Asia Industrial Gases Association
(Webinar 007)

Medical Gas Supply Systems at Healthcare Facilities

Asia Industrial Gases Association

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

MS

Agenda

- Welcome – By Milan Sarkar, AIGA Secretary General
- AIGA Introduction – by Haris Farooqi, AIGA TC Chairman
- Webinar Objectives & Disclaimer
- Introduction of the Presenters
- Past Incidents & Learning Points
- Overview of Medical Gases
- Sources of Supply
- Medical Gas Supply Systems
- Safety Protection Considerations
- System Components
- Testing/Commissioning and Operational Management
- 93% Medical O2 Generators
- Key References
- Wrap-up
- Q&A

AIGA and Key Members

About AIGA: Formed in Dec 2002 in Singapore as a non-profit association representing Industrial Gases companies operating in Asia.

Mission: To promote better safety, health, environmental awareness and security in production, distribution and use of industrial gases.

Active Members: Category - 1 and 2

Air Liquide creative oxygen | AIR PRODUCTS | Linde | AIRWATER www.AirWater.com | Iwatani International Corporation | NIPPON SANSO HOLDINGS | MESSER

Associate Members

G-gas | 盈德气体 YINGDE GASES | 宝钢气体 BAOSTEEL GASES | 杭州制氧机集团股份有限公司 HANGZHOU OXYGEN PLANT GROUP CO.,LTD.

8 National Association Members

- India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand

Representative Offices

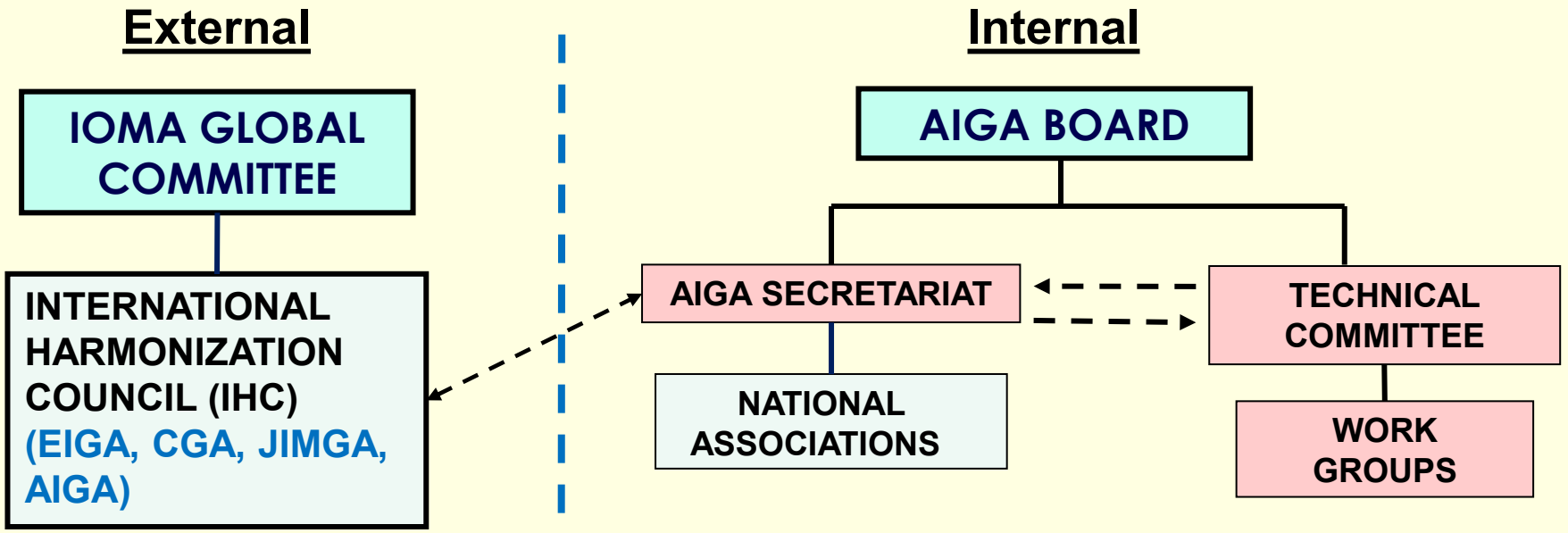
- China and Vietnam

Reciprocal Members

- CGA, EIGA, JIMGA, MEGA & ANZIGA

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Organizational Links



AIGA BOARD Office Bearers & Members

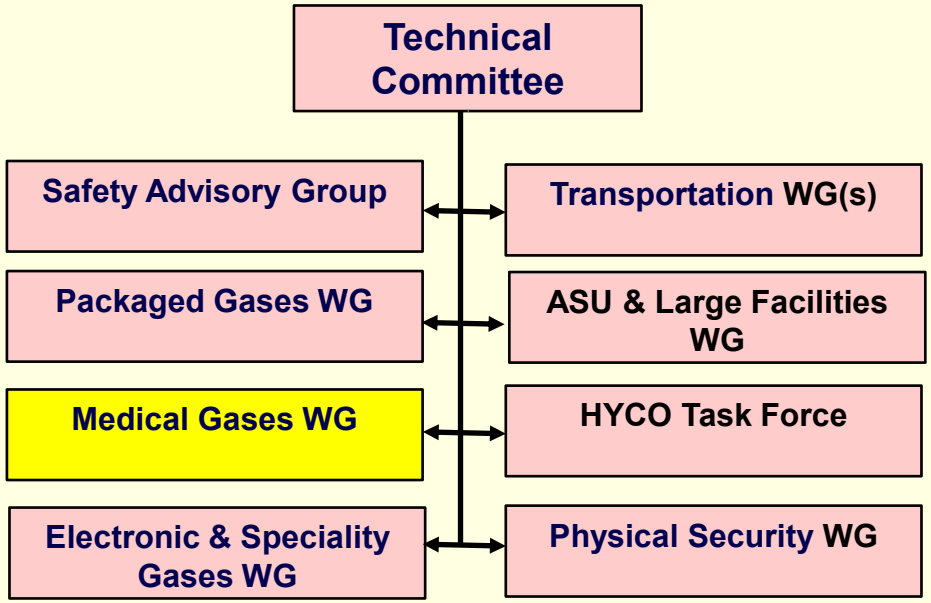
President	**Francois Abrial (Air Liquide)**
Vice-President	John Panikar (Linde)
Treasurer	Hitoshi Ishihara (NSHS)
Secretary	Werner Hickel (Messer)
Members	Wilbur Mok (Air Products) Kiyoshi Shirai (Air Water Inc) Makoto Horiguchi (Iwatani Corp)
Ex-Officio	Haris Farooqi (AP), TC Chairman Milan Sarkar, Secretary General

