13852 Hazardous Gas Handling & Detection

Part 1: General

1.01 The university's intent is to provide the hazardous gases necessary for high-level scientific experimentation in a safe manner which will meet existing codes, regulations, and accepted industrial practice. To this end, these comprehensive guidelines concerning these systems have been developed.

Part 2: Design Guidelines

2.01 **Resources -** Resources for design, use, and handling of compressed gas cylinders and piping include:

29 CFR Part 1910, subpart H

Compressed Gas Association

NC State Health and Safety Manual – Compressed Gas Safety section

NC State Environmental Health and Safety Center – Industrial Hygiene Section

North Carolina Building and Fire Codes

NFPA 45

NFPA 50 - Standard for Bulk Oxygen Systems at Consumer Sites

NFPA 50A, Standard for Gaseous Hydrogen Systems at Consumer Sites

NFPA 50B, Liquefied Hydrogen Systems at Consumer Sites

NFPA 51, Design and Installation of Oxygen-Fuel Gas Systems for Cutting and Welding

NFPA 54, National Fuel Gas Code

NFPA 55, Compressed and Liquefied Gases in Portable Cylinders

NFPA 58, Standard for the Storage and Handling of Liquefied Petroleum Gases

NFPA 99, Standard for Health Care Facilities

- Chapter 3 - Use of Inhalation Anesthetics (flammable and non-flammable)
- Chapter 4 - Use of Inhalation Anesthetics in Ambulatory Care Facilities
- Chapter 5 - Respiratory Therapy

ANSI B31.1.0, Power Piping (including Addenda B31.1.0(a), B31.1.1.0(c), and B31.1.1.0(d)

ANSI B31.2, Fuel Gas Piping

ANSI B31.3, Petroleum Refinery Piping

SEMI Standards – for semiconductor gas and equipment installations

2.02 A process hazard review, involving the appropriate research personnel, EH&S staff, and FP&D staff (as needed) is required at the design phase of new or modified hazardous gas installation projects to projects to determine specific design requirements. The results and recommendations of this review will be made available to the designer.

2.03 Building Gases and Bulk Supply - this section applies principally to cylinder gases. Requirements for utility gases are covered elsewhere in this document or by applicable codes.

Supply of typical building utility gases to laboratories (e.g. natural gas) does not require hazard review if standard design guidelines and compliance with applicable codes/regulations are followed, including adequate leak testing of flammable gas supply lines. Special attention is requested to assure adequate access to gas shutoffs. Avoid obscuring access and visibility to these shutoffs with other equipment or landscaping. Attention is also requested to assure that fragile components of gas systems (gauges, etc) are adequately protected to avoid gas release into areas not rated for flammable atmospheres and that excess flow shutoffs are provided wherever possible.

In the event that bulk distribution of gases or chemicals is anticipated, the quantity of gas in any connected storage vessels must be reviewed against the process safety management requirements in 29 CFR 1910.119 and the EPA RMP. Hazard reviews may also be required by the university, despite quantities under OSHA or EPA thresholds for action. FP&D will contact Environmental Health and Safety to determine hazard review applicability and to assure that bulk chemical or gas sources are listed on university emergency plans.

The design of hazardous compressed gas storage and use systems will frequently involve input and discussion from/between FP&D, the laboratory principal investigator, EH&S, and the designer to achieve and efficient and effective design.

2.04 **General Requirements - Building / Lab Classification -** Design requirements will vary somewhat depending on whether the affected area is considered a HPM operation or hazardous materials usage area. The appropriate designation should be discussed with FP&D prior to design work. It will be rare for a university designation to be HPM.

2.05 **Monitoring** - Gas monitoring will meet the requirements of the NC State Gas Monitoring Standard, (http://www2.ncsu.edu/ncsu/ehs/www99/right/handsMan/index.html) (Appendix XXX) unless exceptions are indicated by NC State EH&S.

All gas monitoring systems must tie into the building fire alarm system, unless otherwise indicated by NC State EH&S. In some cases, local annunciation will be an acceptable and preferred option.

