



Kerr-McGee Oil & Gas Onshore LP

1099 18th Street
Denver, CO 80202
720-929-6000

June 15, 2021

Ms. Julie Murphy
Colorado Oil and Gas Conservation Commission
Department of Natural Resources
The Chancery Building
1120 Lincoln Street, Suite 801
Denver, CO 80203

Re: Air Monitoring Program: SBJ 22-13HZ Pad Production Drilling, Completions and Production Facility
Weld County, Colorado

As required by the Condition of Approval (COA) for the SBJ 22-13HZ Pad, Kerr-McGee is submitting an Air Monitoring Plan for production drilling, completions, and early production facility operations at this location. Montrose Air Quality Services, LLC has been contracted to manage Kerr-McGee's Air Monitoring Program.

This location is subject to the Air Monitoring requirement under CDPHE Regulation 7 VI.C. The cover letter transmitting the plan to the CDPHE and local governments is provided.

The Air Monitoring Program establishes three (3) levels of investigation responses to ensure protection of public health, safety, welfare, the environment, and wildlife resources. Sections 14 and 15 of the air monitoring program detail these levels and responses. If a Level 3 event occurs, Kerr-McGee will notify the COGCC, CDPHE and the local government with jurisdiction over the location of the operations within 48 hours of receiving notification.

Periodic meetings will be scheduled with the COGCC to discuss results and to answer any questions that may arise. Kerr-McGee will offer to schedule periodic community meetings during drilling and completions operations to discuss operations, obtain feedback, and answer questions. Meetings will be virtual until safe to do otherwise.



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June 15, 2021

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Environmental Health Specialist

Mr. Jason Maxey
OGED Director and Local Government Designee
Oil & Gas Energy Department
1301 N. 17th Ave.
Greeley, CO 80631

Re: Air Monitoring Program: SBJ 22-13HZ Pad and Production Facility
Weld County, Colorado

Per CDPHE Regulation 7 VI.C.1.b.(iv), Kerr-McGee is providing the air monitoring plan for this location. The HSE Air Monitoring Program provides the overall monitoring plan guidelines for air monitoring at pre-production operations and production facilities. Specific guidelines for the SBJ 22-13HZ Pad and Production Facility are addressed in the Air Monitoring Location Details. As outlined in the regulation, CDPHE will consult with Local Governments as part of their review.

If you have any questions, please contact Chad Schlichtemeier at Chad_Schlichtemeier@oxy.com.



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1099 18th Street
Denver, CO 80202
720-929-6000

Air Monitoring Location Details

SBJ 22-13HZ PAD
Weld County, Colorado

June 15, 2021

Chad Schlichtemeier
Oxy HSE

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1. COMPANY CONTACT

- The owner or operator name and the contact information of the owner or operator representative for monitoring purposes (Reg. 7 VI.C.1.b.(i))
 - Owner/Operator:
 - Kerr-McGee Oil & Gas Onshore, LP
 - Air Monitoring Contact:
 - Chad Schlichtemeier
Occidental
1099 18th Street
Denver, CO 80202
(720) 929-6867
Chad_Schlichtemeier@Oxy.com

2. LOCATION

- Pad Name(s)
 - SBJ 22-13HZ Pad
- Activity type
 - Production Rig Drilling
 - Completions Operations
 - Production Facility Operations
- Location

	<u>Latitude</u>	<u>Longitude</u>
○ SBJ 22-13HZ Pad	40.315167	-104.956905
○ SNW NSW 13 4N 68W 6 PM		

3. LOCAL GOVERNMENT AND COGCC COORDINATION

- Owners or operators must submit an air quality monitoring plan to the Division and the local government with jurisdiction over the location of the operations and any other local government unit, where applicable, within 2,000 feet of the proposed operations at least sixty (60) days prior to beginning air quality monitoring. Upon the request of any of these local government units within 14 days of receiving the plan, the Division will consult with them as part of its review process. **(Reg. 7 VI.C.1.b.(iv))**

- As shown on the attached map, local governments with 2,000 feet
 - Town of Berthoud
 - Curt Freeze, Community Development Director
cfreeze@berthoud.org
807 Mountain Avenue
P.O. Box 1229
Berthoud, CO 80513-2229
 - Weld County
 - Taylor Robinson – Environmental Health Specialist
trobenson@weldgov.com
Jason Maxey - OGED Director and Local Government Designee
jmaxey@weldgov.com

Oil & Gas Energy Department
1301 17th Ave.
Greeley, CO 80631
- Whether the local government with jurisdiction over the location of the operations has air quality monitoring requirements applicable to pre-production and/or early production operations, a description of those requirements, and a local government contact for air quality monitoring purposes. **(Reg. 7 VI.C.1.b.(iv))**
 - Weld County has jurisdiction over the location and do not have specific air quality monitoring requirements in their code.
- COGCC Coordination
 - Indicate if the COGCC permit required coordination with CDPHE. (yes or no)
 - Indicate if the COGCC permit requires air monitoring (yes or no)

4. PRE-PRODUCTION AND PRODUCTION FACILITY SCHEDULE:

- The planned schedule for drilling and completions operations at the monitoring locations. **(Reg. 7 VI.C.1.b.(ii))**
 - SBJ 22-13HZ Pad
 - Tentative Production Drilling schedule October 20, 2021 – January 3, 2022
 - Tentative Completions schedule March 9 – June 12, 2022
 - Production facility monitoring is tentatively scheduled to commence on June 12, 2022 for a period of 6 months.
 - Air monitoring will tentatively start on October 1, 2021 and will conclude on December 9, 2022. Air monitoring equipment will be removed in between production drilling and completions operations.
 - Actual dates will be provided in the monthly reports

5. WELL API NUMBERS

- The operations to be monitored including the API number of the well(s), location of the operations including latitude and longitude coordinates, and any associated facility or equipment AIRS number(s). **(Reg. 7 VI.C.1.b.(iii))**

<u>Well</u>	<u>Latitude</u>	<u>Longitude</u>	<u>API #</u>
SBJ 13-1HZ	40.315167	-104.956905	N/A
SBJ 13-2HZ	40.315127	-104.956894	N/A
SBJ 13-3HZ	40.315087	-104.956883	N/A
SBJ 13-4HZ	40.315046	-104.956873	N/A
SBJ 13-5HZ	40.315006	-104.956862	N/A
SBJ 13-6HZ	40.314965	-104.956852	N/A
SBJ 13-7HZ	40.314925	-104.956841	N/A
SBJ 13-8HZ	40.314885	-104.956831	N/A
SBJ 13-9HZ	40.314844	-104.95682	N/A
SBJ 13-10HZ	40.314804	-104.956809	N/A
SBJ 13-11HZ	40.314764	-104.956799	N/A
SBJ 13-12HZ	40.314723	-104.956788	N/A
SBJ 13-13HZ	40.314683	-104.956778	N/A

- SBJ 22-13HZ wells API numbers are not available. The AP numbers will be provided in the monthly reports.
- SBJ 22-13HZ Production Facility AIRS number for the permanent water tanks is not available. The AIRS number will be provided in the monthly reports.

6. MONITORING OBJECTIVES

- VI.C.1.b.(ix)(E) An explanation of how the number and placement of monitoring equipment will be adequate to achieve the desired air quality monitoring objectives, considering the monitoring equipment's detection limit and other limitations. **(Reg. 7 VI.C.1.b.(ix)E)**
 - Section 7 in the Kerr-McGee Air Monitoring Program _June 2021 (Program) describes how the program will achieve the air quality monitoring objectives. Attached are site plans (Figures 1 - 3) for the monitoring equipment setup during production drilling, completions operations and after the last well is turned over to production starting the six (6) months of production facility monitoring for this location. The production facility monitoring setup reflects the design of the facility. See Section 5 of the Program for more information on the design of the production facility.

7. MONITORING SITE PLAN

- Monitoring site plan **(Reg. 7 VI.C.1.b.(ix))**
 - VI.C.1.b.(ix)(A) The number of monitors and/or sensors to be deployed. **(Reg. 7 VI.C.1.b.(ix)A)**
 - Production Drilling (See Figure 1):
 - PID analyzers: Six (6) analyzers will be sited around the pads and production facility. See Section 9.1 in the Program for details on the analyzers.
 - Carbon Sorbent Tubes: Twelve (12) will be sited around the pad in addition co-located with PID analyzers. See Section 9.2 in the Program for details on the carbon sorbent tubes.
 - SUMMA® canisters: Will be deployed as outlined in the Program. See Section 9.3 in the Program for details on the canisters.
 - Meteorological Station: One station will be co-located with a PID analyzer. See Section 9.4 in the Program for details on the station.
 - Completions Operations (See Figure 2):
 - PID analyzers: Six (6) will be sited around the pads and production facility. See Section 9.1 in the Program for details on the analyzers.
 - Carbon Sorbent Tubes: Twelve (12) will be sited around the pads and production facility in addition co-located with PID analyzers. See Section 9.2 in the Program for details on the carbon sorbent tubes.
 - SUMMA® canisters: Will be deployed as outlined in the Program. See Section 9.3 in the Program for details on the canisters.
 - Meteorological Station: One station will be co-located

- with a PID analyzer. See Section 9.4 in the Program for details on the station.
 - Production Facility (See Figure 3):
 - PID analyzers: Four (4) will be sited around the production facility. See Section 9.1 in the Program for details on the analyzers.
 - Carbon Sorbent Tubes: Co-located with PID analyzers. See Section 9.2 in the Program for details on the carbon sorbent tubes.
 - SUMMA® canisters: Will be deployed as outlined in the Program. See Section 9.3 in the Program for details on the canisters.
 - Meteorological Station: One station will be co-located with a PID analyzer. See Section 9.4 in the Program for details on the station.
- VI.C.1.b.(ix)(B) The location and height of the monitoring equipment, including for each phase of operations if location and height of the equipment will change (e.g., monitoring placement impacted by sound walls). **(Reg. 7 VI.C.1.b.(ix)B)**
 - See attached Figures 1 - 3 for the tentative monitoring locations during Production Drilling, Completions and Production Facility operations. Exact locations of the monitoring equipment will be provided in the monthly reports.
 - All monitoring equipment will be placed on tri-pods 4 to 7 feet off the ground during each phase of operations.
 - The pad will have sound walls approximately 32 feet tall. Guidance for air modeling recommends being at least twice the height of the structure to eliminate any influence from the structure. The carbon sorbent tubes and the analyzers will be greater than 100 feet from the wall. SUMMA® canisters will be placed at a carbon sorbent tube or analyzer location. There will be no influence from the sound walls.
- VI.C.1.b.(ix)(C) A topographic map and plan of the site, showing the expected equipment layout, including air quality and meteorological monitor locations and their distance from preproduction and production.
 - See Figures 1 - 3 for monitoring equipment locations.
 - Analyzers are generally sited 300 feet from the walls around the preproduction equipment and from the production facility boundary, which is typically identified by a security fence. Construction of the production facility will be ongoing during production drilling operations so the monitoring to the south may be greater than 300 feet from the walls.
 - Carbon sorbent tubes are generally sited 165 feet from the walls around the pre-production equipment and from

the production facility boundary, which is typically identified by a security fence. As discussed for the analyzers, the tube locations to the south may be further from the pad walls during production drilling due to the production facility construction.

- Exact locations of the monitoring equipment will be provided in the monthly reports.
- Equipment Layout
 - Attached are general layouts of the equipment for Production Drilling, Completions operations and a Production Facility that is representative of this location. Production Drilling and Completions operations will be conducted inside walls approximately 32 feet high.
- The location has no terrain to consider in locating the monitoring equipment.

- The map must indicate any obstructions to air flow to the monitor(s) and also show all roads and access ways within a half-mile of the facility and any contiguous structures, whether or not they are part of the production operations. **(Reg. 7 VI.C.1.b.(ix)C)**
 - Attached Figure 4 shows a half-mile radius around the pads and production facility. There are no obstructions around the pad that will influence the monitors.
- A description of how the monitoring equipment, pollutant(s) monitored, and siting plan are expected to detect elevated emissions and achieve at least one of the monitoring objectives listed in Reg. 7 VI.C.1.b.(v). **(Reg. 7 VI.C.1.b.(xi))**
 - Section 9 in the Program details the monitoring equipment to be used at this location and Section 7 in the Program describes how the program will achieve the air quality monitoring objectives. Monitoring equipment will be sited as shown in Figures 1 - 3.