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

AIGA Technical Committee Focus

AIGA TC is currently focused on 8 priority areas:

1. SAG(General Safety & sharing of incidents/ learnings)
2. Packaged Gases
3. Medical Gases
4. Electronics & Specialty Gases
5. Transportation of Packaged & Bulk Gases
6. ASU & Large Facilities
7. HYCO
8. Physical Security



No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Technical Committee: Major Deliverables

- AIGA Publications (available on AIGA website: > 150 in nos
  - > 115 Standards/ Guidelines/ Codes of Practices
  - > 28 Training Packages
  - > 25 Safety Bulletins
  - Several Safety Posters and Position Papers
- Co-hosting of multiple Safety Seminars every year with National Associations
- Engagement with National Associations - face-to-face meetings – 3 per year
- Actively promote AIGA activities among various stake holders
- Participation in global harmonization of standards at IHC
- Carry out need based technical surveys on specific topics
- Sharing of learning from safety events and compilation of safety statistical data
- Collaborate with non-AIGA Associations - AIIGMA (India) & CIGIA (China)
- Communication with IOMA GC and Regional Associations (CGA, EIGA,JIMGA)

Please visit www.asiaiga.org for more details

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Webinar Objectives

Elevated demand for Medical Oxygen amidst the COVID-19 pandemic has led to shortages of oxygen in various parts of the world. Some healthcare facilities are struggling to keep pace with the surge in demand. The Gas Industry stands committed to ensuring that healthcare professionals are equipped with the necessary knowledge to cope with this unprecedented challenge.

The objective of this webinar is to reiterate the key points:

- How to ensure a safe & reliable supply of medical gases to healthcare facilities and patients
- To emphasize that consequence of system failure could be severe, or even fatal
- Importance of understanding the requirements on the design and installation of medical gases supply and pipeline system by both the suppliers and hospitals
- Participants in the webinar should be able to convey this knowledge to related stakeholders in an appropriate manner that is convenient for their country and organisation

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Disclaimer

- All publications of AIGA or bearing AIGA's name contain information, including Codes of Practice, safety procedures and other technical information that were obtained from sources believed by AIGA to be reliable and/ or based on technical information and experience currently available from members of AIGA and others at the date of the publication. As such, we do not make any representation or warranty nor accept any liability as to the accuracy, completeness or correctness of the information contained in these publications.

- While AIGA recommends that its members refer to or use its publications, such reference to or use thereof by its members or third parties is purely voluntary and not binding.

- AIGA or its members make no guarantee of the results and assume no liability or responsibility in connection with the reference to or use of information or suggestions contained in AIGA's publications.

- AIGA has no control whatsoever as regards, performance or non performance, misinterpretation, proper or improper use of any information or suggestions contained in AIGA's publications by any person or entity (including AIGA members) and AIGA expressly disclaims any liability in connection thereto.

- AIGA's publications are subject to periodic review and users are cautioned to obtain the latest edition.

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Presenters

- Sawet Thananirun
- Linde PLC
- Position : Head of Cylinder operation and Customer Engineering Service _ ASEAN
- Experience : 27 Year in Industrial gases operation and installation
- Base location: Thailand

- Jerry Guo
- Air Liquide
- Position : Director of Medical Gases
- Experience : Medical gas supply and business development
- Base location: PR China

Past Incidents & Learning Points

Incident #1 – Oxygen Fire in Hospital

On 29 Sep 2008, the fire occurred at 08:30 hrs in a four bed intensive care ward in the Cardiac Wing

- Paediatric patients were being treated with Berlin Heart machines (where a lot of oxygen is used)
- The fire was all over in 10 minutes and fortunately no patient was hurt

Cylinder – Typical of the one involved in the incident

What the cylinder looked like after the incident

What the hospital ward looked like after the incident

Past Incidents & Learning Points

Incident #1 – Oxygen Fire in Hospital

Incident Investigation

- Electrical fault from a mounted television started the incident
- Excessive number of cylinders in ward, coupled with large quantities of pipeline oxygen delivered to the medical devices in the ward
- Soft toys and combustible material present in the vicinity (Potential oxygen enrichment on soft material, intensifying the fire)
- Cylinder in vicinity became hot in the fire and led to a massive explosion, releasing large amount of oxygen into the fire

Learning Points

- Risk assessments to be carried out to address oxygen safety
- Provide oxygen safety training to staff (oxygen enrichment, combustibles)
- Always use pipeline supplies to minimise the number of cylinders on the ward – especially those brought in by patients

Past Incidents & Learning Points

Incident #2 – Pipeline Oxygen concentration fell to 40%

On 28 Oct 2005, an anaesthetist noticed that the percentage of oxygen in the hospital supply system had dropped from the normal 100% to around 40%, raising independent alarms throughout the hospital.

- Anaesthesiologist mandated no new procedure to commence and all operating theatres were suspended

Incident Investigation

- Med O2 line was **contaminated** with Med Air by contractor in the absence of installation drawing
- Existing lines were **wrongly labelled**
- Contractor **didn't check the line content** before modifying pipework
- Hospital Authority was **not notified about commissioning** of new lines

Proper labelling of pipeline

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Past Incidents & Learning Points

Incident #3 –Portable Liquid Containers(PLCs)- Wrong product connected:

On 7 Dec 2000, a nursing home reported 2 patient deaths and 8 patient injuries following a mix-up in their oxygen supply system

- Several days later, 2 of the injured patients succumbed to injuries from exposure to industrial nitrogen, bringing the death total to 4

Incident Investigation

- The nursing home was running low on oxygen and deployed a maintenance employee to connect a new oxygen PLC to the oxygen supply system
- Employee had selected a nitrogen PLC and discovered that he was unable to connect the vessel due to different fittings. Employee then removed a fitting and install it on the nitrogen PLC. He then proceeded to connect the nitrogen PLC to the oxygen system.

