

CNS OPERATIONS MANUAL ADMINISTRATIVE PROCEDURE 0.36.6 MONITORING FOR INDUSTRIAL GASES	USE: INFORMATION QUALITY: QAPD RELATED EFFECTIVE: 4/22/10 APPROVAL: ITR-RDM OWNER: SHU SUPV DEPARTMENT: SHU
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REV.	DATE	CHANGES
8	7/30/08	Added definition for TLV. In Attachment 1, added Bromine Gas Personnel Exposure limits; selected the most conservative gaseous PELs; added clarification from NOTE above Section 1 to NOTE above Section 2.
9	4/22/10	Revised Threshold Limit Value criteria. Revised Step 2.13 IDLH criteria.

1. PURPOSE

1.1 This procedure provides guidelines and instructions for detection and monitoring of non-radioactive industrial and toxic gases.

2. PRECAUTIONS AND LIMITATIONS

2.1 Procedure 0.36.3 lists the requirements for entering into a confined space.

2.2 Monitoring personnel are not exempt from the issuance of a Confined Space Permit (CSP) when entry is required during the initial survey of the job site. A CSP is not required when monitoring is performed from the outside of the confined space.

2.3 "Never trust your senses". Assume there may be a hostile atmosphere.

2.4 Smoking is prohibited in or near manholes during the initial opening.

- 2.5 If sampling the atmosphere over a liquid, be certain not to allow any of the liquid to enter the sampling instrument. Keep in mind that toxic gases may be released when the liquid is disturbed.
- 2.6 Personnel should refer to the manufacturer's Material Safety Data Sheet (MSDS) before working with chemicals.
- 2.7 Carbon Monoxide (CO) and Hydrogen Sulfide (H₂S) are both toxic and flammable. As a result, when monitoring for known or suspected flammable gases (other than CO or H₂S), the CO or H₂S may read-out, alarm, or over-range due to the cross sensitivity of the contaminant gas with the CO or H₂S sensor. If applicable, disable or remove the CO or H₂S sensors.
- 2.8 **Lower Explosive Limit (LEL)** is defined as the lower limit at which a concentration of combustible mixture can cause an explosion when ignited in a confined area.
- 2.9 **Threshold Limit Value (TLV)** is defined as the concentration for a conventional 8 hour work day and a 40 hour work week, to which it is believed that nearly all workers may be exposed, day after day, without adverse affect.
- 2.10 **Permissible Exposure Limit (PEL)** is the maximum amount or concentration of a chemical that a worker may be exposed to under OSHA regulations. PELs can be defined in two different ways as discussed in the OSHA Regulation 1910.1000 on air contaminants:
- 2.10.1 **Ceiling Values** - At no time should this exposure limit be exceeded. Sometimes denoted with the letter C.
- 2.10.2 **8-Hour Time Weighted Averages (TWA)** - Are an average value of exposure over the course of an 8 hour work shift.
- 2.11 **Short Term Exposure Limit (STEL)** is defined as the concentration to which workers can be exposed continuously for a **short** period of time without suffering from:
- 2.11.1 Irritation.
- 2.11.2 Chronic or irreversible tissue damage.
- 2.11.3 Narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency.
- 2.11.4 STELs are generally used only when toxic effects have been reported from high acute (short-term) exposures in either humans or animals. An STEL is not a separate independent exposure limit, but supplements time-weighted average limits where there are recognized acute effects from a substance whose toxic effects generally chronic (long-term) in nature.
- 2.12 **Immediately Dangerous To Life And Health (IDLH)** is defined as an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere.

