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Operation Discipline in the Upkeep of Medical Gases Installation and Cylinder Back Up System at Healthcare Facilities

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Background

Medical gas supply failure within healthcare facilities is ongoing problem and it has been topic of many publications over the years. The consequences were all potentially life-threatening and are often associated with death. Strict operation discipline and implementation of cylinder backup system are some of the key considerations for a safer and more reliable medical gas supply to healthcare facilities. This publication provides a general guideline to implement cylinder backup system at medical gas installations and highlights the causes as well as detailed methods for prevention of similar accidents.

Case 1 : Central oxygen pipeline failure (Aug 2012)

A central oxygen pipeline failure occurred throughout a hospital after the explosion took place in main oxygen supply system, transpired when a maintenance employee welding in the presence of an unidentified oxygen leak. All elective procedures in hospital were cancelled and operating theatres placed on standby to deal with emergencies only. The failure lasted for almost seven hours after the clinical technologist ordered oxygen cylinders from medical gas stores and connect them to existing system. Within the next hours, the rupture was repaired and oxygen supply to hospital resumed. Fortunately, there were no deaths or serious consequences as a result of the central oxygen pipeline failing.

Lessons to be learned

- Ensure that a cylinder backup system for critical medical gas pipeline system is available. Healthcare facilities is encouraged to conduct regular audit of their central gas supply systems regarding the rate of daily oxygen consumption and adequacy of backup system in the event of an interruption.

- Besides having adequate oxygen cylinder supplies on site, contingency plan on how to obtain additional supplies is recommended.
- Large healthcare facilities with high oxygen consumption might consider having an additional reserve bulk liquid oxygen tank, apart from the primary and secondary supply tanks, with independent pipelines.
- Ensure prominent labelling and shielding of the oxygen feed lines that connect the main supply vessel to the hospital, to avert accidental interruption.
- Ensure that there are ample isolation valves along the oxygen supply line in the hospital, so that leaks can be isolated without interrupting the central supply and ensure that the valve is in open position while the supply is normal.
- Incorporate an external spare connection to the central oxygen piping system, to which an oxygen tanker truck could attach to provide emergency oxygen for the entire institution.

Case 2: <u>Portable Liquid Containers (PLCs)- Wrong product connected (Dec 2000)</u>

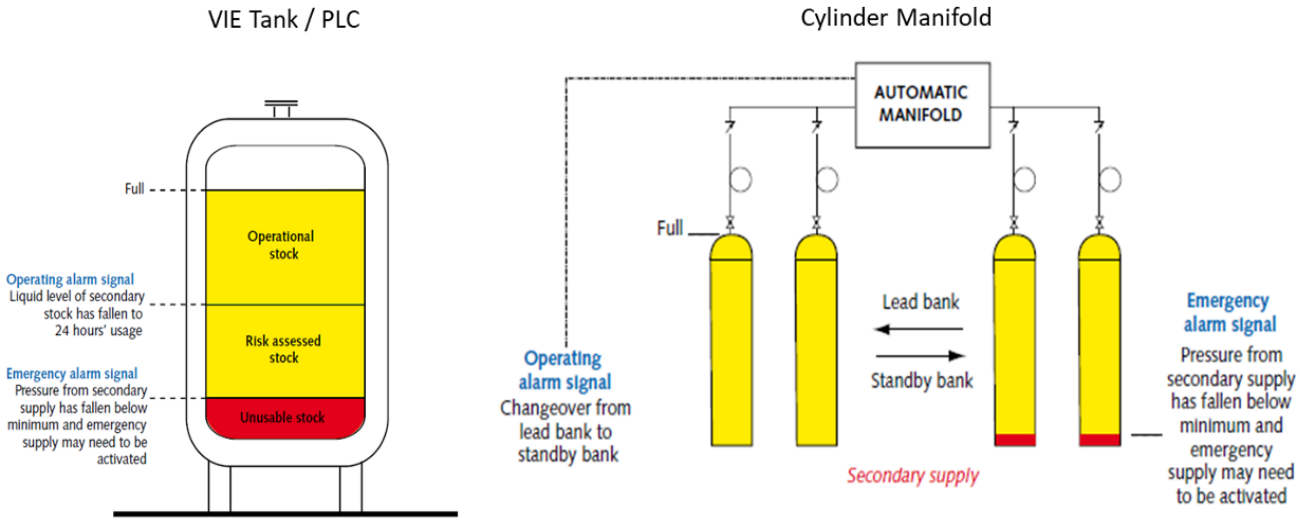
A nursing home was running low on oxygen and deployed a maintenance employee to connect a new oxygen PLC to the oxygen supply system. The employee selected a nitrogen PLC and discovered that he was unable to connect the liquid container due to different fittings. Employee then changed the fitting and installed the nitrogen PLC to the oxygen supply system. This incident has caused oxygen supply contamination, leading to 4 patient deaths and 8 patient injuries due to exposure to industrial