Adapter must not be used

Past Incidents & Learning Points

Incident #4 – Medical gas installation – pipework cross connection

- A hospital wanted to modify its existing gas supply for an expansion project. The modification was to move existing piping to facilitate civil works (by another contractor) and to add connections to supply gases to 8 delivery rooms and an operating theatre
- When performing pre-startup checks in the operating theatres on the next working day, the anesthetist's stations started to alarm indicating low oxygen level in supplied gas. Fortunately, No patients were involved!

Incident Investigation

- Mandatory supervision and oversight must be provided for such as work on hospital installations.
- Contractors should be trained and qualified as employees to be able to work unsupervised.
- To ensure all process changes, design or piping changes MUST be subject to the Management of Change (MOC) process

Overview of Medical Gases

Gas	Uses	GHS Hazards
O_2	- Breathing Assistance - Medical Treatment Deliveries - CMG Mixtures for Hyperbaric Chambers	
Air	- Breathing Assistance - Medical Treatment Deliveries	
N_2O	- Sedation/Anaesthetic	
CO_2	- Insufflating for less invasive surgeries	
N_2	- Cryosurgery Removal - Operate Power Tools	

 Oxidizing

 Compressed Gas (Pressure)

 Harmful (Acute Toxicity)

AIGA *Asia Industrial Gases Association*

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

JG

Overview of Medical Gases

- **Expectations** – Provide uninterrupted supply to end users
  - **Primary** and **Secondary** supply (**Reserve** supply may be installed as per national requirements)
  - **Alarms** for abnormal conditions
  - **Equipment Sizing and Material Selection** based on normal and abnormal situations
  - Able to handle **worst-case** scenarios

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Sources of Supply

Gas in **Cylinders** or **Cylinder Bundles**

Cryogenic liquid in **Stationary Vessels**

Portable Liquid Cylinder

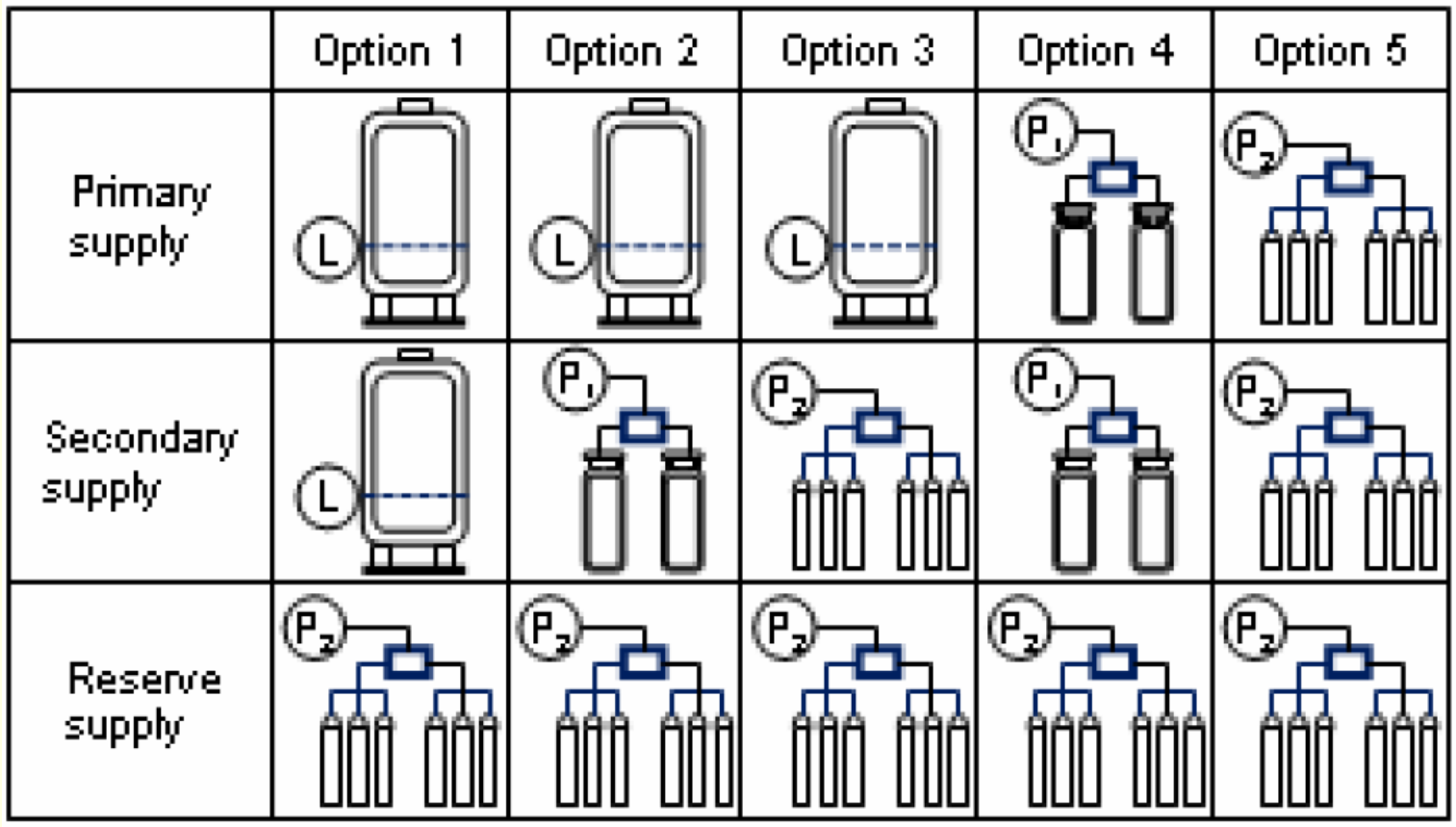
Gas Cylinders connected to a **Manifold**