- 2.13 Personnel shall enter IDLH atmospheres only after adequate ventilation, respiratory protection, or suitable safety measures taken, as directed by the Industrial Safety Coordinator or designee. During emergency situations where access is required into an IDLH atmosphere, Industrial Safety Coordinator designee is defined as Fire Brigade Leader/Incident Commander or Emergency Response Organization (ERO) position responsible for team dispatch (see Attachment 1 for atmospheric conditions considered to be unacceptably risky or IDLH).
- 2.14 Response time for sensors may vary due to environmental conditions. Refer to appropriate instrument manual or procedure for proper sampling and/or response time.
- 2.15 Air monitor sensors may be affected by moisture, humidity, or changing temperature conditions. Erratic or unexpected high or low readings may be due to moisture in sensors or a significant change in temperature. Monitoring equipment may need to be placed in a dry environment or other actions taken to reduce moisture in the sampling stream. Contact Industrial Safety to monitor or sensor Vendor or Industrial Hygienist for proper means to address moisture, humidity conditions, or changing temperature.
- 2.16 The same portable monitors used for personnel "Breathing Zone" monitoring shall not be used for leak detection of equipment or confined spaces known to contain or suspected to contain flammable, inert, or toxic atmospheres (refer to Section 12).

3. REQUIREMENTS

- 3.1 Ensure following equipment and materials are available:
 - 3.1.1 Gas monitor.
 - 3.1.2 Drager Accuro gas detector pump.
 - 3.1.3 Appropriate Drager or MSA sampling tubes.

4. GENERAL MONITORING WITH MULTI-GAS MONITORS

- 4.1 Ensure the multi-gas monitor is in calibration.
- 4.2 Zero the multi-gas monitor in clean air prior to use.

NOTE 1 – Testing stratified atmospheres. When monitoring for entries involving a descent into atmospheres that may be stratified, the atmospheric envelope should be tested approximately every 4'. If a sampling probe or tygon tubing is used, adequate time is allowed to accommodate the sampling speed and detector response.

NOTE 2 – Order of Testing - Today most atmospheric monitors are multi-gas monitors which have the ability to monitor several different types of gases concurrently based on the type of sensors installed in the unit. If the instrument is not a multi-gas unit, then test for oxygen first because most combustible gas meters are oxygen dependent and will not provide reliable readings in an oxygen deficient atmosphere. Combustible gases are tested next because the threat of fire or explosion is both more immediate and more life threatening, in most cases, than exposure to toxic gases and vapors. If test for toxic gases and vapors are necessary, they are performed last.

- 4.3 Position the monitor in the work space. Check where necessary and at various levels. Allow time for sensor(s) to respond to all possible gas dangers.
- 4.4 Withdraw the monitor from the work space and observe any alarm indication. The area may be considered free from those hazards the monitor is designed to measure if no alarm is observed.

WARNING – Do not enter the work space if a hazardous atmosphere is indicated.

- 4.5 If an alarm occurs:
 - 4.5.1 Withdraw the monitor immediately.
 - 4.5.2 Note the alarm(s) in; switch off the monitor to reset the alarm condition.
 - 4.5.3 Switch the monitor on and allow it to complete the self-test sequence.
 - 4.5.4 Return the monitor to the atmosphere being monitored to verify the hazardous condition.
 - 4.5.5 If the monitor alarms again and indicates a hazardous atmosphere, switch off the monitor and inform Job Supervisor of conditions found.
- 4.6 If no alarm occurs, position the monitor near the breathing level.
- 4.7 If at any time while working within the confined space the monitor alarms, evacuate the work space immediately.
- 4.8 For use in service ducts, trenches, supply lines, etc., the hand aspirator should be used or an appropriate gas pump.

5. GENERAL MONITORING WITH DRAGER ACCURO GAS DETECTOR PUMP

NOTE – A multitude of sampling tubes are available for sampling purposes from Drager or MSA. Ensure the tube being used is correct for the hazard being evaluated incorporating the assistance of Industrial Safety, if necessary.

5.1 Perform leak test of equipment as follows:

- 5.1.1 Insert unopened sampling tube into socket of gas detector pump or into end of extension hose, if used.
- 5.1.2 Squeeze pump completely and release.
- 5.1.3 Pump is leak-proof if the end-of-stroke indicator has not appeared after 15 seconds. If indicator appeared within 15 seconds, refer to Drager Accuro Pump Instruction Manual for guidance.
- 5.1.4 Remove sampling tube from socket or extension hose and reset stroke counter.