8. ATTACHMENTS

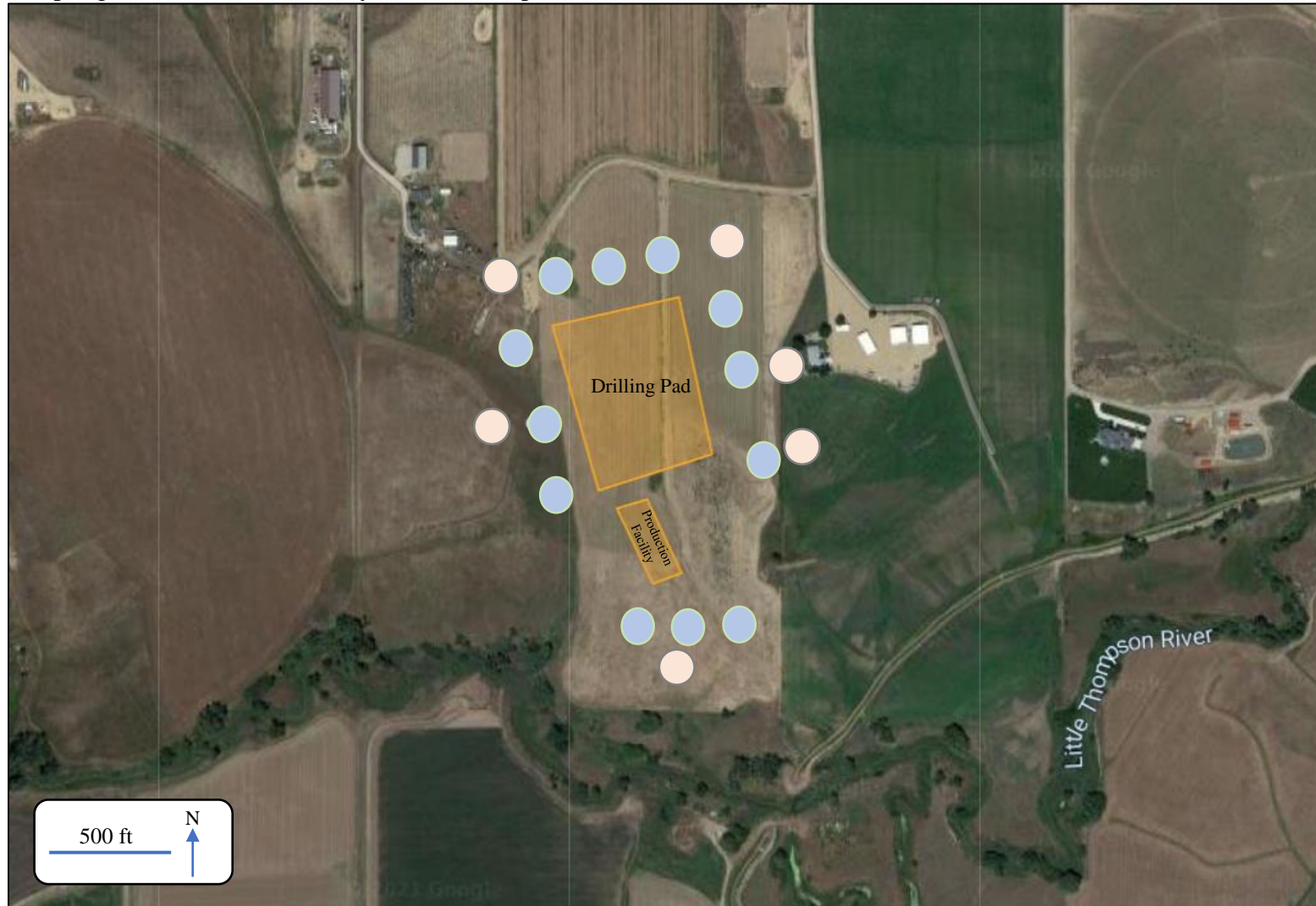
Local Governments – 2000' radius from SBJ Pad



SBJ Drilling Monitoring Map

Sampling Locations

Sampling locations are labeled by ID on the map below.





Location Tag	Monitoring Equipment
	PID Analyzer, Carbon Sorbent Tube
	Carbon Sorbent Tube

Figure 1

SBJ Completions Pad and Production Facility Monitoring Map

Sampling Locations

Sampling locations are labeled by ID on the map below.





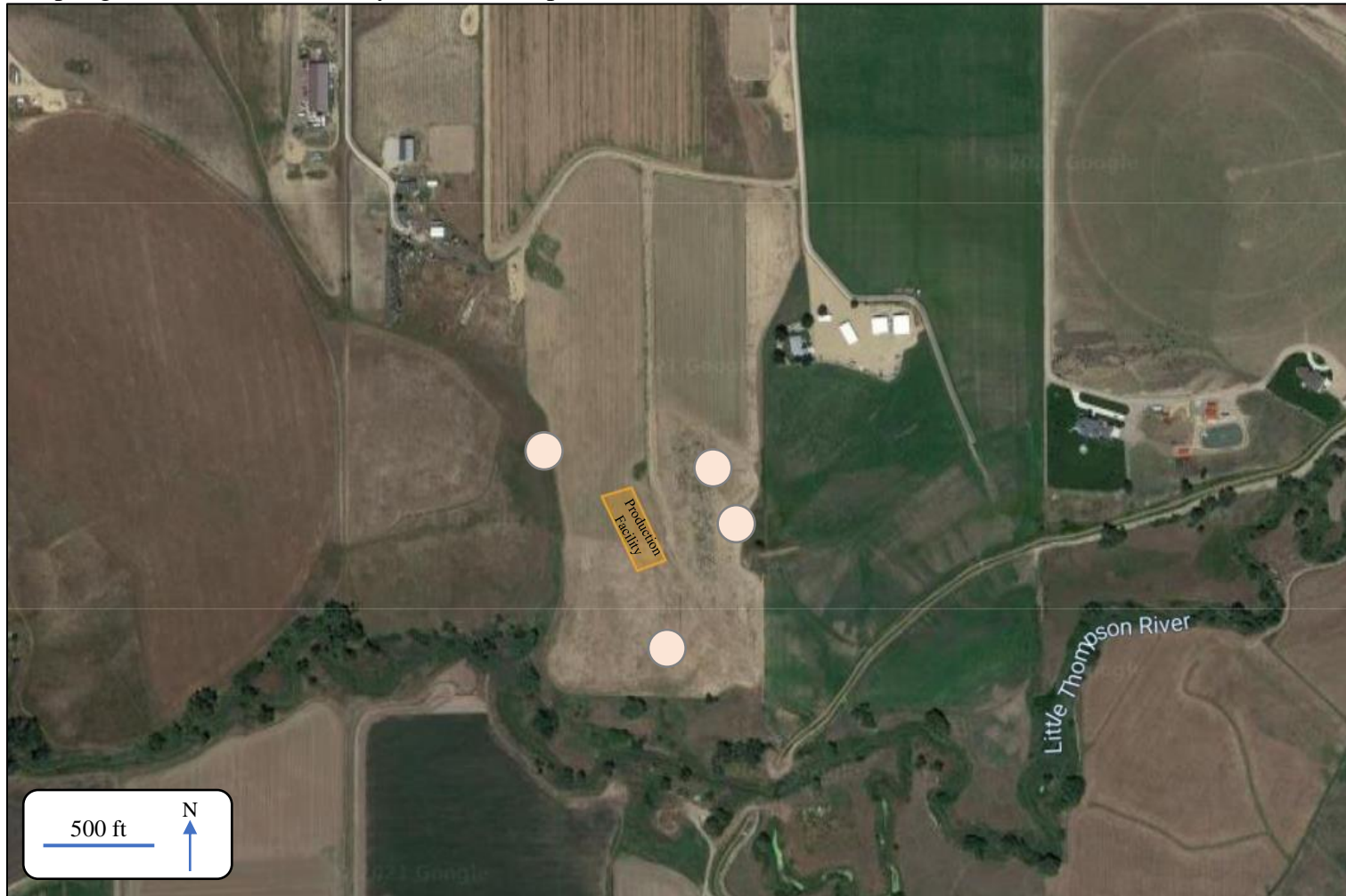
Location Tag	Monitoring Equipment
	PID Analyzer, Carbon Sorbent Tube
	Carbon Sorbent Tube

Figure 2

SBJ Production Facility Monitoring Map

Sampling Locations

Sampling locations are labeled by ID on the map below.




Location Tag	Monitoring Equipment
	PID Analyzer, Carbon Sorbent Tube

Figure 3

SBJ Completions Pad and Production Facility with Half Mile Radius Monitoring Map

Area Map

The area encompassing a half mile radius around the facilities is highlighted in black on the map below.

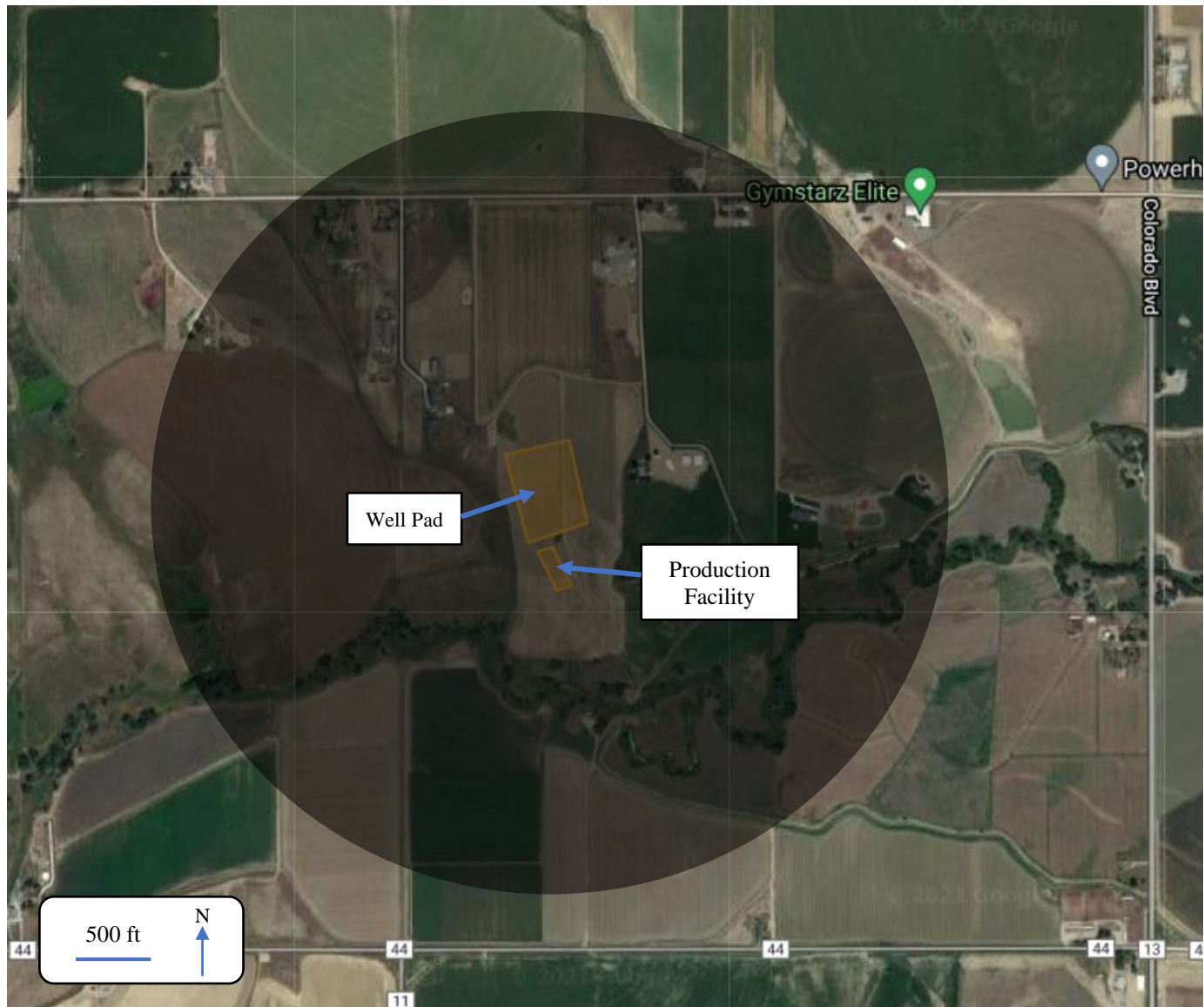
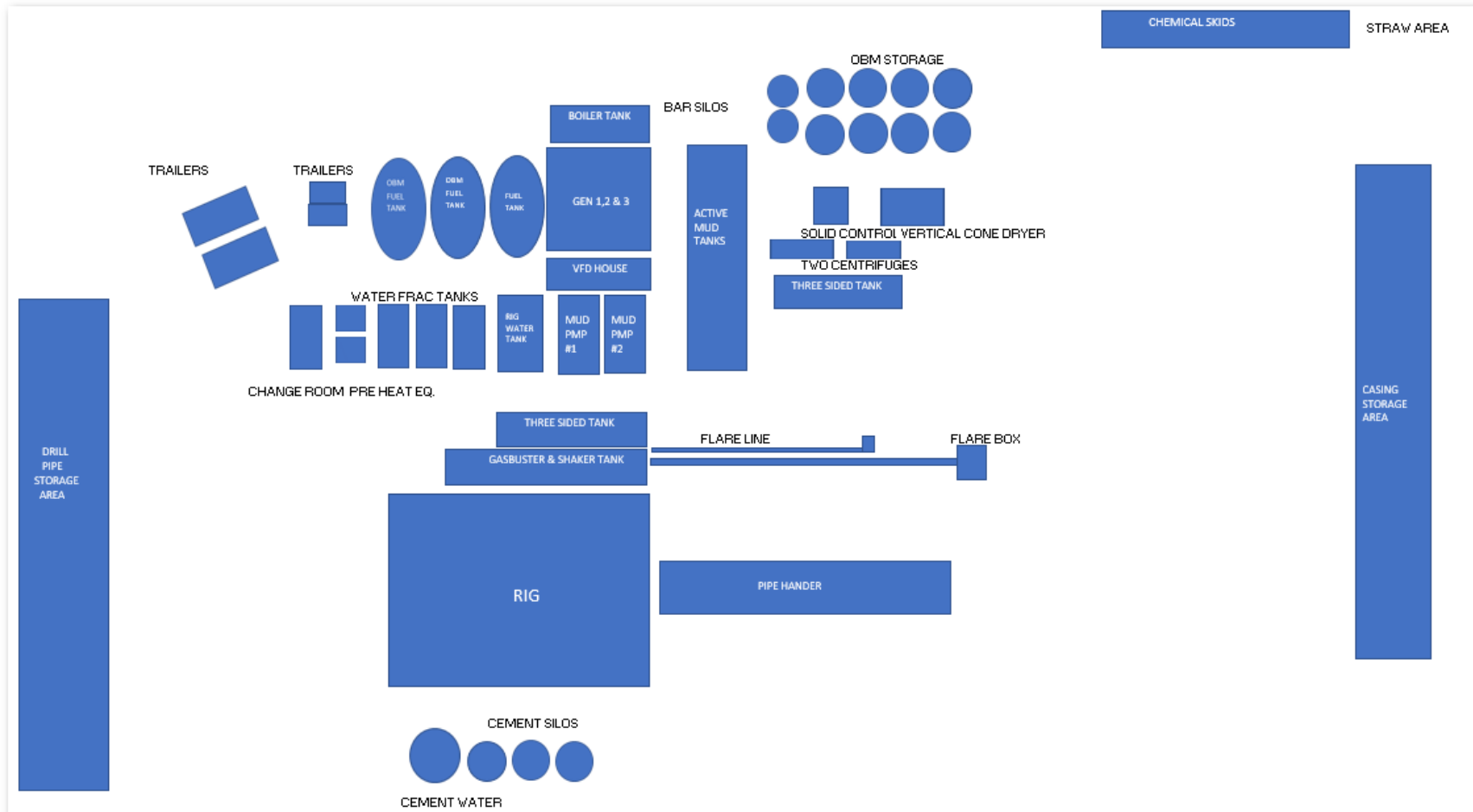


