواسير :

- تحدد أقطار المواسير طبقاً للتصرفات والاحمال المبينة فى الجدول السابق مع أخذ معامل تكرار أو استخدام ١٠٠ ٪
- يحدد قطر الماسورة فى كل حالة طبقاً للرقم الأعلى فى الآتى :

أ – أقصى فاقد إحتكاك بواقع ١ بوصة / رطل مربع لكل ١٠٠ قدم

ب – الحد الأقصى لفاقد الإحتكاك لأبعد مخرج ٥ رطل / بوصة مربعة

- الحد الأدنى لأقطار للأعمدة تكون ٣/٤ بوصه

الحد الأدنى لأقطار للفرعيات تكون ١/٢ بوصه

- الضغط عند المخرج يجب ألا يقل عن ٥٠ رطل / بوصة مربعة .

٤/٢/٤ يراعى الا يقل عدد الأعمدة المغذية للغازات الطبيه عن عامودين بكل جناح على ألا تخدم الفرعة أكثر من ١٢ مخرج .

٥/٢/٤ يراعى إمداد غرف العمليات الكبرى بعامودين بدلاً من عامود غاز واحد .

حـ – يتم وضع أعمدة التغذية بالهواء ، بحيث يتم تقسيم المخارج اللازمة للمرضى فى أى دور أو أى جناح على الأقل على عامودين .

٣/٤ – المواسير :

١/٣/٤ تستخدم مواسير النحاس السيملس والقطع من النحاس المصبوب وفى حالة تركيب المواسير خارج الحائط أو مخترقة الحوائط تكون المواسير من النوع

٢/٣/٤ القطع الخاصة بتوصيل المواسير من النحاس المطاوع أو البرونز تكون قابلة للحام وتنظف المواسير والقطع الخاصة والمحابس لإستعمال الغازات الطبية ويجب حمايتها من التلوث بعد ذلك .

٣/٣/٤ يجب حماية المواسير المدفونه من التآكل والصدأ وتركب داخل جراب أو ترنش خرسانى ويمكن أن يشترك مع باقى مواسير الخدمات من وقود - بخار أو خلافه فى ترنش موحد .

يجب عدم تركيب مواسير الأكسجين المكشوفة فى أماكن تخزين المواد الملتهبة أو المطابخ أو المغاسل وفى حالة تعذر عدم تركيبها فى هذه الأماكن يراعى تركيب مواسير الأكسجين داخل اجربه لحماية المواسير من حدوث تسريب للغاز منها فى هذه الأماكن .

وتستعمل المواسير النحاس النظيفة والتى غالباً ما يتم توريدها وهى مطببه من النهايتين ومشحونة بغاز النتروجين وهذه العملية تمثل أقصى حماية للماسورة النحاس ضد الأكسدة الضارة أثناء نقلها من المصنع حتى الموقع التى تحدث أثناء عمليات اللحام .

والمواسير النحاس تنتج بأقطار من ٣/٨ بوصة حتى ٣ ١/٨ بوصة

أما الأقطار من ٣ ٥/٨ بوصة حتى ٦ ١/٨ بوصة فيتم توريدها نظيفة ومطبه النهايات .

وتصنع المواسير طبقاً للمواصفات الأمريكية ASTM B88 , Typel وتكون نظيفة طبقاً للمواصفات ASTM B 280 بأطوال حتى ٢٠ قدم مبين عليها اللون الكودى . أو أى مواصفات عالمية بديلة .

وللتخلص من الحوادث المميته التى قد تحدث من التبديل من غاز إلى آخر يراعى نظم الأمان التالية :

- راكور الأمان **Pin - Index - Safety - System**

حيث أن لكل نوع من الغازات السابقة يوجد له راكور امان واحد فقط لا يمكن التوصيل إلا بواسطته .

- دليل قطر القلاوظ لنظام الآمان **Diameter Index Safety system**

نظام دليل القطر الآمن تم استحداثه من جمعية الغازات Compressed Gas Association والذى يعمل نظام لعدم خلط قلاوظ الغاز الواحد بغاز آخر وذلك عند تركيب المنظمات على الإسطوانات أو الوصيلات للتخدير أو الأفاقة .

* NFPA-99 "Health Care Facilities Code"

Table 5.1.10.11.4.5 Maximum Pipe Support Spacing

Pipe Size	Hanger Spacing mm	Hanger Spacing ft
DN8 (NPS ¼) (⅜ in. O.D.)	1520	5
DN10 (NPS ⅜) (½ in. O.D.)	1830	6
DN15 (NPS ½) (⅝ in. O.D.)	1830	6
DN20 (NPS ¾) (⅞ in. O.D.)	2130	7
DN25 (NPS 1) (1⅛ in. O.D.)	2440	8
DN32 (NPS 1¼) (1⅜ in. O.D.)	2740	9
DN40 (NPS 1½) (1⅝ in. O.D.) and larger	3050	10
Vertical risers, all sizes, every floor, but not to exceed	4570	15

Table 5.3.10.1.3 Maximum Copper Tube Support Spacing

Pipe Size	Hanger Spacing mm	Hanger Spacing ft
DN8 (NPS ¼) (⅜ in. O.D.)	1520	5
DN10 (NPS ⅜) (½ in. O.D.)	1830	6
DN15 (NPS ½) (⅝ in. O.D.)	1830	6
DN20 (NPS ¾) (⅞ in. O.D.)	2130	7
DN25 (NPS 1) (1⅛ in. O.D.)	2440	8
DN32 (NPS 1¼) (1⅜ in. O.D.)	2740	9
DN40 (NPS 1½) (1⅝ in. O.D.) and larger	3050	10
Vertical risers, all sizes, every floor, but not to exceed	4570	15

5.3.10.1.4 Plastic Pipe Support. The maximum support spacing for plastic pipe shall be in accordance with Table 5.3.10.1.4.

Table 5.3.10.1.4 Maximum Plastic Pipe Support Spacing

Pipe Size	Hanger Spacing mm	Hanger Spacing ft
DN15 (NPS ½) (⅝ in. O.D.)	1220	4.00
DN20 (NPS ¾) (⅞ in. O.D.)	1220	4.00
DN25 (NPS 1) (1⅛ in. O.D.)	1320	4.33
DN32 (NPS 1¼) (1⅜ in. O.D.)	1320	4.33
DN40 (NPS 1½) (1⅝ in. O.D.)	1420	4.66
DN50 (NPS 2) (2⅜ in. O.D.)	1420	4.66
DN65 (NPS 2½) (2⅞ in. O.D.) and larger	1520	5.00
Vertical risers, all sizes, every floor, but not to exceed	3040	10.00

Table 21 Intervals between copper pipe supports

Outside dia mm	Maximum interval for vertical runs m	Maximum interval for horizontal runs m
12	1.2	1.0
15	1.8	1.2
22	2.4	1.8
28	2.4	1.8
35	3.0	2.4
42	3.0	2.4
54	3.0	2.7
76	3.6	3.0

* **Health Technical Memorandum 2022**

Notes:

1. Base colours as follows:

A = yellow ochre 08C35
B = light blue 20E51

2. All colours in this diagram should be taken to be representative rather than exactly accurate.

3. Reference numbers in colour codes conform to BS 4800:1972

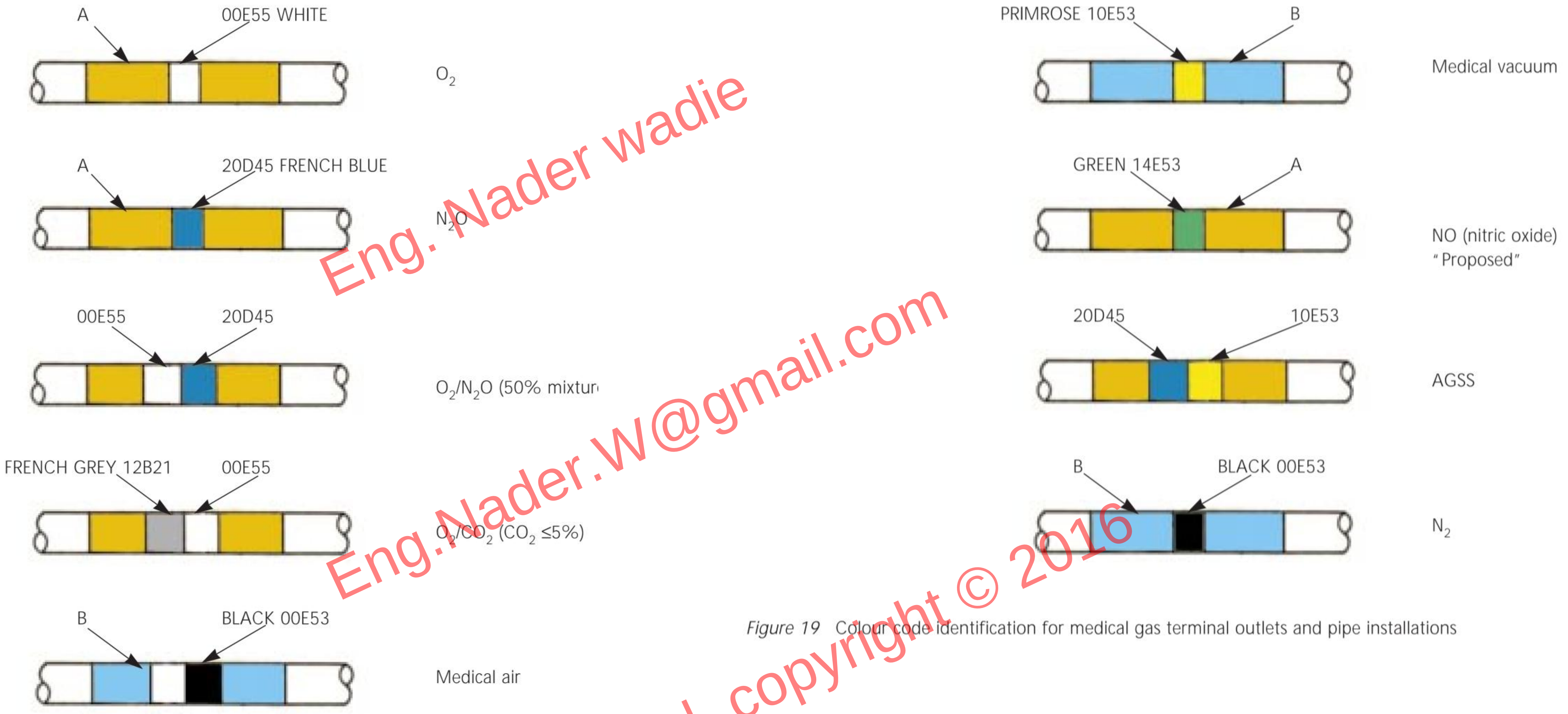


Figure 19 Colour code identification for medical gas terminal outlets and pipe installations

* Health Technical Memorandum 2022

Table 2-8 Color Coding for Piped Medical Gases

Gas Intended for Medical Use	United States Color	Canada Color
Oxygen	Green	Green on white[a]
Carbon dioxide	Gray	Black on gray
Nitrous oxide	Blue	Silver on blue
Cyclopropane	Orange	Silver on orange
Helium	Brown	Silver on brown
Nitrogen	Black	Silver on black
Air	Yellow*	White and black on black and white
Vacuum	White	Silver on yellow[a]
Gas mixtures (other than mixtures of oxygen and nitrogen)	Color marking of mixtures shall be a combination of colors corresponding to each component gas.	
Gas mixtures of oxygen and nitrogen		
19.5 to 23.5% oxygen	Yellow[a]	Black and white
All other oxygen concentrations	Black and green	Pink

Source: Compressed Gas Association, Inc.

[a] Historically, white has been used in the United States and yellow has been used in Canada to identify vacuum systems. Therefore, it is recommended that white *not* be used in the United States and yellow *not* be used in Canada as a marking to identify containers for use with any medical gas. Other countries may have differing specific requirements.

وعند التعامل مع الغازات السابقة سواء فى شبكات مواسير أو اسطوانات فمن المهم الإلتزام بكود الألوان المميز لكل غاز والمبين فيما بعد الكود الأمريكي للألوان :

أكسجين	أخضر
أكسجين طبي	أخضر والجزء العلوى من الإسطوانه فضي
ثانى أكسيد الكربون	رمادي
أكسيد النتروز	أزرق فاتح
إيثلين	أحمر

والكود الإنجليزى للألوان

أكسجين	O_2	أبيض	White
هواء	Air	أسود	Black
شفط	Vacuum	أصفر	Yellow
غاز النتروز	N_2O	أزرق	Blue

*** ASPE code "health care facilities and medical gas and vacuum systems"**

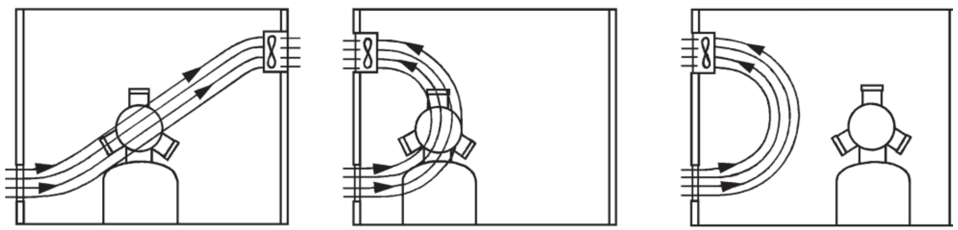
Table 5.1.11 Standard Designation Colors and Operating Pressures for Gas and Vacuum Systems

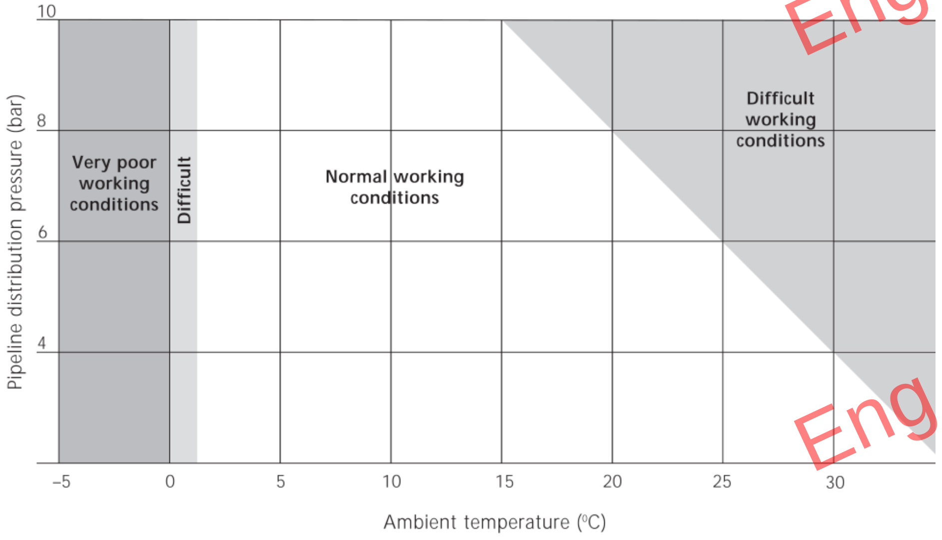
Gas Service	Abbreviated Name	Colors (Background/ Text)	Standard Gauge Pressure kPa	Standard Gauge Pressure psi
Medical air	Med air	Yellow/black	345–380	50–55
Carbon dioxide	CO_2	Gray/black or gray/white	345–380	50–55
Helium	He	Brown/white	345–380	50–55
Nitrogen	N_2	Black/white	1100–1275	160–185
Nitrous oxide	N_2O	Blue/white	345–380	50–55
Oxygen	O_2	Green/white or white/green	345–380	50–55
Oxygen/carbon dioxide mixtures	$O_2/CO_2 n\%$ (n = % of CO_2)	Green/white	345–380	50–55
Medical–surgical vacuum	Med vac	White/black	380 mm to 760 mm (15 in. to 30 in.) HgV	
Waste anesthetic gas disposal	WAGD	Violet/white	Varies with system type	
Other mixtures	Gas A%/Gas B%	Colors as above Major gas for background/minor gas for text	None	
Nonmedical air (Category 3 gas-powered device)		Yellow and white diagonal stripe/black	None	
Nonmedical and Category 3 vacuum		White and black diagonal stripe/black boxed	None	
Laboratory air		Yellow and white checkerboard/black	None	
Laboratory vacuum		White and black checkerboard/black boxed	None	
Instrument air		Red/white	1100–1275	160–185

Table 5.1.12.3.3.2(B) Alternate Test Pressures

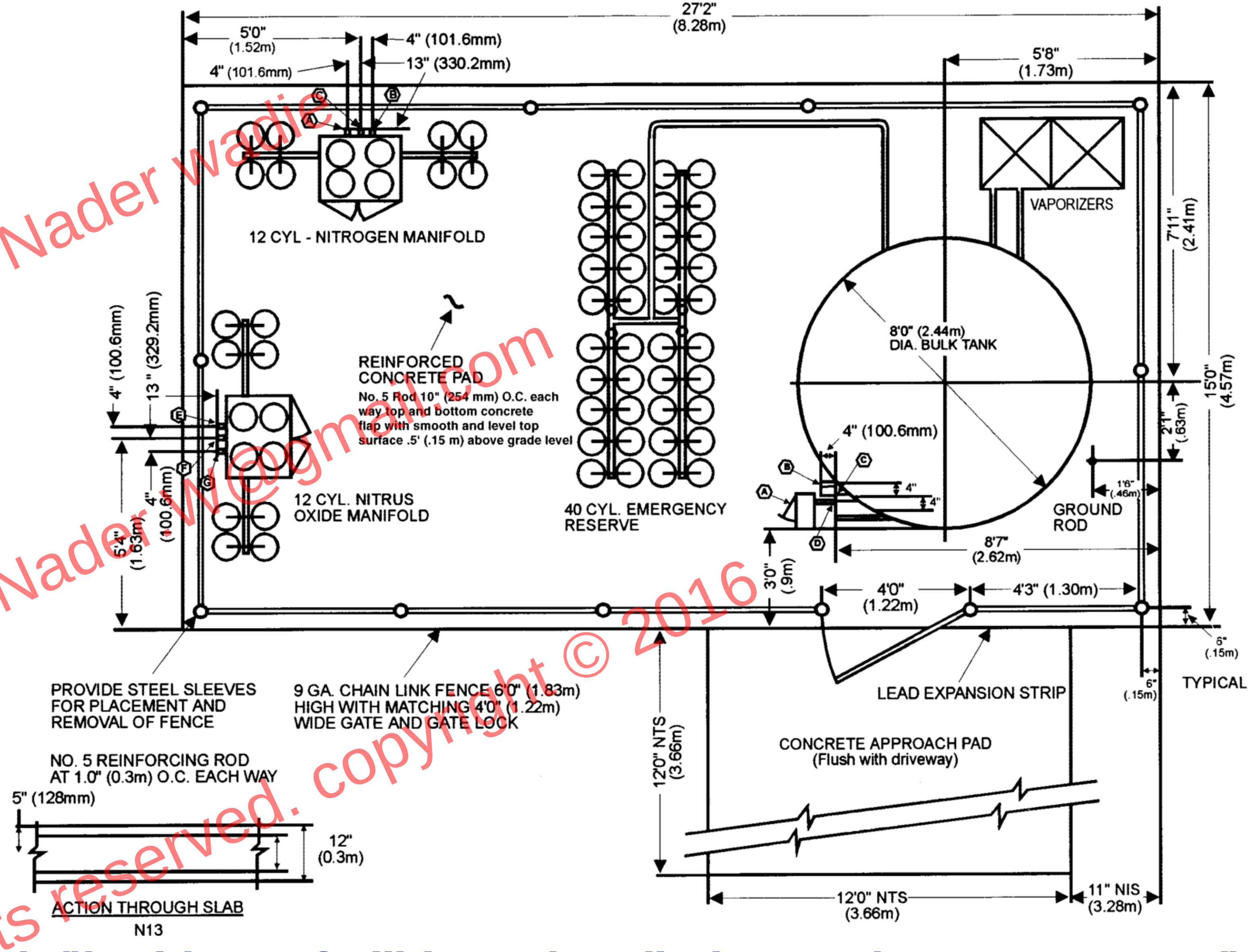
Medical Gas	Pressure (Gauge)
Gas mixtures	140 kPa (20 psi)
Nitrogen/instrument air	210 kPa (30 psi)
Nitrous oxide	275 kPa (40 psi)
Oxygen	345 kPa (50 psi)
Medical air	415 kPa (60 psi)
Systems at nonstandard pressures	70 kPa (10 psi) greater or less than any other system
	HgV vacuum
Vacuum	510 mm (20 in.) HgV
WAGD	380 mm (15 in.) HgV (if so designed)

D. Plant room design





* Health Technical Memorandum 2022



* ASPE code "health care facilities and medical gas and vacuum systems"

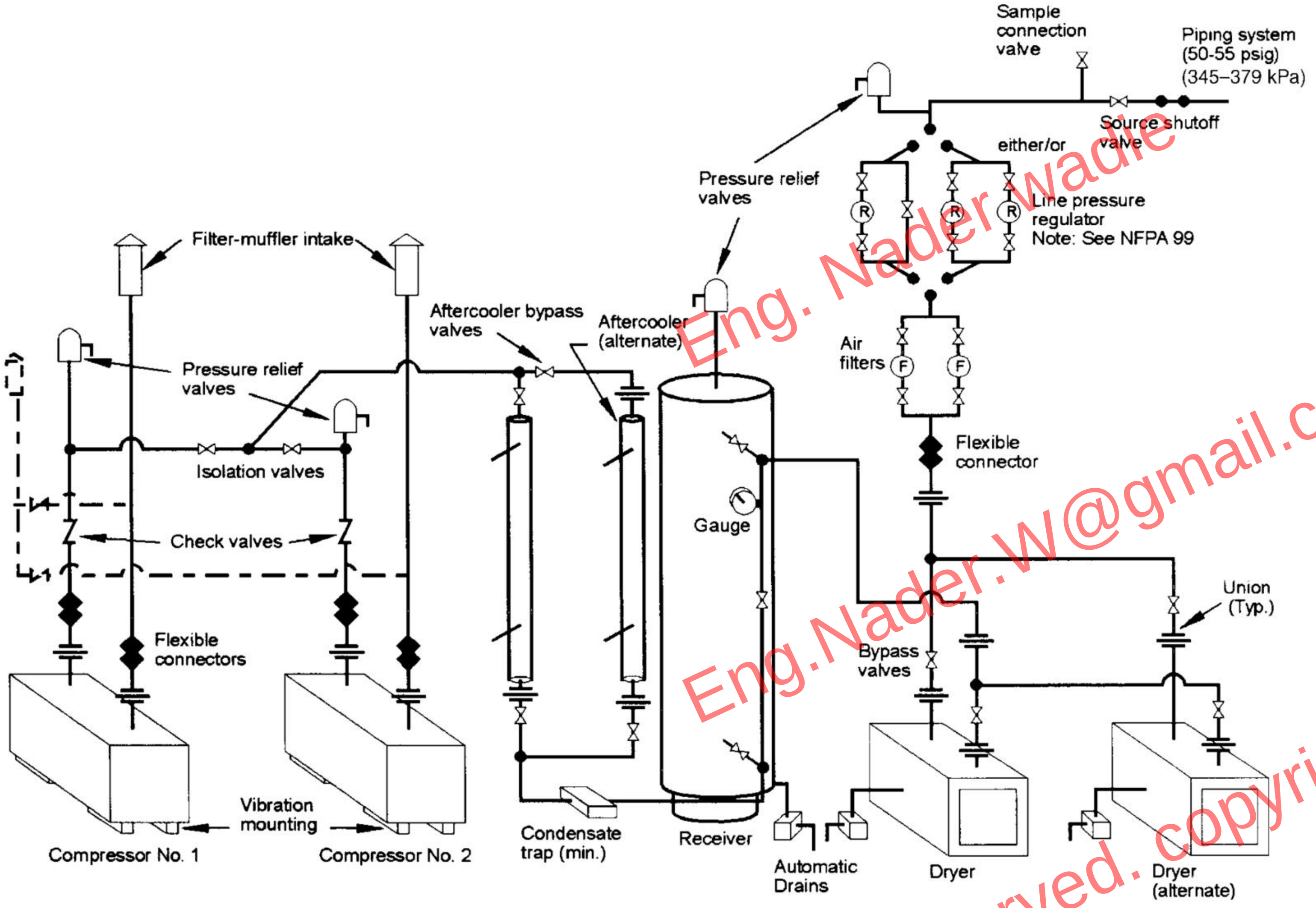


Figure 2-7 Typical Duplex Medical Air-Compressor System (Type 1 Gas System)

Medical-air compressors must draw outside air from above the roof level, remote from any doors, windows, and exhaust or vent openings. Where the outside atmospheric air is polluted, special filters can be attached to the compressor's intake to remove carbon monoxide and other contaminants. Refer to NFPA 99

Where more than two units are provided for the facility, any two units must be capable of supplying the peak calculated demands (see Table 2-5). Provide automatic alternators (duty-cycling controls) to ensure even wear in normal usage. Alternator controls incorporate a positive means of automatically activating the additional unit (or units) should the in-service pump fail to maintain the minimum required pressure.