5.2 Prepare sampling tube for sampling as follows:

- 5.2.1 Check sampling tube expiration date prior to use to ensure shelf-life has not expired.
- 5.2.2 Open tips on both ends of sampling tube by using tip-cutter built into gas detector pump or use separate sampling tube opener supplied with pump.
- 5.2.3 Insert sampling tube into socket of gas detector pump or extension hose, if being used. Ensure tube arrow is pointed toward pump.

5.3 Make a measurement as follows:

- 5.3.1 Check number of strokes required for sampling tube being used by reading instruction sheet supplied with tube.
- 5.3.2 Center fingers in the middle of lower pump plate and squeeze pump completely.
- 5.3.3 Release pump.

NOTE – End-of-stroke indicator will appear when pump is ready for next stroke.

- 5.3.4 Repeat Steps 5.3.2 and 5.3.3, if necessary, or until desired number of strokes is acquired.
- 5.3.5 Check sampling tube for appropriate reading.
- 5.3.6 Remove sampling tube from socket.
- 5.3.7 Flush pump with a few pump strokes in clean air.

6. OXYGEN LEVEL DETERMINATION

NOTE – Acceptable oxygen level is > 19.5% or < 23.5% when entering any containment.

- 6.1 Oxygen shall be monitored using a portable oxygen detecting instrument. The percentage of oxygen in the sample shall be read directly from the meter.
- 6.2 Specific information concerning the operation of the selected instrument can be found in the printed instructions on the instrument, in the instrument manual, or appropriate procedure.
- 6.3 If oxygen concentrations are found to be < 19.5% or > 23.5%, contact Industrial Safety for additional guidance.

7. MONITORING FOR CARBON MONOXIDE

NOTE – Acceptable concentration of carbon monoxide is < 25 ppm.

- 7.1 Determine the carbon monoxide concentration by using one of the multi-gas monitors which contain the CO sensors.
- 7.2 Additional information concerning the use of these instruments can be found in the instrument cases, in the Instruction Manuals, or appropriate procedure.
- 7.3 If the carbon monoxide concentration exceeds 25 ppm, contact Industrial Safety for additional guidance.

8. COMBUSTIBLE GAS INDICATION

NOTE – For the use of specific monitors, refer to the appropriate procedure. Depending on the calibration gas, some combustible gas readings will have a correlation factor that will calculate a true combustible reading. However, if a 10% combustible limit is used, the correlation factor becomes less meaningful.

- 8.1 Instruments used for the detection of combustible gases, including methane and hydrogen, are the multi-gas monitors.
- 8.2 If potential for combustible gas exists, the first test should be taken by inserting a probe into the confined atmosphere through a vent hole or some other opening. Where no openings exist, the entrance cover should be pried open on the downwind side just enough to allow insertion of the probe or instrument. The purpose of this initial test is to determine if any lighter-than-air combustibles have accumulated in the structure.
- 8.3 Remove the cover from outside the structure and perform monitoring of the internal atmosphere.
- 8.4 If the atmosphere exceeds 10% LEL (Lower Explosive Limit), contact Industrial Safety for further guidance.

9. HYDROGEN SULFIDE

- 9.1 Gas monitors are the instruments used for the detection of hydrogen sulfide.
- 9.2 Refer to appropriate procedure for the monitor operation.
- 9.3 If any hydrogen sulfide concentration exceeds 10 ppm, evacuate the area. Industrial Safety may be contacted for further guidance.

10. ETHYL BENZENE

- 10.1 Use the Drager Accuro gas detector pump with appropriate sampling tube for the detection of ethyl benzene.
- 10.2 Refer to Section 5 for gas detector pump operation.
- 10.3 If ethyl benzene is detected in concentrations in excess of the limit listed in Attachment 1, Industrial Safety may be contacted for further guidance.

