FREEPORT-McMoRan

FCX Department of Occupational Health and Safety	SOP #		
	Revision #		03/17/2015
	Version		4
Hazardous Gas Monitoring Systems and Appurtenances	**Task Risk**	X	**High**
			Medium
			Low
			NA
Approval Date:	**Original Date:**		

Contents

1.0 Policy

Purpose	The intent of this standard is, to the extent possible, prevention of harmful exposure to hazardous gases (such as hydrogen sulfide gas) and/or the development of an oxygen deficient atmosphere, through any effective combination of safe design, installation, operation, and maintenance of processes and process equipment; the use of gas monitoring systems and appurtenances; and Standard Operating Procedures.
Scope	This standard applies to all Freeport-McMoRan production/process operations where toxic gases (such as hydrogen sulfide, chlorine, sulfur dioxide, hydrogen cyanide, etc.) are used or generated and/or where an oxygen deficient atmosphere may be created (due to a release of gases such as nitrogen or carbon dioxide that may result in asphyxiation.) NOTE: where the term "hazardous gas" is used, it is intended to include circumstances where oxygen deficient atmospheres are or may be present.
Minimum Standard	The information and criteria provided are to be considered the minimum standard to be met. Any site or operation, at their discretion, can implement any measures that would be more conservative or protective.

2.0 FCX Standard Hazardous Gas Risk Control Measures

2.1 Fixed Sensors

Placement	Placed in process areas near likely/probable hazardous gas pathways or release/discharge points (no more than 10% of monitors shall be located at the perimeter of the process area the intent being to first detect the release of the gas as close to its point of release as possible, taking into account the properties of the gas relative to rising or falling (is the gas heavier or lighter than air) Placed along route of hazardous gas/process chemical delivery lines (from receiving vessel to point(s) of delivery) with consideration given to joints, connections, pumps, sumps, etc. where leaks or releases may occur. Mounted so that the gas will be detected prior to passing through the breathing zone of a person in the area based on the path that the gas would naturally take after leaving a potential source, taking into account the specific gravity of the gas and ambient factors (such as wind or breezes).
Specifications	Fixed sensors must be capable of "immediate" response and shall not be fed by tubing or other remote means to convey the gas to the detector head Visual warning lamps must be equipped with BLUE lens cover and signage displayed with the lamp to designate the specific hazardous gas being indicated. Audible Alarm must be distinct and unique from other alarms in the process area used to indicate other hazards or issues (over-head crane alarms, over-flow alarms, etc.)
Protection	Must be protected from water spray, smoke or any other physical agent which may affect response time or result in sensor damage or false alarms. Consult with the manufacturer to determine acceptable means to achieve protection while maintaining intended response and function of the device
Inspection	Must be: • inspected regularly • bump tested in accordance with manufacturer specifications • maintained and calibrated in accordance with manufacturer specifications

- tested only with a gas concentration specified by the manufacturer

  **NOTE:* each sensor must be initially bump tested daily for 10 consecutive operating days to determine reliability, consistency, and accuracy of response to a challenge gas. Thereafter, bump testing and calibration must be performed, at a minimum, per manufacturer recommendations.

2.2 Personal Monitors

Proper Use	Worn in breathing zone (18" circumference around head); worn on top of clothing (not covered or obstructed); not on helmet Worn by each entrant into the controlled process area
Testing	Bump- tested daily prior to use; maintained/calibrated in accordance with manufactures specifications; test only with a gas concentration specified by the manufacturer
Specifications	Must be multi-functional as relevant, where one or more hazardous gas (hydrogen sulfide, sulfur dioxide, hydrogen cyanide, chlorine, etc.) may be present and/or the risk of an oxygen depleted atmosphere is possible where the potential exists for any process gas to be present outside of enclosed process systems at hazardous levels (see below in "Action Levels for Alarms and Responses")
Maintenance	All monitors are to be returned clean and in good repair—the responsibility of the last user

2.3 Personnel Training

Who Needs Training	Required for: • All individuals who are likely to have exposure to hazardous gases (such as sodium hydrosulfide, Nokes Reagent, molten sulfur, sulfur dioxide gas, cyanide, chlorine, etc.) due to their presence in areas where the hazardous gases are, or may be present at or above the defined action levels defined below • Individuals entering the controlled access process areas
Frequency	Must be repeated annually (refresher) and documented in writing
Content	Training must address: • Hazards and issues related specifically to the hazardous gas (i.e. not just NaHS user training), and any other hazardous substances associated with the process, such as nitrogen, carbon dioxide, sulfur dioxide, hydrogen cyanide, chlorine, etc. • Training must be provided for operational response to an alarm event. • Must be site specific and include training on o evacuation routes o signage, alarms o instrumentation o respiratory protection devices, o safe handling procedures o information relating to contact with other substances (e.g. liquids with pH less than 10 or chemical incompatibilities), o signs/symptoms of exposure to hazardous gas, etc.