All alarms must be annunciated locally, both visually and audibly within the laboratory, and at a central station (note exception to central station annunciation referenced above.) Building alarms shall be annunciated at a building entry remote from sources of gas leakage so that emergency response personnel can review the alarm condition without entering the danger zone. Annunciation shall preferably be located near the fire alarm annunciation point. Alarms requiring building evacuation will also be annunciated at the Public Safety Office and shall be distinguished as a gas alarm, not fire. Information that shall be available to on-site emergency response personnel must include alarm location, set point, gas monitored, and real-time concentration.

2.06 **Gas Detection -** A continuous gas detection system shall be provided to detect gas at or below the PEL or Ceiling limit. It must transmit a signal to a constantly attended control station. The alarm shall be both visible and audible. It shall provide warning both inside and outside of the storage area. Signal transmission to a constantly attended station is not required if only one cylinder is stored. Continuous monitoring is not required when warning properties are at or below the PEL (according to Pocket Guide for Chemical Hazards).

Gas monitoring must be installed in conformance with NC State Gas Monitoring Requirements located in the Appendix

Activation of the monitoring system shall automatically close the shutoff valve on all highly toxic or toxic gas supply lines related to the system being monitored.

Exception: Auto shutdown need not be required for reactors where the toxic or highly toxic gases are operated at pressures less than 15 psi, are constantly attended, and are provided with readily accessible emergency shutoff valves.

2.07 **Smoke detection** [use NFPA 72]) shall be installed when highly toxic gases are stored indoors. Activation shall sound a local alarm

2.08 **Cylinder Receiving and Storage -** Buildings where hazardous gases are received will have an adequate receiving area for gas deliveries. This includes a ramp for gas carts or dock leveler.

Where the need for an outside storage area has been determined (these are discouraged – just-in-time delivery is preferred as the means to prevent excessive lab storage), the storage areas shall meet the requirements of NFPA 55. Toxic and corrosive gases shall not be stored in outside storage areas.

An inside gas storage room (located just off the dock area) may be appropriate for temporary storage of incoming /outgoing gases in heavy cylinder use buildings. This room must be provided with gas cabinets for temporary storage of incoming/outgoing highly toxic cylinders and a specifically designated cabinet for leaking gas cylinders. The room must be maintained under negative pressure with respect to the adjacent areas with high and low level exhaust intakes in addition to cabinet ventilation. A loss-of-exhaust monitor must be provided in the main exhaust takeoff. Balancing dampers on gas cabinets must be locked after balancing.

Non-toxic flammable gases may not be temporarily stored in inside storage rooms containing toxic gases, unless located in an approved gas cylinder enclosure. These non-toxic flammable gases should be handled by just-in-time delivery.

Where inside storage rooms are not provided, and highly toxic gases are received at the building, an exhausted gas cylinder cabinet shall be provided at the loading dock for temporary storage of leaking cylinders.

Exhaust for inside gas cylinder storage areas shall be on emergency power.

Gases not requiring exhaust ventilation will be stored in an area away from the lab doorway with wall mounted cylinder securing devices provided, one securing device per cylinder. "Gang chaining" of cylinders will be avoided.

2.09 **Gas Cabinets -** Toxic and corrosive gases shall be contained in gas storage cabinets. In some cases, to comply with building code requirements, storage of non-toxic flammable gases in storage cabinets will also be required.

Gas cabinets shall meet the requirements of section 2203 of the NC Fire Code.

1. They shall be 0.11046-inch (2.66-mm) steel minimum with self-closing doors and self-closing limited access ports or noncombustible windows to access equipment controls

2. Gas cabinets and exhausted enclosures for the storage of cylinders shall be internally sprinkled

3. Average velocity at the face of access ports or windows shall not be less than 200 fpm with a minimum of 150 fpm at any point of the access port or window

Emergency power shall be provided in lieu of standby power for exhaust ventilation, treatment systems, gas detection systems, emergency alarm systems, and temperature control systems.

Separate cabinets must be provided for separate classes of chemicals.