Operation/Installation discipline

<u>Design and Installation must have</u>

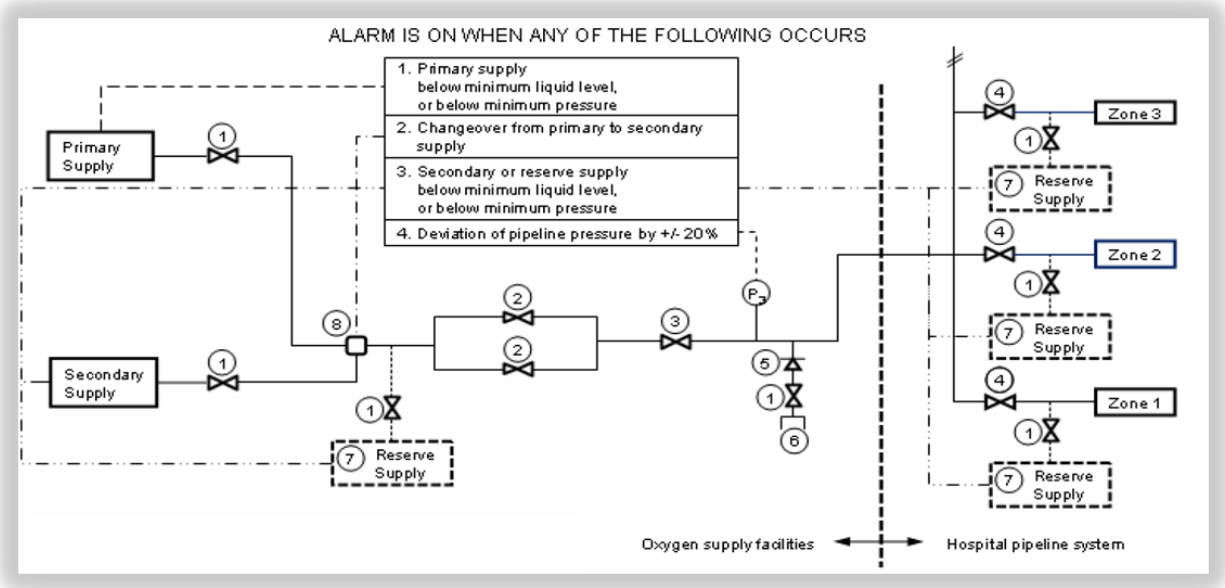
- ***Primary and Secondary supply:*** ("Reserve" supply should also be installed as per national requirements)
    - Primary supply requirements should be based on estimated usage and delivery frequency, Location should be consulted with the gas supplier and demand should be regularly reviewed (eg. O2 demand increase during the Covid-19 Pandemic).

- Secondary supply requirement shall be permanently connected, automatically supply the pipeline, and capable of providing the total oxygen flow requirement in the event of a primary supply failure. As a minimum, the secondary supply should have usable quantity of product to meet expected usage between a request for product delivery and the delivery of the product.



- ***Alarms for abnormal conditions:*** Alarm 'ON' when any of the following occurs with both Audio & Visual and strategically located.