2.4 Material Handling and Receiving

Storage vessel/area	Storage vessel/area must be equipped with a fixed sensor. Where the vessel is vented, placement of the sensor must be such that it would detect release of the hazardous gas from that vent at a point near the vent
Delivery System	Connections of delivery system must be unique or specific for receipt only of the process chemical associated with the hazardous gas (i.e. NaHS reagent, Nokes reagent, ammonia, chlorine, etc.) into the system (connection to the truck or connection from the truck to system piping)
Storage Tanks	Connection points to storage tanks are to be locked at all times other than when receiving the process chemical associated with the hazardous gas. The receptacle system/storage tank must be grounded and a bonding connection used during transfer of material from the delivery vehicle to the storage tank in those instances where the substance is flammable or combustible or the material may evolve flammable or combustible gas or vapor
Receiving	Receipt of material must be under the supervision of a trained FCX employee and is to be monitored (in person, via camera, etc.) during the transfer process
Dangerous Substances	No substances which contribute to the reaction generating hazardous gas should be routed/available at the storage location and no containments should be allowed to hold/contain these substances (i.e. fresh water, rain water, liquids with pH less than 10, etc.) without appropriate precautions and controls to safely manage the evolution of hazardous conditions
Spilled Chemical	Spilled process chemical is to be absorbed, not flushed (unless process water at an appropriate pH is available for the specific substance being washed/diluted)
Labeling	Process reagent lines must be labeled to indicate what they contain as well as the direction of flow of the material in the line.
Gas Capture Systems	Gas capture systems associated with material transfer should be provided where fugitive gases pose a health risk.
Enclosed Processes	Where processes are designed to operate in ranges where hazardous gases are

	or may be generated or evolved, they shall be equipped with local exhaust ventilation systems and shall be enclosed and operated under negative pressure conditions at all times unless safeguards are in place to ensure that exposures are controlled below the action levels defined below.
External Processes	External processes, such as thickeners or stock tanks open to the atmosphere shall be equipped with gas monitoring systems to ensure that exposures are monitored and controlled below the action levels defined below where hazardous gases may be release or evolved.
Emergency/Backup Power	Provisions shall be made to account for power outage/disruption for critical systems such as ventilation systems, fixed monitors, process monitors, etc. which are intended to prevent or manage conditions which may result in exposure to hazardous conditions

2.5 Controlled Area

The process area shall be considered a controlled access area and its boundaries defined and controlled with access limited to authorized personnel.	
Signage	Adequate signage communicating the boundaries of the controlled access area must be provided.
Entrant Requirements	All entrants into the controlled access area must: • have training prior to entry into the area • wear an appropriate personal hazardous gas detection device • carry an escape respirator on their person where it has been determined that they are necessary NOTE: where the risk is due to oxygen deficiency, the respirator must provide supplied air, and cannot be an air-purifying device, and must provide sufficient air to provide for relocation to a safe point • sign in and out • display a visible badge, sticker, or indicator that they are current with their training (similar to a pit driving tag)
Responders	Operators responding to an alarm condition to investigate the cause;

Emergency Responders entering the area; Maintenance personnel entering the area to resolve or correct a problem shall do so using the Buddy System; in addition to the personal monitor, the operator shall use a portable gas detector capable of measuring levels of the hazardous gas(es) being released or suspected of being present. In addition, personnel must be equipped with Supplied Air Respiratory protection when entering an area where atmospheric levels of any hazardous gas(es) is(are) being released to the general atmosphere (i.e. not in contained/enclosed systems)

Personnel responding to or investigating the circumstances of an alarm condition in the operating are shall use supplied air respiratory protection.