AIGA *Asia Industrial Gases Association*

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Sources of Supply

Typical Medical Supply Systems



L : Level Alarm Switch

P : Pressure Alarm Switch

Figure 1: Typical Medical Supply Systems *(Source: AIGA 049/17 Guideline to Medical Oxygen Supply System for Healthcare Facilities)*

Sources of Supply

Storage & Capacity Requirement

- The selection of location should **comply with applicable Local/National regulations**
- **Avoid** installing liquid storage vessel in **indoor environment** or near **drains/pits**
- The control equipment should be **protected** from the **weather** and the area **fenced**
- Oxygen cylinder storage should be separated from vacuum and medical air compressor plant to **avoid** possible **oil contamination**
- Appropriate **undercover** storage facilities for cylinders should be provided to maintain cylinder safety, security and cleanliness
- The capacity of any supply system shall be based on the **estimated usage** and **frequency** of delivery
- Have systems to **regularly review** healthcare facility demand patterns for ensuring that the bulk medical supply can reliably meet this demand

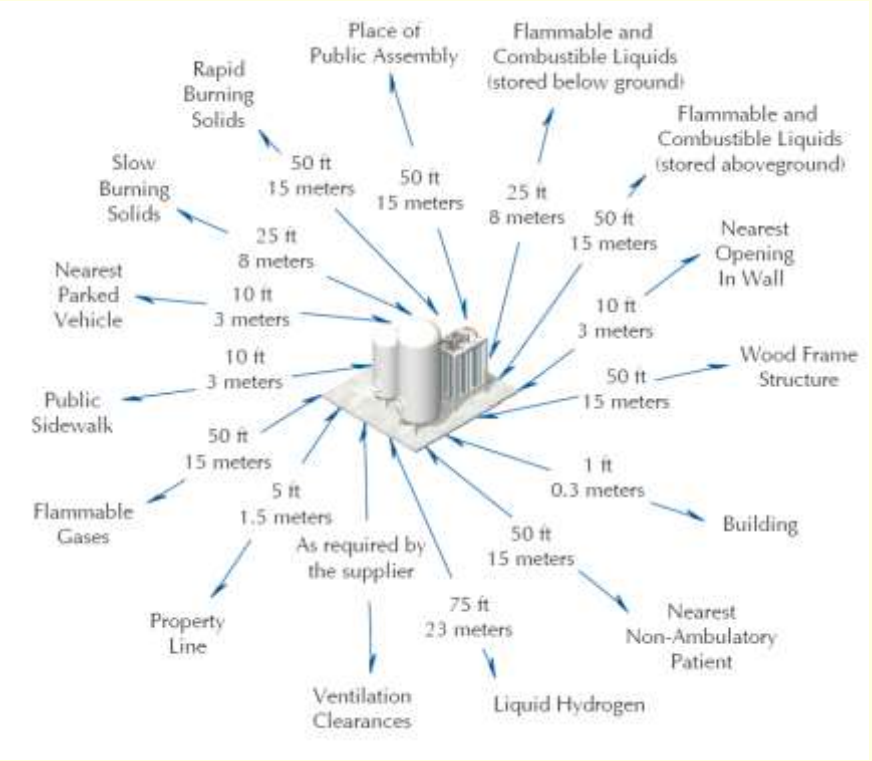


Figure 2 : Safety Distance Guidelines: Refer to NFPA 55 for additional details

Sources of Supply

Capacity :

- Requirements should be based on estimated usage and delivery frequency
- Location should be consulted with the gas supplier
- Demand should be regularly reviewed (eg. O2 demand increase during the Covid-19 Pandemic)

Primary Supply

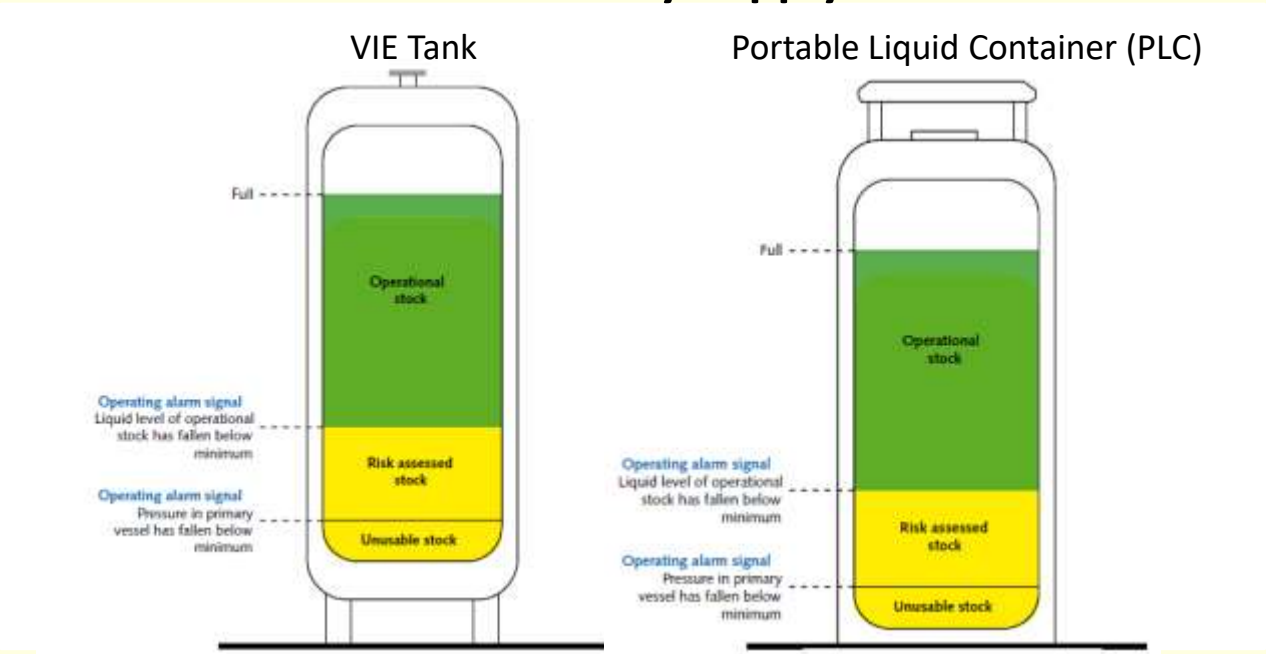


Figure 3 : Primary Supply Stock Management & Reordering *(Source: HTM 02-01 Medical Gas Pipeline Systems Part A)*