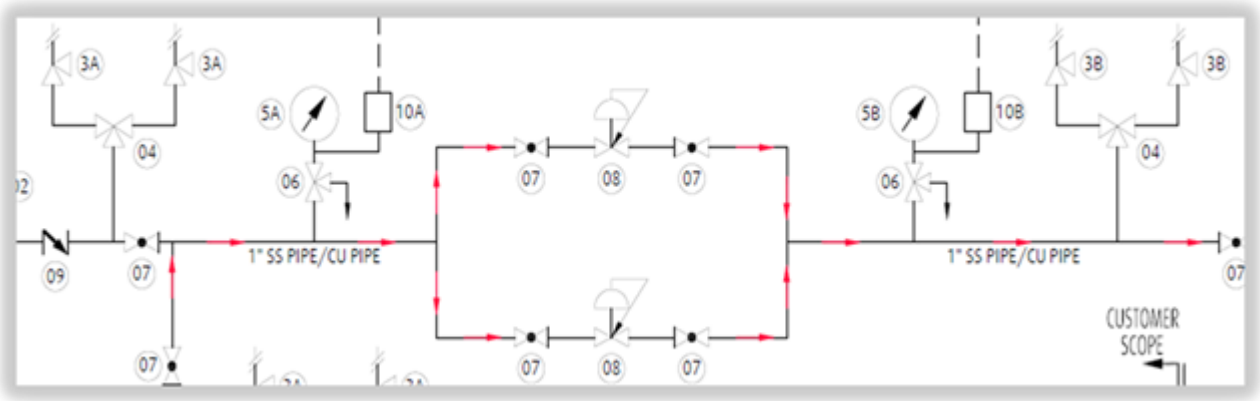
  - Primary Supply – Below MIN Level (Risk assess stock level), Below MIN Pressure.
  - Changeover from primary to secondary supplies.
  - Secondary or Reserve Supply – Below MIN Level (Risk assess stock level), Below MIN Pressure.
  - Deviation of pipeline pressure by more than ± 20 %.



- ***Pressure Reducing Unit***
    - The healthcare facility supply pipeline pressure reducing station should consist of a dual parallel regulator system.
    - Both regulators should always be online, and all isolation valves and regulators to be in 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.

- ***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.

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



- ***Supply system***: Ensure Oxygen Compatible material is used for oxygen supply system what comes into contact with the gas under operating conditions.

Operations and maintenance

- Ensure that the Operation and Maintenance comply to applicable Regulatory requirements.
    - Daily stock checking for Primary and Secondary supply system
    - The valve of the cylinder connected to the secondary/reserve supply system must always be in open position

- Any isolation valve from secondary/reserve supply system should be always in open position
- Functional testing for all alarms and activation of secondary/reserve supply should be done periodically. Recommend practice is once a month
- Critical Instrument calibration eg, pressure switch, level switch and safety valve to be done periodically.
- Ensure that secondary supply system is well maintain and that the Secondary and Emergency supply system are functional tested
- Check the shelf life of the backup medical gases

- Preventive maintenance, repair and risk assessment should be in placed.
- Secondary/reserve supply system leak check should be periodically performed, at least at the time of cylinders change. In case of no cylinders change, the leak check should be performed at least once every year.
- Daily checking and inspection program for Primary and Secondary supply system is recommended or comply with the country regulatory requirement.
- Ensure regular housekeeping and clear and free walkway to Secondary/ Reserve supply system
- Functional Responsibilities to be clarified and communicated, people are well trained and competence.
- Ensure that the operational procedures are available, trained and communicated.
- To ensure on the supply reliability, Cylinder and sources of supply management established.
- Emergency Response Plan to be developed and drilled.

References

AIGA/EIGA/CGA References

- *AIGA 049 - Guideline to medical Oxygen Supply system for healthcare facilities,* Asia Industrial Gases Association, www.asiaiga.org
- *AIGA 019 – Connections for Portable Liquid Cylinders,* Asia Industrial Gases Association, www.asiaiga.org
- *AIGA 024 – Connections for Transportable and Static Bulk Storage Tanks,* Asia Industrial Gases Association, www.asiaiga.org
- *AIGA 016 – Safety Features of Portable Cryogenic Liquid Containers for Industrial and Medical Gases,* Asia Industrial Gases Association, www.asiaiga.org
- *AIGA TP 05/05 – Prevention of Over Pressurization,* Asia Industrial Gases Association, www.asiaiga.org
- *AIGA 059 – Use of Non-Metallic Materials in High Pressure Oxygen Breathing Gas Applications,* Asia Industrial Gases Association,www.asiaiga.org
- *AIGA 113-20: Safe Design and Operation of Onsite Generation of O2 93% for Medical used,* Asia Industrial Gases Association, www.asiaiga.org

- *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,* European Industrial Gases Association, www.eiga.eu

- *CGA M-1 2013 – Standard for Medical Gas Supply Systems at Healthcare Facilities,* Compressed Gas Association, Inc. www.cganet.com

Other Standards

- *ISO 7396-1, 2016 Medical Gas Pipeline Systems – Part 1: Pipeline Systems for Compressed Medical Gases and Vacuum,* International Standards Organisation, www.iso.org
- *HTM 02-01 Medical Gas Pipeline System – Part A: Design, Installation, Validation and Verification and Part B: Operational Management,* NHS England, www.england.nhs.uk
- *NFPA 99, 2015 Health Care Facilities Code,* National Fire Protection Association. www.nfpa.org