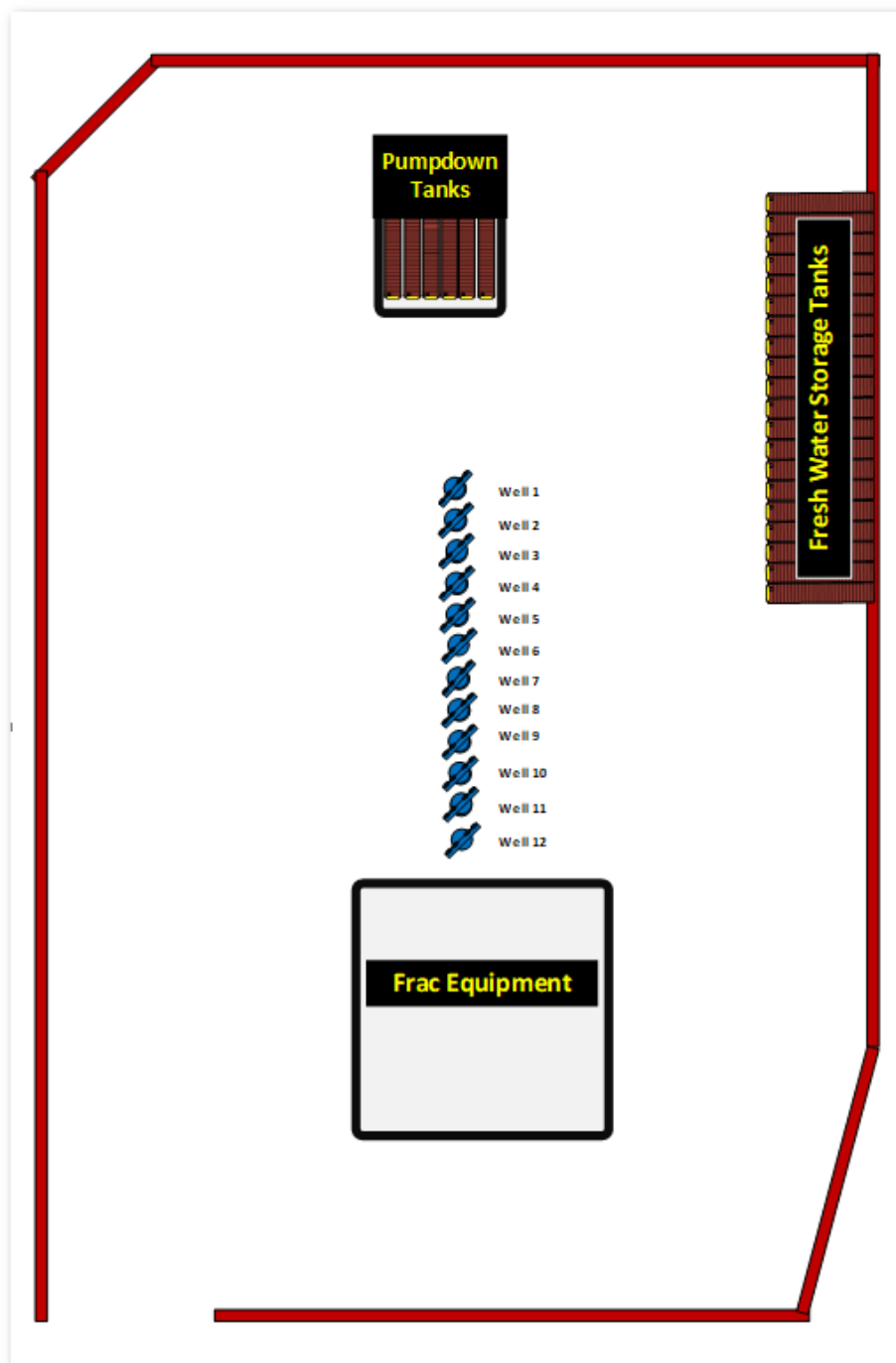
Figure 4

General Equipment Layout Production Rig



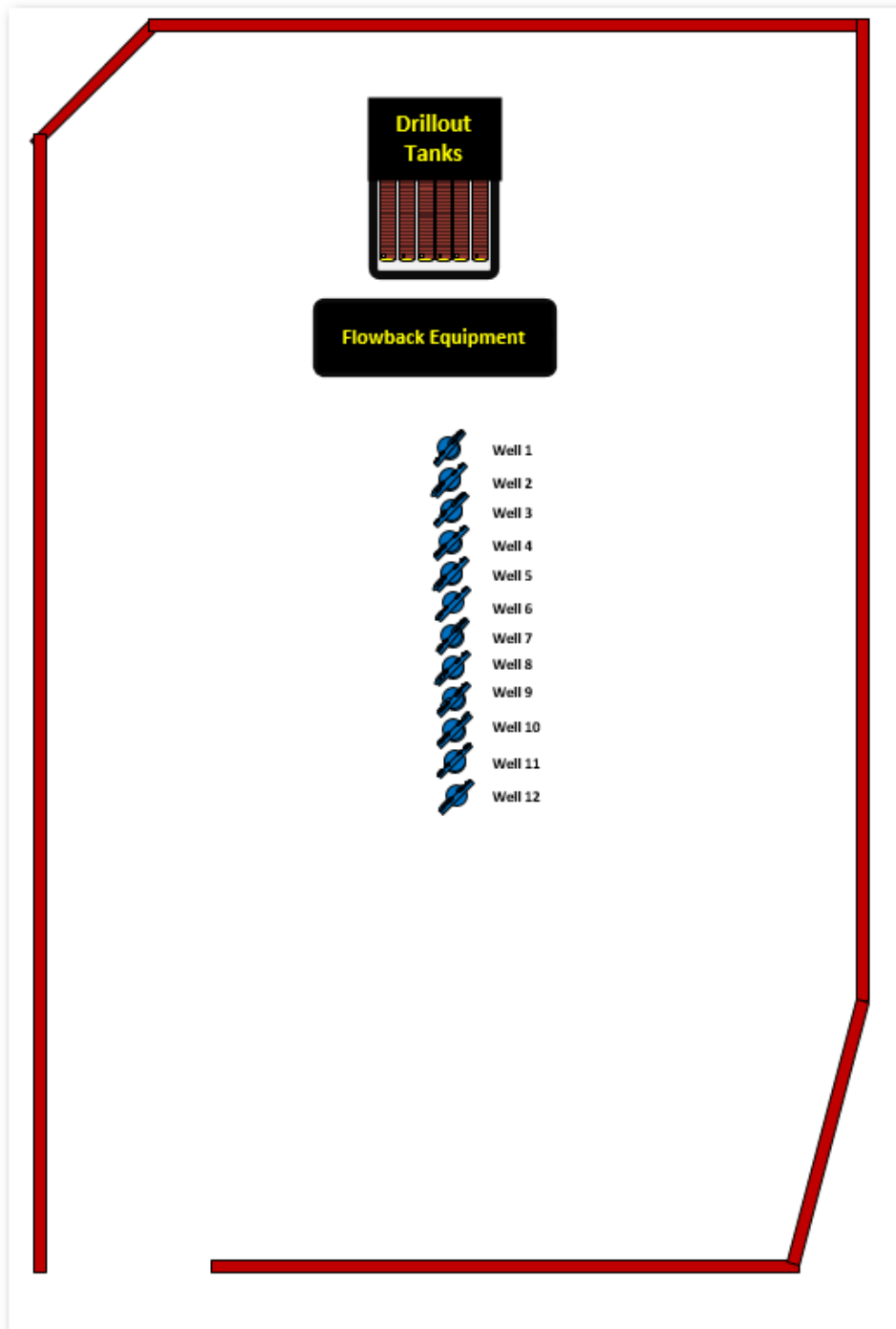
General Equipment Layout

Completions Operations: Frac Equipment

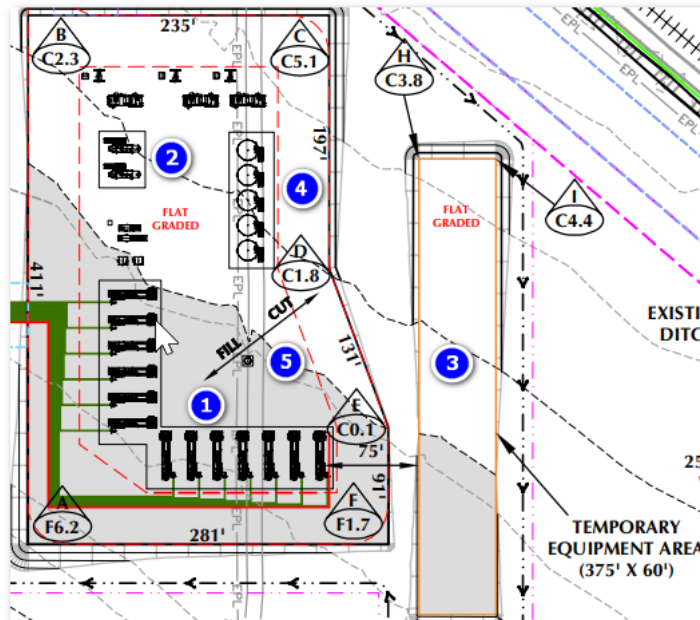


General Equipment Layout

Completions Operations: Flowback and Drillout



General Equipment Layout Production Facility



- 1 – Separators
- 2 – Bulk Separators
- 3 – Temporary Water Tanks
- 4 – Permanent Water Tanks
- 5 – Emissions Control Device (ECD)



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HSE Air Monitoring Program

Chad Schlichtemeier
Oxy HSE

June 2021 (Updated QAPP)

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1. PURPOSE

This document establishes guidelines for conducting air monitoring around pre-production and production facility activities to protect public health, safety, welfare, the environment, and wildlife resources in accordance with CDPHE Regulation 7.

The document will be reviewed periodically and revised if necessary to adapt to changes in technology, operational and monitoring data, and regulatory guidelines.

The air monitoring program will be operated on behalf of Kerr McGee Onshore Oil & Gas LP ("Kerr-McGee") by Montrose Air Quality Services, LLC.

2. CDPHE REGULATION 7

This document follows the requirements set forth in CDPHE Regulation 7 VI.C. For each section, the applicable regulation reference is included in parenthesis as applicable.

3. APPLICABILITY

This document provides the overall monitoring plan guidelines for air monitoring at pre-production operations and production facilities. Specific guidelines, as outlined in this document, for the monitoring location are addressed in a document titled "Air Monitoring Location Details." The Monitoring Plan for each location includes the Kerr-McGee HSE Air Monitoring Program and the Air Monitoring Location Details. **(Reg. 7 VI.C.1.)**

4. MONITORING PLAN SUBMITTAL

The Monitoring Plan will be submitted to CDPHE and Local government with jurisdiction over the location of the operations and any other local government unit, where applicable, within 2,000 feet of the proposed operations at least sixty (60) days prior to beginning air quality monitoring. **(Reg. 7 VI.C.1.b.)**

- **Air Monitoring Location Details** will include whether the local government with jurisdiction over the location of the operations has air quality monitoring requirements applicable to pre-production and/or early production operations, a description of those requirements, and a local government contact for air quality monitoring purposes. **(Reg. 7 VI.C.1.b.(iv))**

5. BULK SEPARATOR PRODUCTION FACILITY

CDPHE Regulation 7 requires air monitoring at production facilities during early production. The bulk separator production facilities are designed to minimize or eliminate air emissions. Monitoring data collected during early production will be used to further support the design. Below are the design aspects of facilities focusing on minimizing or eliminating air emissions.

- Design
 - No condensate tanks
 - Condensate flows from the separator to a pressurize bulk separator into a pipeline. Condensate tanks are the largest source of potential volatile organic compound (VOC) and benzene emissions. This source is eliminated in the bulk separator facility design

- Instrument air
 - All pneumatic controllers at bulk separator production facilities are operated on instrument air. Natural gas-driven pneumatic controllers can be significant source of VOC emissions, which includes benzene due to the number of actuations and potential malfunctions
- Supervisory Control and Data Acquisition (SCADA)
 - Operating parameters on equipment at the bulk separator facilities are monitored continuously through Kerr McGee's Integrated Operations Center (IOC). Operating ranges or status are set for equipment to ensure safe operations and also minimizes or eliminate potential air emissions. The IOC is staffed 24 hours a day/7 days a week and can automatically send out notifications alerting an Operator of a trending parameter or initiate engineering controls, which may include shutting in a facility. Below are some of the parameters that are monitored continuously, and the engineering controls. Figure 3 in Section 18 of this document shows a typical Bulk Separator Facility layout and location of the equipment.

