Gas Handling Systems for Pharmaceutical Industry

This article takes a look at how to safely handle high purity gases in the biopharmaceutical and pharmaceutical plants.

India is among the top five emerging pharma markets. Gas Handling practices at modern biopharmaceutical and pharmaceutical plants today are quite different than those at similar construction sites 20 years ago. In pharmaceutical industry, gases are required in two divisions – Manufacturing and Laboratory.

In Manufacturing division gases are used for cryopreservation, blanketing, pH control, pressure transfer, process chilling, purging, wastewater treatment and other such processes.

In Laboratory division gases are used in Process/Quality Control and R&D for hydrogenation process, reactors, analytical instruments etc.

Commonly used gases are nitrogen, oxygen, hydrogen, argon, helium, air, carbon-di-oxide, HC gases, LPG, nitrous oxides apart from other gases and gas mixtures. Based on the nature of these gases they can be classified as;

- *Asphyxiant:* Minimally toxic but poses danger to human health through asphyxiation when present in sufficient quantities. These gases, when released in closed environment, replace oxygen causing oxygen depletion. Ex-Nitrogen, Argon, Helium.
- *Corrosive:* Corrodes material or tissue with which they come in contact. Mostly they affect in low concentrations over a long period of time. Ex-Ammonia, Chlorine, Nitrogen Di Oxide, Hydrogen Chloride gas.
- *Cryogenic:* Has boiling point less than -90oC. Can cause severe burns to tissue and brittleness in materials. Ex-Nitrogen, Oxygen.
- *Flammable:* Forms a flammable mixture when mixed with air at atmospheric temperature and pressure after attaining lower explosive level (LEL). Ex-Hydrogen, Hydrocarbon Gases.
- *Inert:* Does not react with other materials at ordinary temperature and pressure. They are colorless and odorless, as well as nonflammable and nontoxic. Still they pose danger to human health as they displace amount of oxygen in a confined place. Ex-Nitrogen, Argon, Carbon Di Oxide.
- *Oxidant:* Does not burn but will support combustion and they may also displace oxygen in air. Ex-Air, Nitrogen Oxides.
- *Pyrophoric:* Do not require a source of ignition to explode or catch fire. Pyrophoric gases will ignite spontaneously in air at or below 54°C. Ex-Silane.
- *Toxic:* Chemically produces lethal or other health effects. Ex-Chlorine, Carbon Monoxide, Di Borane, Hydrogen Sulfide.

Generally, end-users do not have the knowledge and expertise on the science behind gas handling systems. Hence major safety hazards are associated with handling of gases. We need to understand that handling of gases is different than handling liquids. Gases are compressible and therefore large quantities of gas fit under high pressure into confined containers like cylinders, bullets etc. Depending on the nature of gas they are filled at various pressures ranging from 2 bar to 220 bar and sometimes even higher. Uncontrolled release of this compressed gas will cause serious safety hazards and can lead to fatal accidents. Design precautions, Correct material and fabrication methods for gas handling systems, Hazard Analysis, operator trainings can avoid accidents in plant laboratories.

Unfortunately, there are very limited regulations related to gas handling

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systems available in India. Frequently referred standards and codes include NFPA 55 for Fire and related hazards, PESO for use of compressed gases and OSHA for safety of the users. Apart from these, ASME B31.8 is generally referred for designing and tubing.

Recently FDA has become very stringent with regulations for pharma sector in particular. In India, from the past one year FDA has issued warning letters to more than eight major pharma companies, Form 483s to several more and even banned certain products manufactured by these companies. Mostly the issues highlighted are regarding good manufacturing practices. So it becomes very important to install gas handling systems and clean fluid handling systems with utmost care and after considering standards, codes and good manufacturing practices.

Gas handling systems have to be always designed by qualified professionals who are aware of applicable standards, codes and good manufacturing practices. They should also be clear about nature of gases, materials of construction, control systems used specifically for gases, implication of gas purity, safety aspects in terms of explosion, fire or gas leakage.

Most of the time the client is unaware of the complete requirements of the gas handling systems they need as piping systems is one of the utility to their core business. Hence the design team has to understand the stated and unstated requirements of the application and design a system accordingly after explaining the same to client.

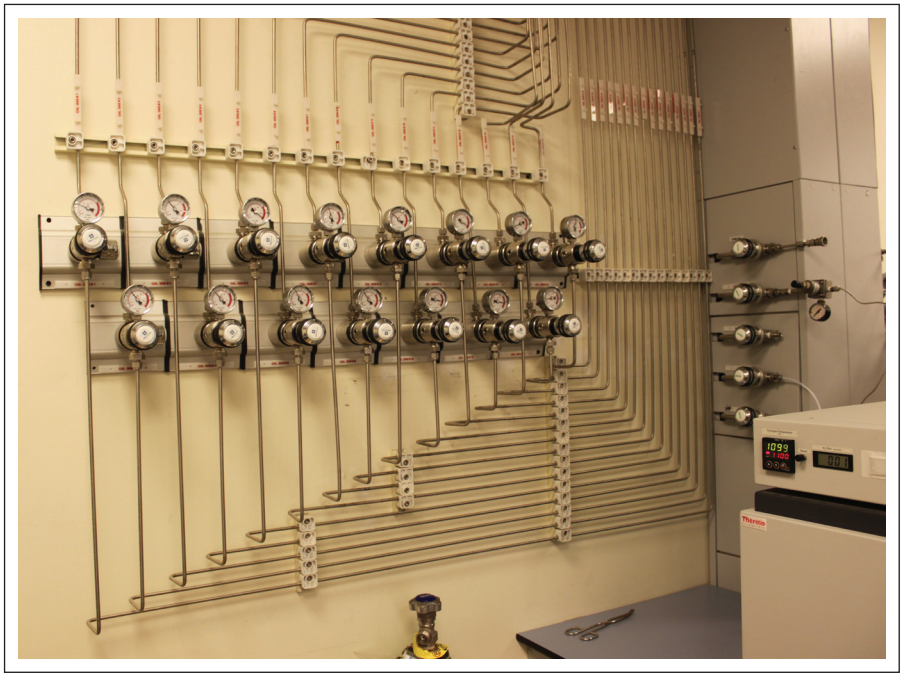
A typical complete gas handling system in a pharma sector would consist of three sections;