Table 2-15 Minimum Pipe Sizes for Medical Air-Compressor Intake Risers

Pipe size, in. (mm)		Flow rate, cfm (L/min)	
2.5	(63.5)	50	(1416)
3	(76.2)	70	(1985)
4	(101.6)	210	(5950)
5	(127.0)	400	(11 330)

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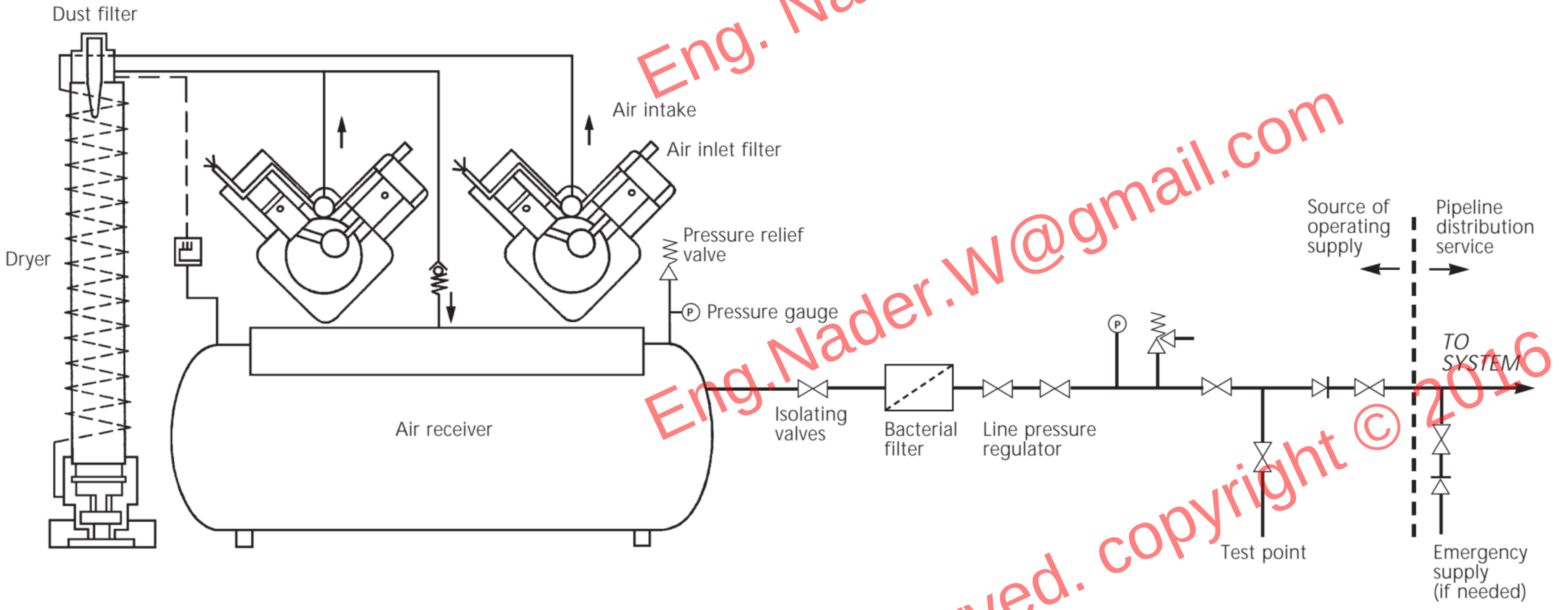
Figure 2 Dental air system



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Each vacuum pump of a duplex system must be sized for 100% of the estimated peak demand. When a triplex or quadruplex system is specified, each pump shall be sized so that in the event of one pump failing, the remaining pumps are capable of maintaining the required vacuum at 100% of the peak calculated demand. Provide automatic alternators (duty-cycling controls) to ensure even wear in normal usage. Alternator controls incorporate a positive means of automatically activating the additional unit (or units) should the in-service pump fail to maintain the minimum required vacuum.

Individual exhaust stacks should be straight and as short as possible. The collection of the duplex stacks to a single stack is permissible if it is assured that back pressure will not be a potential problem for the system in the future. The exhaust system should be piped to the outside environment, have a gooseneck termination, and be properly screened to prevent insects, leaves, and debris from entering. The exhaust vents should be a minimum distance of 25 ft (7.6 m) from any door, window, outside air intakes, or other opening and a minimum distance of 20 ft (6.1 m) above the ground. The prevailing wind currents and the proximity of the power vents and intake louvers are very important factors to be considered when locating the outdoor vacuum-pump exhaust.

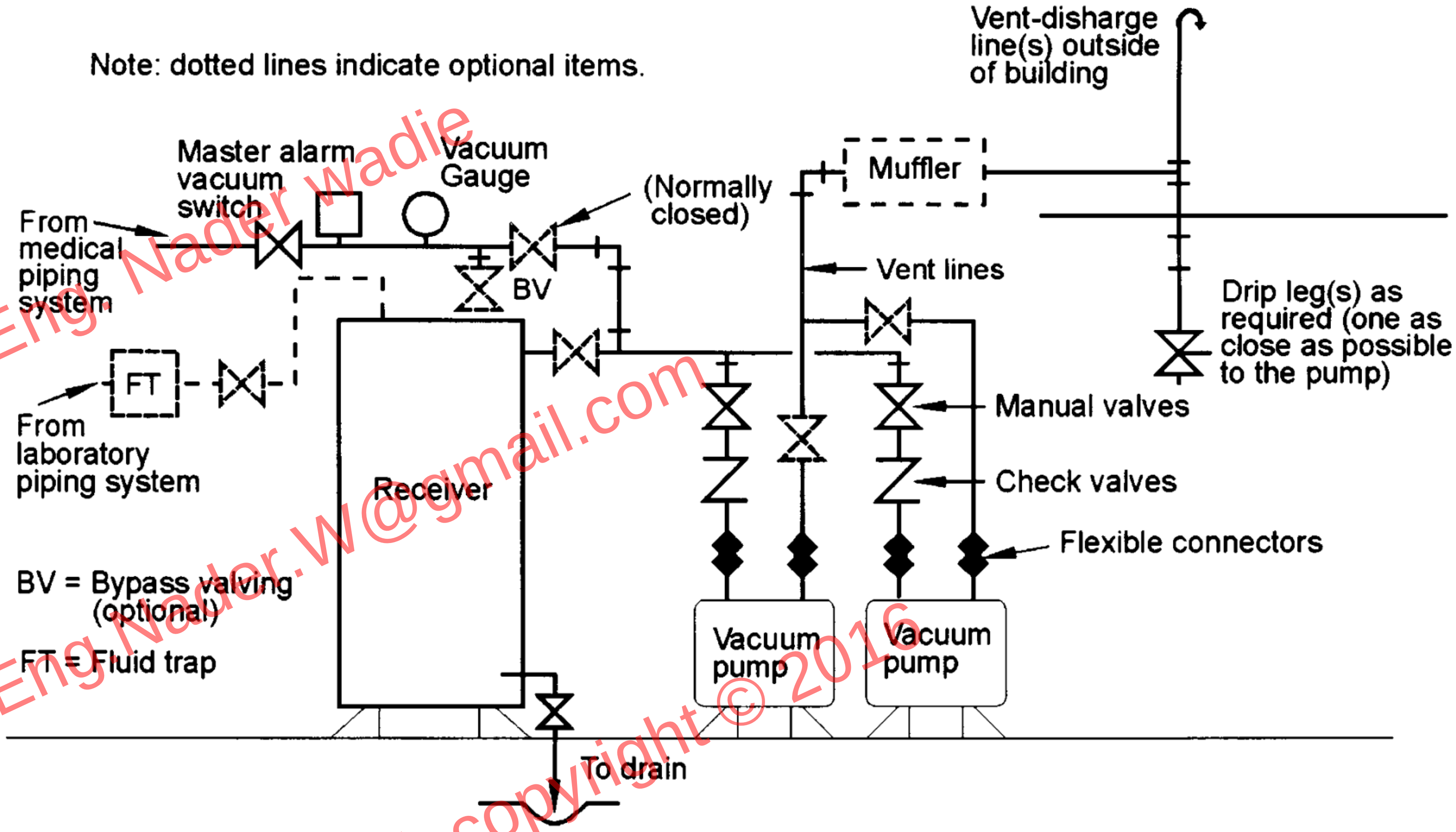


Figure 2-8 Schematic of a Typical, Duplex, Medical-Surgical, Vacuum-Pump System

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Laboratories should be served by a dedicated vacuum line that is separate from the medical vacuum system; be equipped with drainable fluid traps; and be connected by separate laterals, risers, and mains to the receiver.

Table 2-19 Minimum Pipe Sizes for Vacuum Exhaust Risers

Pipe Size, in. (mm)		Flow Rate, cfm (L/min)	
1¼	(31.75)	12	(340)
1½	(38.1)	23	(655)
2	(50.8)	40	(1 140)
2½	(63.5)	70	(1 990)
3	(76.2)	130	(3 685)
4	(101.6)	160	(4 535)
5	(127.0)	350	(9 915)
6	(152.4)	525	(14 875)

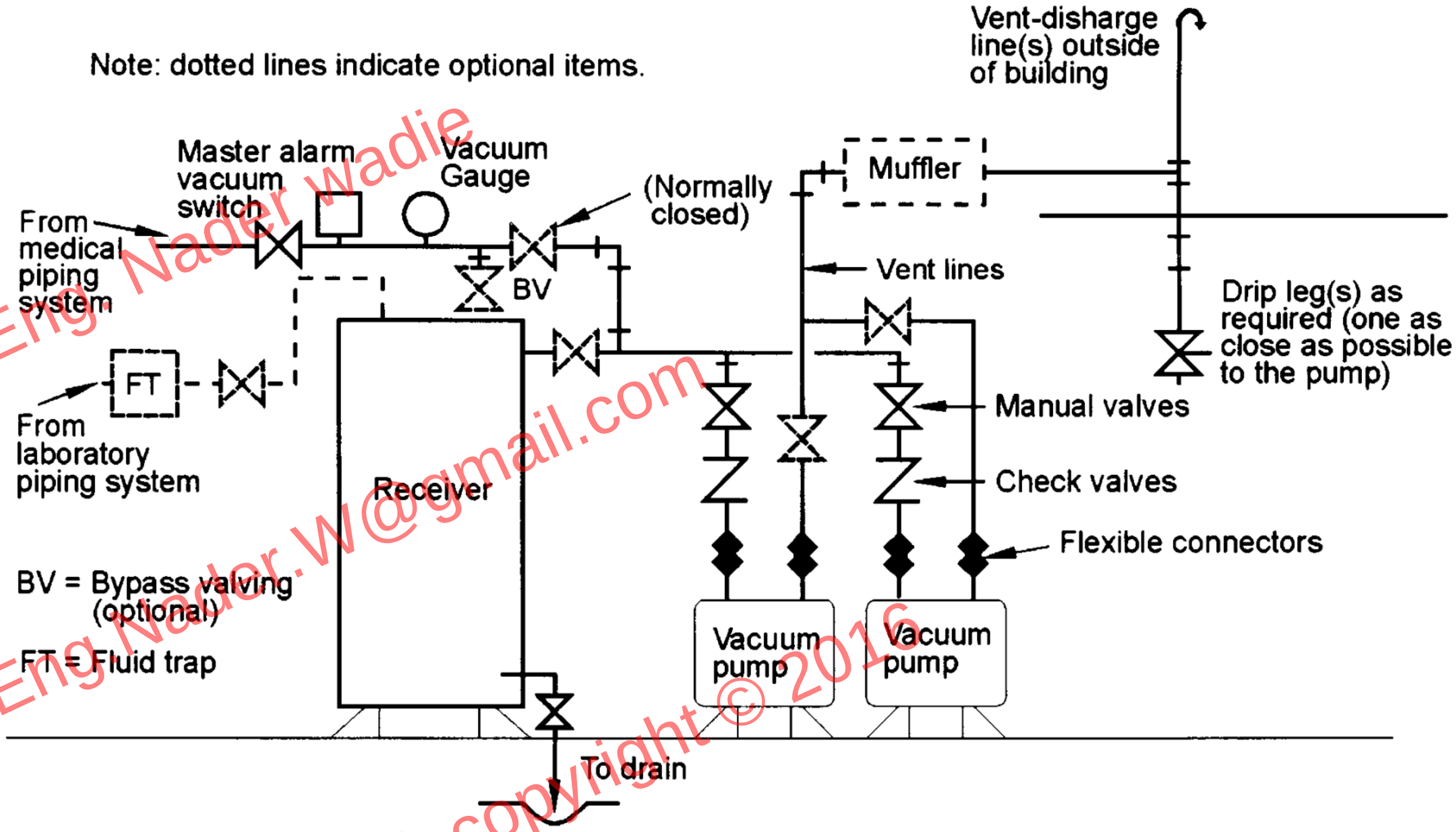


Figure 2-8 Schematic of a Typical, Duplex, Medical-Surgical, Vacuum-Pump System

*** ASPE code "health care facilities and medical gas and vacuum systems"**

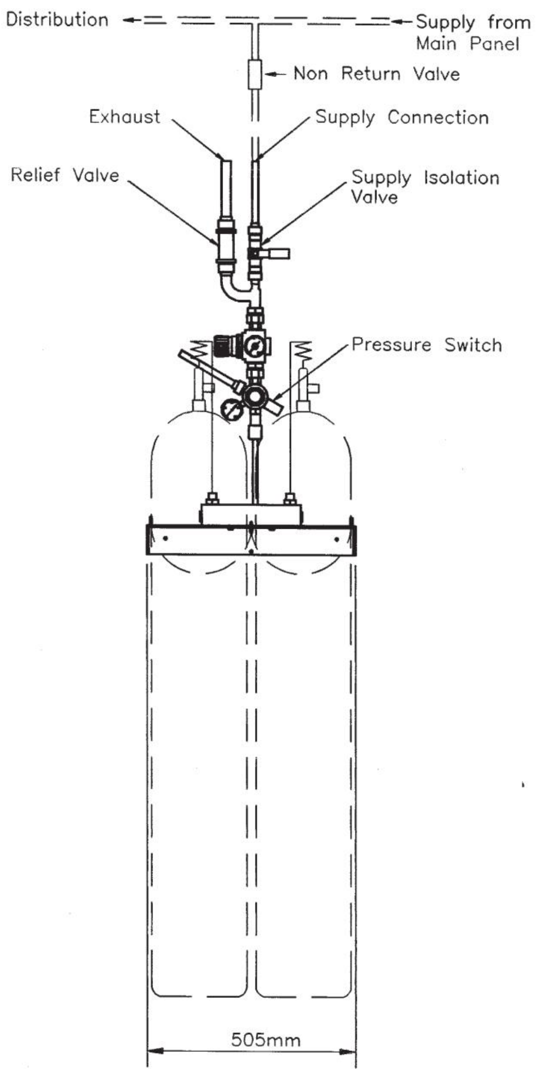
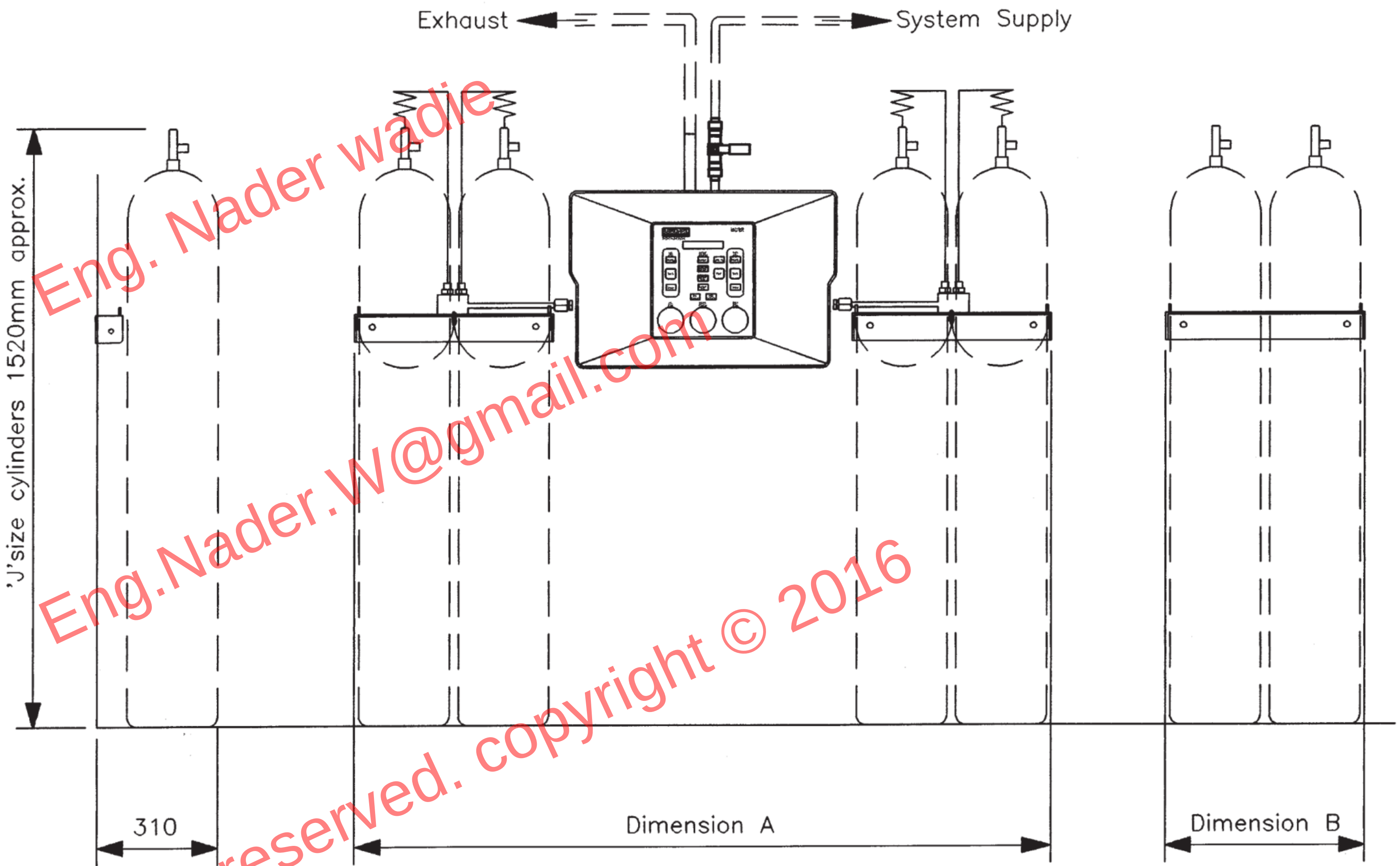


Figure 2 Emergency supply manifiold (reproduced by kind permission of MEDÆS)



* **Health Technical Memorandum 2022**

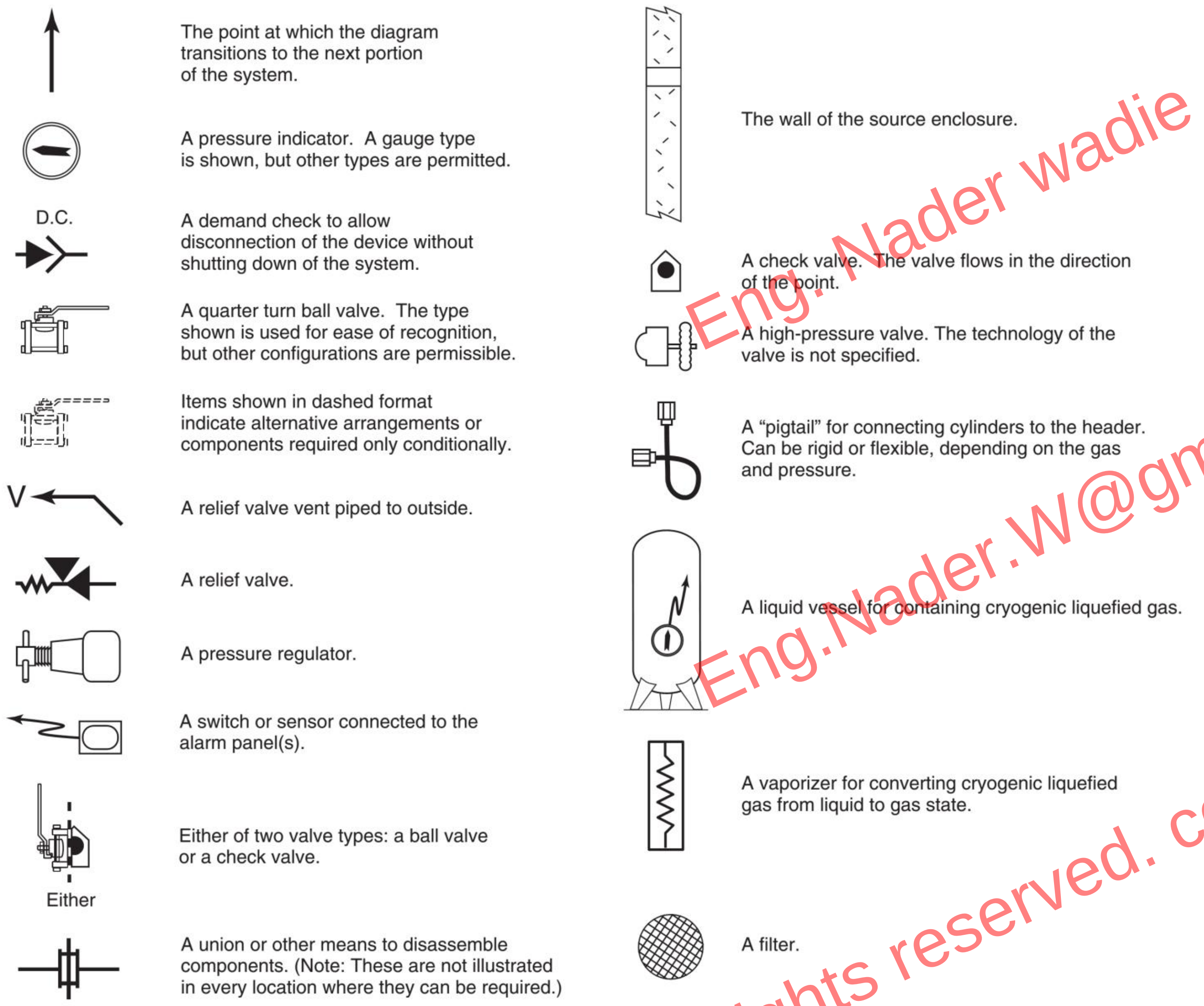


FIGURE A.5.1.3 Legend for Typical Category 1 Source Drawings.

* NFPA–99 "Health Care Facilities Code"

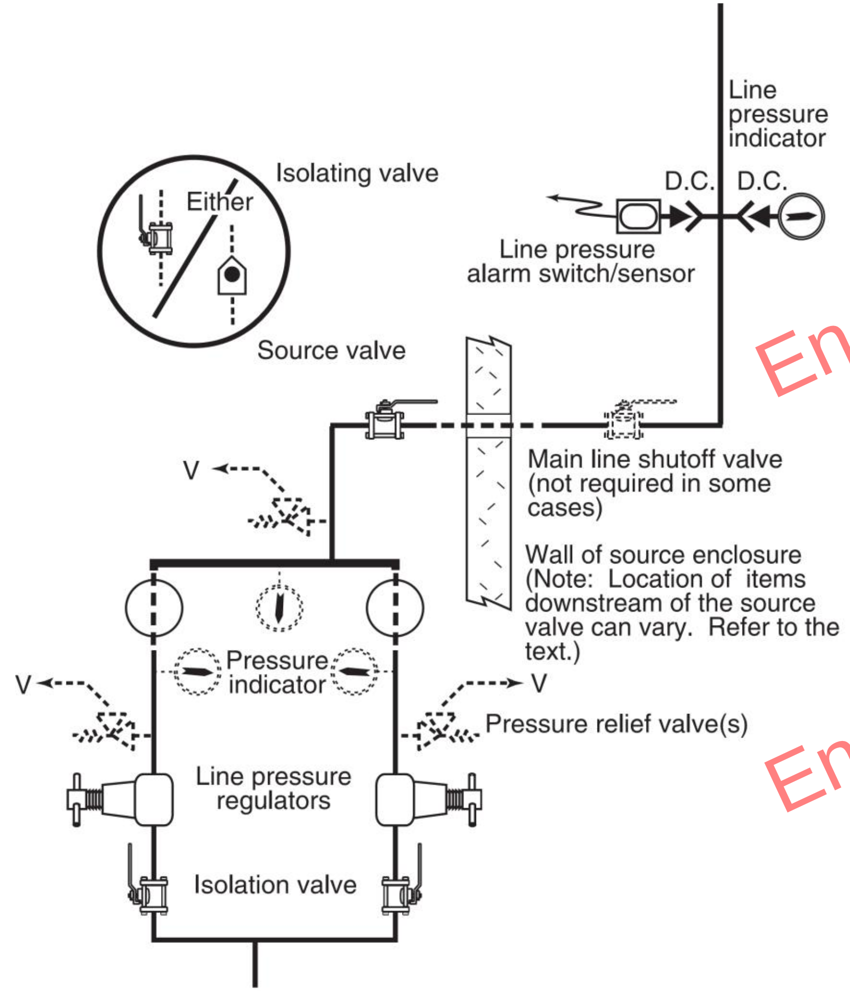


FIGURE A.5.1.3.5 Typical Arrangement for Line Controls at Pressure Sources.

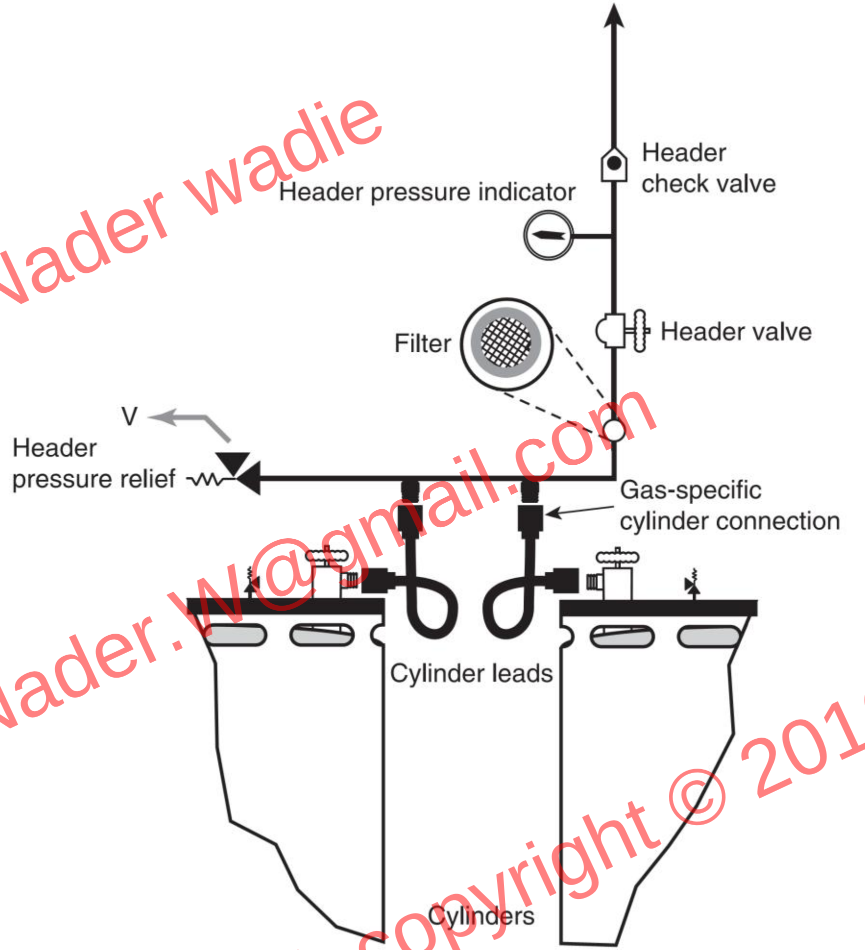


FIGURE A.5.1.3.5.10(b) Header for Cryogenic Gas in Containers.