Equipment	Parameter	Description	Engineering Controls
Tanks - Temp and permanent Water Tanks, Maintenance Tank	Pressure	Monitor tank pressures to prevent over pressurizations causing venting	High Pressure - Automation will shut-in facility
	Liquid Level	Monitor liquid level on tanks to prevent spills and venting	High Level - Automation will shut-in facility
Bulk Separator	Pressure	Monitor vessel pressure to prevent over pressurization causing venting	High Pressure - Automation will shut-in facility
Separator	Temperature	Monitor high/low temperature for safe operations and prevent excess emissions	High Temperature - Automation will shut-in separator and well
	Pressure	Monitor vessel pressure to prevent over pressurization causing venting	High Pressure - Automation will shut-in separator and well
	Burner	Monitor pilot status to prevent raw gas from being vented	Loss of pilot - Automation shuts off pilot valve and main valve. Automation will shut-in well if separator reaches high pressure or low temperature
Emission Control Device (ECD)	Knock-out Pot Liquid Level	Monitor liquid level to prevent liquids from carrying over to the ECD potentially causing smoke	High liquid level - Automation will shut-in facility
	Pilot Light Status	Monitor pilot light to prevent venting of unburned hydrocarbons	Loss of pilot - Automation will shut-in facility
Pneumatic Controllers	Air Compressor Status	All pneumatic controllers are operated on instrument air. Monitor status of the electric air compressor for safe operation.	Air Compressor not operating - Automation will shut-in facility
Wellhead	Pressure	Monitor pressures for safe operation and preventing excess emissions	High/Low Pressure - Automation will shut-in well

6. AIR MONITORING

6.1 Pre-Operations Monitoring

- At least ten (10) days prior to beginning pre-production operations (**Reg. 7 VI.C.1.a**)

6.2 Pre-Production and Production Facility Monitoring

- Drilling - Air monitoring conducted during drilling through the hydrocarbon bearing zones (i.e. Production rig drilling) **(Reg. 7 VI.C.1.a.)**
- Completions – Air monitoring conducted during hydraulic fracturing or refracturing, drill-out, and flowback of an oil and/or natural gas well. **(Reg. 7 VI.C.1.a.)**
- Production Facility - Air monitoring conducted for at least six (6) months after the last well on the pad is turned over to production (TOTP). **(Reg. 7 VI.C.1.a.)**
- The **Air Monitoring Location Details** includes:
 - The owner or operator name and the contact information of the owner or operator representative for monitoring purposes **(Reg. 7 VI.C.1.b.(i))**
 - The planned schedule for drilling and completions operation at the monitoring locations. **(Reg. 7 VI.C.1.b.(ii))**
 - The operations to be monitored including the API number of the well(s), location of the operations including latitude and longitude coordinates, and any associated facility or equipment AIRS number(s). **(Reg. 7 VI.C.1.b.(iii))**

7. MONITORING OBJECTIVES

- The purpose of the air monitoring around pre-production and production facility activities is to protect public health, safety, welfare, the environment, and wildlife resources. Kerr Mc-Gee has established Investigation Levels for the VOC analyzers and analytical results with an associated investigation response. See Sections 14 and 15 for more details on Investigation Levels and Investigation Level Response. One component of an Investigation Level Response is an on-site investigation into the cause of the elevated reading. If the source is identified further analysis will be conducted into the cause, which could lead to the reduction in air emissions. Gas streams at pre-production operations and production facilities typically contain methane, VOCs, and BTEX (benzene, toluene, ethyl benzene and xylenes). Any emissions reduction would potentially reduce all listed pollutants. Kerr Mc-Gee's monitoring objectives covers all three (3) objectives listed below. The monitoring program does not directly monitor methane, but methane is part of the gas stream that is being monitored and, thus, indirectly monitored. Any evaluation for VOCs and BTEX to reduce emissions will in most cases have a corresponding reduction in methane emissions. In addition, Kerr-McGee will review the monitoring program periodically and revise if necessary to adapt to changes in technology and operational and monitoring data. **(Reg. 7 VI.C.1.b.(v))**
 - Detect, evaluate, and reduce as necessary hazardous air pollutant emissions. **(Reg. 7 VI.C.1.b.(v)(A))**
 - Detect, evaluate, and reduce as necessary ozone precursor emissions. **(Reg. 7 VI.C.1.b.(v)(B))**
 - Detect, evaluate, and reduce as necessary methane emissions. **(Reg. 7 VI.C.1.b.(v)(C))**
- The continuous monitoring equipment employed in this program uses photoionization detector (PID) technology. A PID sensor contains a lamp that produces photons

which carry enough energy to break molecules into ions. The PID will only respond to molecules that have an ionization energy at or below the energy of the lamp, the PID used in this program contains a 10.6 electron-volt (eV) lamp. Any VOC that has an ionization energy less than 10.6 eV will be ionized as it passes across the lamp. The produced ions then generate an electrical current that is measured as the output of the detector. While methane has an ionization energy above 10.6 eV, hazardous air pollutants and ozone precursors have an ionization energy below 10.6 eV allowing for detection of elevated emissions. Carbon sorbent tubes and SUMMA® canisters will be used to quantify BTEX emissions. Monitoring equipment will be sited as described in Section 10 and actual locations monitoring location will be included in the site plan as part of the Air Monitoring Location Details. Investigation Levels and Response as described in Sections 14 and 15 are established to protect public health and welfare and to evaluate operations and reduce VOC, BTEX and methane emissions as deemed appropriate. The monitoring program is setup to meet all the objectives in section. **(Reg. 7 VI.C.1.b.(xi))**

8. POLLUTANTS MONITORED

- Air pollutants monitored at pre-production and production facility operations will include VOCs (continuous analyzers), benzene (carbon sorbent tubes) and BTEX (24-hr SUMMA® Canisters). **(Reg. 7 VI.C.1.b.(vi))**

9. MONITORING EQUIPMENT

- Below are the monitoring equipment that will be used at pre-production and production facility operations. **(Reg. 7 VI.C.1.b.(vii))**

9.1 Continuous VOC Analyzer

- SENSIT SPOD Ion Science Photo Ionization Detector (PID)



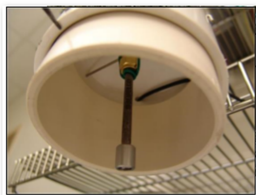
- Lunar Output Canary-S Photo Ionization Detector (PID)



- Data Collection
 - 15-minute block averages based on 1 minute readings
- Data Acquisition
 - Dashboard
 - Airsense is a web-based system used to acquire, manage, and display real-time air quality data. Site personnel can access all data via a password-protected website for viewing recent data, setting up alerts, conducting analyses, downloading data, building automated reports, and maintaining complete oversight of the network.
 - Real-time display of monitoring data
 - 1-minute readings and selected averaging periods (e.g. Investigation Levels)
- Notifications
 - E-mails sent when a monitor reading exceeds an Investigation Levels set in Section 14
- Equipment selection description (**Reg. 7 VI.C.1.b.(vii)**)
 - The PID technology that will be used for continuous monitoring in this program is a tried-and-true VOC monitoring technology that is approved for use in Leak Detection and Repair programs as described in EPA Method 21 Section 6.1 and as a detector for gas chromatography as described in EPA Method 18 Section 2.0. The PIDs ability to respond to hazardous air pollutants and ozone precursors at low concentrations, consume little power, provide data continuously, and scale across a large network are the reasons why the technology was chosen for this program. The specific instrument models that will be used are the Sensit SPOD and Lunar Outpost Canary-S, though other models may be used if these vendors cannot provide instruments in a timely manner, specifics about these monitors can be found in the attached Quality Assurance Project Plan. The only data correction applied to these units is a linear regression between the sensors raw voltage output and known concentration of calibration gas, as described in the Quality Assurance Project Plan. The operating range for the SPOD and Canary-S unit is 0-40 ppm.

- Manufacturer's Specification Sheets - SENSIT SPOD PID and Lunar Outpost Canary-S PID, See Section 19
- Quality Assurance Project Plan – SENSIT SPOD PID and Lunar Outpost Canary-S PID, See Section 19
 - The standard operating procedures that will be employed, to include at minimum **(Reg. 7 VI.C.1.b.(x))**:
 - The continuous monitors used in this program sample every second, and provide 1-minute averaged data to the data platform. The minimum detection limit and precision is calculated as three times the standard deviation, providing a confidence level of 99.7%, of 7 consecutive 1-minute averages with a 1 ppm isobutylene gas. **(Reg. 7 VI.C.1.b.(x)A)**
 - The Investigations and Response Levels for each pollutant monitored and/or sampled and the response procedures or actions that will be taken if elevated levels are observed can be found in Sections 14 and 15. **(Reg. 7 VI.C.1.b.(x)B)**
 - Quality Assurance Project Plan includes:
 - The precision and bias are determined during each monthly calibration, and data quality indicators. **(Reg. 7 VI.C.1.b.(x)C)**
 - Quality control and quality assurance procedures, including calibration intervals and frequency, which will be used to ensure proper operations of the monitoring equipment. **(Reg. 7 VI.C.1.b.(x)D)**
 - PIDs are known to drift with ambient temperature and humidity variation. The PIDs used in this program mitigate the humidity issue by having a hydrophobic filter installed between the lamp and the ambient air. This deters water molecules from entering the ion producing chamber and absorbing radiation. The PIDs are also heated slightly above ambient temperature to improve stability of the detector. The hydrophobic filters are also known to deteriorate over approximately 6-8 weeks of field use, as part of the Quality Assurance Project Plan these filters are replaced during monthly calibrations. If this filter is not replaced, not only will the humidity interference not be mitigated but dust and dirt can enter the ionization chamber dampening the total VOC readings. **(Reg. 7 VI.C.1.b.(x)E)**
 - The data system and operating protocol to be used for data collection, including, but not limited to, data logging, data processing, recording, downloading, backup and storage, and reporting is outlined in Section 12. **(Reg. 7 VI.C.1.b.(x)G)**
 - The methods used for collecting and analyzing speciated or other samples of chemical constituents identified by the Division when indicated necessary based on site-specific concentration thresholds, if applicable, can be found in the attached Standard Operating Procedures for Carbon Sorbent Tube and Summa Canister Collection and Analysis in Section 19. **(Reg. 7 VI.C.1.b.(x)H)**

9.2 Passive Samplers – Carbon Sorbent Tubes



- 14-day deployment schedule
- Analyzed for Benzene
- Tubes located around the pad sited and analyzed in accordance with EPA Method 325
- Equipment description (**Reg. 7 VI.C.1.b.(x)H**):
 - The passive sorbent tube sampling portion of this test program, EPA Method 325A/B entitled “Volatile Organic Compounds from Fugitive and Area Sources” will be followed for both sampling and analysis methodology.
 - The monitoring program will use passive sampling for Benzene utilizing Carbopack X™ tubes. The tube is a stainless-steel net cylinder, with 100 mesh grid opening and 5.8 mm diameter, packed with 530 ± 30 mg of activated charcoal with particle size 35-50 mesh. Volatile organic compounds are trapped by adsorption. The tube is desorbed using a thermal desorber and the extract is analyzed using GC/MS. Benzene concentrations are calculated using the mass of each compound found, the validated Carbopack X™ uptake rates, time sampled, and average field temperature.
 - Field-ready passive samplers will be provided by Enthalpy Analytical in a background-free cooler. Tubes will be individually packaged in sealed vials to prevent against contamination. The cooler includes ice packs to keep the sampled tubes cool throughout the shipping process back to Enthalpy for analysis. Enthalpy’s typical schedule is to provide analytical results for the carbon sorbent tubes on a 7-business day schedule.
- Standard Operating Procedures for collection and analysis can be found in Section 19

9.3 Summa Canisters



- 24-hour time weighted sample
- Analyzed according to EPA Method TO-15
 - Benzene, Toluene, Ethylbenzene, Xylene (BTEX)
- Equipment description (**Reg. 7 VI.C.1.b.(x)H**):
 - For the summa canister sampling portion of this test program, EPA Compendium Method TO-15 entitled “Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)” will be followed for both sampling and analysis methodology.
 - Entech Instruments Silonite™ CS1200E Passive Canister Samplers will be used to collect samples over each 24-hour period. The Entech canisters used will be six-liter stainless-steel canisters lined with ultra-inert surface coatings. The canisters will be cleaned and blanked for use according to laboratory standard operating procedures.
 - The sample inlet height will be approximately one and one half (1.5) meters above ground.
 - The canister samples will be provided by and shipped to Enthalpy. . Enthalpy’s typical schedule is to provide analytical results for the carbon sorbent tubes on a 7-business day schedule.
- Standard Operating Procedures for collection and analysis can be found in Section 19

9.4 Meteorological Station

- Co-located with an analyzer
- Wind speed, wind direction, temperature, barometric pressure, and relative humidity are monitored at 1-minute frequency (**Reg. 7 VI.C.1.b.(viii)**)
- The meteorological equipment installed on the Sensit SPOD units is the Airmar 110WX WeatherStation, and the Lunar Outpost Canary-S uses a RM Young ResponseONE. Both monitors collect wind data via ultrasonic anemometers. The anemometers are installed onsite with the proper side of the anemometer facing North to provide valid

wind direction data. **(Reg. 7 VI.C.1.b.(viii))**

- One meteorological station is co-located and directly tied into a continuous total VOC monitor onsite. The total VOC monitor that is furthest away from any structures that have the potential to interfere with the wind data, and therefore provides the data most representative of site conditions, is chosen to co-locate the meteorological station with. The data from the meteorological station is provided at the same time resolution as the total VOC data and is included in the monitors payload. **(Reg. 7 VI.C.1.b.(x)F)**
- Standard Operating Procedures for the meteorological station can be found in Section 19

10. MONITORING LOCATION SETUP

- The monitoring equipment will be placed on tripods and no additional surface disturbance is required for air monitoring, in alignment with the Colorado Oil and Gas Conservation Commission's site preparation requirements. **(Reg. 7 VI.C.1.b.(ix)D)**
- Drilling and Completions Operations
 - Monitoring Stations
 - Continuous VOC analyzers
 - 4 monitors located roughly in each cardinal direction approximately 300 feet from the pad wall. Depending on locations of building units, occupancy building units or other emission sources, additional monitors may be sited.
 - Meteorological station (1 per pad) co-located with a monitor
 - Carbon sorbent tubes
 - Sited around the Pad approximately 165 feet from wall
 - Siting is determined based on requirements in EPA Method 325
 - 12 tubes plus duplicate and blank
 - 14-day deployment schedule
 - Co-located with each monitor
 - 14-day deployment schedule
 - Depending on locations of building units, occupancy building units or other emission sources, additional tubes may be sited
 - SUMMA® canisters
 - 24-hour samples
 - Monitor readings over Investigation Levels, as needed
 - SUMMA® canisters will be deployed during different phases based results from the analyzers, carbon tubes and SUMMA® canisters results from previous locations during the same phase.