Sources of Supply

Secondary Supply

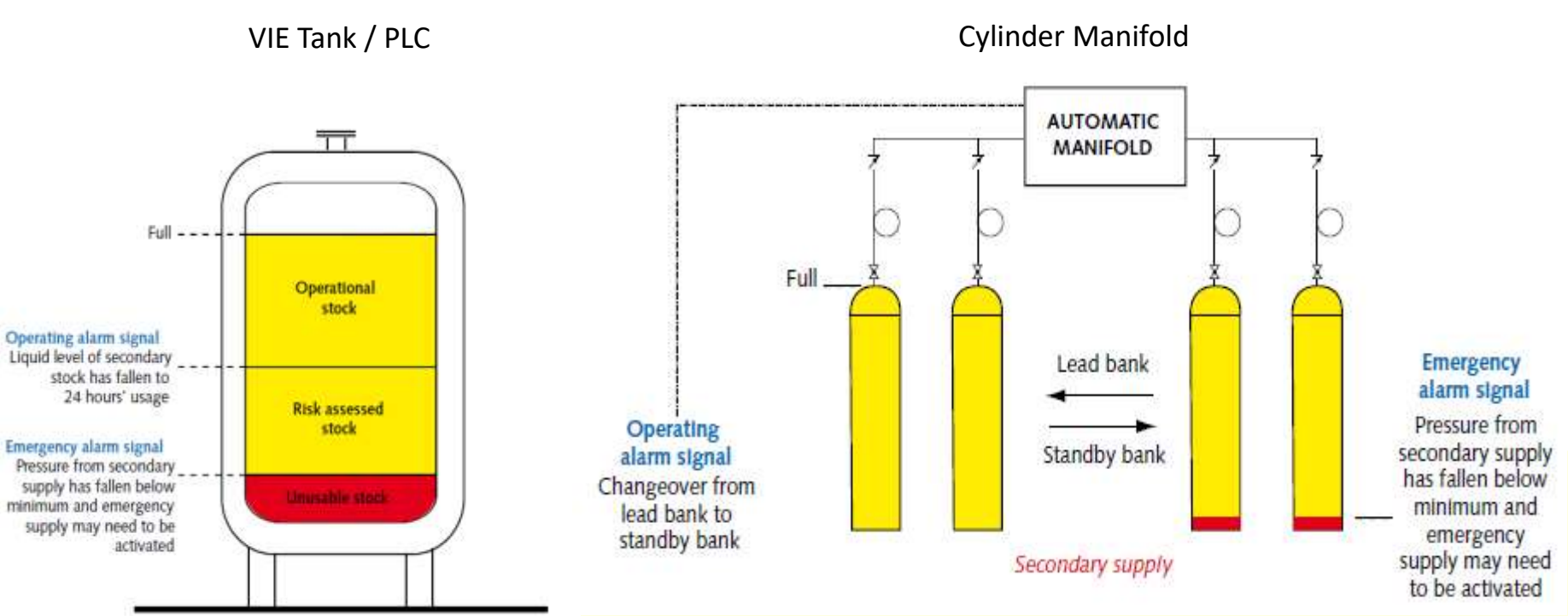
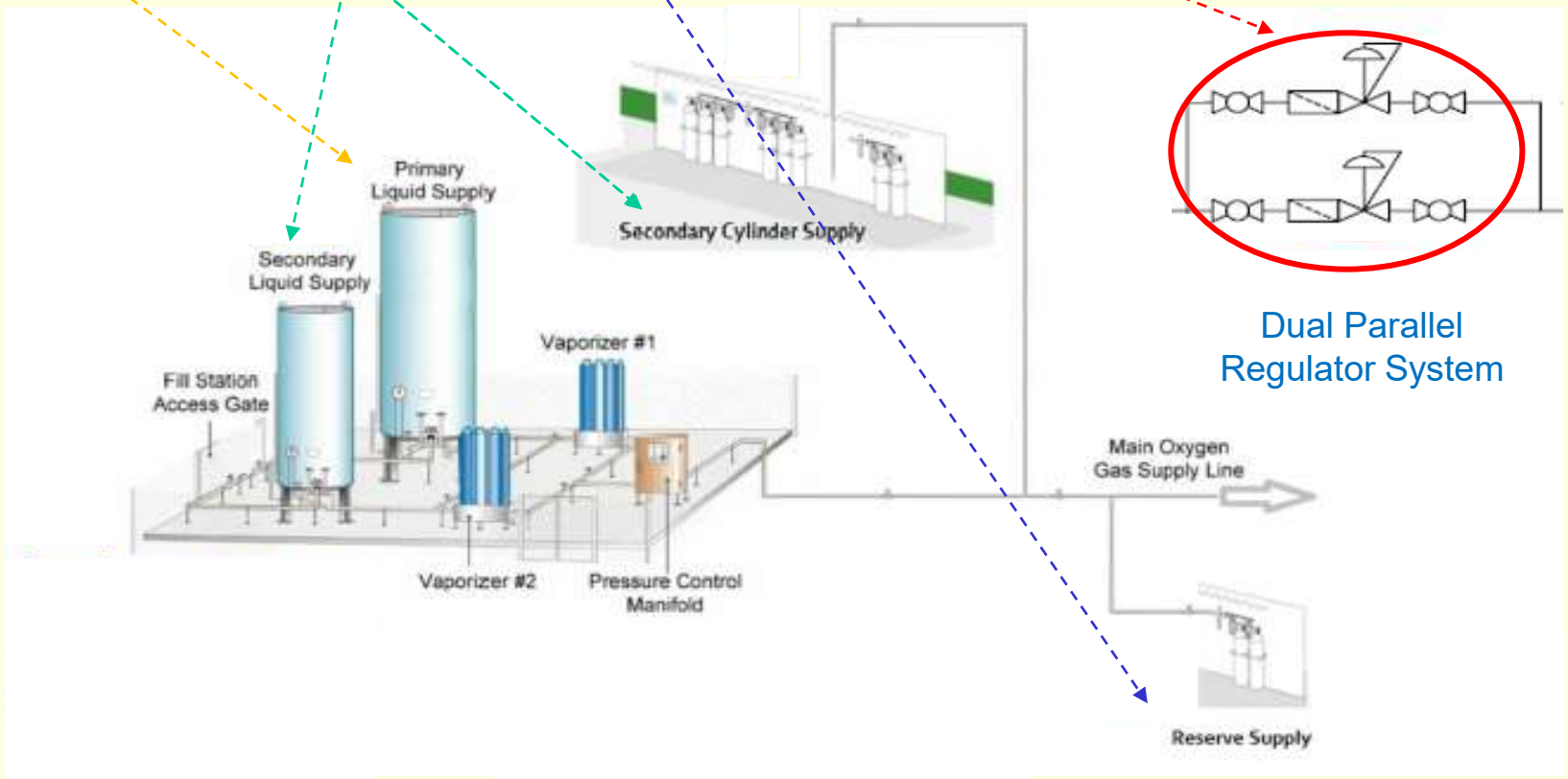