* NFPA–99 "Health Care Facilities Code"

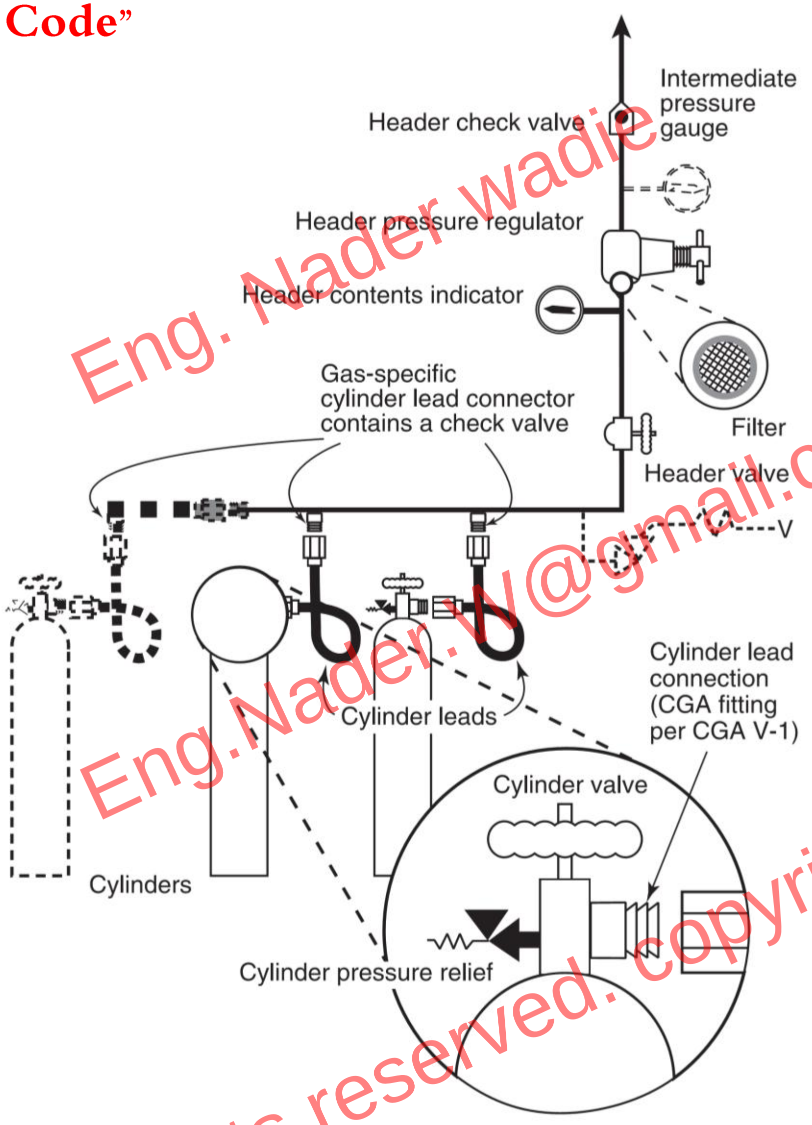


FIGURE A.5.1.3.5.10(a) Header for Gas in Cylinders.

A.5.1.3.5.14 For bulk oxygen systems, see NFPA 55, *Compressed Gases and Cryogenic Fluids Code*. See Figure A.5.1.3.5.14(a) and Figure A.5.1.3.5.14(b). Two possible choices of reserves are illustrated. Both are not required.

A.5.1.3.5.14.4 The local signal arose from the simple need of a maintenance person to know what is going on with any given piece of source equipment. Note that it is not an alarm in the sense of a local or master alarm. It is simply an indicator, which might be a gauge, a flag, a light, or some other possible manifestation that allows a maintenance person to stand at the equipment and know what conditions are present (e.g., which header of cylinders is in service). The elements to be displayed are typically those that will also be monitored at the master alarm, but the local signal is visible at the equipment rather than remotely.

A.5.1.3.5.15 See Figure A.5.1.3.5.15.

If the relief valve on the emergency oxygen supply connection is moved downstream from the check valve in the emergency oxygen line, it should be connected to the system with a demand check fitting.

The emergency oxygen supply connection (EOSC) can be used as a part of the emergency operation plan (EOP) for an unplanned loss of oxygen supply. However, a risk assessment should be conducted by the facility to determine the contingency plan for vital life support and critical care areas. There might need to be interim measures for dealing with the loss of oxygen (e.g., high-pressure oxygen cylinders available for back feeding critical care areas).

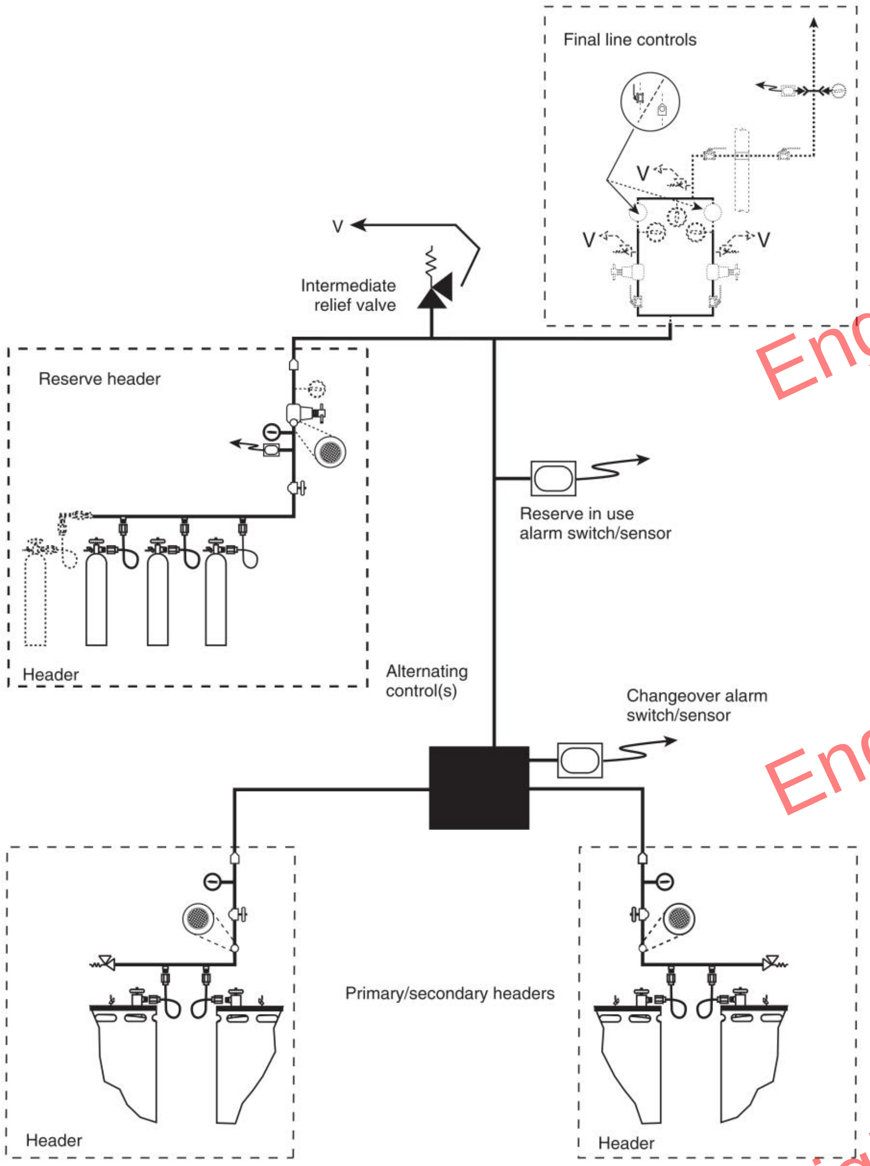


FIGURE A.5.1.3.5.12 Typical Source of Supply for Cryogenic Gas in Containers.

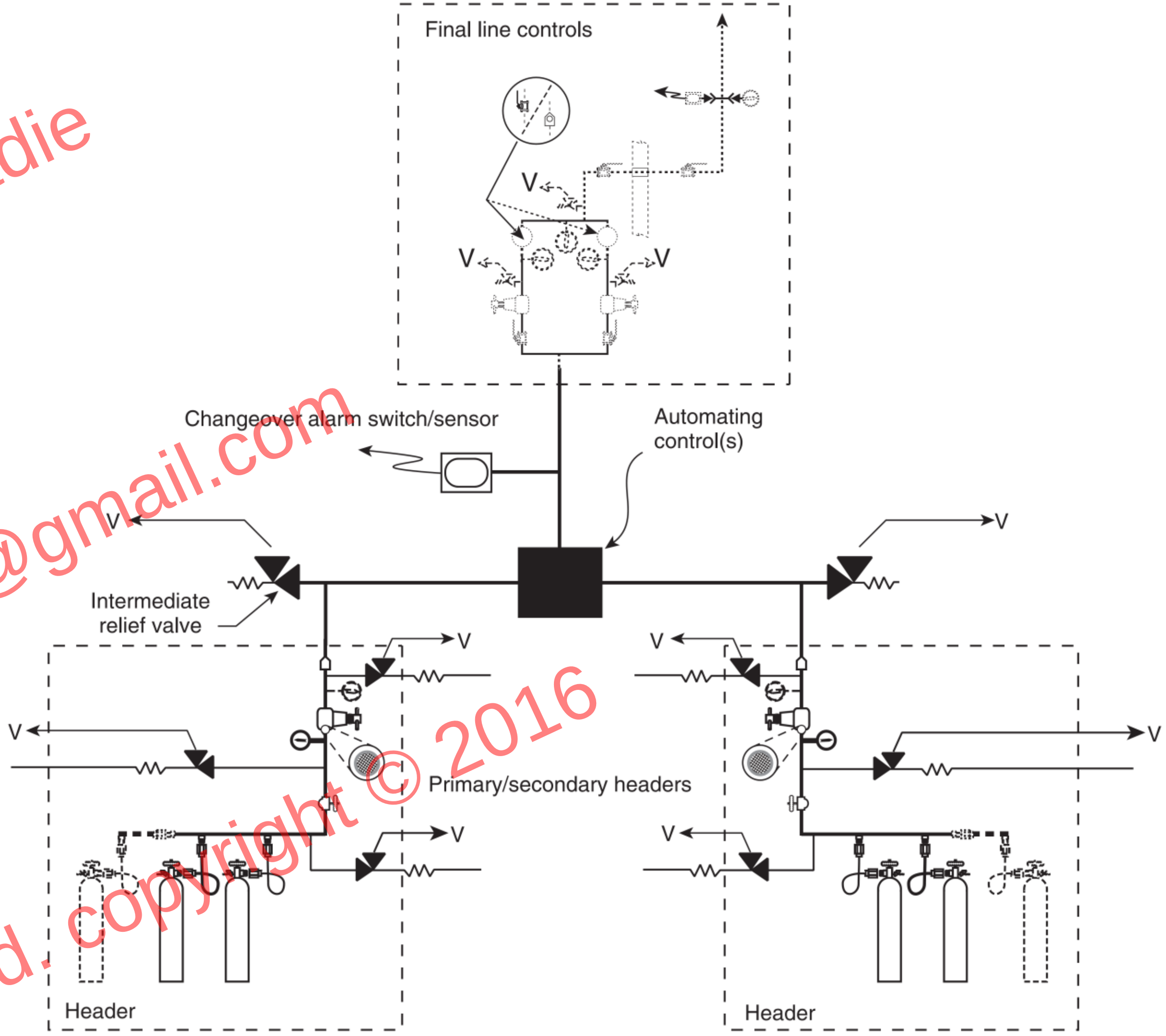


FIGURE A.5.1.3.5.11 Manifold for Gas Cylinders.

* NFPA–99 "Health Care Facilities Code"

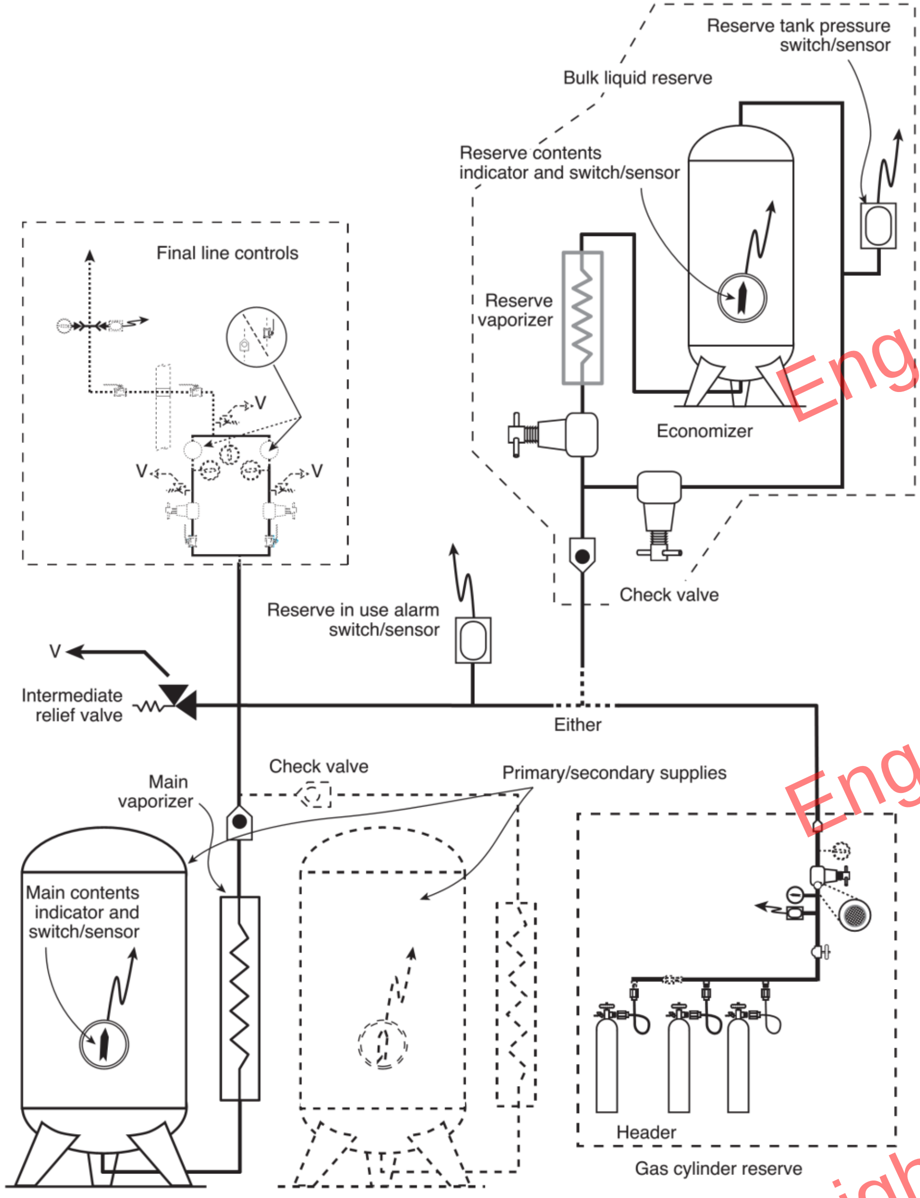


FIGURE A.5.1.3.5.14(b) Typical Source of Supply for Cryogenic Gas in Bulk.

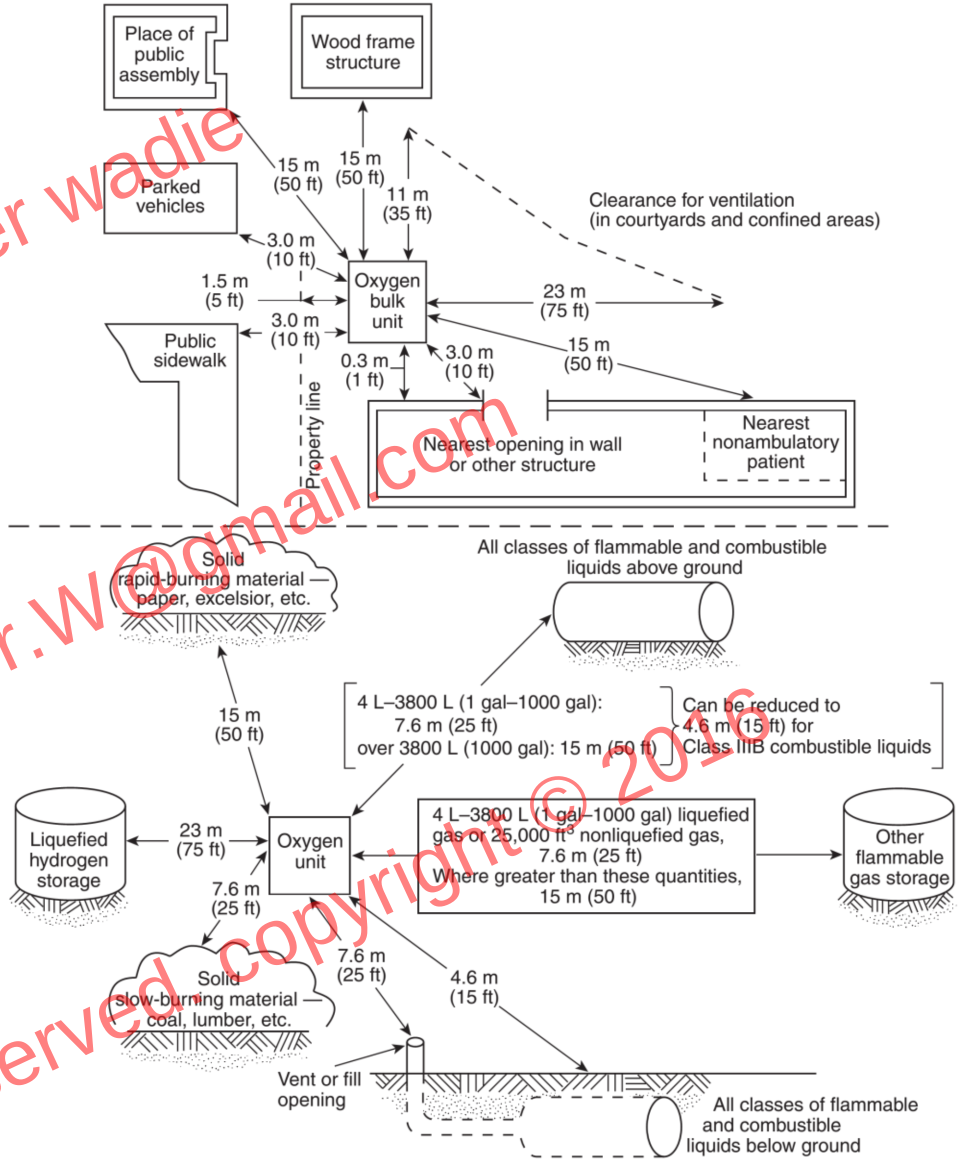


FIGURE A.5.1.3.5.14(a) Distance Between Bulk Oxygen Systems and Exposures.

*NFPA–99 "Health Care Facilities Code"

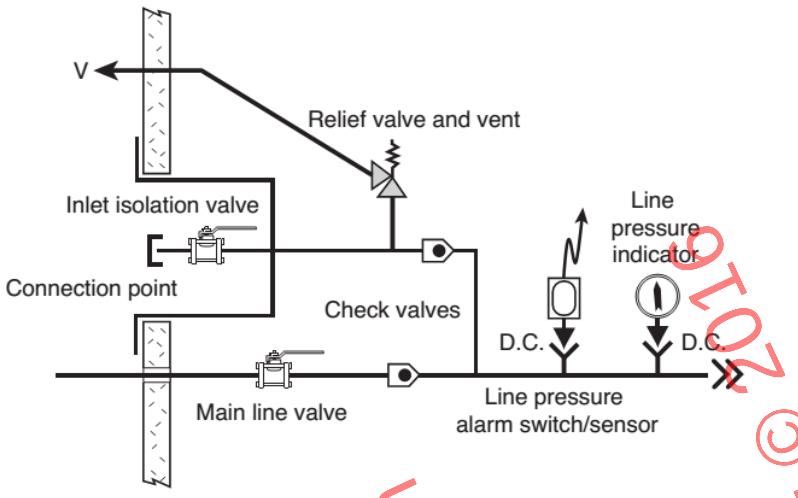
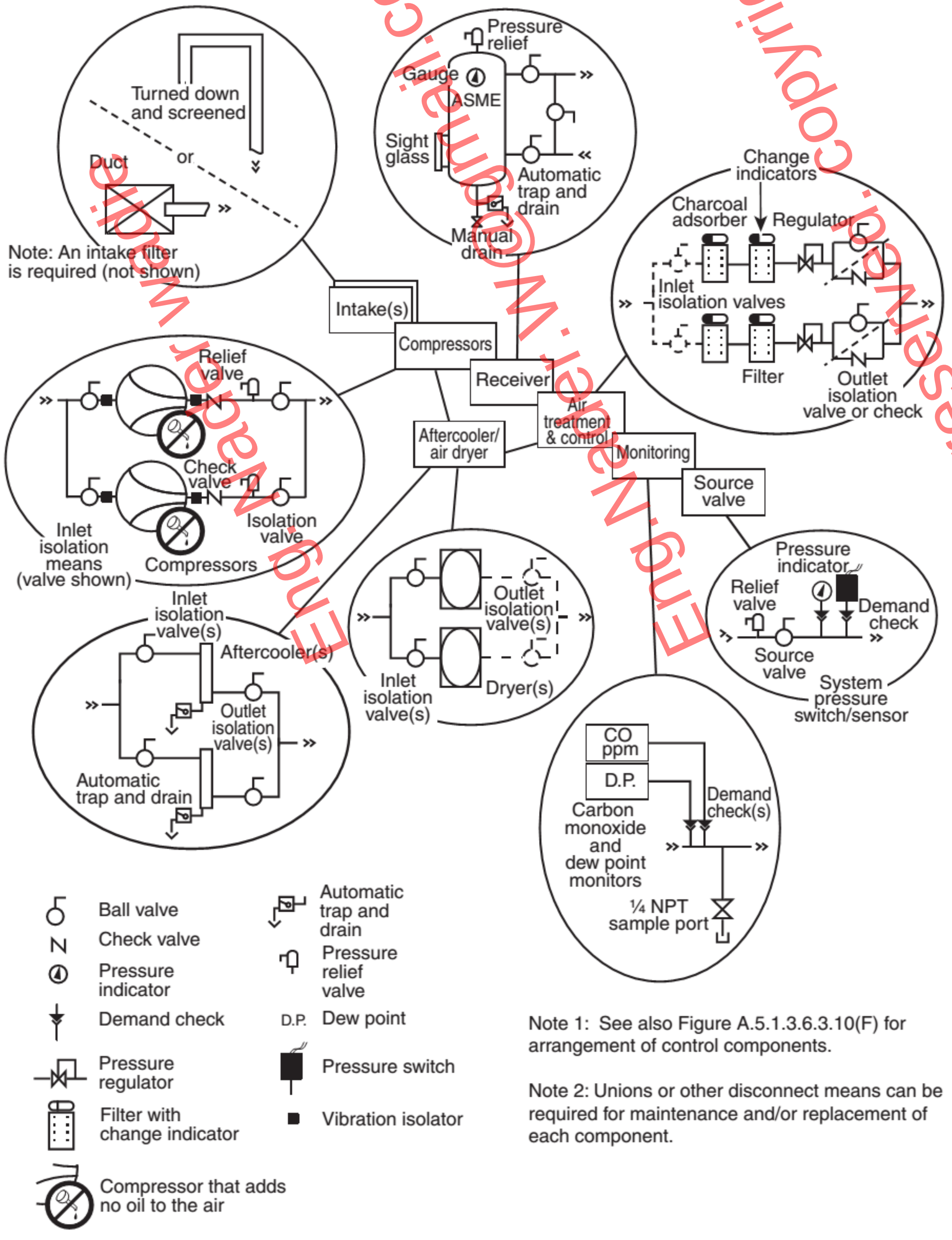


FIGURE A.5.1.3.5.15 Emergency Oxygen Supply Connection.



Note 1: See also Figure A.5.1.3.6.3.10(F) for arrangement of control components.

Note 2: Unions or other disconnect means can be required for maintenance and/or replacement of each component.

FIGURE A.5.1.3.6 Elements of a Typical Duplex Medical Air Compressor Source System (Category 1 Gas Systems).

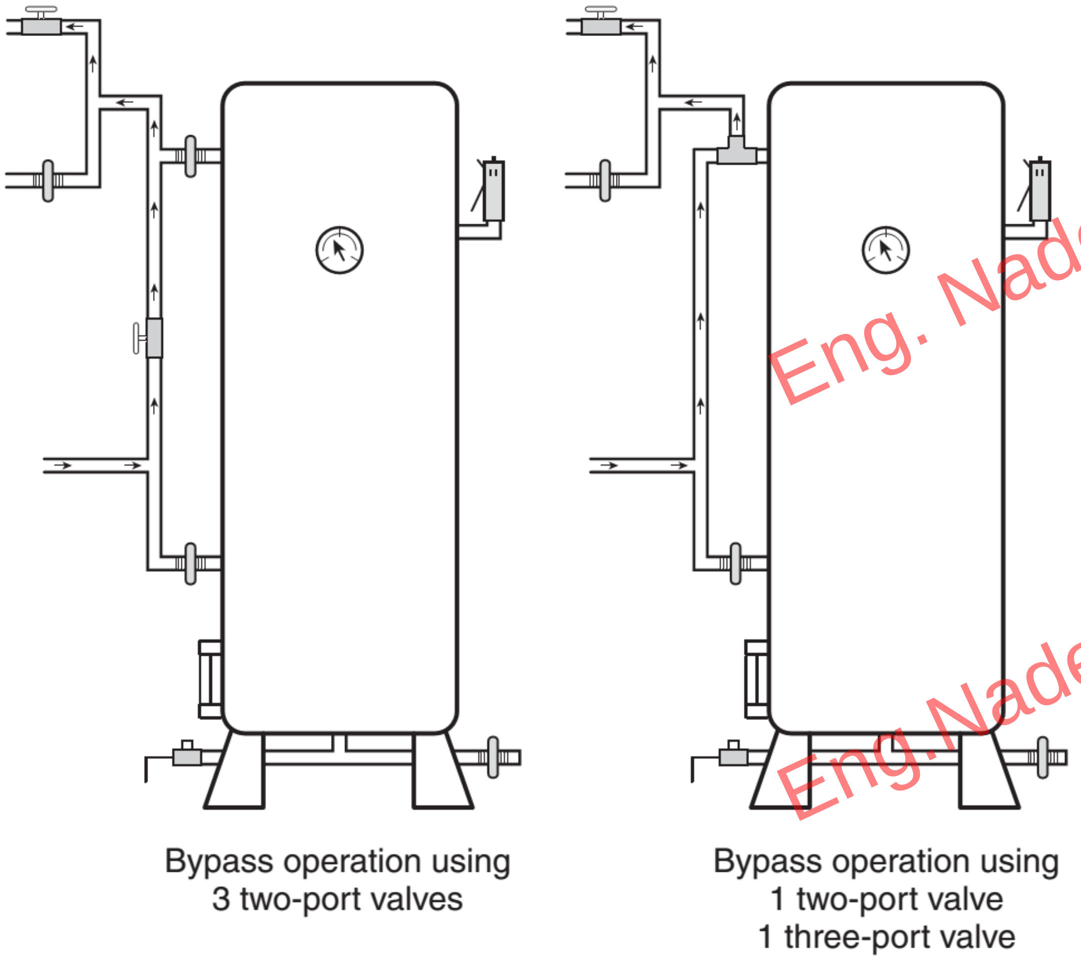


FIGURE A.5.1.3.6.3.9(D) Receiver Valving Arrangement.