Gas Purge Panels used for corrosive, toxic, highly toxic, or pyrophoric gases must meet the minimum requirements listed in the NC State Health and Safety Manual, Compressed Gas Safety section. (In many cases, the principle researcher will provide this equipment.) Design plans will need to include power and pneumatic service to each gas cabinet.

2.10 **Exhaust Ventilation -** Local exhaust ventilation shall be provided to all enclosures around hazardous gas cylinders, gas manifolds, equipment, exhaust pumps, and in-lab exhaust treatment devices, if present. Exhaust pump discharges will be connected to the exhaust ventilation system. See Section 15850 Industrial/Chemical Exhaust Systems for additional information.

Exhaust duct materials will be noncombustible. Stainless flexible ductwork will typically be used.

Exhaust duct sizing will be based on providing a satisfactory face velocity at the access doors to the equipment connected to the exhaust system and to ensure flammable gas concentrations in the duct system of less than 10% of the lower explosive limit (typically controlled to well below 10%). Capture velocities at the equipment access doors will be 200 fpm for gas cabinets and typically 150 fpm for other equipment. A careful review of equipment to be served by the ventilation system is required for accurate local exhaust capacity planning. Lockable exhaust balancing dampers will be provided at each exhaust takeoff.

Exhaust Detection - A university approved proof-of-exhaust indicator should be provided to continuously monitor exhaust ventilation. Selection and installation details are provided in Section _____. In some cases, it will be desirable to provide the researcher with additional relays for equipment and gas shutdown in the event of abnormal operating conditions. An alternate exhaust detector with additional relays may be provided for this purpose. Review proper device selection with FP&D and EH&S.

2.11 **Typical Interlocks -** The final installation will often include controls to accommodate gas shutdown (failsafe manner) under the following conditions:

1. Insufficient exhaust
2. Loss of power
3. Gas detection
4. Smoke detection in work area
5. Excess gas flow
6. Excess gas pressure
7. Loss of cooling water (if water cooled)
8. Tool high pressure (if vacuum tool)
9. Other tool interlocks as appropriate

NCSU EH&S will determine the need for these controls through the process hazard review. The resulting requirements will be provided to the designer through FP&D. Standard hardware and approaches to implement these controls have been developed; however, the best means to incorporate these features into the overall project design will need to be considered.

2.12 **Emergency Power-Off (EPO's) -** EPO's shall comply with Semiconductor Equipment Manufacturers Institute (SEMI) standards. EPO's are to be used in all labs containing hazardous gases. Exceptions may include the use of non-toxic flammable gases in standard lab procedures (AA, GC) if a flow-restricting orifice is provided and the gases are used in small quantities. The emergency power-off button shall terminate gas flow at the cylinder through use of a failsafe design. This typically includes a normally open electrical solenoid and normally closed pneumatic gas shutoff valve. This arrangement will also ensure gas shutdown when a power outage occurs.

2.13 **Emergency Power -** Emergency power shall be provided to fans which are exhausting hazardous gas operations. It may be acceptable to operate these fans at 50% capacity during the power outage. Emergency power shall not be provided to continue operation of processes using hazardous chemicals or gases. Where hazardous gas detection systems are present, these detectors should be operated on emergency power.

2.14 **In-lab Process Gas Piping –** Smaller, less complex piping installations may sometimes be installed by lab personnel. Where high purity is required, refer to SEMI specifications and customer requirements. It should be noted that the use of some higher hazard gases would require the installation of concentric piping. Hazardous gas piping should be tested according to the appropriate SEMI specification, including a high and low-pressure leak test for adequate hold times.

2.15 **Treatment Systems -** Treatment systems shall be considered for toxic and corrosive gas installations when necessary due to environmental or safety considerations. Input on the need for gas treatment should be obtained from NC State EH&S. Where provided, the system must be capable of reducing the concentration of toxic or highly toxic gases to 1/2 IDLH at the point of discharge to the atmosphere. Treatment systems shall be sized to process the maximum worst-case release of the gas based on the maximum flow rate of release and the total quantity from the largest cylinder or tank utilized.