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Environmental Health & Safety

Life Safety Alarm Systems Design Standard

The purpose of this design standard is to provide the minimum engineering and design requirements to be used for the design of life safety gas detection and alarming systems that provide audible and visual warning of hazardous conditions or events that would lead to an adverse effect on humans, property, or the environment.

Fixed gas detection, alarming systems, and components are considered critical control devices and are designed to alert workers to the presence of an unexpected hazard, hazardous atmosphere, or hazardous release of gas and vapor to the environment.

Critical life safety gas detection and alarm systems installed at the UW include, but are not limited to:

- Combustible/Flammable gas detection
- Carbon dioxide detection
- Oxygen-deficient and enriched atmospheres
- Toxic and highly toxic gas detection

General Guidelines

1. Risk assessment

The requirement for an installed hazardous gas and/or oxygen-deficiency monitoring system is determined by a risk assessment. A risk assessment is generally conducted for new construction and renovation projects where compressed gases and cryogenics will be used and/or stored. [UW Environmental Health & Safety](#) (EH&S) can provide support (review and consultation) for this process.

The risk assessment considers the hazards related to the application/use of the gas; volume of gas; room size and volume; exhaust ventilation exchange rate; spill, leak, and other accident scenarios; and engineered protection systems.

A risk assessment determines the requirements for the type of gas detection and alarm system.

- Multiple sensors may be required if there are a variety of gases present.
- Leaked liquid carbon dioxide may create a toxic atmosphere before becoming an oxygen-deficient atmosphere. For this reason, an oxygen monitoring system alone is ineffective in liquid carbon dioxide environments; there may be a need for both CO₂ and O₂ detection.

2. Room or Facility Types

Typical rooms/areas where gas detection and alarm systems may be installed are the following:

- Magnetic resonance imaging (MRI) and nuclear magnetic resonance (NMR) rooms
- Cryogenic/Transmission Electron Microscope (TEM) rooms
- Freezer and tank farms

- Bulk storage tanks, particularly if kept indoors or outdoors below ground level
- Compressed gas manifold rooms or other compressed gas bulk storage

Small rooms where cryogenics are stored/used and compressed gases are in use will likely require installation of gas alarm and detection systems due to the small volume of the room.

System design requirements

If a gas detection and alarm system is required, the system must, at a minimum, be designed with the following elements described in the table below.

Minimum Basis of Design for Existing and New Installations

Criteria	Description
Gas detectors/sensors and system	Meet UL2075 Standard for Gas and Vapor Detectors and Detection systems
Monitoring System*	Building Management System (BMS) – Supervised, addressable with room and building number assigned. It must be supervised by fire panel or an approved continuously monitored station if required by code.
Wiring**	Dedicated circuits properly grounded and shielded (limit electromagnetic interference (EMI)).
Power***	Two independent sources of power, normal and Legally Required Emergency Power or uninterruptible power supply (UPS) (preferred)
Concentration Display	Outside hazard area (% O ₂ , %LEL, ppm)
Calibration feature	Calibration switch
Components	UL Listed (new or replacement)
Alarms	Audible/Visual (device labels required). Trouble signals must be included to alarm when sensor failure, opening circuit protective device, loss of continuity of electrical conductors to sensors, etc.)
Alarm location	80 inches above finished floor (AFF) (6-inches below ceiling)
Audible Alarm	15 dbA above ambient (alarms can be silenced)
Visual Alarm	Follow color guidance (ANSI Z535.1 Safety Colors). Alarms must be of the latching type, requiring a deliberate manual action to reset, cannot reset if hazard is present.
Alarm Location	Inside and outside of room or area (exemption may be allowed for small spaces or non-occupied areas)

Signage	Hazard warning/Emergency Response instructions for personnel (inside and outside)
Maintenance/Calibration	In accordance with the manufacturer's instruction or by applicable codes, whichever is more conservative.
Calibration tolerance	0.5% - 1% recommended for O ₂ . Calibrated to the intended range for each gas.
<i>Additional requirements apply when installed in a hazardous classified location (electrical - NEC 500 and NFPA 70)</i>	

Basis for Recommended Design Practices

*Monitoring System

Gas detection and alarm systems must have local alarm panels integrated with the building management system. The gas detection system must monitor alarm conditions, wiring faults, sensor failure, and loss of power. If the alarm and detection system is considered a "life safety system" by the local authority having jurisdiction (AHJ) the system must be connected to the fire alarm system or an *approved* (by AHJ) continuously monitored (24/7) building monitoring system (BMS). Interlocks with other building or process systems must be reviewed by EH&S.

Local alarm and detection systems

Local alarms and detection systems are not recommended because they do not provide continuous monitoring (24/7) in the event of an actual condition or fault. Historical data for actual failure events may be lost, resulting in a missed opportunity for accident prevention.

Local alarms for unoccupied areas where oxygen-deficient atmospheres could occur and where the rooms require periodic inspections, could pose a risk to first responders during a potential event. (Another argument for recommending continuous monitoring by the BMS).

Alarm Set-points and Signage

Alarm Set-Points for Life Safety Gas Detection and Alarm Systems

Alarm set points of Caution at the TWA - PEL (WAC 296-841) or TLV, whichever is lowest, and Danger at the ceiling limit. STEL can be used if available or 0.5 IDLH, whichever is lowest.