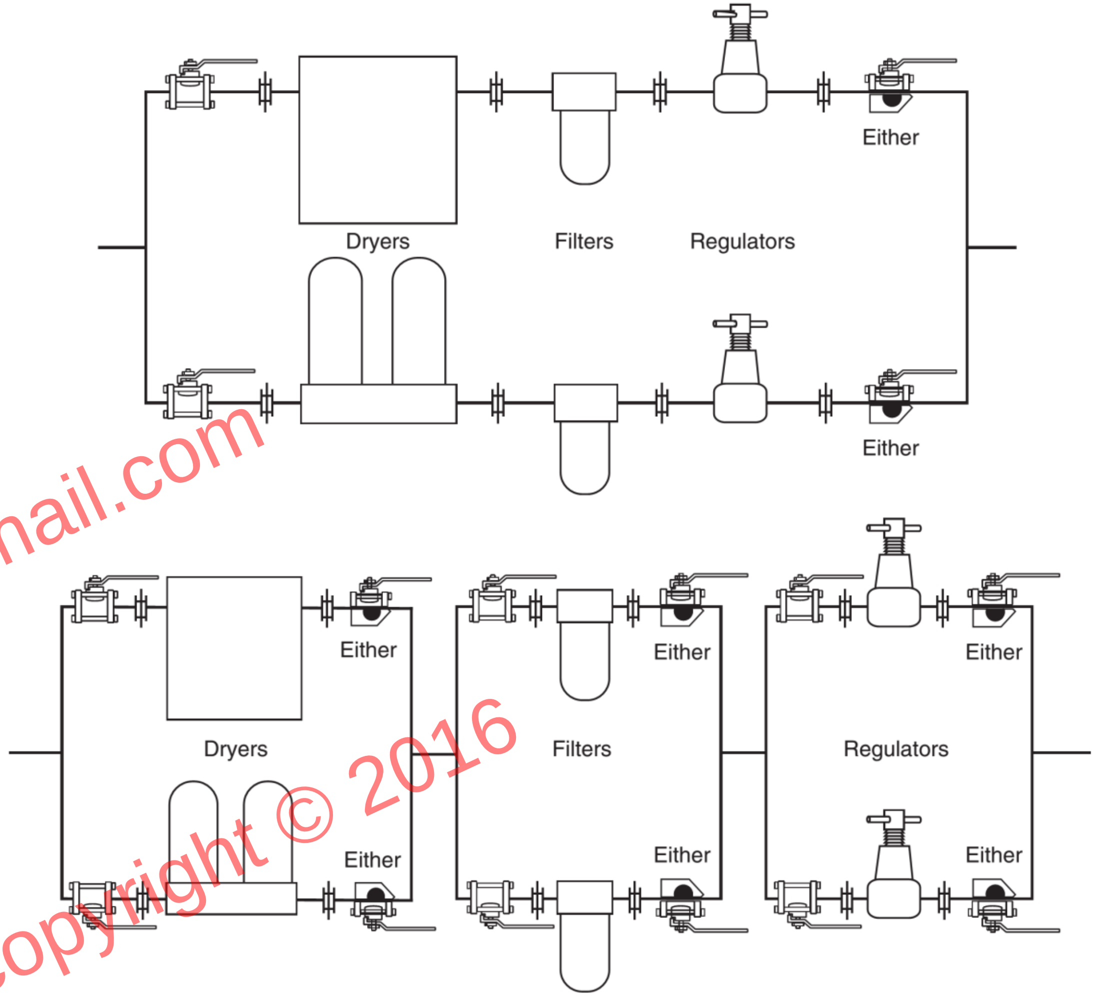


FIGURE A.5.1.3.6.3.9(F) Alternate Valving Sequences for Line Controls in Medical Air.

*** NFPA–99 "Health Care Facilities Code"**

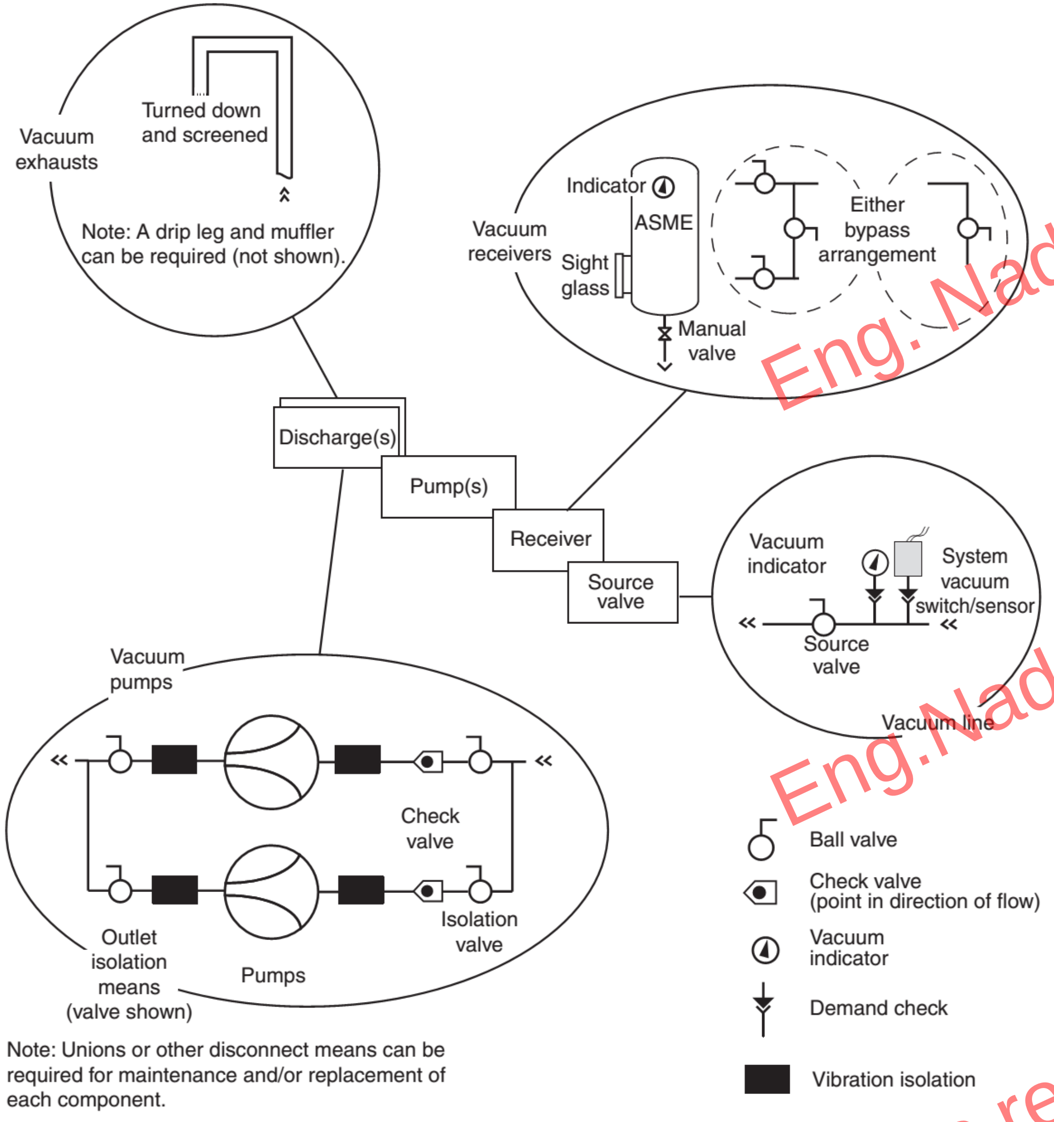


FIGURE A.5.1.3.7 Elements of Typical Duplex Vacuum Source System (Category 1 Vacuum Systems).

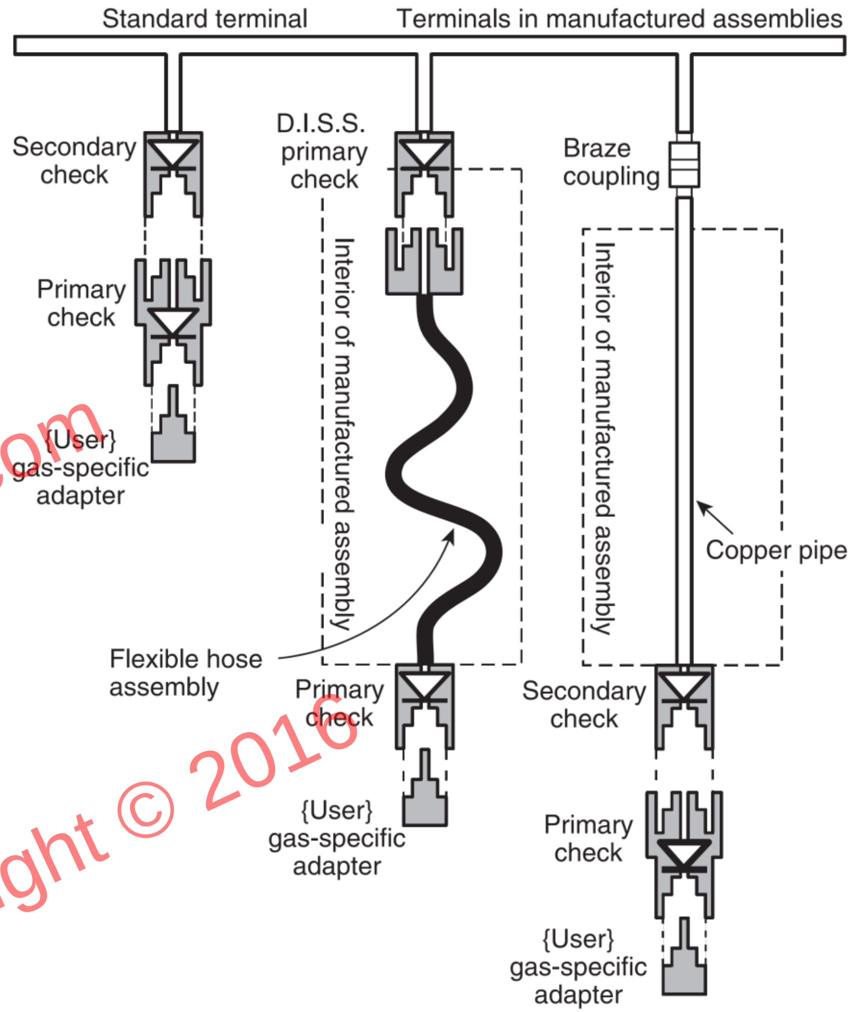
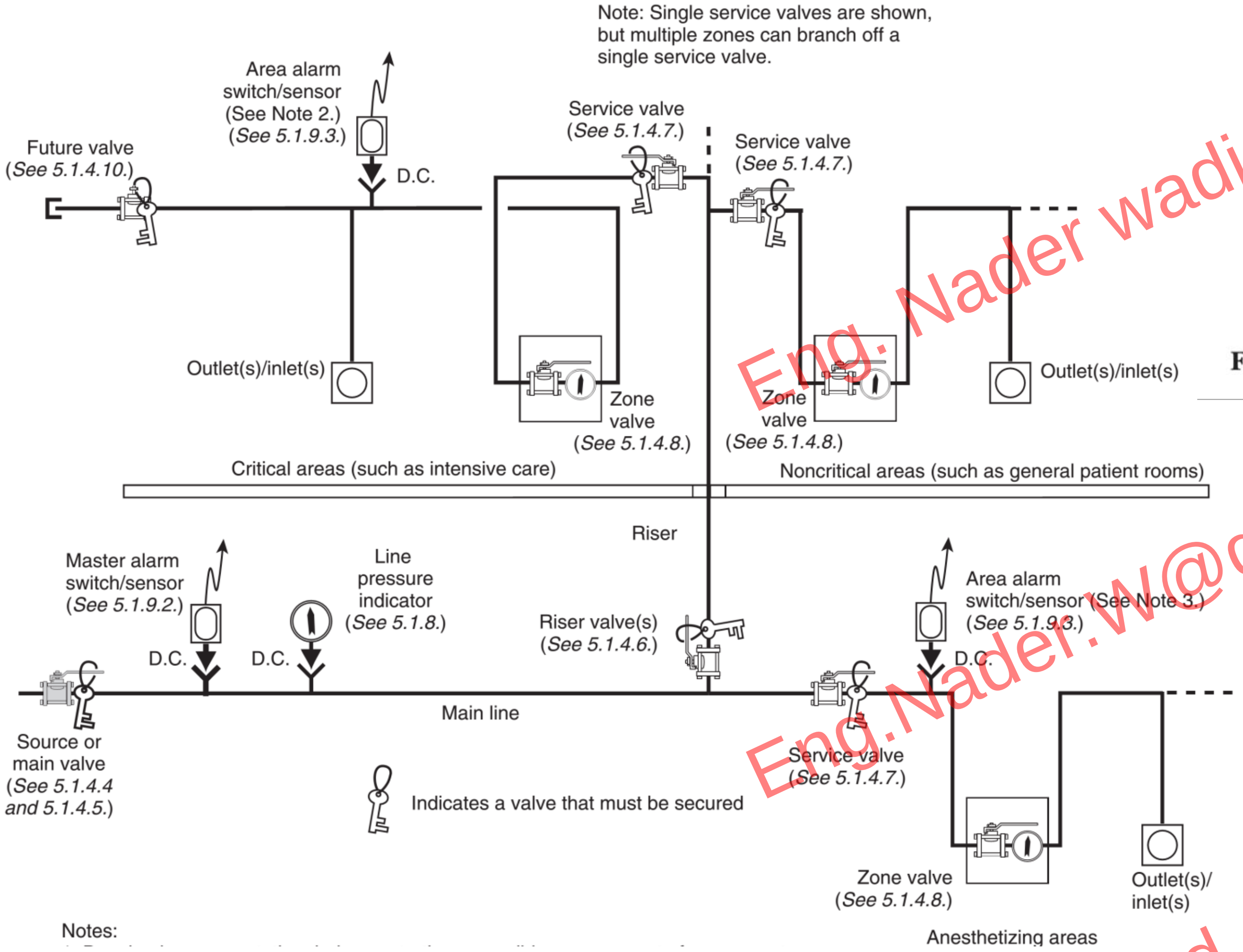


FIGURE A.5.1.6 Terminals in Manufactured Assemblies.

* NFPA–99 "Health Care Facilities Code"



1. Drawing is representational, demonstrating a possible arrangement of components required by the text. The diagram is not intended to imply a method, materials of construction, or more than one of many possible and equally compliant arrangements. Alternative arrangements are permitted if they meet the intent of the text.

2. Area alarms are required in critical care locations (examples might include intensive care units, coronary care units, angiography laboratories, cardiac catheterization laboratories, post-anesthesia recovery rooms, and emergency rooms) and anesthetizing locations (examples might include operating rooms and delivery rooms). Refer to definitions for these areas.

3. Locations for switches/sensors are not affected by the presence of service or in-line valves.

FIGURE A.5.1.4 Arrangement of Pipeline Components.

* **NFPA–99 "Health Care Facilities Code"**

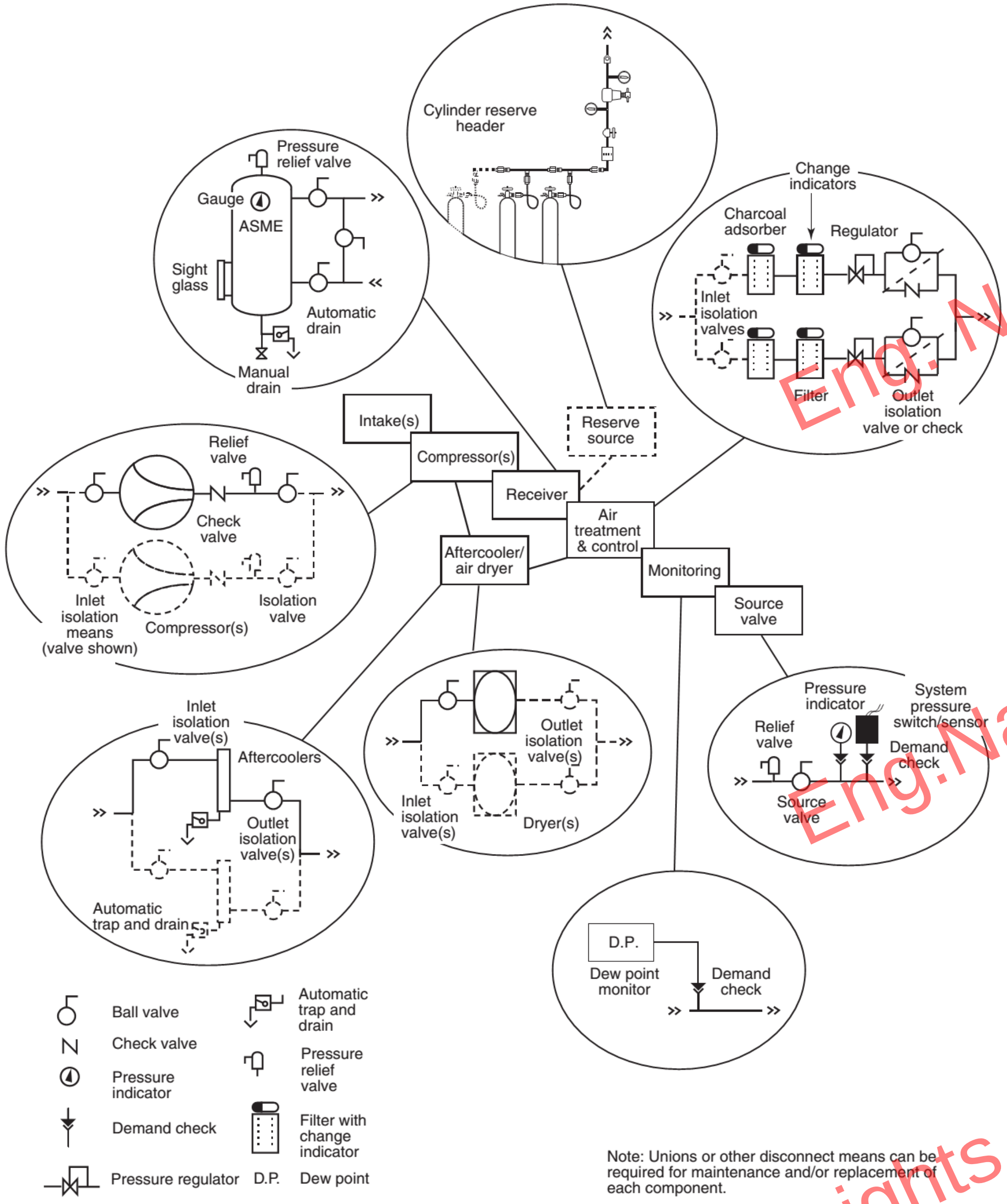


FIGURE A.5.1.13.3.5 Elements of Typical Instrument Air Source.

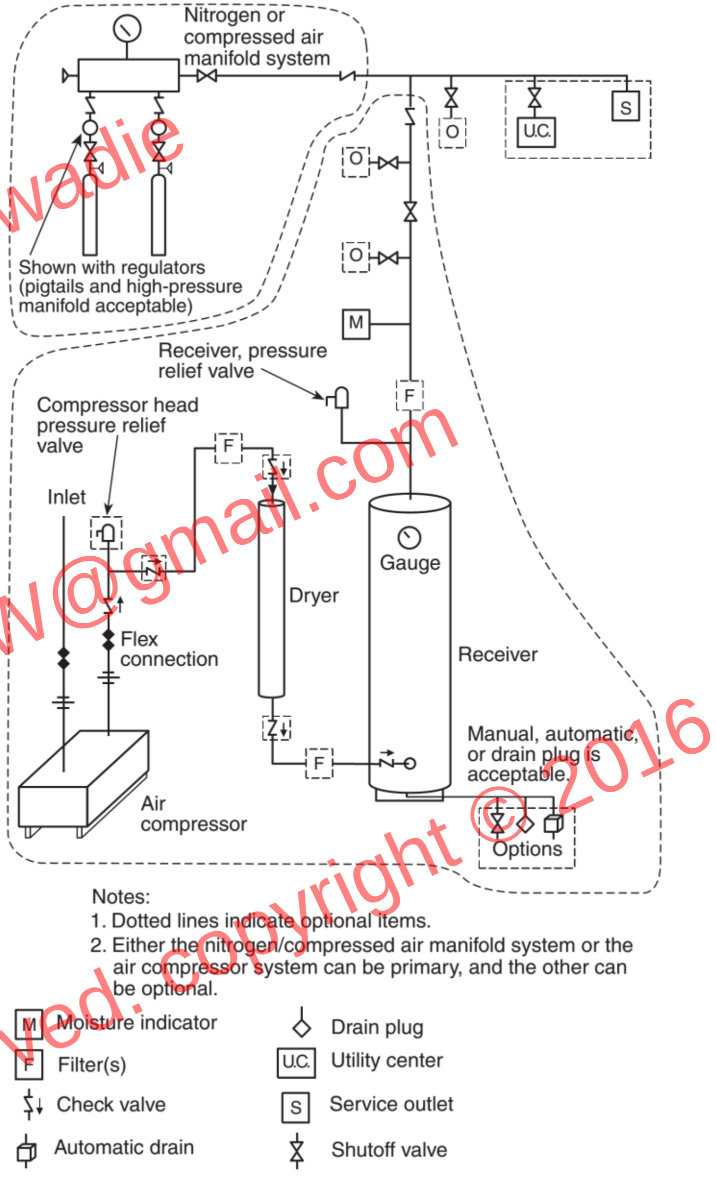


FIGURE A.5.3.3.6 Category 3 Drive Gas Supply System.

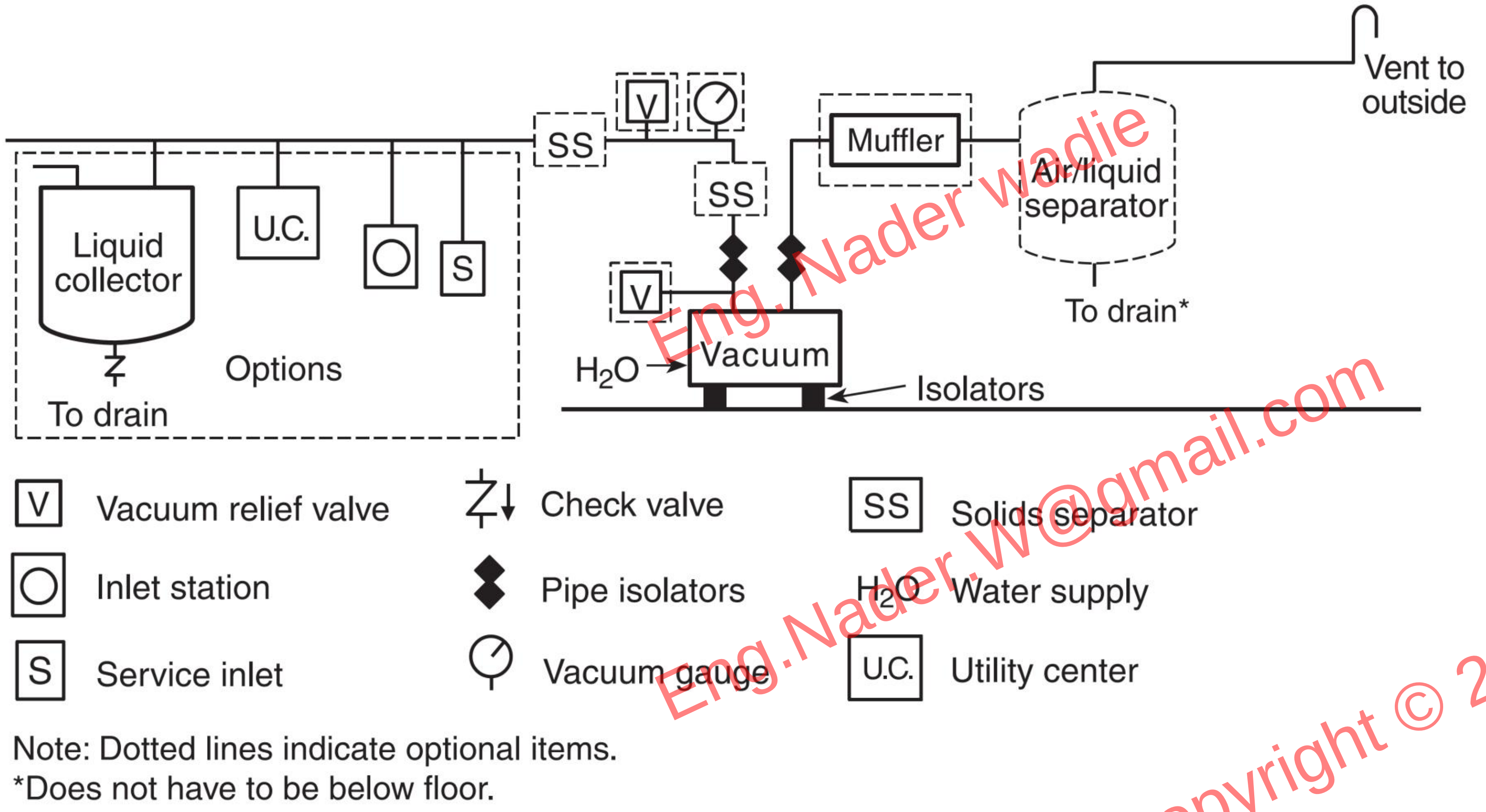


FIGURE A.5.3.3.10.1.3(a) Typical Category 3 Wet or Dry Piping System with Single Vacuum Pump Source.