- Periodic sampling, as needed
 - Typical site layout in Section 16
- Production Facility
 - Some pads may have more than 1 production facility. The monitoring site plan included in the Air Monitoring Location Details will identify the number and layout of all production facilities associated with the pad.
 - Monitoring Stations
 - Continuous hydrocarbon analyzer
 - Meteorological station (1 per pad)
 - Monitors in each cardinal direction approximately 300 feet from the facility
 - 4 total monitors
 - Carbon sorbent tubes
 - Co-locate one tube with each monitor
 - 14-day deployment schedule
 - SUMMA® canisters
 - 24-hour samples
 - Monitor reading over trigger or action level, as needed
 - Periodic sampling, as needed
 - Typical site layout in Section 17
- The **Air Monitoring Location Details** will include:
 - Monitoring site plan (**Reg. 7 VI.C.1.b.(ix)**)
 - The number of monitors and/or sensors to be deployed. (**Reg. 7 VI.C.1.b.(ix)A**)
 - The location and height of the monitoring equipment, including for each phase of operations if location and height of the equipment will change (e.g., monitoring placement impacted by sound walls). (**Reg. 7 VI.C.1.b.(ix)B**)
 - A topographic map and plan of the site, showing the expected equipment layout, including air quality and meteorological monitor locations and their distance from preproduction and production operations. The map must indicate any obstructions to air flow to the monitor(s) and also show all roads and access ways within a half-mile of the facility and any contiguous structures, whether or not they are part of the production operations. (**Reg. 7 VI.C.1.b.(ix)C**)
 - An explanation of how the number and placement of monitoring equipment will be adequate to achieve the desired air quality monitoring objectives, considering the monitoring equipment's detection limit and other limitations. (**Reg. 7 VI.C.1.b.(ix)E**)

11. HEALTH GUIDANCE VALUES

- Health Guidance Values (HGVs): The health-based guidelines are based on *Exposures and Health Risks from Volatile Organic Compounds in Communities Located near Oil and Gas Exploration and Production Activities in Colorado* published by the Colorado Department of Public Health and Environment (CDPHE) on July 16, 2018, in the International Journal of Environmental Research and Public Health. The CDPHE study identified volatile organic compounds VOCs associated with oil and gas operations through review of previous studies conducted in the state of Colorado.
- The HGV for benzene is much lower than other analytes common to the oil and gas industry. Previous air sampling at oil and gas facilities show benzene is the main driver of potential health risk. Focus of the air sampling will be benzene but will include ethylbenzene, Toluene and xylene analysis for some samples. Below are the acute and chronic HGVs for each analyte.

Analyte	Acute Guideline Values (ppb)	Chronic Guideline Values (ppb)
Benzene	9	9 and 3
Toluene	2,000	1,327
Ethylbenzene	5,000	230
m, p, o -Xylene	2,000	23

- Acute exposure: An acute health exposure is a short-term exposure to a substance that results in biological or physical harm to the person exposed. For example, the 9 ppb acute guideline for benzene is the estimate of the daily human exposure without appreciable risk of adverse, non-cancer health effects over 1 to 14 days of exposure. For comparison to the acute guideline for SUMMA® canisters, 24-hour samples will be taken per recommendation from a Certified Industrial Hygienist. Letter from Kahuna Ventures included in Section 19.
- Chronic exposure: A chronic health exposure is a repeated or continuous exposure over a much longer period of time to a substance that results in biological or physical harm to a person exposed. In their study, the CDPHE defined a chronic exposure as a scenario in which a person breathes the outdoor air continuously (24 hours per day, 365 days per year) for a lifetime (average of 70 years) and the measured concentrations of the compounds in the air remain constant over the entire lifetime. Production facilities will be in operation beyond one (1) year. Therefore, the sampling results are compared to the acute and chronic HGVs. The evaluation against the chronic HGVs will be based on the mean of all samples taken.
- Pre-production activities (Drilling and Completions operations) will be short in duration (i.e. less than 6 months), the results from each 24-hour SUMMA® canister sample and

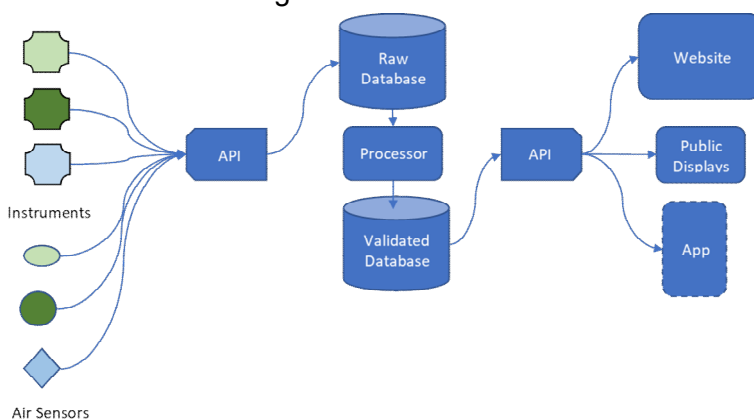
carbon sorbent tube result will be evaluated against the acute HGVs for each compound.

- Production facilities will be in operation beyond one (1) year. The sampling results will be compared to the acute and chronic HGVs. The evaluation against the chronic HGVs will be based on the mean of all 24-hour SUMMA® canister samples and carbon sorbent tube results. The evaluation for acute exposure will follow the Pre-production process.

12. MONITOR DATA AND REPORTING

■ Monitoring Data

- The data platform used for this monitoring program, AirSense, does not allow for data to be edited or modified. Users can tag and invalidate data but not directly edit data. In addition, as described in the diagram below, all data sent by instruments are stored in the Raw Database that is only inserted by the API and only can be read by the processor. The Airsense site gives users no direct access to the Raw dDatabase. When calibrating sensors, the data is saved to a new data point leaving both the raw and processed data points. All calibration or scaling adjustments are logged and date-stamped to identify when settings have changed. Even if changes are made, no actual data is modified. These settings allow for scaling and truncating, but the data is never directly modified, they are for viewing and alerting purposes only. All monitors data is delivered to AirSense via cellular communication. The monitors also have local data storage so in the event of a cell tower going down all data collected during that time period can be recovered. All records and documents pertinent to the perimeter monitoring program will be stored indefinitely on back-up computer servers and backed up onto offsite disk storage.



■ Reporting

Monthly reports of monitoring conducted will be submitted to the Division by the last day of the month following the previous month of monitoring (e.g., by June 30 for the previous May 1-31), including **(Reg. 7 VI.C.2.b.)**:

- The month and year of the monitoring period. **(Reg. 7 VI.C.2.b.(i))**
- A description of the monitoring equipment and the pollutant(s) monitored. **(Reg. 7 VI.C.2.b.(ii))**

- A description of the monitored operations including **(Reg. 7 VI.C.2.b.(iii))**:
 - The phase of operation (e.g., prior to pre-production, during pre-production operations, early production) and activities occurring during the monitored period. **(Reg. 7 VI.C.2.b.(iii)(A))**
 - API number of the well(s). **(Reg. 7 VI.C.2.b.(iii)(B))**
 - Location of the operations, including latitude and longitude coordinates. **(Reg. 7 VI.C.2.b.(iii)(C))**
 - Any associated facility or equipment AIRS number(s). **(Reg. 7 VI.C.2.b.(iii)(D))**
 - The date, time, and duration of any monitoring equipment downtime. Downtime will be considered any 15-minute block average where less than 75%¹ of the 1-minute data points within that block are recorded. **(Reg. 7 VI.C.2.b.(iii)(E))**
 - The date, time, and duration of the operations malfunctions and shut-in periods or other events investigated for influence on monitoring. **(Reg. 7 VI.C.2.b.(iii)(F))**
- For the first monthly report after beginning monitoring during preproduction operations, a summary of air quality condition results monitored prior to beginning pre-production operations, including time series of the results at 15-minute block average time resolution and a statistical summary of the air quality results monitored prior to beginning preproduction operations, including number of observations, maximum concentrations or levels, periodic averages, and data distributions including 5th, 25th, median, 75th and 95th percentile values. **(Reg. 7 VI.C.2.b.(iv))**
- A summary of monitored air quality results, including time series plots at 15-minute block average time resolution and a statistical summary including number of observations, maximum concentrations or levels, periodic averages, and data distributions including 5th, 25th, median, 75th and 95 percentile values. **(Reg. 7 VI.C.2.b.(v))**
- A description of responsive action(s) taken as a result of monitoring results, including the date; concentration or level measured; correlations with specific events, activities, and/or monitoring thresholds; and any additional steps taken as a result of the responsive action. **(Reg. 7 VI.C.2.b.(vi))**
- The results of any speciated or other samples of chemical constituents identified by the Division and collected when site-specific concentrations indicate such samples are necessary. **(Reg. 7 VI.C.2.b.(vii))**
- A summary of meteorological data, including in the time intervals identified for concentration readings in this air quality monitoring plan during the time period of responsive action(s). The meteorological data will be assessed in the same intervals as the sampling and/or measurement intervals. **(Reg. 7 VI.C.2.b.(viii))**
- A description of how the only processing and correction that is applied to the raw data is a linear regression that is determined during calibrations. A description of

¹ Per EPA's *QA Handbook Volume II, Appendix D, January 2017* common recommendation for data completeness

why any, if any, data is missing and that any data below the detection limit will be reported as the detection limit. **(Reg. 7 VI.C.2.b.(ix))**

- In the last monthly report, a certification by the company representative that supervised the development and submission of the monitoring reports that, based on information and belief formed after reasonable inquiry, the statements and information in the monthly reports are true, accurate, and complete. **(Reg. 7 VI.C.2.b.(x))**

- Recordkeeping

The following records will be kept for a minimum of three (3) years, unless otherwise specified, and upon request make records available to the Division. Local governments identified in the Air Monitoring Location Details may request those records from the Division. If the Division has not requested the records and a local government(s) identified in the Air Monitoring Location Details requests the records from the Division, the Division shall request the records from the owner or operator. **(Reg. 7 VI.C.2.a.)**

- The air quality monitoring plan. **(Reg. 7 VI.C.2.a.(i))**
- Monthly reports and the data necessary to inform the monthly reports, as provided in the Reporting Section above. **(Reg. 7 VI.C.2.a.(ii))**
- Activity logs to inform the description of the monitored operations in the monthly report. **(Reg. 7 VI.C.2.a.(iii))**
- At a minimum, for a period of one year after the monthly report, the underlying raw data associated with each monitor. **(Reg. 7 VI.C.2.a.(iv))**
- At a minimum, for a period of one year after the monthly report, the meteorological data in the time intervals as close to the sampling and/or measurement intervals as possible. **(Reg. 7 VI.C.2.a.(v))**

13. OPERATIONS RECORDS

- During air monitoring operations, daily activity will be recorded at the facility.

14. INVESTIGATION LEVELS

14.1 Continuous Analyzers

- At previous pre-production monitoring locations with air monitoring, co-located benzene and VOC data were collected. In comparing the data, the VOC ppm to benzene ppb correlation is approximately 1 ppm VOC = 1 ppb benzene. This correlation will continue to be updated as more data is gathered. Kerr-McGee has established three Investigation Levels that equate to benzene levels well below the 9 ppb guideline value, but at levels previous monitoring indicate a potential change in emissions at the location.
 - Level 1
 - 15 minute VOC block average (based on 1 minute readings) over 3 ppm VOC
 - Level 2
 - 2 readings over Level 1 reading in a 2 hour period
 - 15-minute VOC block average (based on 1-minute readings) reading over 5 ppm VOC

- Level 3
 - 12-hour average readings (based 15-minute block averages) over 2 ppm VOC

14.2 Analytical Data

- SUMMA® canister
 - Level 2
 - 24-hour result greater than 9 ppb benzene
 - Level 3
 - Subsequent 24-hour results greater than 9 ppb benzene
- Carbon sorbent tubes
 - Level 3
 - 14-day average result greater than 9 ppb benzene
 - Data and Operations Review
 - 14-day average result greater than 2 ppb benzene

15. INVESTIGATION LEVEL RESPONSE

15.1 Continuous Analyzer

- Investigation responses will be coordinated through Kerr McGee's Integrated Operations Center (IOC).
 - The air monitoring program will be operated by Montrose Air Quality Services, LLC. Airsense software will be used to manage the data from the monitors. In the event there is a monitor reading above an Investigation Level, an e-mail notification will be sent to the IOC.
 - Monitor readings greater than the Investigation levels will require an investigation into the potential cause(s) of the high reading(s) including any corrective action, as necessary.
 - Responsibilities during an investigation response:
 - IOC:
 - Notify the monitoring location (Drilling or Completions) of the elevated reading requiring an immediate investigation.
 - Notification of event sent to internal distribution list including management and HSE
 - Document event and send out follow-up notifications
 - Levels 2 and 3 – Dispatch IR team to location for inspection.
 - Level 3 – Notify HSE
 - Monitoring location:

- As soon as it is safe conduct an on-site investigation
 - Report investigation findings and any corrective action to IOC
 - Formal Incident response from facility within 24 hours
- IR team (Levels 2 and 3)
 - Conduct IR inspection at monitoring location
 - Contact IOC after completion of inspection to report findings
 - If abnormal emissions noted contact monitoring location
- HSE
 - Level 1 or 2 - Evaluate the need for 24-hour SUMMA® canister sampling.
 - Level 3 – Deploy 24-hour SUMMA® canister sampling within 24 hours of receiving the final results.
 - 4 SUMMA® canisters in each cardinal direction at monitor location or other locations, as deemed appropriate
 - Sample(s) analyzed EPA Method TO-15 for BTEX
 - Review monitoring data, meteorological data, distance to nearest downwind receptor
 - Review investigation findings and make any necessary notifications.
 - Level 3
 - Activate Emergency Response Team (ERT). The ERT includes:
 - President & General Manager
 - Director Operations
 - Director HSE
 - Director Drilling Completions and Well Servicing
 - Director Regulatory
 - Director Communications and Public Affairs
 - Managing Counsel
 - ERT will evaluate facility operations to ensure protection of public health and welfare
 - COGCC, CDPHE, and Local Government with jurisdiction over the location of the operations, will be contacted within forty-eight (48) hours of receiving notification of Level 3. **(Reg. 7 VI.C.1.b.(ix)B)**