- *Gas source:* Gas bank, generator, compressor, quads, bullets, cryo tanks. Storage and installation space.
- *Gas tubing with accessories and control systems:* supports, tubing, tube fittings, valves, pressure gauges, regulators, inline purification panels, change over panels.
- *Safety features:* flash back arrestors, safety relief valves, gas monitoring systems, leak detection systems, integration to BMS.

The important factors to consider while choosing a Gas Handling System would be;

- Type of gas.
- Application of the gas.
- Pressure requirement at source and user points.
- Flow requirement at all user points.
- Ambient working condition where system is being installed.
- Structure of the building where the system is being installed.
- Codes and Standards applicable in the geographical region of installation.
- Safety features required as per the nature of gases and applicable codes & standards.

Designing of this system has to be with optimum cost, maximum efficiency with complete conformation to all safety aspects. A designer has to understand pressure and flow requirements at each user points. Line sizing has to be done according to scientific calculations to reduce unnecessarily higher sized lines there by controlling cost. Line layout has to be done keeping accessibility, maintenance activity and aesthetics into consideration. In earlier days copper and brass were preferred as material of construction, however, now stainless steel has become the material of choice due to its strength, corrosion resistance, durability and easy availability. Gas bank/source area and storage area has to be chosen and designed to ensure



Aesthetic installation

Installation of Gas Handling System in a typical laboratory

safe ventilation, safety to environment and to avoid accidental manipulation of systems.

The lines carry gases at high pressure and even small negligence or lack of professional approach during installation will lead to major safety incidents. Material has to be procured only from reliable sources with assured quality. Further, Installation has to be done by qualified and certified professionals only. While installation leak integrity has to be validated and specific precautions related to gases have to be taken, aesthetic finish is equally important.

Connecting joints are done by ferrule type fittings, TIG welding or Orbital welding. Orbital welding is most preferred as it is almost hundred percent leak proof. Orbital welding also reduces contamination areas in fluid system reducing chances of viral colonies in the line. Touching upon safety aspects, there are inline safety features and offline safety features. Inline safety features include flash back arrestors, pressure relief valves, excess flow valves and vent lines. These systems have to be placed effectively in a gas line.

Offline safety features include gas level monitoring system, leak detection sensor, automatic shutoff system. These will be monitored on a gas monitoring system with audio visual alarms. Latest advancements have options for sending SMS alerts in case of an emergency, which enables us to monitor remotely. Integration into BMS (Building Management System) can activate fire safety system and shutoff some electrical grids as additional safety. As associate safety feature smoke detectors, water sprinklers and fire extinguishers at designated places are also required. However, this will be covered by fire safety system professionals.

Thus installed gas handling system needs proper validations from time to time in order to ensure purity of gases, proper functionality of instruments and accessories. Again, this is to be done by authorised and trained personnel only. It involves complete leak audits, pressure testing, calibration of instruments and sensors, replacement of worn out/used up material and minor modifications as per user's latest requirements. An AMC with proficient contractor is highly recommended to achieve the same.

Some common problems faced by end users are;

Reduced pressure at user points: Pressure and flow requirements of the line have to be checked. Line sizing has to be checked. Source pressure has to be checked and line has to be checked for leakages.

Corrosion of tubes: Nature of gases in the line has to be studied and suitable MOC has to be selected. Corrosion may be due to outside ambient and working conditions also.

Functionality problems in valves and regulators: Bad material quality or improper handling by users.

Excessive gas consumption: Pressure and flow requirements of line have to be checked. Leak audit has to be carried out.

Impurities in gases: Purification panels have to be checked and activated. Leak audits have to be done. Line has to be checked for corrosion.

Vibrations in lines: Pressure and flow requirements of line have to be checked. Line sizing has to be checked. Tube supports have to be checked.

Aesthetically bad: Care has to be taken during installation. Cosmetic changes on case to case basis have to be looked into. If required, specific segments can be replaced.

Unable to trace the gas lines for maintenance: Proper tagging and colour coding has to be done. As-built drawings should be updated and available.

In all, handling gases safely is of paramount importance to avoid accidents and incidents. We have worst example of gas disasters like Bhopal Gas tragedy. The tragedy occurred because of small negligence. Small or big, accidents are always serious and we can avoid accidents only by pre planned precautionary measures. Selecting right contractor, right design and right material is the key to have peace of mind. Safe systems need not necessarily be costly, it can be achieved through right engineering. ■

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