* NFPA–99 "Health Care Facilities Code"

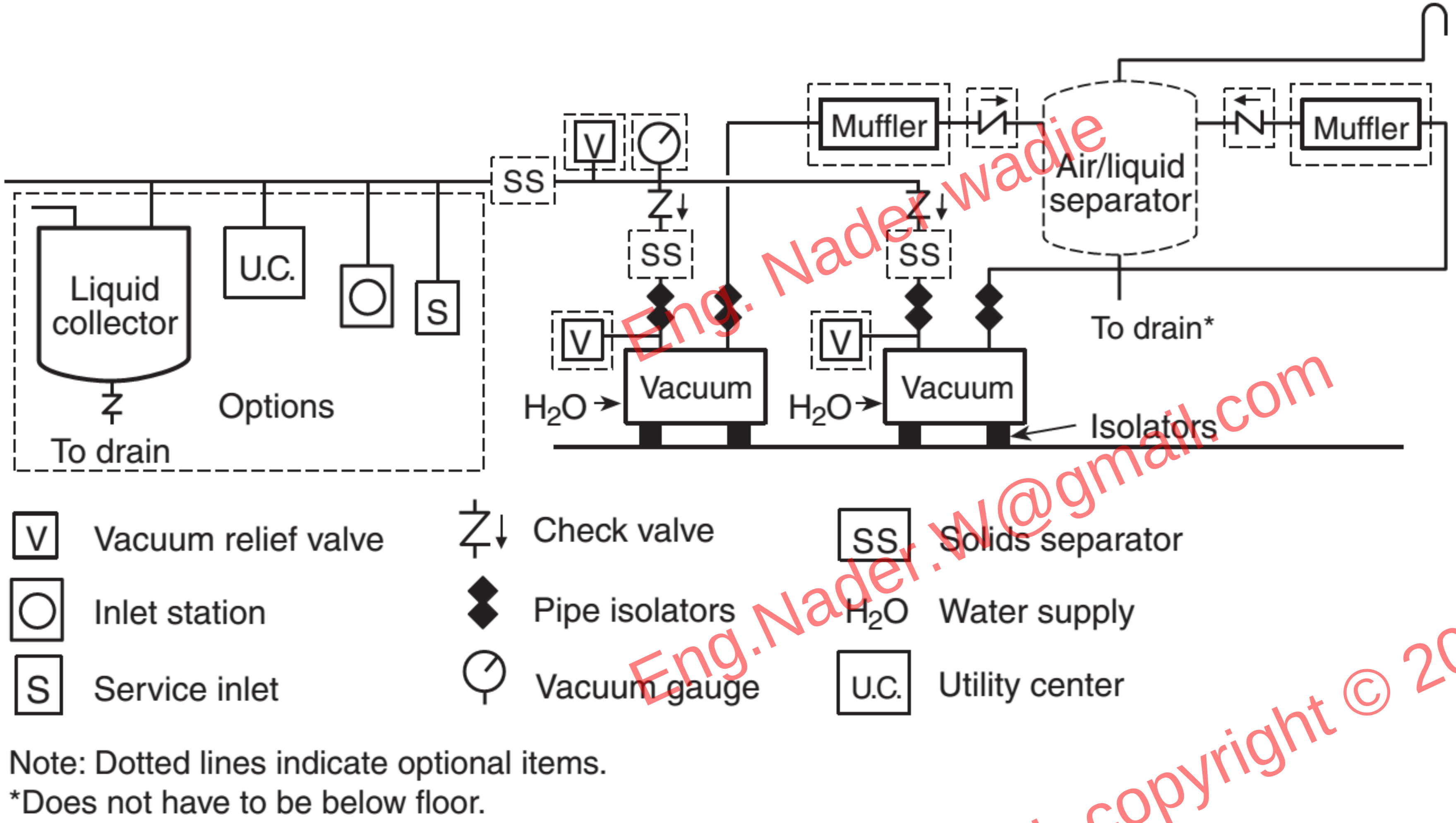


FIGURE A.5.3.3.10.1.3(b) Typical Category 3 Wet or Dry Piping System with Duplex Vacuum Source with Air/Liquid Separator.

* NFPA–99 "Health Care Facilities Code"

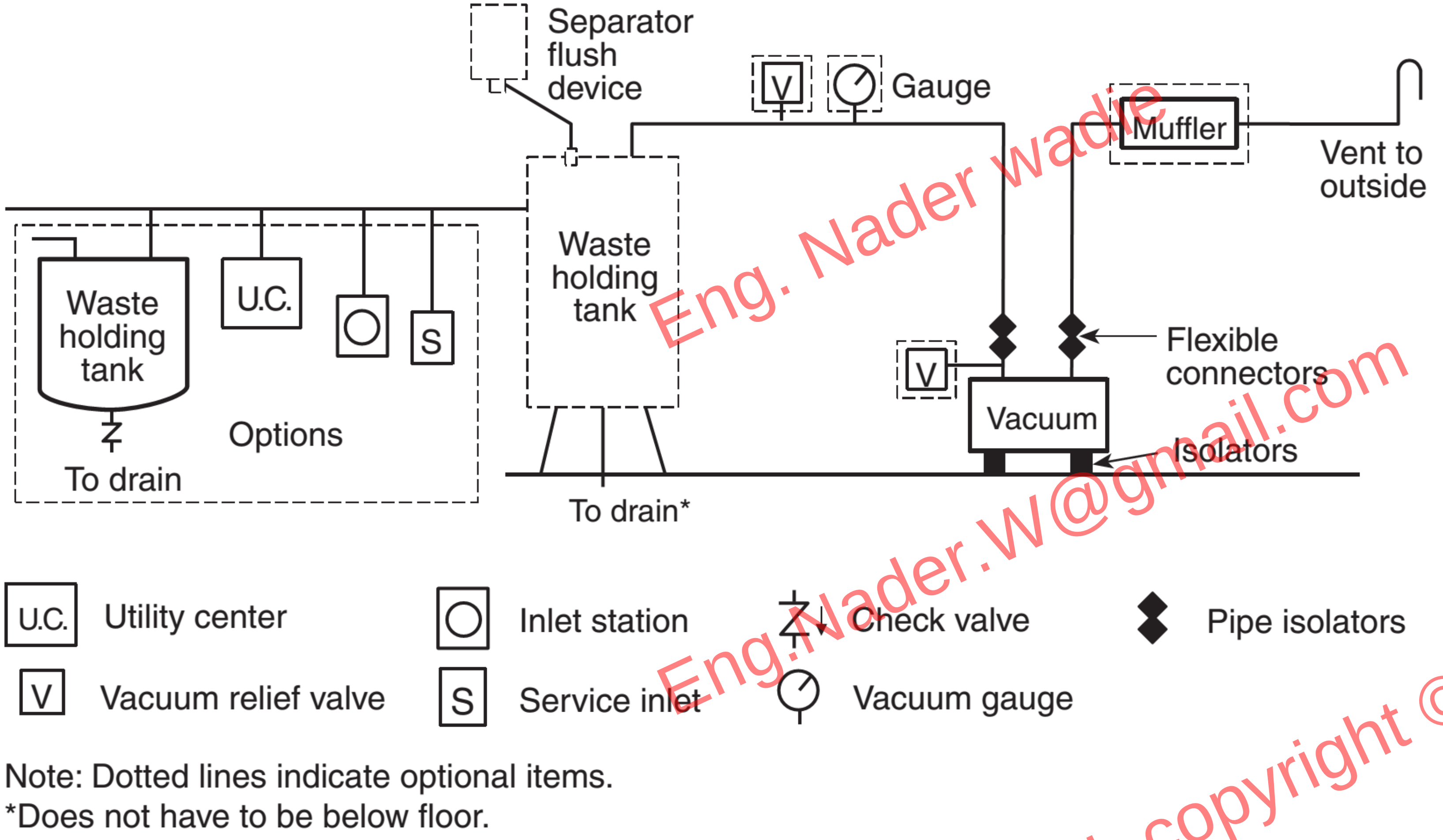


FIGURE A.5.3.3.10.1.3(c) Typical Category 3 Wet or Dry Piping System with Single Vacuum Source.

* NFPA–99 "Health Care Facilities Code"

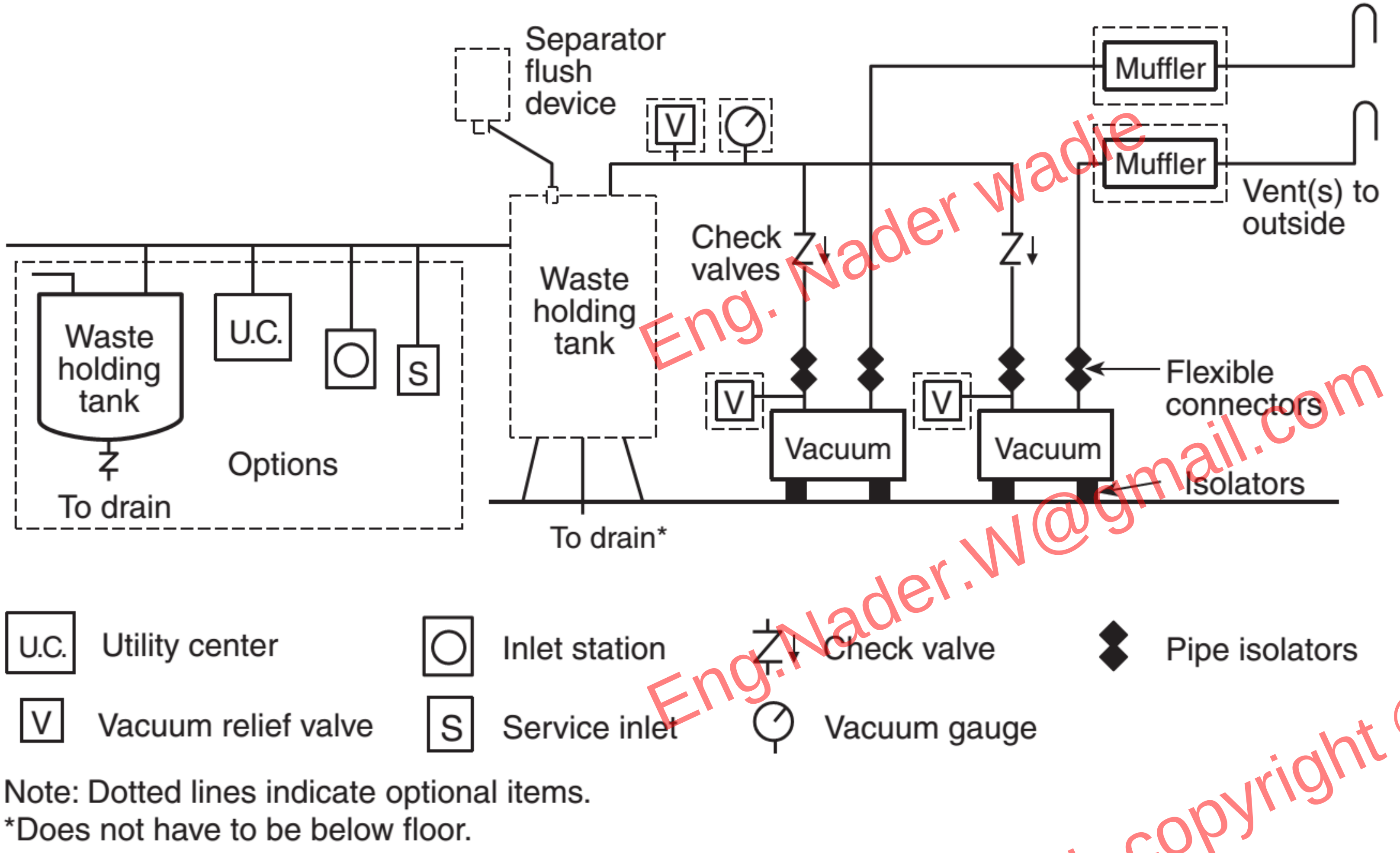


FIGURE A.5.3.3.10.1.3(d) Typical Category 3 Wet or Dry Piping System with Duplex Vacuum Source with Waste Holding Tank.

* NFPA–99 "Health Care Facilities Code"

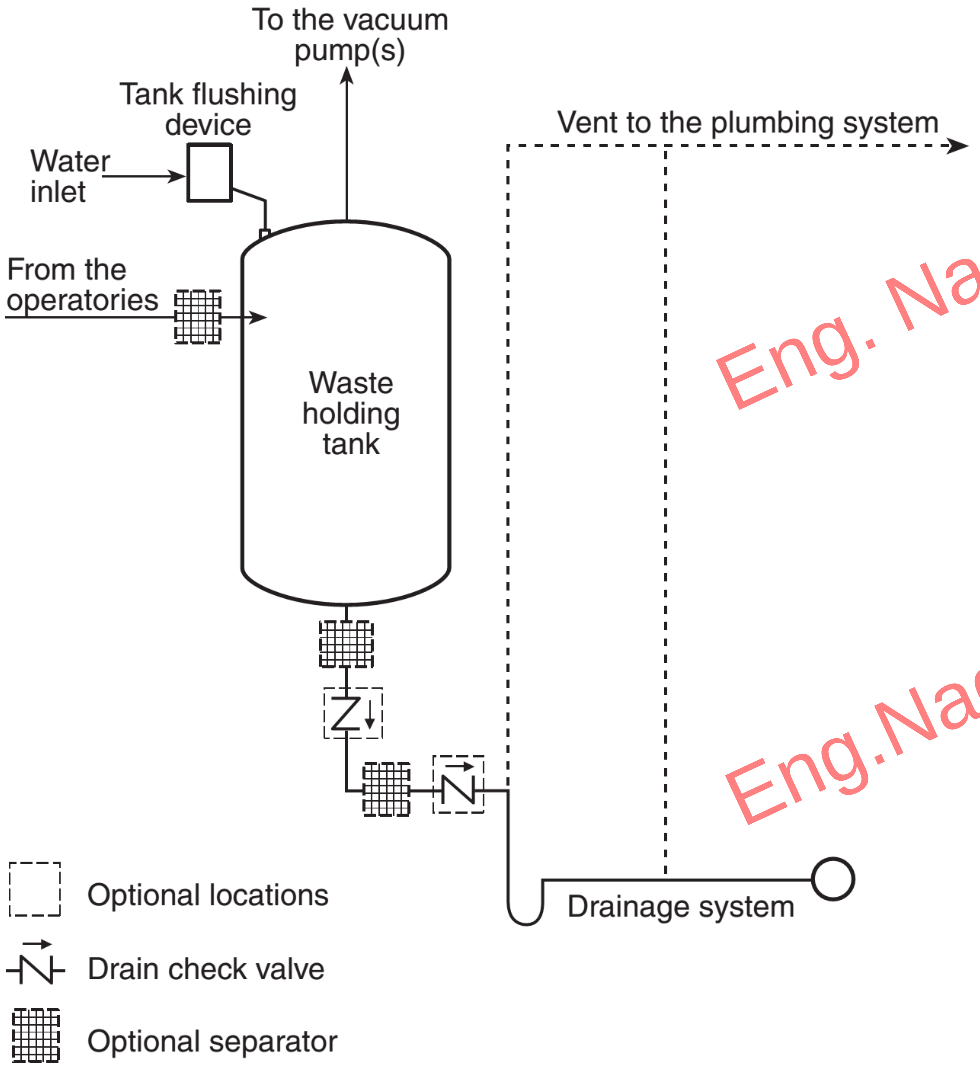


FIGURE A.5.3.3.10.1.3(4)(a) Drainage from Gravity Drained Liquid Collector Tank.

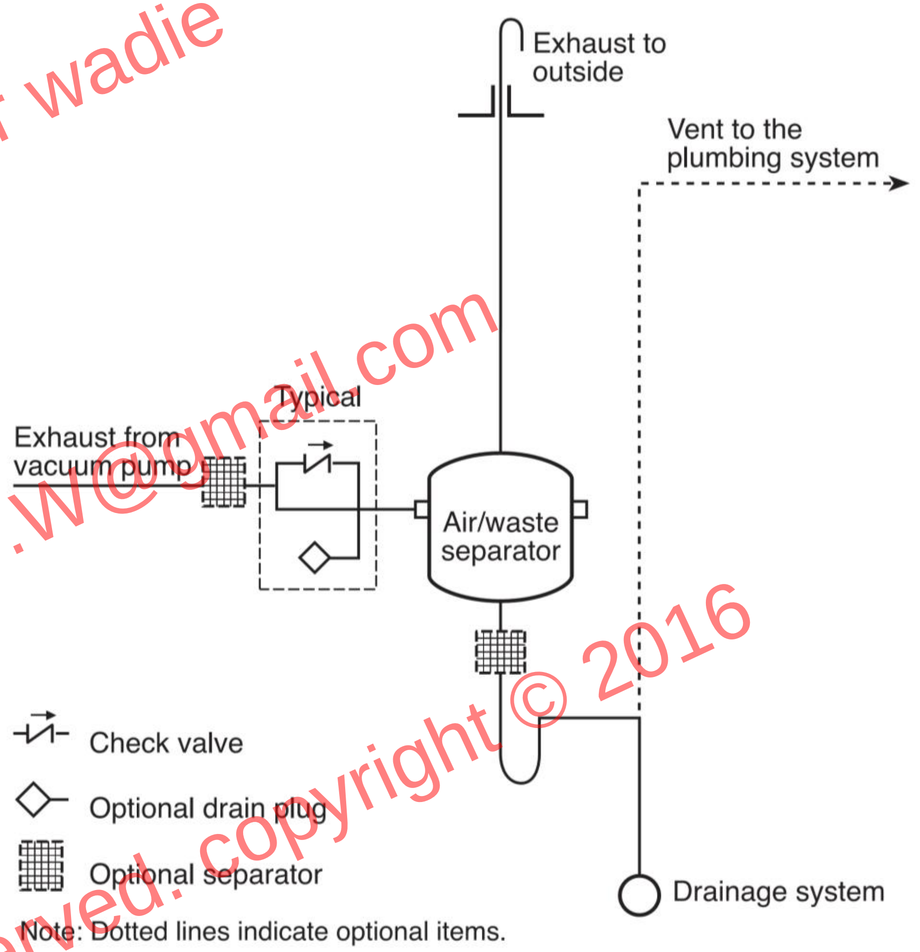
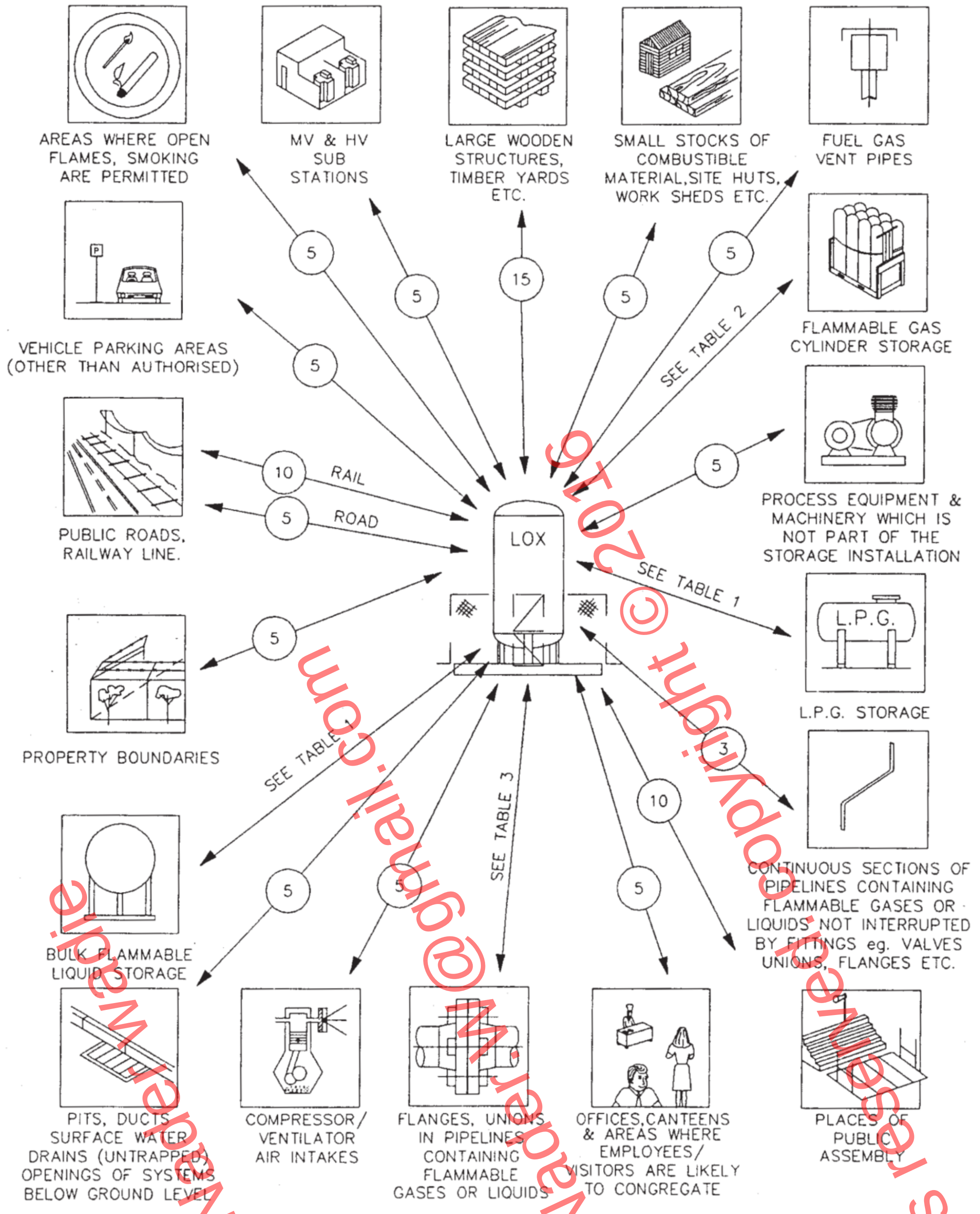


FIGURE A.5.3.3.10.1.3(4)(b) Drainage from Positive Discharge Vacuum Pump Through Air/Liquid Separator.

* NFPA–99 "Health Care Facilities Code"

SAFETY DISTANCES FOR LIQUID OXYGEN STORAGE UP TO 20 TONNES NET LIQUID CAPACITY (DISTANCES IN METRES)



NOTE: (1) The safety distances are measured from the exposure to
a) any point on the storage system where in normal operation oxygen leakage or spillage can occur or
b) the tank outer jacket.
c) or the vessel nozzles, whichever gives the greater distance.

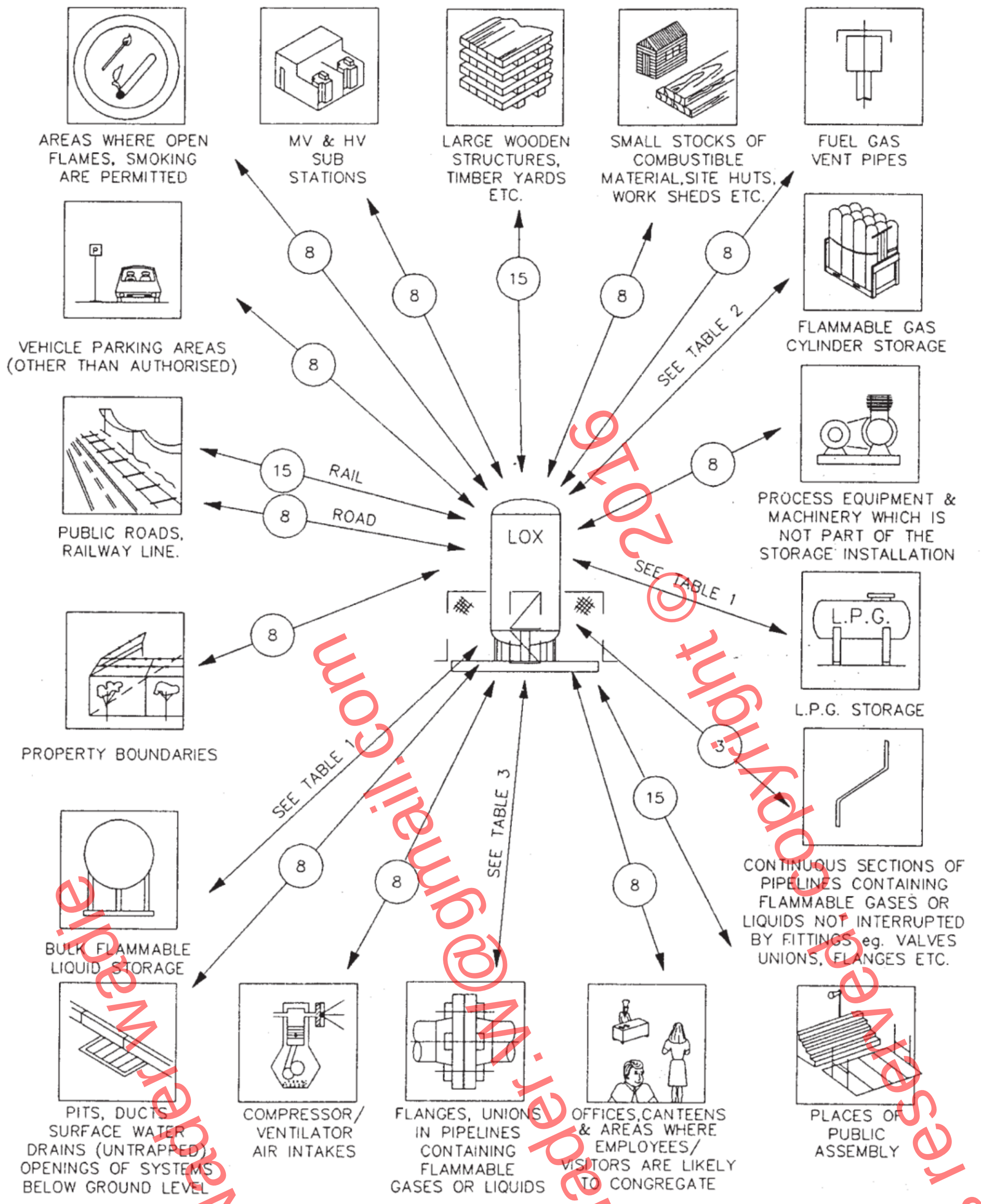
NOTE: (2) Assumed maximum liquid phase pipework diameter 40mm ($1^1/_2$") nominal bore, for the liquid oxygen piping.

NOTE: (3) For buildings, the distances are measured to the nearest opening in the building e.g. doors, windows, ventilation openings.