15.2 Analytical Data

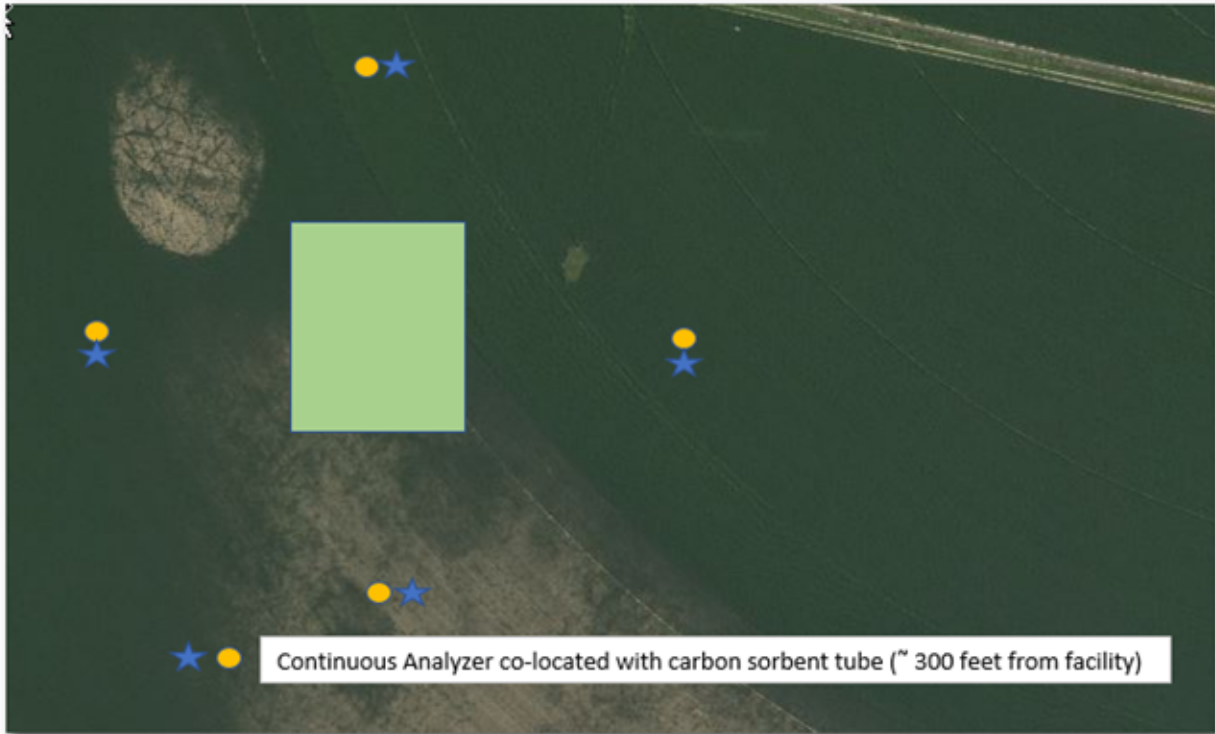
- SUMMA® canisters and carbon sorbent tubes samples will be sent to a lab to be analyzed. If results show a benzene level over an Investigation Level, the Investigation Response process is as follows:

- 24-hour SUMMA® canisters less than 9 ppb benzene, Kerr McGee will follow the Investigation Response for the continuous analyzers in Section 15.1, as appropriate.
- 24-hour sample - SUMMA® canister greater than 9 ppb benzene
 - Level 2 Investigation response for continuous analyzers in Section 15.1
 - Follow Agency for Toxic Substances and Disease Registry (ATSDR) guidance
 - The acute inhalation MRL for benzene is 9 ppb. An MRL is a health-based value developed to protect the health of the general population. MRLs are derived for acute (1 to 14 days), intermediate (>14 to 364 days), and chronic (365 days and longer) exposure durations. MRLs are intended to serve as a screening tool to help professionals decide if to conduct additional investigations
 - Conduct additional 24-hour SUMMA® canister sampling
 - 4 – SUMMA® canister in each cardinal direction at monitor location or other locations, as deemed appropriate
 - Sample(s) analyzed EPA Method TO-15 for BTEX
 - If subsequent 24-hour SUMMA® canister sampling results greater than 9 ppb benzene, Kerr McGee will follow the Level 3 Investigation Response for continuous analyzers in Section 15.1.
- 14-day carbon sorbent tube greater than 9 ppb benzene, Kerr McGee will follow the Level 3 Investigation Response for continuous analyzers in Section 15.1.
- Carbon sorbent tubes - 14-day average greater than 2.0 ppb benzene
 - Based on the results from carbon sorbent tube sampling at previous pre-production monitoring locations, a result greater than 2 ppb benzene indicates a potential change in emissions at the location. If there is a tube result greater than 2 ppb, operations during the 14-day period will be reviewed and corrective action employed, as necessary
- COGCC, CDPHE, and Local Government with jurisdiction over the location of the operations, will be contacted within forty-eight (48) hours of receiving notification of Level 3. **(Reg. 7 VI.C.1.b.(ix)B)**

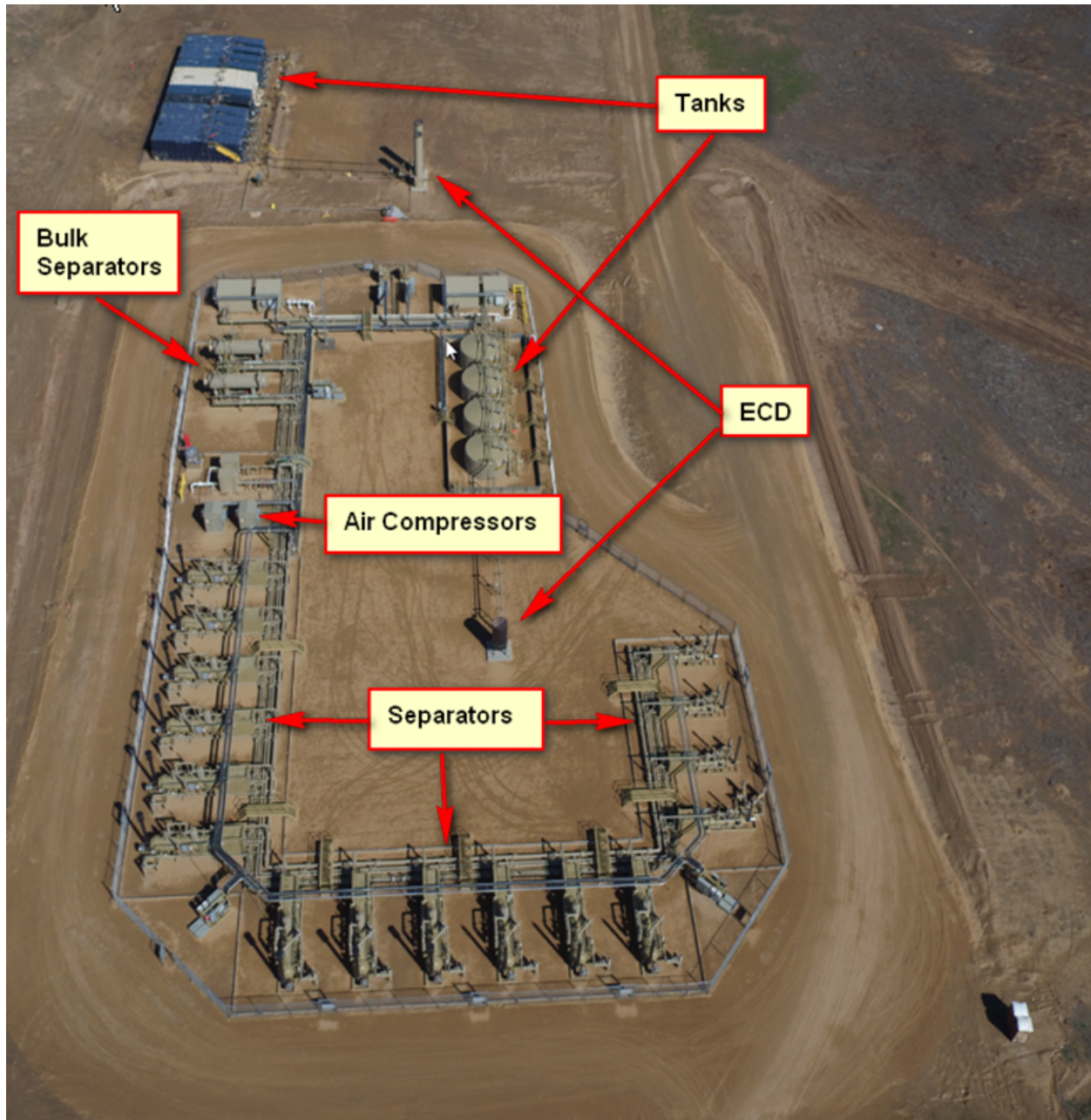
16. FIGURE 1 – PRE-PRODUCTION SITE TYPICAL MONITORING CONFIGURATION



17. **FIGURE 2 – PRODUCTION FACILITY SITE TYPICAL MONITORING CONFIGURATION**



18. FIGURE 3 – BULK SEPARATOR FACILITY TYPICAL LAYOUT



19. ATTACHMENTS

Quality Assurance Project Plan – PID Analyzers

QUALITY ASSURANCE PROJECT PLAN OCCIDENTAL PETROLEUM

Prepared For:

Occidental Petroleum

1099 18th St #1800
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Prepared By:

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Document Number:

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1.0 OBJECTIVES AND SUMMARY OF TEST PROGRAM

1.1 BACKGROUND

Occidental Petroleum's (Oxy) air quality (AQ) monitoring network to be deployed around pre-production well pads will provide real-time AQ data. The network will utilize low-cost cutting-edge air pollution sensor technology, redeveloped with solar, battery storage and data connectivity to make it useful for widescale deployment and replicable in any oil and gas facility. Each participating well pad will receive a minimum of four (4) sensors and data access via a data platform dashboard. The dashboard will display real time data and recent alerts, while the backend data platform will create insights for AQ patterns near each pad, leading to operational improvements, as well as generate automated alerts for stakeholders.

1.2 GENERAL

The procedures outlined in this document cover the quality assurance procedures to be utilized in the deployment, operations and maintenance of the sensors. Two different sensor manufactures will be used in the quality assurance program as outlined in Table 1-1:

**TABLE 1-1
MONITORING SENSORS**

Manufacturer	Model	Manufactured State
Sensit	SPOD	Indiana
Lunar Outpost	Canary-S	Colorado

The sensors measure volatile organic compounds (VOCs) in the air. A specification sheet on the sensors can be found in Appendix A. As part of this program, an AQ data platform, developed by AirSense, manages, quality controls, and reports the sensor data.

1.3 PROJECT CONTACTS

1.3.1 Personnel

A list of project participants is included below in Table 1-2:

**TABLE 1-2
PROJECT PERSONNEL**

Occidental Petroleum

Project Contact: Chad Schlichtemeier
Title: Rockies HSE Manager
Address: 1099 18th St #1800
Denver, CO 80202
Telephone: 720-929-6867
Email: chad_schlichtemeier@oxy.com

Montrose Air Quality Services, LLC Information

Project Contact:	Austin Heitmann	Patrick Clark, PE, QSTI
Title:	Project Manager	VP Ambient and Emerging Tech.
Address:	990 W. 43 rd Ave.	990 W. 43 rd Ave.
	Denver, CO 80211	Denver, CO 80211
Telephone:	303-670-0530	303-670-0530
Email:	ahaitmann@montrose-env.com	pclark@montrose-env.com

1.3.2 Responsibilities

Table 1-3 below details the roles and responsibilities of the project team.

**TABLE 1-3
PERSONNEL RESPONSIBILITIES**

Person/Company	Primary Assignment
Chad Schlichtemeier (Oxy)	Overall Project Coordinator
Austin Heitmann (Montrose)	Sensor deployment, sensor operations, sensor maintenance and QA/QC, data platform management

2.0 EQUIPMENT DESCRIPTION

2.1 SENSORS

The Sensit's SPOD and Lunar Outpost's Canary-S are air quality monitoring systems equipped with a single Ion Science photoionization detector (PID), cellular communication, and powered via a solar panel and battery. A multitude of units can be deployed to create a network of real-time, localized data focusing on air quality and meteorological measurements. The sensors can monitor VOCs, wind speed, wind direction, temperature, relative humidity and barometric pressure. A complete datasheet summarizing the specifications of the SPOD and Canary-S can

be found in the Appendix of this test plan. Both units communicate via a cellular back haul directly to the data platform.

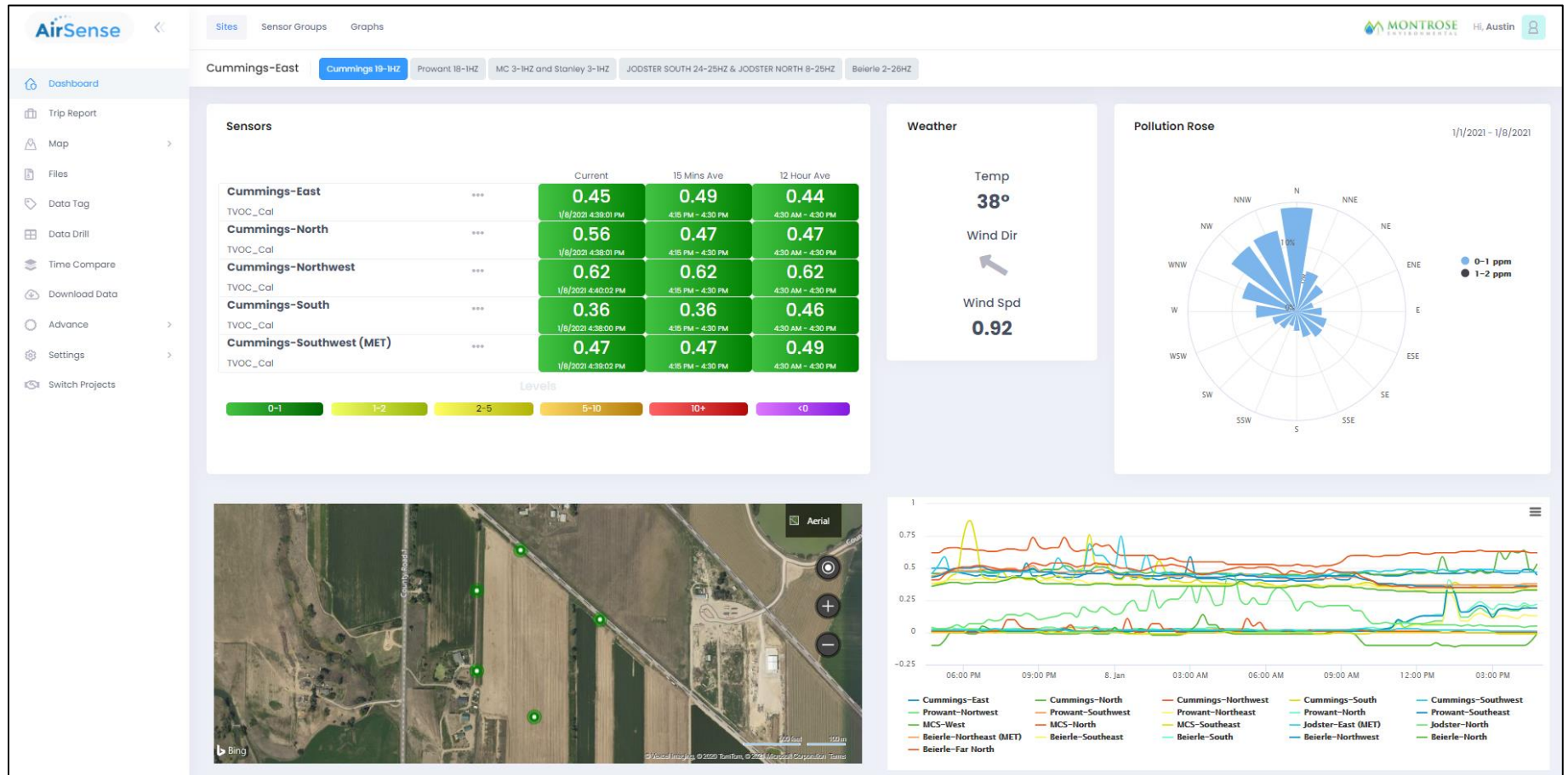
2.2 DATA PLATFORM

The AirSense data management platform handles traditional air monitoring data and next generation air sensor data. The AirSense system is a cloud based system that ingests data, performs quality control, calibrates air sensor data, and distribution of air sensor data. AirSense handles up to 1-second data (fixed or mobile), any pollutant or parameter, and offers intuitive navigation to view and display data for public and technical applications.