Figure 4 : Secondary Supply Stock Management & Reordering *(Source: HTM 02-01 Medical Gas Pipeline Systems Part A)*

Medical Gas Supply Systems

- **Dual Parallel Regulator System**
- **Primary, Secondary & Reserve Supply Sources**



Safety Protection Considerations

Alarm System

Alarm 'ON' when any of the following occurs:

- Primary Supply – Below MIN Level, Below MIN Pressure
- Changeover from primary to secondary supplies
- Secondary or Reserve Supply – Below MIN Level, Below MIN Pressure
- Deviation of pipeline pressure by more than ± 20 %

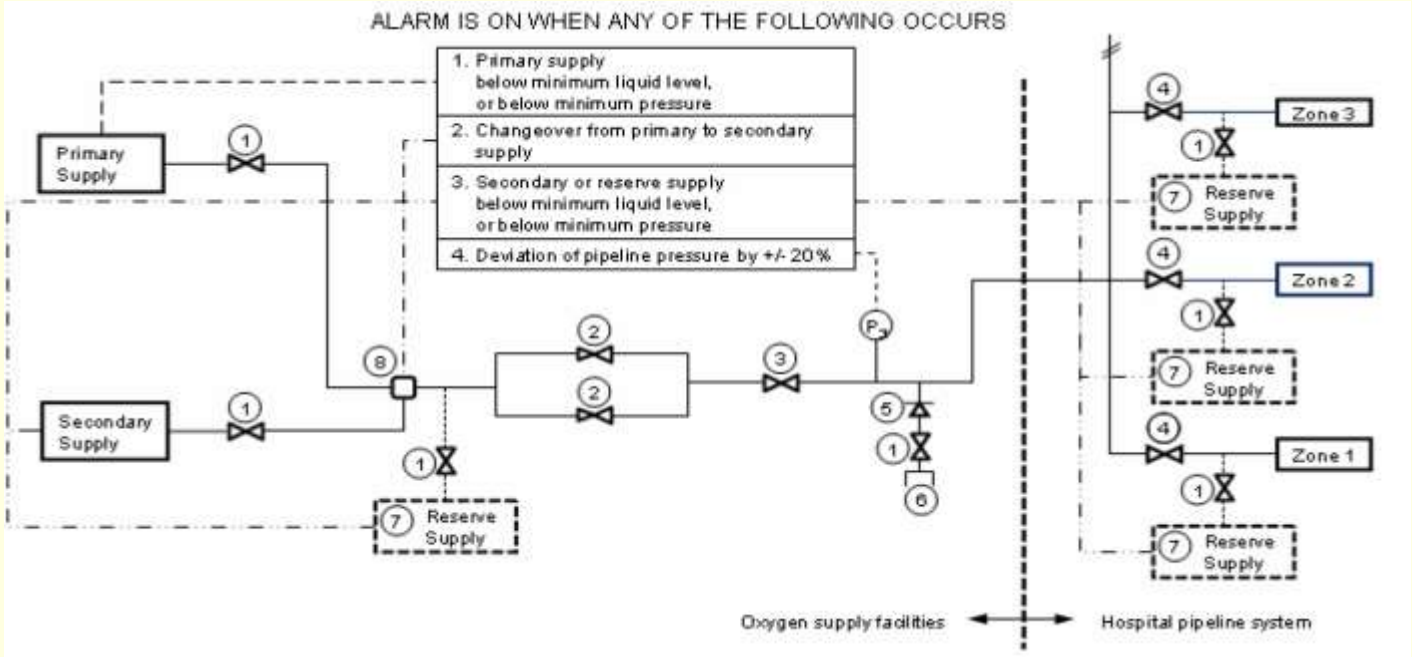


Figure 5: Typical Alarm Systems *(Source: AIGA 049 Guideline to Medical Oxygen Supply System for Healthcare Facilities)*

Safety Protection Considerations

Alarm System

Requirements:

- **Both** Audio and Visual Alarms
- Silencing of an existing audio alarm shall not prevent a new alarm from blaring
- Periodic tests
- Master Alarm to be strategically located

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

System Components

Pressure Reducing Unit

- The healthcare facility supply pipeline pressure reducing station must consist of a **dual parallel regulator system**
- Both regulators must be **online** and all **isolation valves** and regulators must be in the **open** position.
- The design based on a single pressure regulator with a **by-pass is not accepted.**
- The **nominal distribution pressure** should be within the range of 400 kPa to 500 kPa.