NOTE: (4) For tables 1, 2 & 3 see Tech Data Sheet No. G4309

Figure 7 Safety distances for cryogenic storage vessels (reproduced by kind permission of BOC and BCGA)

SAFETY DISTANCES FOR LIQUID OXYGEN STORAGE 20 TONNES TO 200 TONNES NET LIQUID CAPACITY (DISTANCES IN METRES)



NOTE: (1) The safety distances are measured from the exposure to

a) any point on the storage system where in normal operation oxygen leakage or spillage can occur or
b) the tank outer jacket
c) or the vessel nozzles, whichever gives the greater distance.

NOTE: (2) Assumed maximum liquid phase pipework diameter 50mm (2") nominal bore, for the liquid oxygen piping.

NOTE: (3) For buildings, the distances are measured to the nearest opening in the building e.g. doors, windows, ventilation openings.

NOTE: (4) For tables 1, 2 & 3 see Tech Data Sheet No. G4309

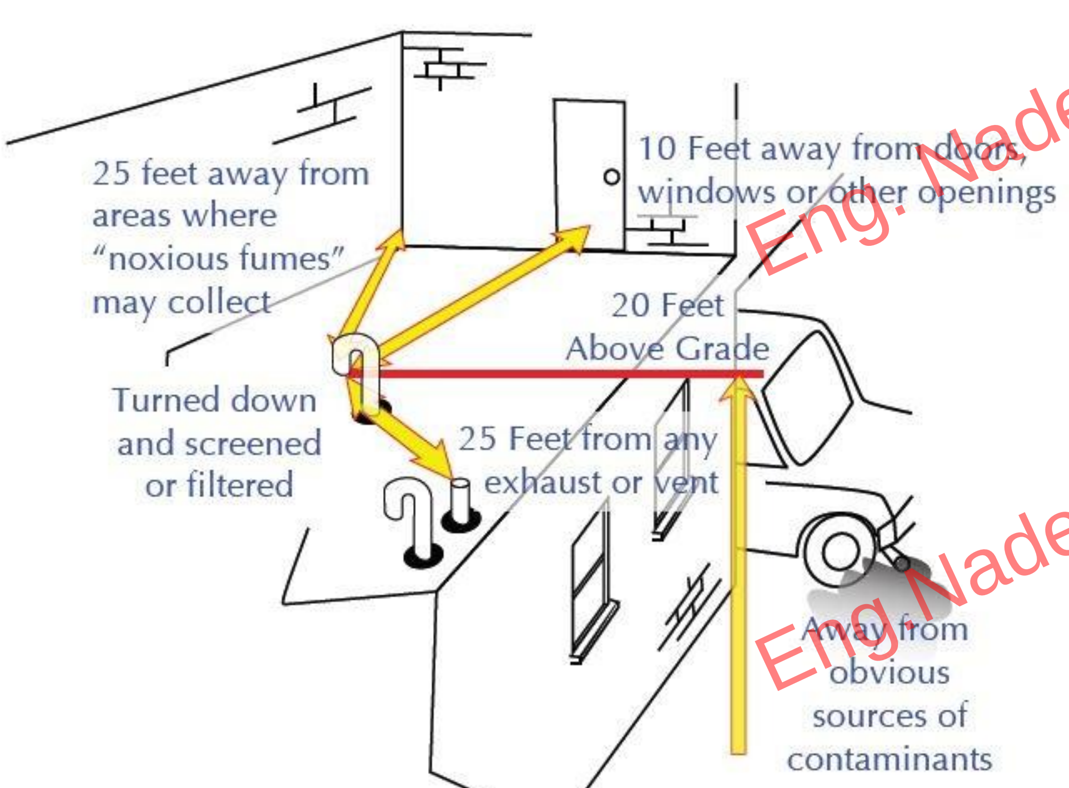
* Health Technical Memorandum 2022

Table 2-10 Exterior Bulk Oxygen-Storage Installation Criteria

Bulk Tank Separation Distances, ft (m)	Item
1 (0.30)	Building structure (except wood frame)
5 (1.52)	Property line
10 (3.05)	Parked vehicles, sidewalk, structure openings
15 (4.57)	All classes of flammable and combustible liquids stored below ground. Class III B liquid, 1000 gal (3785 L) or less, above-ground storage.
25 (7.62)	Solid slow-burning material, coal, lumber, etc., underground tank vent or fill openings. Above-ground flammable and combustible liquids, 1000 gal (3785 L) or less, except Class III B liquids.
35 (10.67)	Clearance for ventilation one side.
50 (15.24)	Public assembly area, open or enclosed. Wood-frame structure. Non-ambulatory patient area.
75 (22.86)	Liquefied hydrogen storage above ground. Clearance for ventilation one side.
25 (7.62)	1000 gal (3785 L) liquefied gas or 25,000 ft^3 (700 m^3) non-liquefied gas.
50 (15.24)	Over 1000 gal (3785 L) of liquefied gas or over 25,000 ft^3 (700 m^3) of non-liquefied gas.

Source: NFPA no. 50.

*** ASPE code "health care facilities and medical gas and vacuum systems"**



1. يجب أن يكون للموقع مساحة كافية للأنظمة و المعدات نفسها وكذلك توفر مساحة كافية للصيانة. وبما أننا لم نقم بعض بتحديد سعة المحطة ولم نحدد الأجهزة, فيعتبر إختيار المساحة المناسبة مُعضلة, ولكن بالخبرة الكافية يمكن تقدير الأنظمة والمعدات المطلوبة سعتها وتخمين المساحة الطلوبة لذلك. الصيانة النموذجية تحتاج الى مسافة وصول تبعُد ثلاثة أقدام من الأمكان المفتوحة عند جميع جوانب المعدات. هذه المساحة يمكن تقليصها في ظروف معينة ولكن في هذه المرحلة فمن الحكمة تحديد هذه المساحة الموصى بها كاملة إذا أمكن.

2. التأكد من وجود منفذ وصول لتركيب الأنظمة في الموقع المحدد. قد يكون من الضروري التأكد من المسار داخل المبنى الذي سيسلك لترحيل المعدات والأنظمة إلى موقع التركيب.

3. التهوية الجيّدة لغرفة الأنظمة والمعدات ويجب أن لا تتعدى درجة حرارة الغرفة بأي حال من الأحوال 105 درجة فهرنهايت (40 درجة بمقياس سيلزيوس) حتى وإن كانت المعدات و الأنظمة في حالة التشغيل. لذلك يجب أن تكون التهوية كافية لتقوم بحمل الحرارة المتولده من المعدات. قد يكون من الضروري في بعض الحالات تبريد الغرف الميكانيكية التي بها الأنظمة.

4. توفر الخدمة الجيدة للكهرباء.

5. قم بإختيار الموقع المناسب لفتحات سحب الهواء الجوي لتغذية الضواغط. يُحتم كود NFPA أن تكون فتحات سحب الهواء على بعد 3 أمتار (10 قدم) من أي فتحة أخرى, على إرتفاع 6.1 متر (20 قدم). وأن يوفر الموقع هواء غير ملوث في كل الظروف الجوية والطقوس.

6. تأكد من أن موقع فتحات سحب الهواء للضواغط بعيد عن أي فتحات تنفيس أخرى أو نوافذ خاصة بعيداً عن العوادم (مثل عوادم نظام السحب vacuum system, عوادم الصرف الصحي, المطابخ, مراوح الطرد و عوادم مولدات الكهرباء وغيرها).

٥/٤ - نظم الإمداد بالاكسجين:

١/٥/٤ – أسس التصميم :

– التركيبات الكبرى يجب امدادها عن طريق خزان مركزى للإكسجين السائل بالموقع. التركيبات الصغرى تغذى من خلال إسطوانات أكسجين تتصل بموزع .

من ١ – ١٠٠ مخرج أكسجين عن طريق موزع وإسطوانات .

أكثر من ١٠٠ مخرج أكسجين عن طريق خزان مركزى .

– الطريقة الإفتراضية لتحديد الإحتياجات الأولية للأكسجين هى :

أ – فى حالة خزان مركزى : يحدد ٥٠٠ قدم مكعب للسرير / الشهر زائد موزع وإسطوانات إحتياطى لإحتياجات يوم واحد .

ب – فى حالة الإسطوانات : يحدد إسطوانة للسرير للموزع الرئيسى وضعف هذا العدد للموزع الإحتياطى .

الإسطوانة = ٢٤٤ قدم مكعب

ويراعى ترك مكان فى غرفة الإسطوانات لتخزين الإسطوانات الإحتياطية .

٨/٢/٤ المعامل قد تحتاج فى بعض الأماكن لبعض الغازات مثل الأكسجين والهيدروجين والهليوم وثانى أكسيد الكربون والنتروجين أو الأرجون .

١/٨/٢/٤ يتم امداد هذه الغازات عادة عن طريق اسطوانات وليس مركزيا عن طريق شبكة مركزية .

٨/٤ - نظم الإمداد بالهواء المضغوط:

١/٨/٤ أسس التصميم :

يوجد أربعة أنواع من نظم الهواء المضغوط وهى الهواء المضغوط للمعامل – الهواء المضغوط الطبى للمستشفيات (وهو الهواء اللازم للمرضى) – هواء مضغوط للأسنان – وهواء مضغوط لنظم المبانى .

ويجب اعتبار كل نوع نظام كامل مختلف عن الآخر .

٢/٨/٤ نظم الهواء المضغوط للمعامل :

أ – يتم تجهيز المخارج المتصلة بنظام مركزى فى المعامل طبقاً للبرنامج المطلوب والإحتياجات المختلفة .

ب – يجب تزويد النظام بكمبرسورات (كباسات) من الطراز اللفاف

Rotary Liquid - ring - type compressors

كامل بخزان الهواء والفلاتر وصمام تثبيت الضغط قادر على تزويد هواء مضغوط جاف ونظيف وخالى من الزيوت عند ٥٥ رطل / بوصة مربعة وبحيث لا يزيد الفاقد فى الضغط عن ٥ رطل/بوصة مربعة والضغط عند المخرج يكون ٥٠ رطل/بوصة مربعة .

جـ – يزود الأماكن المطلوب امدادها بضغط منخفض بصمامات تخفيض ضغط .

د – فى حالة طلب هواء جاف أو فى حالة مرور المواسير خلال أماكن باردة يزود النظام بمجفف للهواء.

هـ – يزود كل مخرج فى المعمل بواحد قدم مكعب فى الدقيقة مع الأخذ فى الإعتبار معامل تكرار الإستعمال كما هو مبين فى الجدول رقم (٤–٥) .

و - الفرعات التى تخدم قاعات الدروس يجب أن تؤخذ معامل الإستخدام بنسبة ١٠٠٪ بغض النظر عن عدد المخارج .

فى حالة وجود أكثر من قاعتين للدروس يؤخذ معامل الإستخدام بواقع ٨٠٪.

ز - تحدد أقطار المواسير بحيث يؤخذ فى الإعتبار الإحتياجات المستقبلية .

ح - الحد الأدنى للأقطار تكون كالآتى :

١/٢/٨/٤ نظم الهواء الطبى للمستشفيات

أ - يتم تجهيز المخارج المتصلة بنظام مركزى طبقاً للبرنامج المطلوب لخدمة المرضى .

ب - تصمم هذه النظم طبقاً للإحتياجات المطلوبة وبحيث تفى باشتراطات NFPA Standard 56F

جـ - يزود النظام بكمبروسور(بكباس) من الطراز Rotary liquid ring - type compressor كامل بخزان الهواء والفلاتر وصمام تثبيت الضغط وقادر على تزويد هواء مضغوط جاف ونظيف وخالى من الزيوت عند ٥٥ رطل / البوصه المربعه. وبحيث لا يزيد الفاقد فى الضغط عن ٥ رطل / البوصة المربعة والضغط عند المخرج يكون ٥٠ رطل / البوصة المربعة .

د - مواسير الدخول لكل كمبروسور يتم تركيبها منفصله على السطح كاشتراطات NFPA 56F

هـ - تجهيز مخارج الهواء المضغوط على الأقل فى الأماكن والتصرفات المبينة فيما بعد وطبقاً للجدول التالى : (جدول رقم ٤-٦)

و - يراعى عدم تطبيق معامل الإستخدام على المخرج الآخير من الماسورة ويطبق معامل الإستخدام على المخارج الإضافية على الماسورة .

ز - يجب عدم الأخذ فى الإعتبار معامل الإستخدام عندما يكون حجم الهواء الناتج من التطبيق أقل من حجم الهواء الناتج من مخرج واحد .

ح - يتم وضع أعمدة التغذية بالهواء بحيث يتم تقسيم المخارج اللازمة للمرضى فى أى دور أو أى جناح على الأقل على عامودين .

ط - يتم تغذية غرفة العمليات الكبرى بأكثر من عامود .

ى - الحد الأدنى للأقطار تكون كالآتى :

٣/٨ بوصة لتغذية مخرج واحد

١/٢ بوصة لتغذية الفرعات الأخرى

٣/٤ بوصة للأعمدة

٣/٤ بوصة للمواسير الرئيسية .

ك - تجهز النظام بنظام إنذار وأمان .

٤/٩ - نظم الإمداد بالشفط (التفريغ) Vacuum Systems

٤/٩/١ عام

تجهيز المستشفيات بنظام مركزى للشفط أو التفريغ (Vacuum) وذلك لامداد الجراح بوسيله مستمرة لشفط السوائل الزائدة خلال العمليات أو شفط مخلفات الجراحة أو لنظافة الأجهزة الدقيقة فى المعامل أو لنقل سوائل أو غازات من وعاء لأخر .

وطلمبات التفريغ تركب عادة فى البدروم أو أعلى السطح مع توفير ضغط سحب مستمر من ١٩-٢٥ بوصة زئبق عن طريق منظم تفريغ Vacuum regulation وتتكون الطلمبات عادة من عدد ٢ طلمبه تفريغ وتحدد سعة كل طلمبة بحيث تكون ١٠٠٪ من الحمل الكلى للنظام أو على الأقل ٧٥٪ من الحمل وتجهز بخزان ويركب عليه أجهزة الأمان والتشغيل .

ويراعى تركيب مجموعات شفط مستقلة لكل من المستشفى والمعمل .

يراعى تركيب ماسورة راجع Exhaust من طلمبات التفريغ لخارج المبنى ، كما يراعى تركيب طبب تسليك على المواسير ويراعى تركيب صلبية بدلاً من التيهات عند التقاطعات لتركيب طبه تسليك عليها ، كما يجهز النظام بطبه لإزالة الرواسب والمخلفات اسفل كل عاموه Drip pockets

٤/٩/٢ نظم الإنذار

يجهز النظام بانذار صوتى ضوئى فى حالة انخفاض نظام الشفط عن ٨ بوصة زئبق .

هذا الإنذار يجب تجهيزه على الماسورة الرئيسية الموصلة للخزان ويتم توصيل نظام الإنذار بالكهرباء الرئيسية والإحتياطية للمبنى .

٤/٩/٣ نظم امداد مواسير الشفط .

١ - يتم امداد مواسير الشفط بطريقة مماثلة لمواسير الأكسجين فيما عدا الآتى:

أ - لا يتم توصيل نظام الشفط بأى صرف صحى لصرف سوائل ومخلفات المريض.

ب - تجهيز المواسير ببيان مكتوب عليها شفط Vacuum

جـ - يتم تركيب وصلات مانعة للأهتزازين من طلمبة التفريغ وماسورة التهوية Exhaust pipe

جدول رقم (٤-٧) يبين العلاقة من المواقع المختلفة والتصرف المطلوب لكل مدخل

جدول رقم (٤-٨) يبين العلاقة بين عدد المداخل وأقل تصرف Cfm

جدول رقم (٤-٩) يبين الفاقد فى الضغط فى المواسير

جدول رقم (٤-١٠) يبين القطر الأدنى لماسورة طلمبة الشفط الى السطح .

Table 2-11 Cryogenic Storage Tank Capacities

Gross Volume, gal (L)	Net Liquid Capacity, gal (L)	Capacity Oxygen, ft³ (10⁶ L)	Approximate Weight Empty Vessel, lb (kg)	Approximate Weight Vessel Loaded with Oxygen, lb (kg)
330 (1249.1)	314 (1188.5)	36,200 (1.02)	4,000 (1816)	7,000 (3178)
575 (2176.4)	535 (2025)	61,500 (1.74)	5,800 (2633.2)	10,900 (4948.6)
975 (3690.4)	920 (3482.2)	105,700 (2.99)	9,300 (4222.2)	18,100 (8217.4)
1,625 (6150.6)	1,533 (5802.4)	176,100 (4.99)	10,400 (4721.6)	25,000 (11 350)
3,400 (1286.9)	3,250 (12 301.3)	374,000 (10.59)	18,500 (8399)	49,400 (22 427.6)
6,075 (22 993.9)	5,935 (22 463.9)	684,999 (19.40)	27,999 (12 711.5)	83,500 (37 909)
9,200 (34 822)	8,766 (33 179.3)	1,009,000 (28.57)	34,000 (15 436)	117,500 (53 345)
11,000 (41 635)	10,500 (39 742.5)	1,215,000 (34.41)	40,000 (18 160)	139,750 (63 446.5)

Note: Consult local supplier for available tank capacities.

Table 2-13 Sizing Chart for Nitrous Oxide Cylinder Manifolds

Number of Operating Rooms	Duplex Manifold Size			
	Indoor		Outdoor	
	Total Cylinders	Cylinders per Side	Total Cylinders	Cylinders per Side
4	4	2	4	2
8	8	4	10	5
10	10	5	12	5
12	12	6	14	7
16	16	8	20	10

Note: Based on use of 489 ft^3 (13.85 X 10^3 L) K-cylinders.

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Table A.11.3.1 Typical Medical Gas Cylinders' Volume and Weight of Available Contents [All Volumes at 21.1°C (70°F) and 101.325 kPa (14.696 psi)]

Cylinder Style and Dimensions	Nominal Volume [L (in.³)]	Contents	Name of Gas						Mixtures of Oxygen	
			Air	Carbon Dioxide	Helium	Nitrogen	Nitrous Oxide	Oxygen	Helium	CO_2
B	1.43 (87)	kPa (psig)		5778 (838)				13,100 (1900)		
8.89 × 33 cm (3½ in. O.D. × 13 in.)		L (ft³)		370 (13)				200 (7)		
		kg (lb-oz)		0.68 (1–8)				—		
D	2.88 (176)	kPa (psig)	13,100 (1900)	5778 (838)	11,032 (1600)	13,100 (1900)	5137 (745)	13,100 (1900)	*	*
10.8 × 43 cm (4¼ in. O.D. × 17 in.)		L (ft³)	375 (13)	940 (33)	300 (11)	370 (13)	940 (33)	400 (14)	300 (11)	400 (14)
		kg (lb-oz)	—	1.73 (3–13)	—	—	1.73 (3–13)	—	*	*
E	4.80 (293)	kPa (psig)	13100 (1900)	5778 (838)	11,032 (1600)	13,100 (1900)	5137 (745)	13,100 (1900)	*	*
10.8 × 66 cm (4¼ in. O.D. × 26 in.)		L (ft³)	625 (22)	1590 (56)	500 (18)	610 (22)	1590 (56)	660 (23)	500 (18)	660 (23)
		kg (lb-oz)	—	2.92 (6–7)	—	—	2.92 (6–7)	—	*	*

M	21.9 (1337)	kPa (psig)	13,100 (1900)	5778 (838)	11,032 (1600)	15,169 (2200)	5137 (745)	15,169 (2200)	*	*
17.8 × 109 cm (7 in. O.D. × 43 in.)		L (ft^3)	2850 (101)	7570 (267)	2260 (80)	3200 (113)	7570 (267)	3450 (122)	2260 (80)	3000 (106)
		kg (lb-oz)	—	13.9 (30–10)	—	—	13.9 (30–10)		*	*
G	38.8 (2370)	kPa (psig)	13,100 (1900)	5778 (838)	11,032 (1600)	15,169 (2200)	5137 (745)	15,169 (2200)	*	*
21.6 × 130 cm (8½ in. O.D. × 51 in.)		L (ft^3)	5050 (178)	12,300 (434)	4000 (141)	5000 (176)	13,800 (487)	6000 (211)	4000 (141)	5330 (188)
		kg (lb-oz)	—	22.7 (50–0)	—	—	25.4 (56–0)	—	*	*
H or K	43.6 (2660)	kPa (psig)	15,169 (2200)	5778 (838)	15,169 (2200)	15,169 (2200)	5137 (745)	15,169† (2200†)	*	*
23.5 × 130 cm (9¼ in. O.D. × 51 in.)		L (ft^3)	6550 (231)	15,840 (559)	6000 (212)	6400 (226)	15,800 (558)	6900 (244)	6000 (212)	15,840 (559)
		kg (lb-oz)	—	29.1 (64)	—	—	29.1 (64)		*	*

Notes:
These 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 mixture.
†275 ft^3/7800 L cylinders at 2490 psig are available on request.
Source: Compressed Gas Association, Inc.

* NFPA–99 "Health Care Facilities Code"

Table 14 Capacities of medical gas cylinders used on manifolds

Gas		Nominal capacity (litres) at 137 bar g	**Usable capacity (litres)
Oxygen J size		6,800	6,540
Nitrous oxide	J size	18,000	
	G size	9,000	8,900
Nitrous oxide/oxygen mixtures G size		5,000	4,740
Medical air J size		6,400	6,220 5,550
Oxygen/carbon dioxide mixture (5% CO_2) J size		6,800	6,540
Nitric oxide AU size		1,500*	–
Nitric oxide AK size		4,000*	–

* This may be subject to change.

** The usable figures are for discharges down to a gauge pressure of 7 bar g. Two sets of figures are provided for air – for 400 kPa systems and 700 kPa systems – the latter is for discharge down to 15 bar g.

* **Health Technical Memorandum 2022**

Table 2-12
Selection Chart for Oxygen Manifolds

Hospital Usage Cu. Ft. (10^3 L) per month		Duplex Manifold Size: Total Cylinders	Duplex Manifold Size: Cylinders per Side
5,856	(165.8)	6	3
9,760	(276.4)	10	5
13,664	(386.9)	14	7
17,568	(497.5)	18	9
21,472	(608.0)	22	11
25,376	(718.6)	26	13
29,280	(829.1)	30	15
33,154	(938.8)	34	17

Note: Based on use of 244 ft^3 (6909.35 L) H-cylinders.

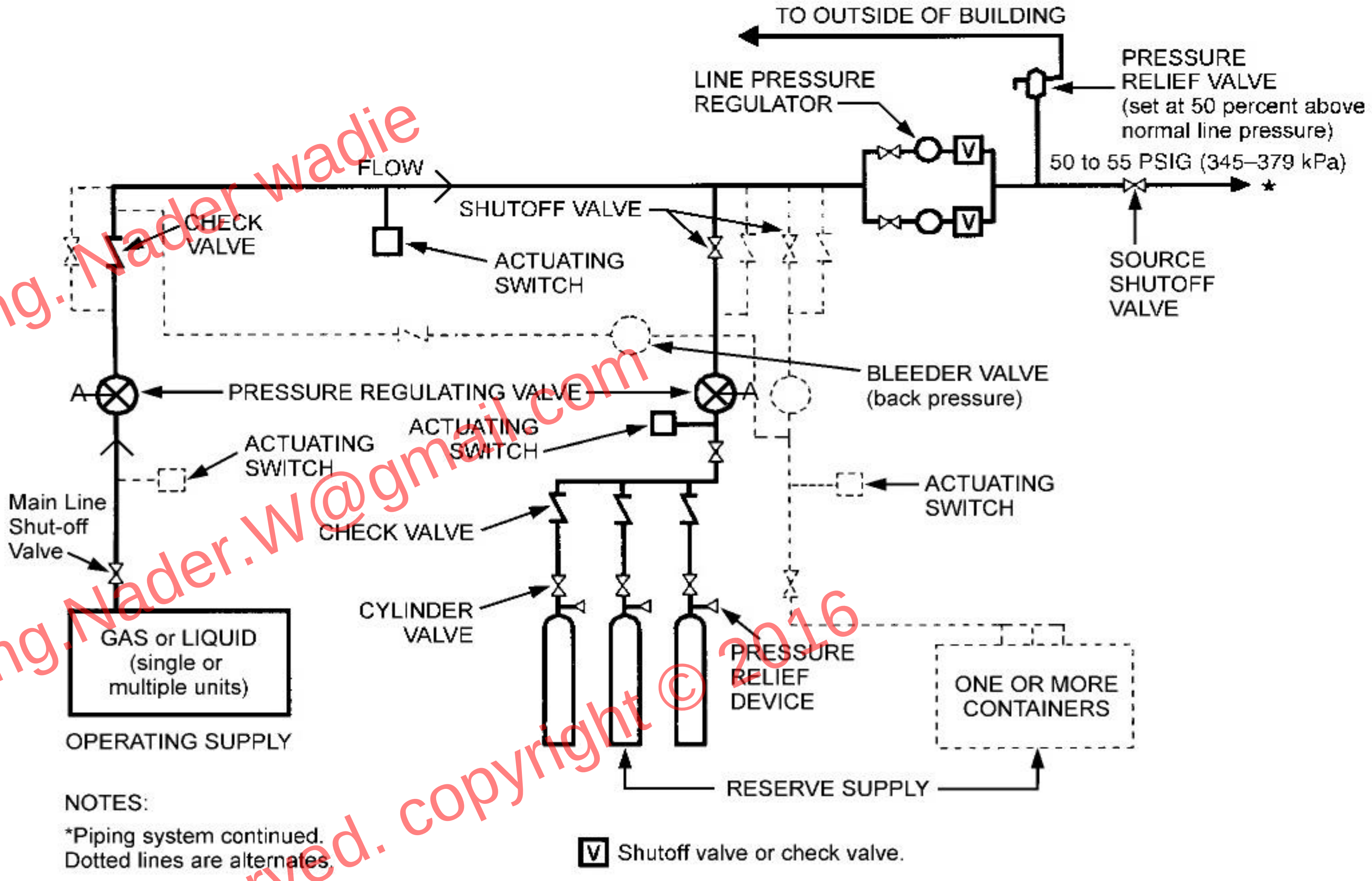


Figure 2-5 Typical Bulk Supply System (Schematic)

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Table 2-12
Selection Chart for Oxygen Manifolds

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13,664	(386.9)	14	7
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25,376	(718.6)	26	13
29,280	(829.1)	30	15
33,154	(938.8)	34	17

Note: Based on use of 244 ft^3 (6909.35 L) H-cylinders.