For Oxy and Montrose personnel AirSense's dashboard provides a summary of the operational status of network. For each well pad, AirSense provides a display showing 1-minute, 15-minute, and 12-hour average readings, site maps, and meteorological data.

Occidental Petroleum Quality Assurance Project Plan

FIGURE 2.1
SCREEN SHOT OF THE AIRSENSE DASHBOARD



3.0 QUALITY ASSURANCE QUALITY CONTROL

3.1 DEPLOYMENT PROCEDURES

The following procedures will be followed prior to deploying a sensor to a pad. Any sensors not meeting all the requirements outlined below will be returned to the manufacturer.

3.1.1 Sensor Deployment/Maintenance Log

Upon completion of the sensor pre-delivery checks, the sensors will be received by Montrose and a sensor deployment/maintenance log initiated. The log will be stored on Montrose's server which is only accessible by Montrose personnel and will contain the following minimum information:

- Sensor serial number
- Sensor model number
- AirSense key
- Results of the initial sensor calibration check out procedures
- Deployment location, date and time
- Filter replacement schedule
- History of notes, issues and maintenance procedures organized by date

3.1.2 Gas Calibration

A calibration would be performed on all equipment during the initial deployment effort. Montrose personnel would complete monthly calibration checks on each PID sensor using a Zero Air, 3 ppm, and 5 ppm isobutylene certified cylinder. A gas hood is installed over the top of the PID sensor and gas is flowed at approximately 0.5 L/min across the sensing portion of the PID face.

**TABLE 3-1
MINIMUM GAS CALIBRATION CRITERIA**

Parameter	Minimum Criteria ¹
3 ppm Precision	$ 3 \cdot SD^2 \leq 50$ ppb
Zero Air Error (Bias)	<10% of span gas bottle value
3 ppm Error (Bias)	<25% of bottle value
5 ppm Error (Bias)	<20% of bottle value

Based on the response of the analyzer to each concentration of gas a linear fit will be applied to the data to produce a slope and intercept that is applied to the raw VOC parameter. Once the units are deployed to the field some minor adjustments are made to the unit's baseline reading,

¹ Based on 1-minute readings

²Standard Deviation

this adjustment is considered when evaluating if the calibration met the minimum criteria outlined above.

3.1.3 Wind Direction Siting

The sonic anemometers North orientation marker's stated direction is conducted using a Brunton pocket transit. The field personnel sites the monitor during the initial deployment and then confirms this reading during each subsequent monthly calibration checks. An acceptable check will verify that the North siting is within 10 degrees. If the verification check fails the monitor will be adjusted and this will be noted in the monthly report.

3.2 ON GOING QUALITY ASSURANCE QUALITY CONTROL

The following procedures will be followed on an on-going basis to assure the quality of collected data.

3.2.1 Data Platform Alerts

The AirSense data platform will alert Montrose and Oxy according to the table below. Alerts will be in the form of an immediate e-mail notification.

**TABLE 3-2
PLATFORM ALERT CRITERIA**

Parameter	Minimum Criteria
Range check	-1 to 100 ppm
Sticking check	Constant value for more than 15 1-minute data points
No data alerts	When no data is received for more than 15 minutes emails alerts will be issued at a frequency of once per 6-hours

3.2.2 Montrose Quality Assurance Checks

Montrose will review the nightly reports generated as outlined in section 4.0 to verify that the field criteria in Table 3-3 is met.

**TABLE 3-3
MINIMUM FIELD CRITERIA**

Parameter	1-Minute Average Minimum Criteria
Data Recovery	>90% over 48 hours

Baseline Variation Over 24 Hours	+/- 0.2 ppm
----------------------------------	-------------

If any of the criteria laid out in Table 3-3 fail the following procedures will be followed depending on the parameter in question and a back-up sensor will be ready to replace a failed sensor at all times:

Data Recovery: If the sensor fails to meet the data recovery minimums as laid out in Table 3-3 a technician will inspect the unit. Each day is defined as the 24-hour period beginning when the nightly reports are generated at approximately midnight mountain time. The inspection will consist of checking for any loose connections within the unit that may be causing a power failure and that 12 volts of power is being generated by the solar panel and can be traced back to the barrel jack plugged in the device. If the technician cannot determine the cause of the data recovery the unit will be returned to the manufacturer for a more in-depth review.

Baseline Variation Over 24 Hours: It is expected that there will be slight baseline variation over 24 hours due to environmental conditions. If this baseline fluctuates more than 0.2 ppm in either direction from the average baseline over a 24-hour period a field technician will inspect the unit. If the technician cannot determine the cause of the baseline fluctuation the unit will be returned to the manufacturer for a more in-depth review.

3.2.3 Monthly Quality Assurance Procedure

Monthly a bump test will be conducted on the PID detector to verify that the data collected during the month prior is quality data. This bump test will consist of a different 3 ppm isobutylene gas, if available, then was used for the initial calibration and to pass the reading must be within +/- 25% of the gas bottle value.

If the unit fails a bump test:

A full three-point calibration will be done on the unit, as outlined in section 3.1.2, and a full inspection will be performed to determine why the bump test failed. If a reason for the failed bump test cannot be determined the unit will be returned to the shop for maintenance and/or the full three-point calibration will be used to update the slope and intercept described in section 3.1.2.

If the unit passes a bump test:

The unit will be redeployed to the field without making any adjustments to the calibration factors. Though the calibration factors may be adjusted if the unit nearly failed the bump test.

3.2.4 Consumables Replacement Schedule

The hydrophobic particulate filter built into the electrode stack on each Ion Science detector deteriorates after approximately 6-8 weeks due to the UV light produced by the lamp. Once this filter deteriorates dust and other particulate can enter the lamp cavity and cause a diminished signal. An additional filter is installed prior to the PID but not in direct contact with the UV lamp. This additional filter has no impact on the VOC concentrations entering the PID. The lamp used to produce the UV light needs replacing approximately every 12 month. After approximately 6 months of field monitoring the monitor will be swapped out with another unit that has had it's consumables replaced and has been calibrated as described in Section 3.1.2.

4.0 REPORTING

A nightly system report will be issued by the AirSense data platform and e-mailed to the principle party's at Oxy and Montrose. The system report will have at a minimum, the following 24 hour data summary of each parameters listed below. An example system report can be found in the Appendix B.

- Sensor ID
- Minimum value
- Maximum value
- Average value
- Percent data capture
- Alerts that occurred

APPENDIX A

Example Nightly System Report

Occidental Petroleum Quality Assurance Project Plan



Denver: 24 Hour (10/15/2019 7:30:44 AM - 10/16/2019 7:30:44 AM/UTC)

Site Name	Instrument Name	Parameter Name	Last Updated	Percent Complete	Max Value	Min Value	Average Value
Canary-S	Bruce Randolph (CS19)	PM2_5	10/16/2019 5:57:06 AM	94.1	15.5	1.9	5.9
	CAMP Collo (CS13)	PM2_5	10/16/2019 5:57:10 AM	92.78	13.9	2.1	5.2
	Canary-S-DU1	PM2_5	10/16/2019 5:57:08 AM	93.4	10.5	1.1	4.8
	Canary-S-DU2	PM2_5	10/16/2019 5:57:08 AM	93.47	38.9	1.5	5.4
	Canary-S-DU3	PM2_5	10/16/2019 5:57:10 AM	93.54	12.2	1.1	4.7
	Fairview Elementary (CS9)	PM2_52	10/16/2019 5:57:06 AM	93.54	204.2	2.4	26.5
	Garden Place (CS8)	PM2_5	10/16/2019 5:57:08 AM	93.54	17.8	1.8	6.8
	Gust (CS15)	PM2_5	10/16/2019 5:57:03 AM	94.44	12.8	1.0	5.5
	I-25 Denver Collo (CS16)	PM2_5	10/16/2019 5:57:06 AM	94.24	60.9	1.6	10.0
	I-25 Glo Collo (CS2)	PM2_5	10/16/2019 5:57:07 AM	93.54	43.4	1.9	8.8
	I-25 Glo Collo (CS3)	PM2_52	10/16/2019 5:57:05 AM	93.54	43.7	2.1	8.8
	I-25 Glo Collo (CS4)	PM2_52	10/16/2019 5:57:07 AM	93.54	45.9	2.2	9.4
	La Casa Collo (CS5)	PM2_5	10/16/2019 5:57:05 AM	93.54	53.8	2.2	9.6
	NJH CS Collo (CS1)	PM2_5	10/16/2019 5:57:05 AM	93.54	17.8	1.8	6.1
	Northeast Early (CS10)	PM2_5	10/16/2019 5:57:06 AM	93.54	17.7	1.5	6.0
	Prep Academy (CS17)	PM2_5	10/16/2019 5:57:04 AM	94.17	11.9	1.4	5.4
	Sabin (CS11)	PM2_5	10/16/2019 5:57:08 AM	92.64	72.9	1.5	8.1
	Sanderson Gulch II (CS12)	PM2_5	10/16/2019 5:57:07 AM	92.29	47.2	1.6	7.3
	South High (CS18)	PM2_5	10/16/2019 5:57:07 AM	94.24	57.6	1.1	5.7
	Swansea Elementary Collo (CS7)	PM2_5	10/16/2019 5:57:07 AM	93.54	26.5	2.6	7.9
	University Prep-Steele (CS20)	PM2_5	10/16/2019 5:57:05 AM	92.71	11.3	1.2	4.5
Clarity	La Casa Collo (CN A0051F54) Updated-Clarity	pm2_5ConcMass	10/16/2019 7:21:24 AM	18.12	13.2	0.2	4.3
sFTP	SAMS	PM2.5 - Local Conditions	10/16/2019 5:59:00 AM	85.56	12.7	1.3	4.4

Adjustment	Intercept	x1Coef	x2Coef	x3Coef	r2	Last Updated
CS5	1.84162191	0.58013888	0.02001846	0.00062910	0.35354714	10/11/2019

TD Enviromental
(707) 310-5541
TD Enviromental

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For questions, please use Table 1-3 to contact the individual that would be most prepared to answer your question.

Standard Operating Procedure – Collection and Analysis of Carbon Sorbent Tubes

STANDARD OPERATING PROCEDURE

SOP Title: Passive Tube Sampling
Document Number: 928ET-772315-SP-2
Revision Number: R0

Implementation Date: September 9, 2020
SOP Owner (Department): AQS
SOP Approval: Austin Heitmann, CPM

EPA Method 325 Sample Tube Deployment:

1. Remove ice packs from passive sampler (PS) cooler. Freeze them in a horizontal position in a dedicated, contaminant-free freezer until ready for use in the return shipment.
2. Allow the PS to equilibrate to ambient temperature at the sampling location for 1 hour prior to deployment
3. Inspect sample shelter for damage or indication of insect infestation. Replace if damaged or infested. DO NOT spray sample shelter with any type of insect repellent.
4. Complete data sheet/chain-of-custody with required information:
 - Name of sample shelter
 - PS identification number etched on exterior of PS, and whether PS is a primary sample, duplicate sample, or field blank (S,D, or B)
 - Date and time
 - Any abnormal conditions in the vicinity (e.g., operation of a portable generator, evidence of tampering with sample shelter)
5. Don powder-free nitrile gloves to prevent contamination with body oils, hand lotions, perfumes, etc.
6. Remove PS cartridge from sample shelter (if applicable)
7. Remove PS from vial. Check that the fittings of the PS are not loose – do not use if loose.
8. Remove brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug from the grooved end of the PS. The grooved end will be on the origin side of the arrow etched on the tube. This indicates it is the inlet end of an active sample. Do not use tube if media leaks when opened.
9. Insert PS in cartridge, and install a diffusion cap on the open end
10. The diffusion cap has two o-rings that seal against the sample tube. Slide the sample tube until both o-rings have sealed against the tube and the inlet end of the tube is just against the diffusion cap screen. The sampler must ensure that the diffusion cap has been pushed on far enough to seal both o-rings. It may take some force with a twisting action to slide the tube far enough into the diffusion cap to seal properly
11. Place the brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug into the original glass vial, cap the vial, and return to the sample cooler
12. Install field blank or duplicate PS, as applicable
 - Note: diffusion caps are not placed on field blanks. Leave brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug secure.
 - Per Section 9.3.2 of EPA Method 325A, field blanks must be placed in two separate sampling quadrants respective to the geometric center of the facility
 - Duplicate samples are installed in a manner identical to primary samples