2.6 Action Levels for Alarms and Responses

Alarm[1] Set Points

Substances and Action Thresholds

Gas	Low Alarm Set Point	High Alarm/Evacuation[2]
Hydrogen Sulfide	10 ppm	20 ppm; multiple[3] 10 ppm
Chlorine	0.5 ppm	1 ppm
Hydrogen Cyanide	2.0 ppm	4.7 ppm
Sulfur dioxide	2.0 ppm	5 ppm
Carbon dioxide	5000 ppm	30000 ppm
Oxygen	19.5 %	<19.5 % or > 23.5%
Ammonia	25 ppm	35 ppm
Nitrous Oxides*	3 ppm	5 ppm
Carbon Disulfide	10 ppm	30 ppm
Carbon Monoxide	25 ppm	50 ppm

[1]applies to both personal and fixed sensor devices—personal devices are to be worn by each individual in the process area where the gas is odorless, has poor warning properties, or an inability to perceive the gas may develop
[2]evacuation of personnel who are not equipped with adequate PPE to safely remain in the work area
[3]multiple devices alarming concurrently in the general process area
*Applies to the various nitrogen compounds such as nitrogen dioxide (NO_2); nitric oxide (N_2O); or nitrous oxide (NO)

Shut off Switches

An emergency shut-off ("kill switch" or "panic button") should be provided in accessible locations at operating and reagent storage areas.

Consider installation at areas around the perimeter of the restricted access boundary where they could be activated during an evacuation.

These emergency shut-off switches should be designed to prevent accidental activation.

Alarms

Alarm at single fixed sensor	Alarm at 2 or more fixed sensors
1. Do not approach, but attempt to determine the cause or reason for the alarm	1. Evacuate the immediate vicinity of the alarm area. All traffic into area halted, except for properly equipped and trained responders
2. Wait for alarm to stop before approaching the vicinity of the sensor	2. Wait to determine if the alarm condition is temporary/transient. Determine the cause for the alarm
3. Retreat if personal detector alarms or indicates an increasingly higher ppm level of hazardous gas or reduction of oxygen (as applicable)	3. Do not re-enter unless properly equipped or until the source of the problem has been identified and controlled in a safe manner

Example for reaction to sensor response:

1 sensor at +20 but less than 30 ppm, blue light flashes and we leave the area (CO2 and NaHS flow stopped as we currently do), but if the condition lasts for more than 30 second duration, evacuation alarm sounds
1 sensor at +30 but less than 40 ppm, blue light flashes and we leave the area (CO2 and NaHS cut as we currently do), but if the condition lasts for more than 20 second duration, evacuation alarm sounds
1 sensor at +40 but less than 50 ppm, blue light flashes and we leave the area (CO2 and NaHS cut as we currently do), but if the condition lasts for more than 10 second duration, evacuation alarm sounds
+50 ppm no change to current set up

Response to Alarm	The intent of the personal and fixed sensor alarms is to indicate increased risk. In each situation where an alarm occurs on either the personal or fixed device, it is acceptable for the workers in the area to move to a point distant from the alarm location where the personal monitor response falls below the low alarm value (indicated above in the Alarm Set Point Table.) A general evacuation and "emergency response" is not required so long as the workers present in the detection vicinity of the fixed sensor alarm can safely move to a new position where the personal monitor readings fall below the low alarm value. If the alarm condition is transient (it either ends or drops below the low alarm point), work can resume. An alarm at a fixed sensor does not necessitate a general evacuation where it is of short duration (20 seconds) and is decreasing over a 2 to 3 minute period to an acceptable value. In the case of multiple alarms occurring simultaneously, all workers must move to a location where their personal monitor indicates levels below the low alarm point. Resumption of work can occur with cautious approach to the alarm location and observing the personal monitor to validate that the gas levels are within the acceptable, safe ranges for all gases being monitored. In those instances where alarms repeatedly occur; gas levels are exceeding the high alarm level; gas reading levels are fluctuating ; multiple fixed sensors are responding; the area of the increased risk is increasing; or any other similar conditions, an evaluation of the problem is required to determine and resolve the condition(s) causing the gas release.
pH Detectors	For H_2S risks from a NaHS or NOKES source that are not contained in a negative pressure ventilated and enclosed system, pH detectors monitoring areas with direct personal exposure will have an initial alarm at 9.8 and automated system responses (shut-down, reagent flow cessation, etc.) at 9.5. ***OR*** Where there is potential to evolve/generate concentrations of H_2S from NaHS or NOKES, pH detectors for liquid/pulp are required to monitor all processes where direct personnel exposure may occur. The pH measurements shall trigger processes responses that include an initial alarm at pH 9.8 and automated system response (shut-down, reagent flow cessation, etc.) at pH 9.5
Other Sensors	Other sensors may be incorporated into the process control and hazardous gas management system. Action taken as a result of these indications must ensure that 'fail safe' is maintained.
Temperature Alarms	Where thermal degradation can occur, with a subsequent

	uncontrolled/unplanned release of hazardous gas, monitoring and control must be implemented to ensure that excursions into unacceptable zones (high or low) cannot occur. For NaHS/Nokes, temperatures of the reagents at or above 120°F could cause off gassing, conversely, crystallization may occur at the freezing point of the reagent—low temperature alarms should be set at a point 3-5 degrees above that freezing point.
Storage Tanks	Over-filling of storage vessels can result in a release of liquid or hazardous gas; low levels may result in excessive temperature build-up where a submersible heating unit is not submersed. Do not fill above 85% capacity; continuously monitor temperatures.