System Components

Pressure Relief Valve

- Medical oxygen pipeline system should be provided with a **pressure relief device downstream** of the line pressure regulator
- A **three-way valve** to be installed for the safety device can be exchanged for a certified replacement in accordance with the frequency required by the Regulations

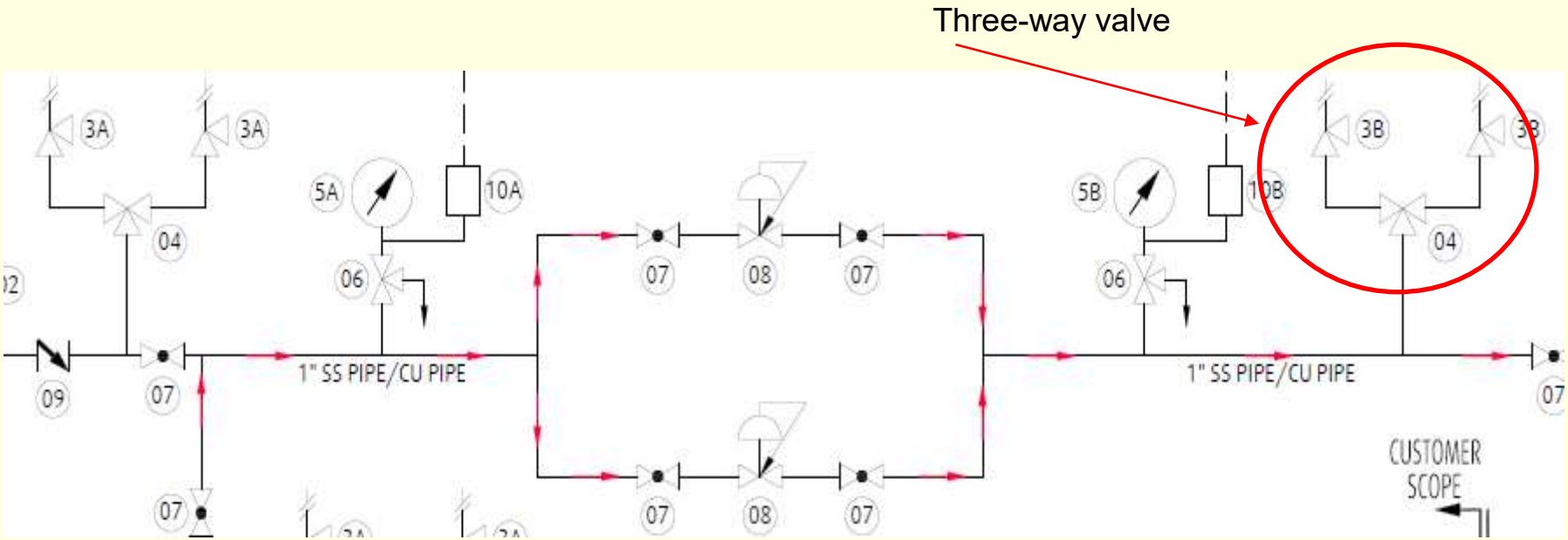


Figure 5: Typical Pressure Relief Device locations

System Components

Check Valve and Filter

- Check valves should be installed to **prevent cross flow** between the different supply systems