Gas or Hazard	CAUTION: Alarm 1 (HI)	DANGER: Alarm 2 (HI-HI)
Lower Explosive Limit (LEL)	25% LEL 10% LEL - for confined spaces	50% LEL
O ₂	Caution can be used to accommodate a low/high alarm level for O ₂ .	< 19.5% and >23.5%
CO ₂	5000 ppm	20,000 ppm
Refrigerants	100 ppm	1000 ppm ¹ <i>Flammable refrigerants – see LEL</i>
NO ₂	1 ppm	5 ppm
CO	35 ppm	200 ppm (5-minute)
H ₂	1% (LEL = 4%)	2% (50% of LEL)
H ₂ O ₂ (hydrogen peroxide)	1 ppm	3 ppm
CH ₄	1.25% (LEL = 5%)	2.5%
HCN	2.5 ppm	4.7 ppm
H ₂ S	10 ppm (ACGIH TLV = 1 ppm)	15 ppm (ACGIH TLV = 5 ppm)
NH ₃	25 ppm	35 ppm
Chlorine	0.5 ppm	1.0 ppm (ceiling)
Ozone	0.1 (EPA ambient = 0.07 ppm – 8hr)	0.3 ppm

¹ Alarm levels are refrigerant specific, subject to OSHA revision and must conform to OSHA values at the time of building permit submittals.

Example of Alarm Signage

Warning Device		General Condition	Emergency Action Required
Visual	Audible		
Red Light	Evacuation alarm, klaxon sound, white, beacon	Danger	Do Not Enter/Evacuation
Yellow Light	Other sounds, bells, buzzers (not related to evacuation sound)	Caution	Limit free access of workers and warn them to be on alert, or Warning of first interlock condition (trouble in system)

****Wiring**

Dedicated circuits must be provided for each monitoring panel to allow for calibration and maintenance activities to occur without disabling other monitors/sensors that could be located on the same circuit. An exception can be made to allow multiple panels/sensors within the same room for a common hazard condition.

*****Power**

Life safety alarm systems must be backed up by emergency power or uninterruptible power supply (UPS). The reason for this is to ensure the continuous operation of this safeguard. The type of power supplied to the alarm and detection system will depend upon the level of risk. The level of reliability required for the type of emergency power increases when the alarm and detection system is the primary or secondary barrier. Additionally, if a loss of power will affect the function of the sensors and alarm systems, the power must be UPS.

Remote Readout of Concentration

The readout of the concentration must be remotely located or reported to an area outside of the hazard area.

Personnel must not enter a hazardous atmosphere without knowing the concentration of oxygen or hazardous gas, or the severity of the condition ([WAC 296-841 Airborne Contaminants](#); [WAC 296-824 Emergency Response](#)).

Design Evaluation & Submittals Construction Drawing (CD Phase)

All gas detection alarm and detection products must be reviewed and accepted by EH&S prior to procurement.

Detailed design, construction drawings, and product submittals must be reviewed and accepted by EH&S.

Commissioning

1. The commissioning of the systems must be performed according to a documented Commissioning Plan per UW requirements.
2. Commissioning must consist of inspection and pre-testing/calibration of completed individual systems and equipment before conducting cross-functional testing of equipment and systems.
3. Life safety gas detection and alarm systems, sensors, and equipment must be commissioned by a third-party commissioning agent, or the UW, at the time of installation.
4. Commissioning must include, but not be limited to, the following:
 - a. Building automation interfaces and notification
 - b. Electrical interlocks
 - c. Electrical shunting (if installed)
 - d. HVAC interlocks (fan shutdowns, fire/smoke dampers (FSD closures if configured)
 - e. Gas detection – includes alarm set-points, alarms, visual, audible (sound level)
 - f. Fire alarm system interfaces (if installed)
 - g. Process Control System interfaces (if installed)
 - h. Battery charging shutdown interlocks
5. Commissioning documents, instrument data sheets, and calibration records must be provided to the UW for each life safety alarm system tested.
6. Testing of the life safety gas detection and alarm systems must be coordinated with the UW site fire protection representative.
7. Additionally, life safety gas detection and alarm systems must receive written UW acceptance before hazardous, toxic, highly toxic, flammable, or explosive materials are placed into use or storage.
8. Certificates of completion and testing records must be provided to the UW with the turnover package submittals.
9. Completed System Tests
 - a. The installation contractor must perform a complete functional test of each system and submit a written report to the UW Project Manager (PM) attesting to the proper operation of the completed system prior to final inspection and commissioning.
 - b. Gas detection and alarming critical control device interfaces, alarms, and failure conditions must be tested.
 - c. Where the BMS (or FACP) is used for detection and alarming for life safety alarm conditions, the BMS (or FACP) must be verified by testing that the alternate power system is capable of operating the system for the period and in the manner specified.
10. Retesting
 - a. Deficiencies indicated by tests must be corrected and work affected by such deficiencies must be completely retested.
 - b. The system test must verify that the total system meets specifications and complies with applicable state and local codes and ordinances.

11. Report of Tests and Inspections

- a. A written record of inspections, tests, and detailed test results in the form of a test log must be provided with the Commissioning Plan.
- b. The test log of the satisfactory completion of tests must be submitted to the UW PM and UW EH&S.

References

International Fire Code – Life Safety Alarm systems (e.g., refrigerant)

WAC 296-800-31070 Install and maintain an appropriate employee alarm system.

NFPA 72 Fire Alarm Code

FM Loss Prevention Data Sheet 7-45, Safety Controls, Alarms, and Interlocks (risk assessment, process safety, human factors, reliability)

FM LPDS 5-49 Gas and Vapor Detectors and Analysis Systems (provides guidance substantiating monitoring requirement)

ANSI/ISA –S92.04.01 Part I 1996 - Performance Requirements for Instruments Used to Detect Oxygen Deficient/Oxygen Enriched Atmospheres (Revised 2013)

ANSI/ISA-RP92.04.02 Part II – 1996 Installation, Operation, and Maintenance of Instrument used to Detect Oxygen Deficient/Enriched Atmospheres (revised 2013)

ANSI Z535 Safety Colors