2.7 Respiratory Protection

Respirator specifications	Where respirators are required, full face devices are recommended; A schedule to establish change-out or replacement of cartridges/canisters for any air purifying devices (specifically, cartridges even if not used)shall be defined and implemented Supplied air respirators must conform to the provisions of the FCX Respiratory

	Protection Program; at a minimum, air quality must be Grade D
Personnel Requirements	For any "tight-fitting" devices personnel must be clean shaven per FCX Respiratory Protection Program (RPP) and the device shall be fit-tested in accordance with the RPP Hands-on practice with the device must be provided during training
Self-Rescuers	Self-rescuer" (mouth insert style devices) have no assigned protection factor, do not protect the face/eyes and shall not be used

2.8 Pre Startup Safety Review

Process Steps	1. Refer to and comply with OSHA 29CFR-1910.119 regarding pre-startup safety review. 2. A review of the recommendations resulting from a hazard evaluation process must be performed and the approved recommendations must be

completed as part of a safety review.

3. Quality Analysis/Quality Control evaluations must be performed by Construction to ensure that the installed system meets design criteria and approved recommendations resulting from a hazard evaluation process. Time must be included in governing schedules to allow for theses evaluations.

4. A detailed pre commissioning and commissioning plan will need to be developed to include all appropriate tests/challenges required to validate the installed system responses. Time must be included in governing schedules to allow for theses evaluations. These plans must include:

    a. reference to all applicable engineering documents to allow for successful review of construction/implementation against design,
    b. detail on hazard mitigation requirements to keep commissioning personnel safe,
    c. temporary emergency evacuation procedures specific to conditions as they may exist at the time testing is to commence,
    d. temporary hazard alerting equipment and procedures in the event portions of the permanent hazard notification system are not available when pre-commissioning and/or commissioning activities are to occur.

5. A review and sign off of the results of the pre commissioning activities (i.e. forced simulation of hazardous condition with calibration gas) will be incorporated into a pre startup safety review, which will be completed prior to the introduction of process chemicals associated with hazardous gasses.

6. Commissioning will validate through testing/challenging that the installed system is functional and the measured system response meets the design intention.

3.0 Engineering Guidelines

Automated Process Control System	Where a control system is being used as a safety response system, an assessment of the automated control system is required. It should include: - An assessment of the CPU scan time

	- An assessment of the network utilization - An assessment to ensure safety controller and related equipment will not be subjected to interference from un-related process control - Jumpers shall not be configurable that override approved engineering control
Evaluation	An evaluation must be performed (i.e. HAZOPS) to recognize, evaluate and control occupational risks prior to commencement of any construction or alteration activities. As applicable, the Management of Change (MOC) process shall be completed.

4.0 Maintenance/General Specifications Guidelines

Instruments	Regarding instruments integral to the safety response system, ensure design allows for continuous instrument signal by maintaining a sensor in service while performing maintenance on others.
Testing and Inspections	At a minimum, an annual test of safety response system must be performed in order to ensure mechanical integrity of the system. It is suggested that this challenge is coordinated with routine evacuation drills. The frequency of inspections and tests of process equipment shall be consistent with applicable manufacturers' recommendations and good engineering practices, and more frequently if determined to be necessary by prior operating experience. Appropriate checks and inspections shall be performed to assure that equipment is installed properly and consistent with design specifications and the manufacturer's instructions, documented in writing and retained.
Replacing parts	Maintenance specifications must ensure that components are replaced with the originally specified parts to prevent issues associated with component failure. Where identical component replacement is infeasible, the site's Management of Change process must be used. Modifications to either the operating procedures or installed equipment must be done by qualified individual who have been trained regarding the hazardous gasses that may be evolved by the process. Modifications shall follow prescribed approval processes before they are implemented.
Equipment Suitability	In the construction of new plants and equipment, assure that equipment as it is fabricated is suitable for the process application for which they will be used and assure that subsequent parts and components continue to maintain that suitability. Assure that maintenance materials, spare parts and equipment are suitable for the process application for which they will be used.