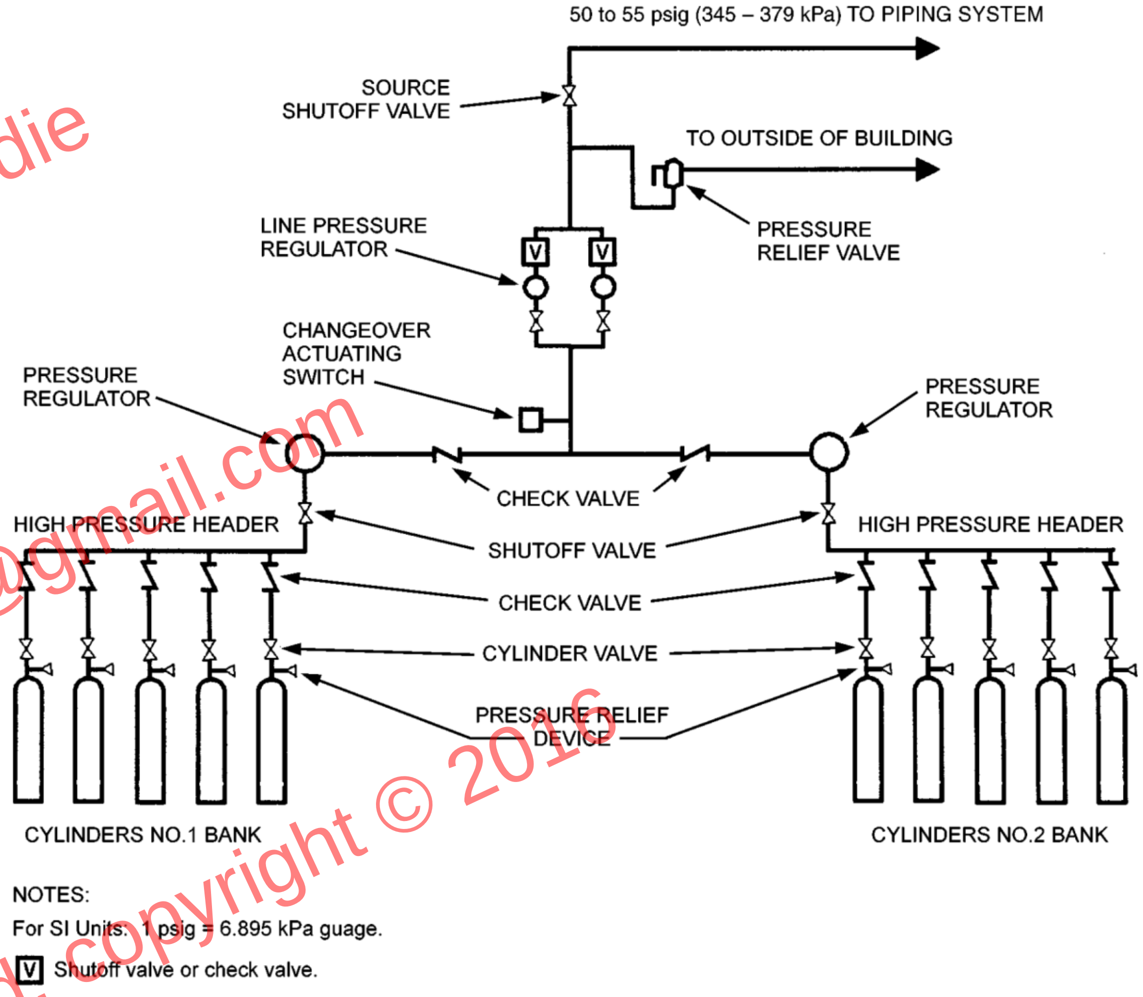


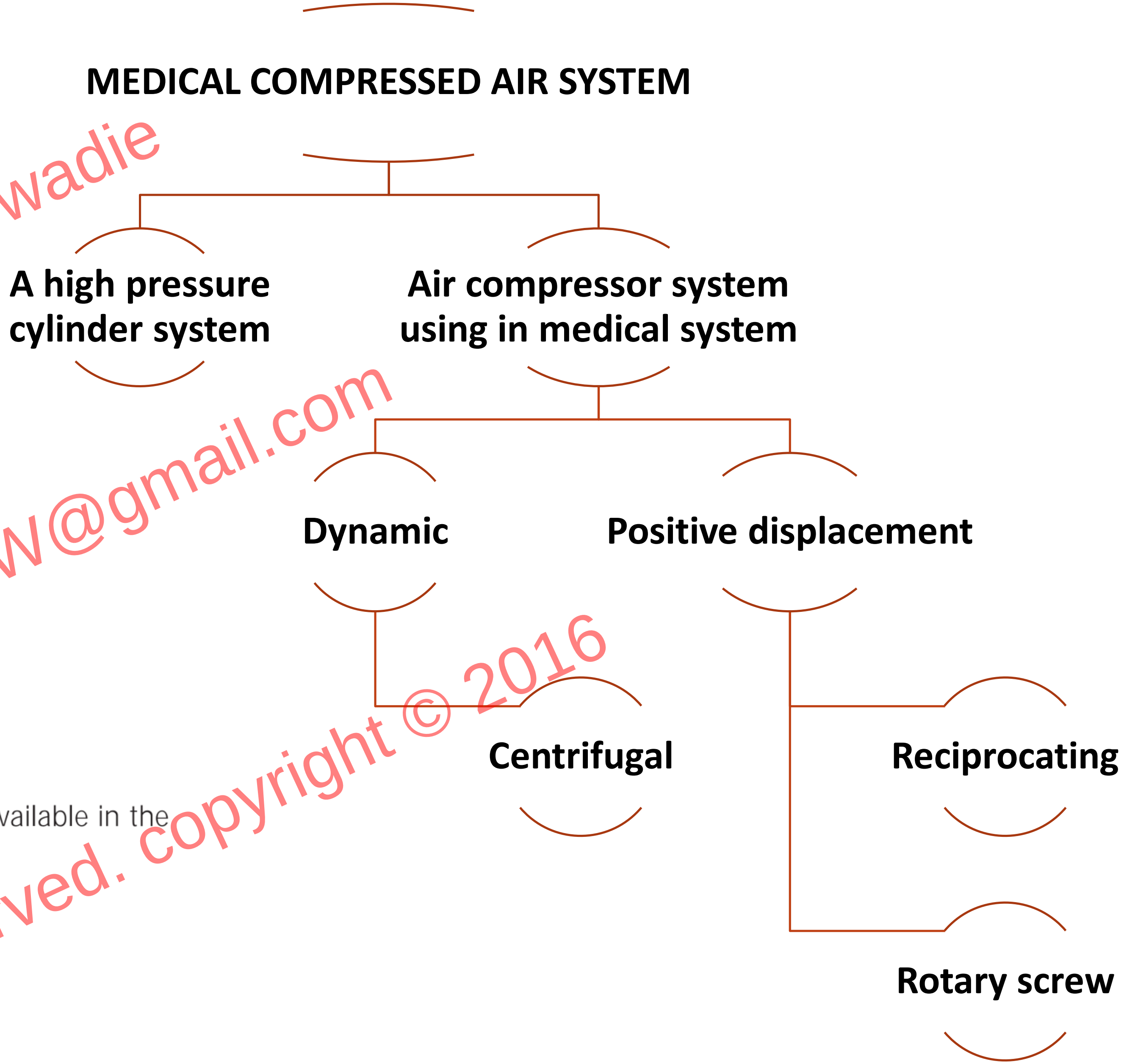
Figure 2-6 Typical Cylinder Supply System without Reserve Supply (Schematic)

Note: Supply systems with different arrangements of valves and regulators are permissible if they provide equivalent safeguards (Level 1 gas system).

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Medical compressed air system:

1. Medical air compressors shall be designed to prevent the introduction of contaminants or liquid into the pipeline by one of the two methods:
   - Air compressor eliminate oil anywhere in the compressor (**using liquid ring, Rotary screw and permanently sealed bearing compressor**)
   - Separate the oil-containing section from the compression chamber (**Compressor have extended heads**)
2. Medical compressors must be manufactured medical purposes as a reliable source of oil free, moisture free and low temperature compressed air. Acceptable compressors types include oil-free, oil-less and liquid ring.



Compressor types

7.10 There are many different types of compressor currently available in the market. Three types which are most commonly available are:

a. reciprocating piston compressors;

b. rotary vane compressors;

c. rotary screw compressors.

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Compressor noise

6.102 The noise level produced by the compressors will increase with the capacity of the supply system. The maximum free field noise level for unsilenced compressed air plant, at 1 m from the plant, varies with the type and power of the plant but should not normally exceed the following values:

Reciprocating	Screw	Vane	Power
85 dBA	76 dBA	76 dBA	7.5 kW
89 dBA	78 dBA	76 dBA	7.6–15 kW
93 dBA	80 dBA	79 dBA	15.1–22 kW
97 dBA	92 dBA	90 dBA	22.1–60 kW

Table 2 Compressor plant noise levels

Power (kW)	Maximum free field noise level at 1 m – unsilenced plant (dBA)	Maximum free field noise level at 1 m – silenced plant or in acoustic cabinet (dBA)
1.5	67.5	58
1.8	73.5	59
2 × 1.5	75	
2 × 2.2	80	

Pump noise

9.11 The noise level produced by the pumps will increase with the capacity of the supply system. For larger systems this can result in an unacceptable noise level at the pump. The maximum free field noise level at 1 m from the unsilenced pump should not exceed the following values for individual pumps:

Power	Noise Level
5 kw	75 dBA
5.1–15 kW	82 dBA
15 kW	89 dBA.

* Health Technical Memorandum 2022

A positive-displacement compressor is normally rated in actual cubic feet per minute (acfm). This is the amount of air taken from atmospheric conditions that the unit will deliver at its discharge. Within a broad range, changes in inlet air temperature, pressure, and humidity do not change the acfm rating of either the reciprocating or the rotary screw compressor. The centrifugal compressor's capacity, however, is affected slightly by the inlet air conditions due to the nature of the compression process. For example, as the air temperature decreases, the capacity of the dynamic compressor will increase. The capacity of a centrifugal compressor is normally defined in inlet cubic feet per minute (icfm) . In an effort to obtain an "apples to apples" comparison of various compressors, many manufacturers specify their capacity requirements in standard cubic feet per minute (scfm). This sometimes causes much confusion because many people do not fully understand how to convert from acfm or icfm to scfm. The design engineer specifying scfm must define a typical inlet air condition at the building site and their set of "standard" conditions (normally 14.7 psia [101.4 kPa], 60°F [15.6°C], and 0% relative humidity). Typically, the warmest normal condition is specified because as the temperature goes up scfm will go down.

To convert from acfm to scfm, the following equation is used.

Equation 2-1

$$scfm = acfm \times \frac{P_i - (P_{pi} \times \%RH)}{P_{std} - (P_{p\ std} \times \%RH_{std})} \times \frac{T_{std}}{T_i}$$

where

P_i = Initial pressure

P_{pi} = Partial initial pressure of water vapor in 100% humid air at the temperature in question

RH = Relative humidity

P_{std} = Pressure under standard conditions

$P_{p\ std}$ = Partial standard pressure of water vapor in 100% humid air at the temperature in question

RH_{std} = Relative humidity at standard conditions

T_{std} = Temperature at standard conditions, °F (°C)

T_i = Inlet temperature, °F (°C)

Equation 2-1a

This equation is derived from the Perfect Gas law, which is:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

or:

$$V_2 = V_1 \times \frac{P_1}{P_2} \times \frac{T_2}{T_1}$$

where

P_1 = Initial pressure

V_1 = Initial volume

T_1 = Initial temperature

P_2 = Final pressure

V_2 = Final volume

T_2 = Final temperature

*** ASPE code "health care facilities and medical gas and vacuum systems"**

For a reciprocating or rotary-screw compressor, the conversion from acfm to scfm is simple. The inlet air conditions and standard conditions are inserted into the above formula and multiplied by the acfm capacity of the unit. It makes no difference what the design conditions are for that compressor, as these do not figure into the formula. In the case of a dynamic compressor, the icfm air flow at the given inlet conditions is inserted in place of the acfm in the formula. Another design issue that the engineer should be aware of is how altitude affects the output of the compressor. At altitudes above sea level, all medical-air systems have reduced flow. In these cases, the required sizing will need to be adjusted to compensate. To do this, multiply the scfm requirements by the correction factor in Table 2-14.

Table 2-14 Altitude Correction Factors for Medical-Air Systems

Altitude, ft (m)	Normal Barometric Pressure, in. Hg (mm Hg)	Correction Factor for SCFM (L/min)
Sea level	29.92 (759.97)	1.0 (28.31)
1,000 (304.8)	28.86 (733.04)	1.01 (28.6)
2,000 (609.6)	27.82 (706.63)	1.03 (29.16)
3,000 (914.4)	26.82 (681.23)	1.05 (29.73)
4,000 (1219.2)	25.84 (656.33)	1.06 (30.01)
5,000 (1524)	24.90 (632.46)	1.08 (30.58)
6,000 (1828.8)	23.98 (609.09)	1.10 (31.14)
7,000 (2133.6)	23.09 (586.48)	1.12 (31.71)
8,000 (2438.4)	22.23 (564.64)	1.15 (32.56)
9,000 (2743.2)	21.39 (543.3)	1.17 (33.13)
10,000 (3048)	20.58 (522.7)	1.19 (33.69)

*** ASPE code "health care facilities and medical gas and vacuum systems"**

High-pressure gas (nitrogen) systems Surgical instruments are used to drill or cut bones and metals. Surgical applications include neurology, where instruments are used to cut the cranium; in orthopedic service for bone work and joint replacement; for facial reconstruction; and during open-heart surgery.

There is currently available a series of instruments with the highest pressure requirements and the greatest flow rates of all instruments: 200 psig (1379 kPa) at the instrument and a maximum flow rate of 15 scfm (7.08 L/s) to operate effectively. Recent developments have resulted in a new series of tools that requires only 120 psig (827.4 kPa) with a maximum flow rate of 12 scfm (5.66 L/s) to achieve the same effectiveness as the older, higher-pressure line of tools. Other manufacturers of pneumatically operated instruments commonly use a pressure of 160 psig (1103.2 kPa) and a maximum flow rate of 15 scfm (7.08 L/s). For the foreseeable future, there will be a mixture of instruments in use by various facilities.

Revisions in NFPA 99 made provisions for pressures up to 300 psig (2068.4 kPa), up from a maximum of 200 psig (1379 kPa) previously allowed. Care must be taken to ensure that all components of a proposed distribution system, including connectors, hose, etc., are rated and approved for the higher pressures.

The following should be considered when selecting and sizing nitrogen manifolds and determining the number of cylinders required:

1. The size of the cylinder: 224 ft^3 (6343 L) H-cylinder (see Table 2-16).
2. The number of operating rooms served by the nitrogen gas.
3. Provide 1 cylinder per operating room for in-service and reserve supplies.
4. Determine the flow rate and pressure requirements of utilized instruments.

Table 2-16 Selection Chart for Nitrogen Cylinder Manifolds

Number of Operating Rooms Piped with Nitrogen	Duplex Manifold Size	
	Total Cylinders	Cylinders per Side
1	2	1
2–4	4	2
5–8	8	4
9–12	12	6
13–16	16	8
17–20	20	10
21–24	24	12
25–28	28	14

Note: Based on use of 224 ft^3 (6343.35 L) H-cylinders.

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Vacuum Systems

"Vacuum" is a negative pressure created by the vacuum pumps within the piping system. The evacuation of the air from the piping system allows ambient air to be pulled from station inlets and exhausted to the outside. The volume of air, in cubic feet per minute (cfm) (liters per minute [L/min]), in the piping is greater than the volume of the ambient air (cfm) (L/s) at atmospheric pressure entering the system, due to expansion under vacuum. In a vacuum system acfm is the air that has been expanded in a vacuum volumetric flow. Values of acfm are much greater than values of scfm. To convert acfm to scfm at 19 in. Hg (482.6 mm Hg), divide acfm by 2.73. For the ratio of scfm to acfm at other pressures, refer to Table 2-17.

At altitudes above sea level, all vacuum systems have reduced flow. In these cases, the required sizing will need to be adjusted to compensate. To do this, multiply the total demand in scfm by the appropriate multiplier shown in Table 2-18.

In other words, to size the medical vacuum system correctly in accordance with NFPA 99 recommendations of scfm at 19 in. Hg (482.6 mm Hg), apply the correction factor listed in Table 2-18 to the peak calculated demand in scfm at 19 in. Hg (482.6 mm Hg).

Table 2-17 ACFM to SCFM Conversion Table

Vacuum Level (in. Hg)	Ratio at Sea Level (scfm:acfm)
0	1:1
15	1:2
18	1:2.5
19	1:2.73
20	1:3
21	1:3.33
22	1:3.75
23	1:4.28
24	1:5
25	1:6
26	1:7.5
27	1:10
28	1:15
29	1:30
29.5	1:60

Table 2-18 Altitude Correction Factors for Vacuum Systems

Altitude, ft (m)	Normal Barometric Pressure	Multiplier used for required SCFM
0 (0)	29.92" Hg	1.0
500 (152.4)	29.39" Hg	1.02
1,000 (304.8)	28.86" Hg	1.04
1,500 (457.2)	28.33" Hg	1.06
2,000 (609.6)	27.82" Hg	1.08
2,500 (762)	27.32" Hg	1.10
3,000 (914.4)	26.82" Hg	1.12
3,500 (1066.8)	26.33" Hg	1.14
4,000 (1219.2)	25.84" Hg	1.16
5,000 (1524)	24.90" Hg	1.20
6,000 (1828.8)	23.98" Hg	1.25
7,000 (2133.6)	23.09" Hg	1.30
8,000 (2438.4)	22.23" Hg	1.35
9,000 (2743.2)	21.39" Hg	1.40
10,000 (3048)	20.58" Hg	1.45

*** ASPE code "health care facilities and medical gas and vacuum systems"**

Example 2-3

A facility total demand is 27.5 scfm to produce a 19 in. Hg (482.6 mm Hg) vacuum at sea level. If this facility is located at 5000 ft (1524 m) above sea level, you take the 27.5 scfm and multiply it by 1.20 (the correction factor from Table 2-18) to get the adjusted total requirement of 33.3 scfm at 5000 ft (1524 m) above sea level.

Be sure to use actual cubic feet per minute (acfm) (actual liters per minute [aL/min]) to size vacuum pumps. The patient vacuum system is intended to be a dry vacuum system. However, occasionally fluids enter the piping system accidentally. This should not affect the operations of the vacuum pumps, but it will eventually restrict flow, as the pipes' inner walls become coated with dry body fluids, dust, and debris. Some facilities use the vacuum system to remove airborne smoke particles from electrosurgical or laser-surgery areas. This is not a recommended application for the vacuum system. The smoke contains particulates, hydrocarbons, and water, which, if captured, will condense on the pipes' inner walls, producing a tar-like substance that will eventually restrict flow.

*** ASPE code "health care facilities and medical gas and vacuum systems"**

E. System control and warning system

Based upon the latest recommendations of the NFPA, zone valves that are accessible to other than authorized personnel should be installed inside of valve boxes that are provided with breakable or removable windows. This valve is to be readily operable from a standing position in the corridor on the same floor it serves.

Shut-off valves should be located in medical-gas systems at the following locations:

1. Source equipment outlet shut-off valves.
2. The main supply line entering the building.
3. The base of each medical-gas riser adjacent to the riser connection.
4. Each floor distribution zone serving patient areas.
5. Each anesthetizing locations.
6. Each critical (intensive) care area, emergency room, and recovery room.

System control valves

- Source shut-off valves
- Main shut-off valves
- In-line shut-off valves
- Zone valve-box assemblies

Valves, fittings, and other components The valve(s) and box assemblies should be full-port ball valve(s) with 90° from the open to the closed position. The size of the valves should be based upon the size of pipe they serve so as not to provide a reduction (or restriction) in the flow of the pipeline system.

A gauge, installed downstream of the zone valve, is required in the patient room.

The locations cited above are the minimum recommendations; local plumbing codes, NFPA standards, and site conditions should prevail in the final determination of the valve placement. All piping, except control-line tubing, shall be identified. All service-main, branch-main, and riser valves shall be tagged, and a valve schedule shall be provided to the facility owner for permanent record and reference.

Valves and fittings and other components shall be cleaned for oxygen service.

٤/٢/٦ الصمامات والمحابس

٤/٢/٦/١ محابس الغلق تكون من النوع الكروى وتركب داخل غرفة محابس بشباك بلاستيك وفى حالة تجميع مجموعة محابس معاً يجب تركيبهم فى غرفة محابس مجمعة .

للفرعات ذات الأقطار ١ ١/٤ بوصه فأكثر يركب كل محبس فى غرفة محبس مستقلة .

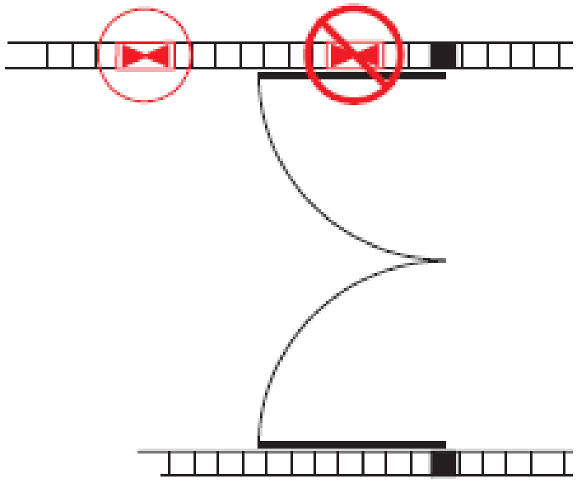
٤/٢/٦/٥ يزود محبس غلق خارج غرف التخدير والعمليات على كل خط وتوضع بحيث تكون جاهزة ويمكن التوصيل عليها فى جميع الأحوال للإستعمال فى حالة الطوارئ وتجهز هذه المحابس والمخارج بحيث إذا تم غلق إمداد الغاز إلى أى أحدى غرف التخدير أو العمليات لا تؤثر على الأخرى .

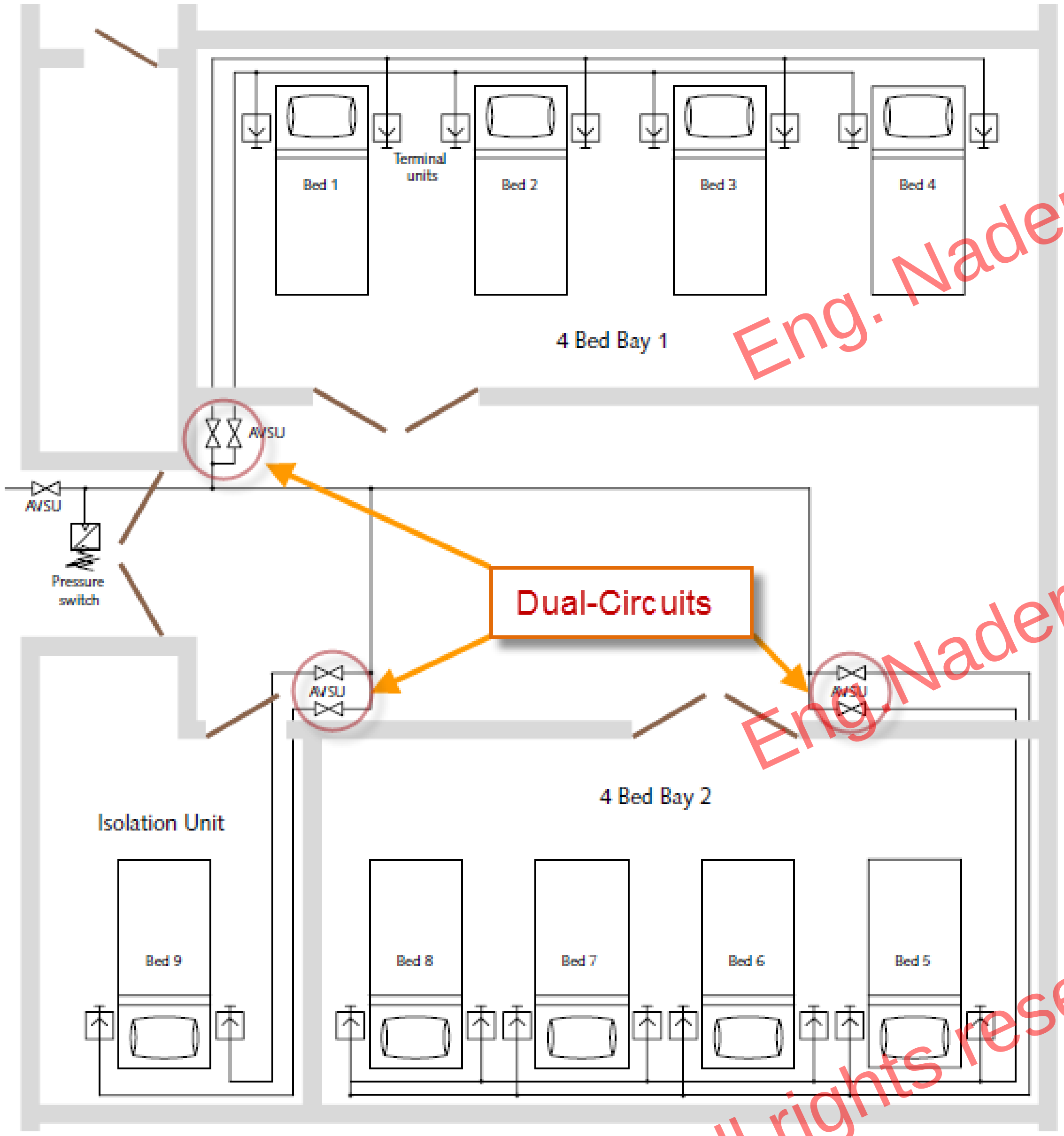
*** ASPE code "health care facilities and medical gas and vacuum systems"**

*تحديد مواضع صمامات خدمة المناطق AVSUs (Zone Valves):

يتم تركيب صمامات AVSUs بحيث يمكن الوصول اليها من قبل طاقم المستشفى وتكون داخل صندوق له غطاء يمكن إزالته في حالة الطوارئ. قواعد تحديد أماكن AVSUs تعتبر جاسئة نسبيا وتعتبر من أصعب مراحل التصميم. يجب تحديد مواضع AVSUs بحيث تكون متوافقة مع القواعد التالية:

1. لا يسمح لأي وحده طرفية Terminal Units بالتواجد بدون AVSUs في نفس الطابق, او بمعنى آخر لابد لكل وحدة طرفية من أن يتم التحكم بها بواسطة AVSU موجود في نفس الطابق.
2. لكل قسم لابد من توفر AVSU تتحكم به وتسمى Departmental AVSU ويتم تركيبها عادة بالقرب من باب مدخل القسم ليسهل الوصول اليها في حالة الطوارئ أو عند الصيانة
3. في أي وحدة أو قسم للرعاية الحرجة Critical Care لابد من التحكم بها بواسطة AVSU الخاص بها ويتم تركيب دائرة مزدوجة Dual-circuit.
4. يتم صف و ترتيب AVSUs بنفس الترتيب المقترح بواسطة الكود لترتيب وصف الوحدات الطرفية.
5. يجب أخذ الحذر للتأكد من أن AVSUs غير محجوبة بواسطة الأبواب وغيرها وتكون في موقع آمن قدر الإمكان ويمكن رؤيتها و الوصول إليها بسهولة. قم باختبار الباب وفتحه للتأكد من أنه لن يحجب AVSU في حالة فتحه وإذا قام الباب بحجب AVSU فلا بد من اختيار مكان آخر لتركيب AVSU.
6. يجب وضع وتركيب AVSUs خارج المكان الذي تتحكم به.
7. يتم اختيار المواضع التي يجب تواجد AVSUs فيها حسب الكود. الشكل أدناه يبين هذه المواضع حسب الكود البريطاني HTM 02-01.