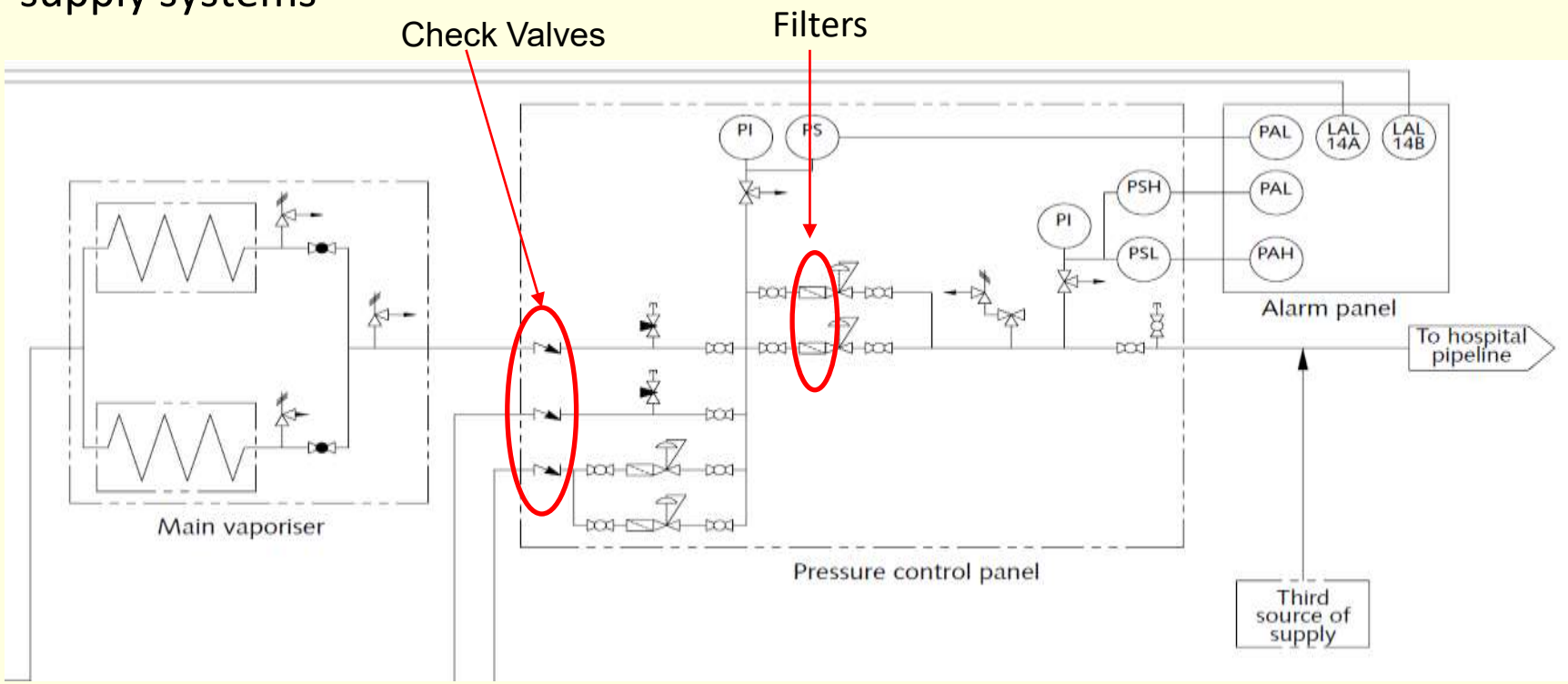


Figure 5: Typical locations of Check Valves and Filters

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

System Component

Material Selection

- Ensure **Oxygen Compatible material** is used for oxygen supply system which comes into contact with the gas under operating conditions
  - Metals – Austenitic SS304 / 316, Copper and Alloys, Monel (CS / MS Forbidden, Al with some conditions)
  - Non-Metals – PEEK, PTFE (Only for Cryogenic Application, NO HALOGENS) *Refer to AIGA 059*
  - Lubricants – Avoid use of oils & greases
- Consider flammability and Auto ignition temperature

Ref AIGA 059: Use of Non Metallic Materials in High Pressure Oxygen Breathing Applications

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Testing/Commissioning and Ops Management

Testing and Commissioning

- Carry out Pre Start Up Safety Review to ensure that all the necessary design, safety and performance requirements of the supply system will be met
  - It is required for new installations, additions/modifications to existing installations

Operation Management system

- Compliance to applicable Regulatory requirements
- Clarity about Functional Responsibilities
- Availability of Operational procedures
- **Training and communications**
- Cylinder and sources of supply management established
- Preventive maintenance, repair and risk assessment
- **Emergency Response Plan**

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Medical O2 93% Generators

- PSA Oxygen 93% can be manufactured on-site within the healthcare facility, under the responsibility of the healthcare facility qualified personnel
- **Suitable for production and supply of oxygen** at sites **where access for cylinders and liquid oxygen supplies are difficult**
- 93% O2 manufactured via PSA process are allowed for medical use by most country Authorities
- Oxygen 93% are produced using pressure swing adsorption process (PSA) or vacuum swing adsorption (VSA)

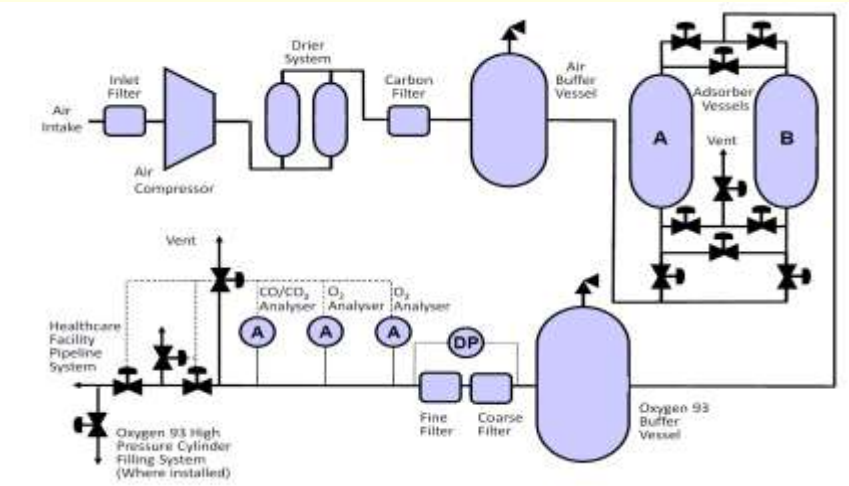


Figure 5: Typical 93% PSA Oxygen Generator Skid and Process Flow Scheme (not meant for design)

Key References

International Standards

- ISO 7396-1, 2016 Medical Gas Pipeline Systems – Part 1: Pipeline Systems for Compressed Medical Gases and Vacuum
- HTM 02-01 Medical Gas Pipeline System –
  - Part A: Design, Installation, Validation and Verification
  - Part B: Operational Management
- NFPA 99, 2015 Health Care Facilities Code

AIGA/EIGA/CGA References

- **AIGA 049 - Guideline to medical Oxygen Supply system for healthcare facilities**
- AIGA 019 – Connections for Portable Liquid Cylinders
- AIGA 024 – Connections for Transportable and Static Bulk Storage Tanks
- AIGA 016 – Safety Features of Portable Cryogenic Liquid Containers for Industrial and Medical Gases
- AIGA TP 05/05 – Prevention of Over Pressurization
- AIGA 059 – Use of Non-Metallic Materials in High Pressure Oxygen Breathing Gas Applications
- AIGA 113-20 : Safe Design and Operation of Onsite Generation of O2 93% for Medical used
- EIGA Doc 73/08/E Design Considerations to mitigate the potential risks of toxicity when using non-metallic materials in high pressure oxygen breathing systems
- CGA M-1 2013 – Standard for Medical Gas Supply Systems at Healthcare Facilities

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Suggested Actions for Participants

An increase in the demand for Medical Gases amidst the COVID-19 Pandemic has prompted:

- Increased frequency of cylinders changeout or stationary tank top up
- Temporary systems to cope with higher Medical Gases demand
- Increased capacity of bulk medical gas supply system
- Additional vaporizers / higher frequency of vaporizer de-icing
- Higher than normal reorder points within the facility
- Increased regulator set pressure or use of existing spare regulator in parallel
- Reduced licensing time for new system or upgrading of existing system

- If you do encounter any of the above changes, we urge you to immediately review your facilities or medical supply systems
- Use Management of Change (MOC) Process with review and approval by competent people while doing any modification/addition etc
- Share the knowledge with people associated with design, installation, Operations and Maintenance of the Supply Systems at hospitals

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Q&A

Please use messaging for your questions

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org

Thank You

No 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org