5.0 Engineering Deliverables

Engineering deliverables need to include the following in addition to standard contractual deliverables:	
Specifications Required	Specifications are required for: • Safety system related instrumentation • Safety Valves • Safety equipment
Process Safety Information	• Ensure that the OSHA Process Safety Management standard is reference as best practice. • Ensure safety system is documented via a Cause and Effect diagram.
Engineering Drawings	Engineering Drawings must include: • Cause and Effect Diagram • Instrumentation and Equipment Control Schematics for safety circuits • Hazardous gas sensor locations • Globally Harmonized System (GHS) compliant signage drawings (refer to the OSHA Hazard Communication standard, 29 CFR 1910.1200 • Evacuation plan including map with routing. Where applicable, indication of wind indicators (wind sock/flag) to direct personnel to the upwind refuge.

6.0 Definitions

Definitions	
Appurtenances	Devices, monitors, gauges, etc. which include, but are not limited to, pH meters, temperature gauges, level gauges, etc. which monitor process parameters which directly or indirectly are capable of providing information to predict or anticipate a release of a hazardous gas
Breathing Zone	An 18 inch diameter zone around the head
Buddy System	A procedure in which two people, the "buddies", operate together as a single unit so that they are able to monitor and help each other
Controlled Area	A defined area (marked, signed, fenced, or otherwise denoted) into which entry/traffic is limited and requirements for entry have been established, such as signing in/out; hazard training; use of personal monitors; having an escape respirator; or other site-specific measures implemented
Fail Safe	A design or programed control that causes a valve to automatically open or close (depending on its function) to ensure that a safe condition results by that action
Hazardous gas	For purposes of this standard, process-related gases such as hydrogen sulfide, nitrogen, carbon dioxide or other toxic/harmful gases which can be released from the process or conditions which may result in oxygen deficient or oxygen rich atmospheres
Instrumentation	Equipment to detect unsafe ambient conditions: • Hazardous gas sensors specific to the gases used or evolved by processes • O_2 sensors • Equipment to detect unsafe operating conditions • pH meters (low pH, high pH) • Temperature monitors • Level gauges • ORP (Oxidation Reduction Potential) meters

Process Control System	Instrumented control system for monitoring, managing and control of the facility's process:
	• Capable of monitoring and recording of hazardous gas in the ambient air and/or process deviations
	• Capable of initiating a safety system response based on
	  • Process deviations
	  • Ambient air conditions out of tolerances

Process Equipment	As a standardized operating philosophy, “fail safe” shall be the default unless specifically determined otherwise. Related to process equipment as part of risk control (i.e.) Process control valves
Restricted Access Area	Any process/production area where personnel presence is desired to be minimized for safety reasons, and where specific training, sign in/sign out, specialized equipment (e.g. personal monitors, radios, tools, etc.), or other provisions have been implemented to limit access. The intent is also to prohibit traffic into and through the area as a “travel path” or passage to adjacent work areas.
Safety Equipment	Safety equipment is equipment designed and utilized to mitigate and control risk. **EXAMPLES:** • Block and bleed valves • Audible and Visual alarms • Local exhaust ventilation systems • Building roof fans designed for ambient air exchange • Process scrubbers to eliminate evolved hazardous gas • Intrinsically safe electrical systems, tools, and equipment as relevant to the physical properties (e.g. flammability) of the hazardous gas and potential to be present at or above the Lower Explosive Limit
Safety Integrity Level Rating (SIL Rating)	Measurement of performance required for a safety instrumented function. Rating is applicable for electrical/electronic controls only Refer to IEC 61508 – Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems.
Safety Shutdown	A safety shutdown is the safety system’s response to a potentially un-safe condition • Detection of an emergency condition via push-buttons / emergency stop initiated by operating personnel • Detection of a process deviation that would result in an evolution of hazardous gas from the process • Detection of hazardous gas in the ambient air EXAMPLE: An example of a safety system response would be to • Initiate the failure mode of provided process safety valves (e.g. block/bleed) • Initiate an ambient air exchange in the building via provided building fans • Initiate audible and visual alarms in the affected area

7.0 References

References	1. IEC 61508 – Functional Safety of Electronic Safety related systems 2. IEC 61511 – Functional Safety – Safety Instrumented Systems for the process industry sector 3. ISA84 – Safety Instrumented Systems Expert Certification 4. The purple book from OSHA http://www.osha.gov/dsg/hazcom/ghs.html 5. OSHA Title 29 CFR-1910.119 http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9760 6. OSHA Title 29 CFR 1910.1200 http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099 7. MSHA Title 30 CFR http://www.msha.gov/30cfr/0.0.htm

8.0 Records

The following records must be retained according to the FCX Records Retention Policy	• Employee Training Records • Annual program review • Equipment inspection records • Exemption Documents

9.0 Revision History

20 **Rev 1**	Initial Release	
20 **Rev 2**	This update includes	Revised Formatting