عدد و مواضع AVSU

Department	O_2	N_2O	N_2O/O_2	MA4	SA7	VAC	AGSS	He/O_2	AVSU	Alarm
Accident and Emergency									1 set (1)	1 set hp/lp (9)
Resuscitation room, per trolley space	2	2	–	2	–	2	2	–	2 sets*	
Note: One set either side of the trolley space, if installed in fixed location, eg trunking; or both sets in an articulated supply pendant that can be positioned either side of the bed space.										
Major treatment/plaster room per trolley space	1	1	1p	1	1p	1	1	–	1 set/8 TUs	
Post-anaesthesia recovery per trolley space	2	–	–	2	–	2	–	–	2 sets*	
Note: One set either side of the trolley space, if installed in fixed location, eg trunking; or both sets in an articulated supply pendant that can be positioned either side of the bed space.										
Treatment room/cubicle	1	–	–	–	–	1	–	–	1 set/8 TUs	
Operating department									1 set (1)	
Anaesthetic rooms (all)	1	1	–	1	–	1	1	–		
Operating room, orthopaedic										
For anaesthetist	2	1	–	2	–	2	1	–	1 set per suite (2)(3)	1 set per suite hp/lp (10)
For surgeon	–	–	–	–	4	2	–	–	–	–
Note: Orthopaedic surgery is normally performed in operating rooms provided with ultra-clean systems. Such systems are much more effective in terms of airflow when provided with partial walls. These walls may be effectively used to include terminal units that can be supplied by rigid pipework. Such installations do not suffer from excessive pressure loss when surgical air is required at high flows.										
Operating room, neurosurgery										
Anaesthetist	2	1	–	2	–	2	1	–	1 set per suite (2)(3)	1 set per suite hp/lp (10)
Surgeon	–	–	–	–	2	2	–	–		
Note: If multi-purpose pendants are used, there may be some loss of performance of surgical tools because of bore restrictions and convolution of the flexible connecting assemblies at the articulated joints.										

Warning systems:

1. To give warn about any pressure fluctuation by using line-pressure sensing switches

Warning systems
- **Master alarms**
- **Area alarms**
- **Interface controls (Relays) provided in computerized signal equipment**

Master alarms NFPA requires that two master-alarm panels be provided, located (1) in the engineer's office and (2) in an area where a 24-hour surveillance is maintained. The master alarm provides its signals by a pressure switch (vacuum switch) located immediately downstream from the source's main shut-off valve or at the site of the source. For example, with a liquid-oxygen system, various pressure switches are located at the bulk site, which provide signals to main of reserve changeover, reserve in use, reserve failure, and low reserve. Additional oxygen signals needed for the master alarm are line pressure high and line pressure low.

Typical manifold gases, such as nitrous oxide, require signals to the master alarm to indicate line pressure high, line pressure low, and reserve supply in use.

Area alarms Area alarms are local alarms usually provided with a self-contained pressure switch and a gauge located in the panel. These area alarms monitor the line pressure in areas in order to indicate if the pressure increases or decreases from the normal operating pressure. Except in the operating or delivery area, locations where each operating or delivery room is valved, the area alarm signals are from the specific line supplying the area, with the individual room shut-off valve being the only one between the actuating switch and the room outlets.

Care should be taken by the engineer to locate the area alarm in convenient view of the nursing personnel who normally work in the area covered. In case of a stoppage of the medical gas or any other alarm condition, the proper personnel must take prompt and precise corrective actions. Area alarm signals for critical zones should be interfaced with the master-alarm panels.

Interface controls In order to advise total building maintenance systems of any malfunctions in the medical-gas systems, most manufacturers usually provide a relay interface control so that easy and compatible signals can be provided by the total building maintenance and control system.

٤/٤ - نظم الإنذار:

١ - يتم تزويد نظام انذار طبقاً لإشتراطات NFPA 56F

٢ - تحدد أماكن محطات الإنذار على الرسومات .

٣ - تزود مبينات ضغط على كل محطة إنذار .

٤ - يتم تغذية نظام الإنذار عن طريق الكهرباء العمومية وكهرباء الطوارئ

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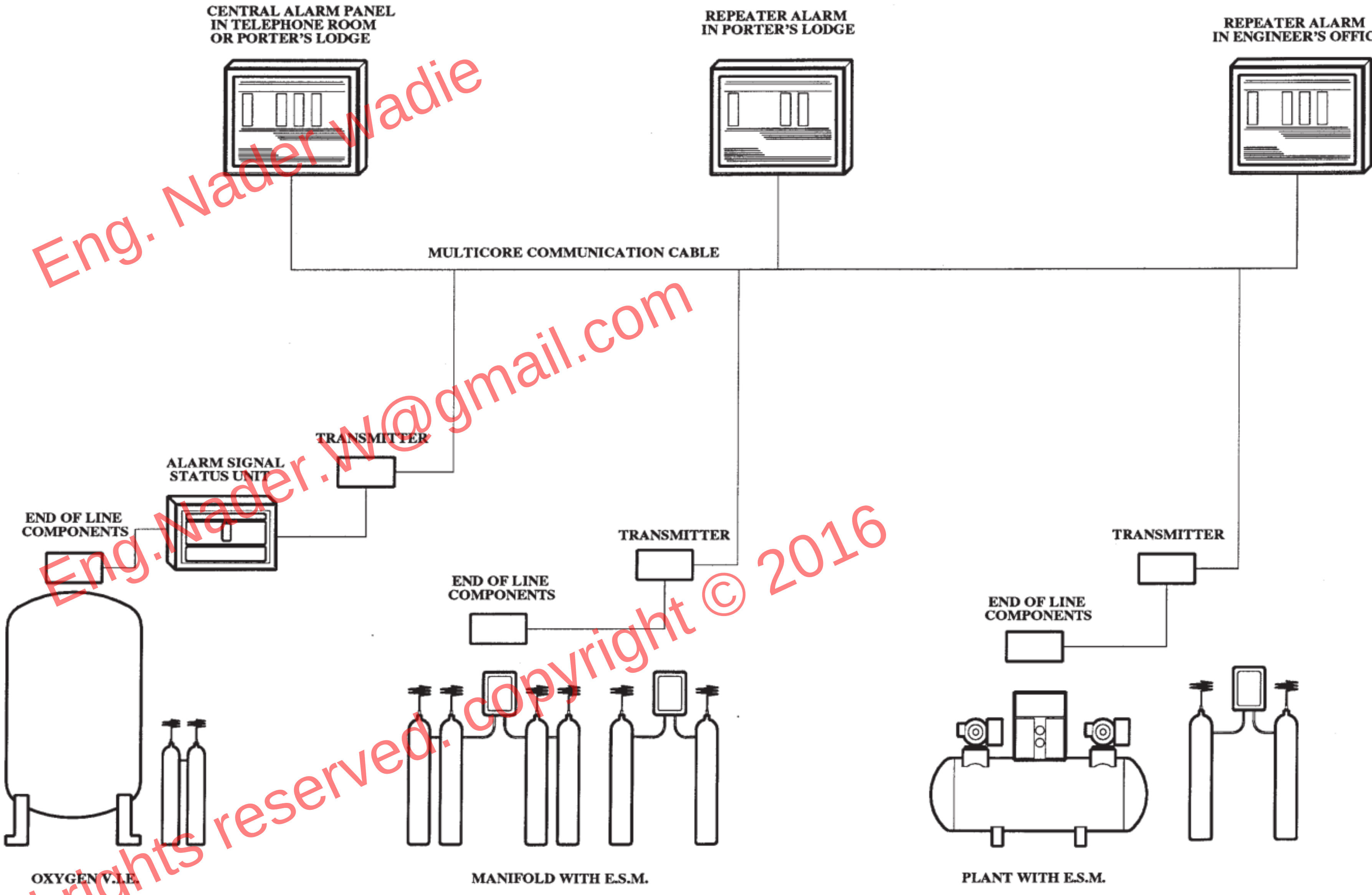
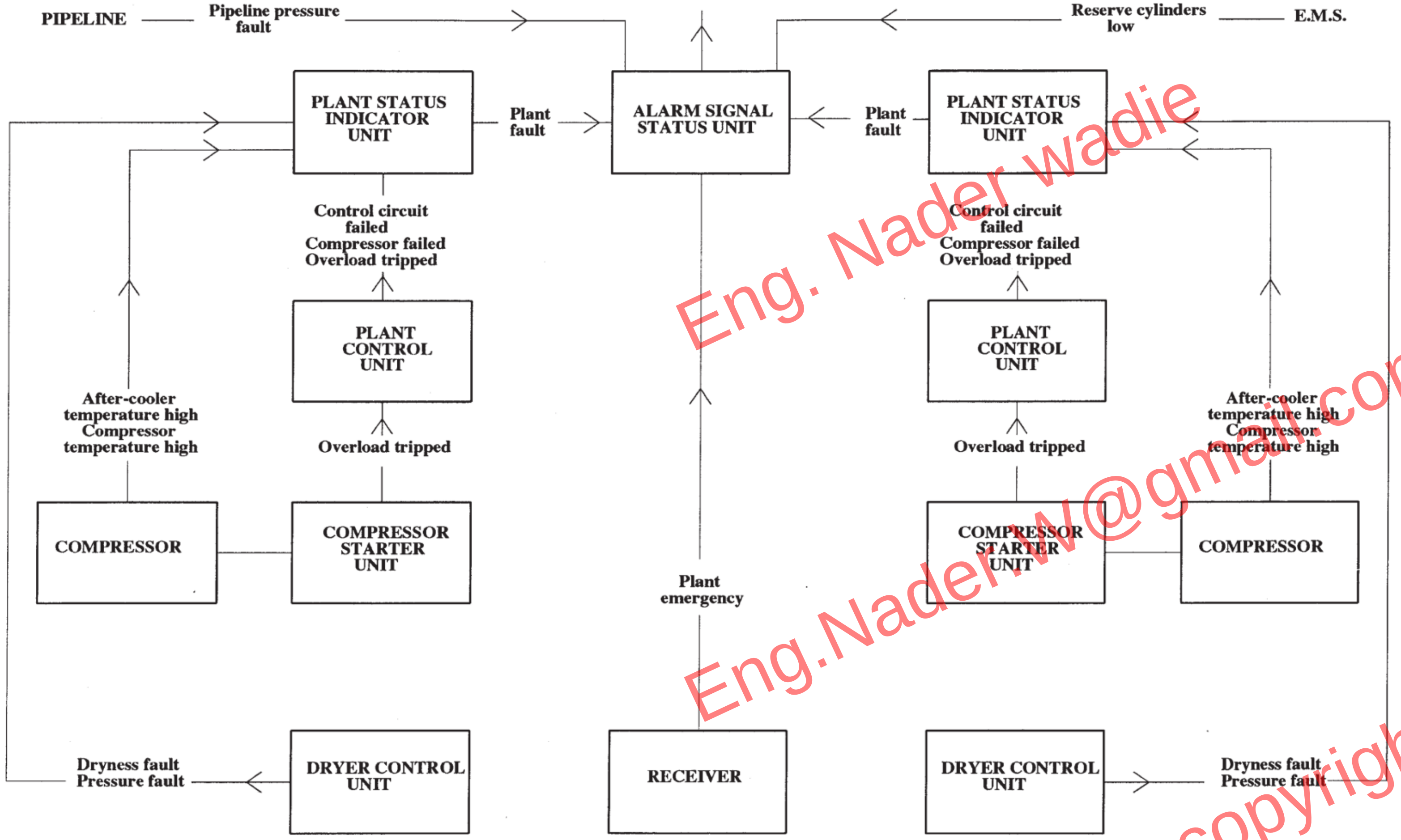


Figure 16 Typical warning and alarm system layout (reproduced by kind permission of Shire Controls)

Figure 18 Signal path for typical plant (reproduced by kind permission of Shire Controls)



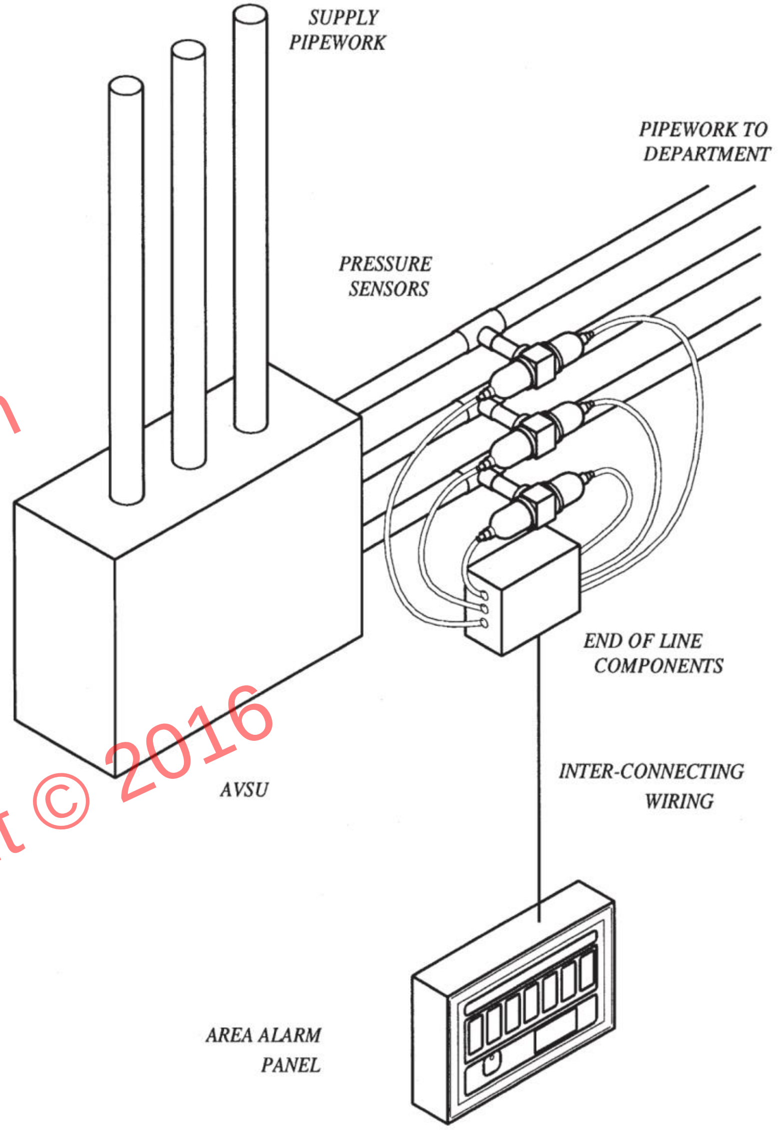


Figure 17 Typical area alarm panel (reproduced by kind permission of Shire Controls)

* Health Technical Memorandum 2022

Manifold indicator unit:
There should be indicators to show the following conditions:

1. for each automatic manifold:
   - a green "running" indicator for each bank. This should display when the bank is supplying gas, irrespective of the pressure;
   - a yellow "empty" indicator for each bank when the running bank is empty and changeover has occurred;
   - a yellow "low pressure" indicator for each bank to be illuminated after changeover, when the pressure in the bank now running falls to the low pressure setting;
2. for each emergency/reserve bank a yellow indicator to be illuminated when the pressure in the bank falls below 14 bar g for nitrous oxide or below 68 bar g for other gases;
3. for the pipeline distribution system a red "low pressure" and a red "high pressure" indicator to be illuminated when the respective conditions occur.

Alarm signal status unit: The following indication of manifold conditions should be provided:

Indication	Legend
1. green "normal"	normal
2. yellow "duty bank empty, standby running"	change cylinders
3. yellow "duty bank empty, standby low"	change cylinders immediately
4. yellow "emergency/reserve banks low"	reserve low
5. e. red "pipeline pressure fault"	pressure fault

* Health Technical Memorandum 2022

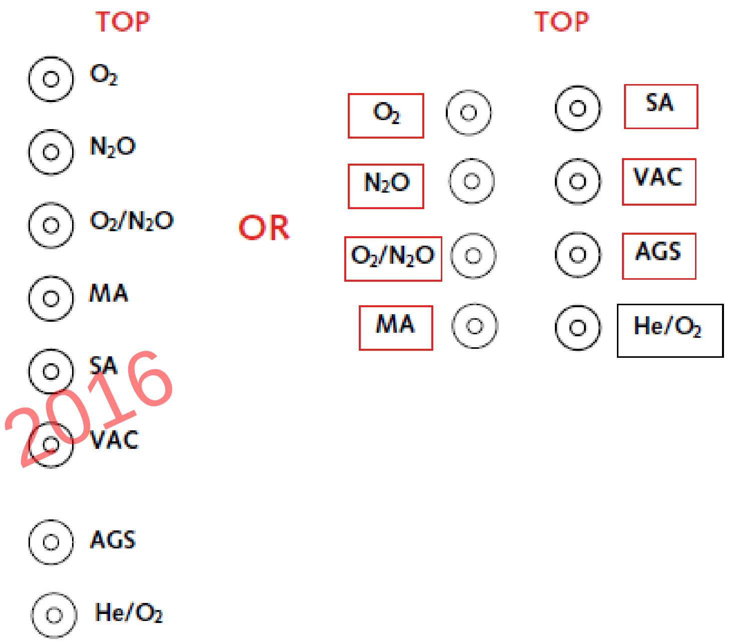
F. Terminal Units

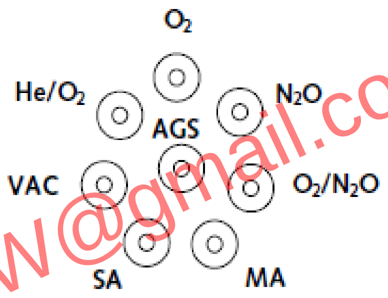
HTM2022: Mounting heights for terminal units should be between 900 mm and 1400 mm above finished floor level (FFL) when installed on walls or similar vertical surfaces.

٤/٢/٧ اشكال وطراز المخارج يجب اعتمادها من إدارة المستشفى في حالة وجود أكثر من مخرج تركب عادة على قاعدة مشتركة بحيث تكون من اليسار إلى اليمين بالترتيب العالي أكسجين – أكسيد نتروز – هواء مضغوط – وشفط .

WALL MOUNTED TERMINALS – Horizontal array

WALL MOUNTED TERMINALS – Vertical array





CIRCULAR (eg pendant) – Viewed from below

Where, in some ward areas, terminal units are installed in recesses behind covers/decorative panels etc, allow an additional 100 mm on each side of the outermost terminal units and 200 mm from centre to top of recess and 300 mm from centre to bottom of recess. The depth of the recess should be 150 mm.

3.17 Terminal units which are wall mounted should be located as follows:

a. distance between centres of adjacent horizontal terminal units:

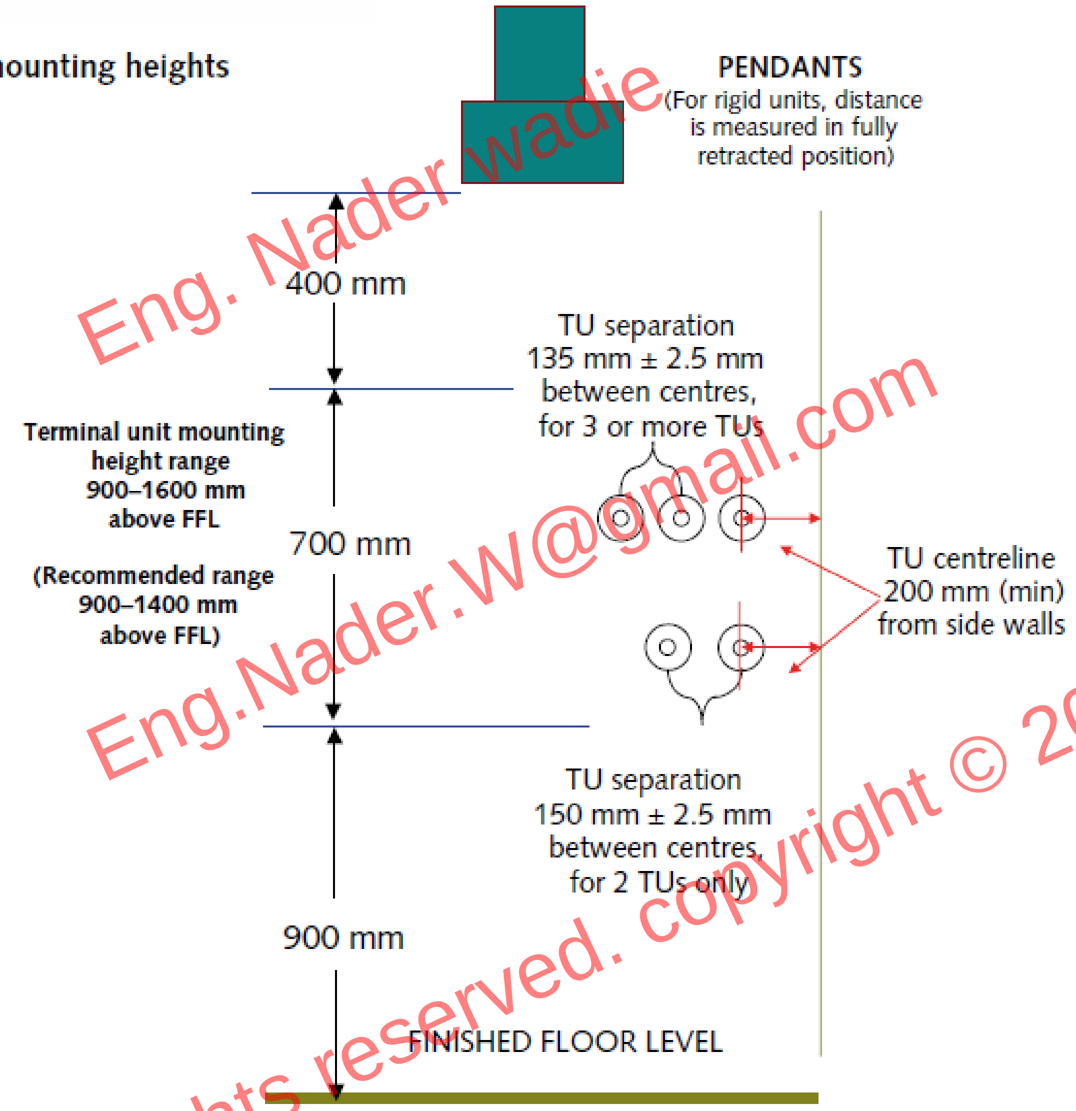
(i) 35 ± 2.5 mm for three or more terminal units;

(ii) 150 ± 2.5 mm for two terminal units only;

This should be sufficient for double flow meters to be used, for example between an oxygen terminal unit and a vacuum terminal unit serving two bed spaces;

b. the distance between the centre of the terminal unit and a potential obstruction on either side (for example when installed in a corner) should be a minimum of 200 mm on either side.

Terminal unit mounting heights



بعض اشتراطات الكود المصري:

٦/٤ - نظم الامداد بأكسيد النتروز:

١/٦/٤ - أسس التصميم

- تتبع الطريقة الأفتراضية السابقة لتحديد الأقطار الإبتدائية للمجمع الداخلى لأكسيد النتروز (يراعى مراجعة المورد قبل التوريد)
- يزود اسطوانة واحدة للتشغيل وضعف هذا العدد كاحتياطى .
- يراعى توفير مسطح كاف فى غرفة الإسطوانات للإسطوانات الإحتياطية .
- يراعى عدم تركيب موزع أكسيد النتروز خارج غرفة لتلافى مشاكل التشغيل فى الجو البارد .

يتم اختيار مكان الوحدة بالإشتراك بين مجموعة المصمم والمعمارى والمورد .

يراعى توفير ممرات لدخول سيارات الخدمة ومراعاة حد أدنى للإرتفاعات .

- تجهز الأماكن التالية بمخارج لأكسيد النتروز وطبقاً للتصرفات المبينة فيما بعد ، وقد تم امداد بعض الغرف الأخرى بمخارج لأكسيد النتروز طبقاً لبرنامج التشغيل .

يراعى مراجعة برنامج الامداد والإحتياجات لجميع المخارج والجدول رقم (٤-٣) يبين أماكن امداد المخارج المختلفة وتصرفات كل منها .

٧/٤ - نظم الامداد بالنتروجين:

١/٧/٤ أسس التصميم

- تتبع الطريقة الإفتراضية لتحديد الأقطار الإبتدائية لمجمع النتروجين (يراجع مع المورد قبل الإنتهاء من التصميم)

تزود ٢/١ ١ اسطوانه لكل غرفة عمليات تحتاج إلى نتروجين وضعف هذا العدد كاحتياطى للمجمع الإحتياطى .

يراعى توفير مسطح كاف فى غرفة الإسطوانات للإسطوانات الإحتياطية .

يتم إنشاء وتحديد موقع وحدات الإمداد بالإشتراك بين كل من الجهاز المصمم والمعمارى . يراعى توفير ممرات لسيارات الخدمة ومراعاة حد أدنى للإرتفاعات .

* **Notes**:

Fire detection system

2.32 Smoke or heat detector heads should be installed in the plantrooms, medical gases manifold rooms and (when internal) medical gases cylinder stores in any hospital having a fire detection system in accordance with HTM 82 'Firecode alarm and detection systems'.

و – يراعى عدم تطبيق معامل الإستخدام على المخرج الآخير من الماسورة ويطبق معامل الإستخدام على المخارج الإضافية على الماسورة .

ز – يجب عدم الأخذ فى الإعتبار معامل الإستخدام عندما يكون حجم الهواء الناتج من تطبيقه أقل من حجم الهواء الناتج من مخرج واحد .

Any Questions ?