11. HYDROGEN GAS (ALTERNATE METHOD)

- 11.1 Use the Drager Accuro gas detector pump with appropriate sampling tube for the detection of hydrogen gas.
- 11.2 Refer to Section 5 for gas detection pump operation.
- 11.3 If hydrogen gas is detected in concentrations in excess of the limit listed in Attachment 1, contact Industrial Safety.

12. CHECKING FOR EXPLOSIVE GAS AFTER A NITROGEN PURGE

WARNING 1 – Most LEL sensors require 5% to 10% oxygen present in the sample to properly identify the explosive gas. A low oxygen environment may cause the LEL reading to be lower than actual. Once all oxygen has been purged from the LEL sensor, a reading of zero will be displayed even though an explosive gas may be present.

WARNING 2 – The Optimum Water System may generate hydrogen gas in the primary piping and vessel internals. Nitrogen is purged through the primary piping to expel the hydrogen. Nitrogen can displace oxygen needed by the LEL sensor. Oxygen is needed by the LEL sensor to properly detect an explosive gas.

NOTE 1 – Any Technician trained in the use of the confined space monitoring instruments can perform a purge check.

NOTE 2 – Any time a LEL sensor over-ranges (OR+), it will remove power to the sensor to prevent damage. If the LEL displays flashes OR+, the sensor is no longer operating.

- 12.1 The nitrogen should be allowed to purge adequately through the sample point before sampling.

- 12.2 Sample the purged gas near the exit point allowing the purged gas to mix with room air.
- 12.3 Monitor the oxygen sensor reading to prevent the oxygen concentration from dropping below 10% O₂.
- 12.4 If the LEL sensor over-ranges:
 - 12.4.1 The instrument should be purged with clean air.
 - 12.4.2 The confined space instrument should be turned off by holding the ON/OFF button and following directions.
 - 12.4.3 After a short time, the instrument can be turned back on again by holding the ON/OFF button and following directions. The LEL sensor is now reset.
 - 12.4.4 The instrument should be calibrated again. The instrument may no longer properly quantify the explosive gas but can still detect the presence of explosive gas.
- 12.5 An LEL reading of 20% to 25% correlates to ~ 1% hydrogen. For other explosive gases, contact Safety or Chemistry.
- 12.6 The carbon monoxide sensor (CO) has a high cross-sensitivity to hydrogen and acetylene and will over-range (OR+) when exposed to these gases. The sensor can be purged in clean air and allowed to return to a normal reading for continued use.
 - 12.6.1 CO sensor alarms can be used as an indication of hydrogen gas in the purged line. Less than 1.0% hydrogen will cause the CO sensor to over-range.
- 12.7 If the presence of hydrogen gas is detected, inform the workers to consult with the Safety Department before proceeding with work.

13. RECORDS

- 13.1 No quality records are generated by this procedure.

1. FLAMMABLE GASES

NOTE – During real time monitoring, not when performing instrument checks or calibrations, inform the Control Room if any value reaches 50% of LEL to assess entry into the Emergency Plan.

Name	LEL
Acetylene	2.5 %
Carbon Monoxide	12.5%
Hydrogen	4.0%
Hydrogen Sulfide	4.0%
Methane	5.0%

2. TOXIC GASES

NOTE – During real time monitoring, not when performing instrument checks or calibrations, inform the Control Room if any value reaches STEL to assess entry into the Emergency Plan.

Name	PEL (TWA ppm)	STEL (ppm)	IDLH (ppm)
Ammonia	25	35	300
Bromine	0.1	0.2	3.0
Carbon Dioxide	5000	30,000	40,000
Carbon Monoxide	25	200	1,200
Chlorine	0.5	1.0	10
Chlorine Dioxide	0.1	0.3	5.0
Ethyl Benzene	100	125	800
Hydrogen Chloride	2.0	5.0	50
Hydrogen Sulfide	10	15	100

3. OXIDIZING

Name	Applicable Limits In Air
Oxygen	< 19.5% or > 23.5%

4. INERT GASES

NOTE 1 – The limiting factor involved with inert gasses is Oxygen deficiency. OSHA considers any Oxygen concentration < 19.5% as the IDLH.

NOTE 2 – Inform the Control Room if any value reaches IDLH to assess entry into the Emergency Plan.

Name

Argon

Helium

Nitrogen

1. DISCUSSION

1.1 At CNS there are various potential sources of atmospheric contamination. Some of these sources are:

1.1.1 Inert gas used for oxygen exclusion (nitrogen).

1.1.2 Combustion products.

1.1.3 Carbon dioxide from fire extinguishing.

1.1.4 Welding gases (enclosed areas).

1.1.5 Vapors from painting (enclosed areas).

1.1.6 Vapors from petroleum products.

1.1.7 Hydrogen (OWC hydrogen gas generation system, generator cooling system, batteries, and disassociation of water in the reactor).

1.1.8 Asphyxiants and irritants, found most often in confined areas (water and oil storage tanks, open manholes).

1.1.9 Methane from bacterial action (tanks and pits).

1.2 Some of the gases which should be carefully observed and monitored prior to entry and during the time which personnel are within the confined volume are:

1.2.1 Carbon Monoxide - One of the most common asphyxiants encountered in industry. It is formed by the incomplete combustion of fuel containing carbon. It may be found in the vicinity of a fire or a leak in an exhaust system (flue gas or internal combustion engines).

1.2.2 Oxygen - Oxygen has two fundamentally important properties: it supports combustion and it supports life. Since oxygen is necessary for life, it must be present in sufficient quantity. Oxygen deficiency occurs in confined spaces where the level of oxygen has been reduced below the limit to support life. Oxygen content in the air can become fatally low in a brief period of time. Some of the more common causes of this problem are oxidation of metals, bacterial action, combustion, and displacement by other gases. An enriched oxygen atmosphere will accelerate combustion. Oxygen gas is produced by the Optimum Water Chemistry (OWC) Gas Generation System, located in the OWC Building, and subsequently injected into the Off-Gas System in the Steam Jet Air Ejector (SJAЕ) Room. Bottled oxygen, also stored in the OWC Building, is injected into the Condensate System just downstream of the condensate pumps.

- 1.2.3 Hydrogen - Used in generator cooling. Hydrogen gas is also produced by the OWC Gas Generation System, located in the OWC Building, and subsequently injected into the condensate system just upstream of the condensate booster pumps. Hydrogen is also produced by the disassociation of water from radiation in the reactor, which is seen in the off-gas. The presence of hydrogen will be especially significant in the Off-Gas and Augmented Off-Gas Systems. Hydrogen is also a by-product of battery charging. It is lighter than air so it will be found in pockets at the ceiling of enclosures.
- 1.2.4 Argon - Commonly used during the welding of certain metals. It is more dense than air so it will settle in pockets below the welding area.
- 1.2.5 Carbon Dioxide - Used to fight fire. Being heavier than air, carbon dioxide will settle in pockets and displace oxygen.
- 1.2.6 Nitrogen - Used primarily to purge primary containment. Since it is approximately the same density as air, it can be dispersed by proper ventilation. Areas of poor ventilation may contain greater than expected concentrations of nitrogen and consequently may be deficient in oxygen.
- 1.2.7 Combustible Gases and Vapors - Includes naturally occurring gases (such as methane and hydrogen gas) and the vapors of a large group of liquids which are used as fuels and solvents. Monitoring shall be required in fuel tanks and other areas where explosive mixtures may be present.
- 1.2.8 Hydrogen Sulfide - Classified as an irritant in low concentrations, but is even more toxic than carbon monoxide, because it inflames the mucus membranes and results in the lungs filling with fluid. This colorless gas has a characteristic rotten egg odor, which renders the sense of smell ineffective. Hydrogen sulfide may be found in sewage treatment or wherever organic matter containing sulfur decomposes and shall be monitored constantly during work.
- 1.2.9 Methane - The chief constituent of natural gas and is extremely explosive. It is non-toxic, but may reduce the oxygen content of an atmosphere, causing asphyxiation. Methane is often found in the vicinity of sanitary landfills and has been detected in tanks where bacterial action is taking place (i.e., reactor water cleanup and condensate phase separator tanks). It is lighter than air and tends to accumulate in high spots or pockets. This can present a dangerous situation in storage tanks or sewers where access is normally gained at the top of the confined area.
- 1.2.10 Dangerous Air Contamination - An atmosphere presenting a threat of causing death, injury, acute illness, or disablement due to the presence of flammable and/or explosive, toxic, or otherwise injurious or incapacitating substances.

- 1.2.11 Ethyl Benzene - Used primarily as an additive to diesel fuel. Acute exposure results in a local irritant effect on the skin and mucous membranes. Chronic exposure can lead to nervous system disorders and upper respiratory tract inflammation. Monitoring is required when entering a diesel fuel tank.
- 1.2.12 Chlorine - Used in chemical treatment of Circulate Water and Service Water Systems. Chlorine gas can be recognized by its pungent, irritating odor, which is like the odor of bleach. Chlorine is not flammable but can react explosively with other chemicals such as turpentine or ammonia. Chlorine gas stays close to the ground and spreads rapidly. When chlorine gas comes in contact with moist human tissues, such as the eyes throat and lungs, an acid is produced that can damage these tissues.
- 1.2.13 Chlorine Dioxide - This is a yellow to reddish-yellow manufactured gas which does not occur naturally in the environment. When added to water, chlorine dioxide forms chlorite ion, which is also a very reactive chemical. High levels of chlorine dioxide can be irritating to the nose, eyes, throat, and lungs.
- 1.2.14 Hydrogen Chloride - This is a colorless to slightly yellowish gas with a pungent odor. On exposure to air, the gas forms dense white vapors due to condensation with atmospheric moisture. The vapor is corrosive and air concentrations above 5 ppm can cause irritation. When mixed with water or atmospheric moisture, a highly corrosive atmosphere is formed. The most common source of Hydrogen Chloride gas is from Muriatic (Hydrochloric) Acid.
- 1.3 Dangerous air contamination due to the flammability of a gas or vapor is defined as an atmosphere containing the gas or vapor at a concentration > 10% of its lower explosive (lower flammable) limit.
- 1.4 Dangerous air contamination due to the toxicity of a substance is defined as the atmospheric concentration immediately hazardous to life or health.
- 1.5 Assistance from an Industrial Hygienist may be obtained, as needed, to ensure adequate controls or monitoring is in place.

2. REFERENCES

2.1 COMMITMENTS AND OBLIGATIONS MATRIX

COMMITMENTS AND OBLIGATIONS	AFFECTED STEPS
QAPD	None

2.2 CODES AND STANDARDS

- 2.2.1 NUREG 0041.
- 2.2.2 Threshold Limit Values and Biological Exposure Indices for 1991-1992, American Conference of Governmental Hygienists.

2.3 DRAWINGS

2.3.1 B&R Drawing 2091, Sheets 1 through 6.

2.4 VENDOR MANUALS

2.4.1 CNS Number 2000, Drager Accuro Gas Detector Pump Instrument Manual.

2.5 PROCEDURES

2.5.1 Procedure 0.36.3, Confined Space Procedure.

2.6 MISCELLANEOUS

2.6.1 Confined Area Entry, BioMarine Industries, Inc.

2.6.2 CR 94-0058.

2.6.3 Dangerous Properties of Industrial Materials by N. Irving Sax.

2.6.4 Drager Multi-Pac Operating Manual.

2.6.5 MSA Industrial Safety Equipment Catalog, Section 10, Technical Information.

2.6.6 Quick-Comm, Item 4852651, Grand Gulf, Methane Gas Hazard, dated March 21, 1990, 10:22 A.M.