STANDARD OPERATING PROCEDURE

SOP Title: Passive Tube Sampling
Document Number: 928ET-772315-SP-2
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Implementation Date: September 9, 2020
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EPA Method 325 Sample Tube Deployment:

1. Remove ice packs from passive sampler (PS) cooler. Freeze them in a horizontal position in a dedicated, contaminant-free freezer until ready for use in the return shipment.
2. Allow the PS to equilibrate to ambient temperature at the sampling location for 1 hour prior to deployment
3. Inspect sample shelter for damage or indication of insect infestation. Replace if damaged or infested. DO NOT spray sample shelter with any type of insect repellent.
4. Complete data sheet/chain-of-custody with required information:
 - Name of sample shelter
 - PS identification number etched on exterior of PS, and whether PS is a primary sample, duplicate sample, or field blank (S,D, or B)
 - Date and time
 - Any abnormal conditions in the vicinity (e.g., operation of a portable generator, evidence of tampering with sample shelter)
5. Don powder-free nitrile gloves to prevent contamination with body oils, hand lotions, perfumes, etc.
6. Remove PS cartridge from sample shelter (if applicable)
7. Remove PS from vial. Check that the fittings of the PS are not loose – do not use if loose.
8. Remove brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug from the grooved end of the PS. The grooved end will be on the origin side of the arrow etched on the tube. This indicates it is the inlet end of an active sample. Do not use tube if media leaks when opened.
9. Insert PS in cartridge, and install a diffusion cap on the open end
10. The diffusion cap has two o-rings that seal against the sample tube. Slide the sample tube until both o-rings have sealed against the tube and the inlet end of the tube is just against the diffusion cap screen. The sampler must ensure that the diffusion cap has been pushed on far enough to seal both o-rings. It may take some force with a twisting action to slide the tube far enough into the diffusion cap to seal properly
11. Place the brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug into the original glass vial, cap the vial, and return to the sample cooler
12. Install field blank or duplicate PS, as applicable
 - Note: diffusion caps are not placed on field blanks. Leave brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug secure.
 - Per Section 9.3.2 of EPA Method 325A, field blanks must be placed in two separate sampling quadrants respective to the geometric center of the facility
 - Duplicate samples are installed in a manner identical to primary samples

STANDARD OPERATING PROCEDURE

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13. Install PS shelter cartridge with PS in sample shelter and confirm that the end of the PS with the diffusion cap installed is pointed directly downward
14. Remove powder-free nitrile gloves and discard
15. Repeat this sequence of steps for next PS installation

Sample Recovery and Re-deployment:

Samples will be recovered after 14 consecutive days of sampling, or at another frequency as dictated by the site specific sampling program. Sample recovery should be conducted in the same location sequence as deployment and ideally at clock times that corresponds to exactly 14-days.

1. Inspect sample shelter for damage or indication of insect infestation. Replace if damaged or infested. DO NOT spray sample shelter with any type of insect repellent.
 - If sample shelter is replaced, document height of replacement shelter from the ground and confirm new location coordinates
2. Complete data sheet/chain-of-custody with required information:
 - Name of sample shelter
 - PS identification number etched on exterior of PS, and whether PS is a primary sample, duplicate sample, or field blank (S, D, or B)
 - Date and time
 - Any abnormal conditions in the vicinity (e.g., operation of a portable generator, evidence of tampering with sample shelter)
 - Don powder-free nitrile gloves to prevent contamination with body oils, hand lotions, perfumes, etc,
 - Remove PS cartridge from sample shelter
3. Remove diffusion cap from the end of the and slide PS from cartridge, and replace the original brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug on the open end.
4. Ensure that the brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug on both ends of the PS are secure using one quarter turn past finger-tight with the 9/16" and ½" wrenches. Do not over tighten the brass fittings as this could damage the Teflon® ferrule inside the fitting and compromise the seal. Note: Loose caps discovered at the analytical laboratory following shipment could invalidate the sample.
5. Place the sealed PS in the original glass vial, cap the vial, and secure in the original sample cooler
6. Inspect diffusion cap and remove from service if dirty
7. Remove powder-free nitrile gloves and discard

STANDARD OPERATING PROCEDURE

SOP Title: Passive Tube Sampling
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13. Install PS shelter cartridge with PS in sample shelter and confirm that the end of the PS with the diffusion cap installed is pointed directly downward
14. Remove powder-free nitrile gloves and discard
15. Repeat this sequence of steps for next PS installation

Sample Recovery and Re-deployment:

Samples will be recovered after 14 consecutive days of sampling, or at another frequency as dictated by the site specific sampling program. Sample recovery should be conducted in the same location sequence as deployment and ideally at clock times that corresponds to exactly 14-days.

1. Inspect sample shelter for damage or indication of insect infestation. Replace if damaged or infested. DO NOT spray sample shelter with any type of insect repellent.
 - If sample shelter is replaced, document height of replacement shelter from the ground and confirm new location coordinates
2. Complete data sheet/chain-of-custody with required information:
 - Name of sample shelter
 - PS identification number etched on exterior of PS, and whether PS is a primary sample, duplicate sample, or field blank (S, D, or B)
 - Date and time
 - Any abnormal conditions in the vicinity (e.g., operation of a portable generator, evidence of tampering with sample shelter)
 - Don powder-free nitrile gloves to prevent contamination with body oils, hand lotions, perfumes, etc,
 - Remove PS cartridge from sample shelter
3. Remove diffusion cap from the end of the and slide PS from cartridge, and replace the original brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug on the open end.
4. Ensure that the brass Swagelok® nut with Teflon® ferrule and brass Swagelok® plug on both ends of the PS are secure using one quarter turn past finger-tight with the 9/16" and 1/2" wrenches. Do not over tighten the brass fittings as this could damage the Teflon® ferrule inside the fitting and compromise the seal. Note: Loose caps discovered at the analytical laboratory following shipment could invalidate the sample.
5. Place the sealed PS in the original glass vial, cap the vial, and secure in the original sample cooler
6. Inspect diffusion cap and remove from service if dirty
7. Remove powder-free nitrile gloves and discard

STANDARD OPERATING PROCEDURE

SOP Title: Passive Tube Sampling
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8. If immediately installing new PS at the sample location, perform the sequence of steps described in Sample Deployment
9. Repeat this sequence of steps for next PS recovery

Sample Packaging and Shipping:

Once all PS are collected and secured in the original sample cooler, the sample cooler must be shipped priority overnight to the analytical laboratory. Per Section 8.5.4 of EPA Method 325B, PS must be analyzed within 30 calendar days of the end of sample collection.

1. If shipping is not done on the same day as sample recovery, samples may be placed in a contaminant-free refrigerator for storage and the ice packs frozen to be placed in the shipping cooler. Per Section 8.5.4 of EPA Method 325B, PS must be stored below 23°C (73.4°F).
2. Each set of samples will contain their own unique chain-of-custody form that is included in the sample cooler. Relinquish the samples by signing the chain-of-custody in the "Relinquished by" section and indicate the selected shipping agency in the "Received by" section. Place the original chain-of-custody form inside a plastic baggie in the corresponding
3. Ensure that at least one temperature blank glass vial is included in the sample cooler.
4. Place the original two frozen ice packs into the sample cooler when ready for shipping.

Note: Do not write, etch, or place labels anywhere on the weatherproof sample shelter, glass vial or PS itself. The lids of the glass vials may be marked with a shelter ID to facilitate sample collection. However, do not use permanent marker, paint, or any other marking tool that contains a high level of VOC to write the sample IDs on the sample label.

Note: Sampled sorbent tubes **MUST NOT** be placed in the same container (e.g., shipping cooler, refrigerator) as clean conditioned, sampling tubes.

Enthalpy Analytical Standard Operating Procedure

Determination of Volatile Organic Compounds (VOCs) by EPA Method 325B

Enthalpy SOP #	ENT222	Revision #	3.0
Author	David Berkowitz	Date Authored	September 4, 2013
Revised by	Glenn Graham	Date Revised	April 19, 2019

Pages 22

Technical Director/designee Approval: *A. F. [Signature]* Approval Date: 6-28-19Quality Assurance Director/designee Review: *Valgene [Signature]* Review Date: 6-28-19Effective Date: 7-12-19

1.0 Scope and Application:

This document describes the procedures for thermal desorption – gas chromatography/mass spectrometry (TD-GC/MS) analysis of volatile organic compounds (VOCs) collected on sorbent tubes using passive sampling. Table 1. in Appendix A. contains the list of analytes that may be determined using this SOP.

2.0 Summary of Method:

Sorbent tubes are conditioned, blanked, and shipped to the field for deployment. Sorbent tube samples received at the laboratory for analysis are thermally desorbed and analyzed by GC/MS for trace-level VOCs.

Critical steps included in the process of thermal desorption of each sample are: Leak testing under stop flow, ambient conditions, internal standard addition, tube purging, thermal desorption of the sample tube, refocusing on a cold trap, secondary desorption of the cold trap with transfer/injection of the sample to the capillary GC column for analysis of the analytes of interest.

Measures included for the purposes of water management include: Selection of hydrophobic sorbents for the sample tube and optional dry purging of the sample tube for approximately an hour on a tube purging station prior to analysis. The tube may be optionally dry purged prior to thermal desorption to the cold trap. See also SOP ENT226.

2.1 Exceptions to Method Criteria:

- 2.1.1 Enthalpy will run a minimum of one initial calibration per year to verify continuing instrument linearity instead of the three month criteria from the method.
- 2.1.2 Since the ICAL points have already been demonstrated to be valid compared to the ICV run after the ICAL, the CCV5 analyses made daily serves to demonstrate the continuing solution validity. Therefore, ICVs will only be run with ICALS and not every three months as per the method criteria.

- 2.1.3 Enthalpy will accept BFB criteria for the m/z 96 response compared to m/z 95 ion response to be acceptable up to and including 14% due to protonation of the 95 ion from using hydrogen as a carrier gas.
- 2.1.4 Gas Standards in cylinders will be considered valid for use until the date of expiration listed by the supplier.
- 2.1.5 Tubes which will not pass leak check due to damage on the very ends of the tube may be analyzed if the damage can be mitigated with micro-mesh or similar material to allow the leak test to pass.
- 2.1.6 CCVs which fail the method internal standard response criteria but pass the RF criteria and are consistent with the remainder of the CCVs in the sequence may be used without rerunning the associated sample tubes if a recollect injection passes all criteria on rerun prior to performing maintenance or tuning. This would confirm a bad injection on the CCV and not a bad spike of the internal standard.

3.0 Definitions:

- 3.1 Thermal Desorption (TD) – The use of heat and a flow of inert (carrier) gas to extract volatiles from a solid matrix.
- 3.2 Blanking – The desorption and confirmatory analysis of conditioned sorbent tubes prior to shipping for field sample collection.
- 3.3 Continuing Calibration Verification (CCV) – A midpoint calibration standard analyzed periodically throughout the sequence to verify the linearity of the multipoint calibration.
- 3.4 Focusing Trap – A cooled secondary sorbent trap integrated into the thermal desorber to refocus analytes desorbed from the sample tube.
- 3.5 Initial Calibration Verification (ICV) – A second source standard analyzed after the Initial Calibration to verify accuracy of the initial calibration.
- 3.6 Field Blank (FB) – Blank tubes shipped to and from the sampling site. Field blank tubes are handled in the same manner as sample tubes, but are not opened to the atmosphere during sampling.
- 3.7 Method Blank (MB) – Analysis of a laboratory blank conditioned tube preferably from the same batch as the tubes used for the field samples. Not a field blank. The method blank is used to verify the contaminant level of the analytical system.
- 3.8 System Blank (SB) – An optional analysis of an empty stainless steel tube (no sorbent packing in tube) used to verify that the instrument is contaminant free.
- 3.9 Standard Conditions – Standard temperature and pressure are defined in EPA Method 325B as 25°C (298.2K) and 760mmHg, respectively.
- 3.10 LOQ (Limit of Quantitation) – Value equal to the lowest calibration standard level used in generating the instrument calibration

4.0 Safety:

Appropriate personal protective equipment should be worn including a lab coat, gloves and safety glasses as deemed necessary.

5.0 Equipment and Supplies:

- 5.1 Thermal Desorption system – Perkin Elmer ATD650 or equivalent.
- 5.2 Thermal Desorber Interface – Uniformly heated transfer line with direct connection to the capillary column.
- 5.3 Thermal Desorption Tubes – Compatible with Perkin Elmer ATD650. Tubes should be 89 mm long, 6.5 mm o.d. (outer diameter) and 5 mm i.d. (inner diameter) made of stainless steel or inert-coated stainless steel with the central section packed with up to 60 mm of sorbent. The sorbent is typically supported between two 100 mesh stainless steel gauzes. When tubes are used for diffusive sampling, they must have an internal diffusion (air) gap of 1.5 cm between the sorbent retaining gauze at the sampling end of the tube and the gauze in the diffusion cap.
- 5.4 Long term storage caps – Two piece ¼” metal Swagelok – type tube caps with PTFE ferrules.
- 5.5 Short term/analytical caps – Caps are made of inert material such as PTFE and compatible with the automated TD system.
- 5.6 Storage and transportation containers – Clean glass jars, metal cans, or non-emitting polymer boxes are used to transport and store tubes. A small packet of activated sorbent material may be included in the shipping container with un-sampled conditioned tubes to safeguard against ambient contamination.
- 5.7 Tube conditioning apparatus – A dedicated tube conditioning unit must be leak-tight, allow precise and reproducible temperature selection ($\pm 5^{\circ}\text{C}$), offer a temperature range at least as great as the thermal desorber and support inert gas flows of up to 150 mL/min through each tube. A TD system may be used provided it supports a dedicated tube conditioning mode in which the inert gas effluent is directed to vent without passing through the key parts of the sample flow-path.
- 5.8 Tube Purging Station – A dedicated tube purging station must be leak-tight, and support controlled inert gas flows through each tube at ambient temperature.
- 5.9 Unheated injection port for loading standards onto blank tubes – The apparatus should have a push-fit or finger-tightening connector for attaching the sampling end of blank sorbent tubes without damaging the tube. It must have a means of controlling the carrier gas flow between 50 and 100cc/min. A low emission septum must be used allowing the introduction of liquid or gas standards via appropriate syringes.
- 5.10 Mass Spectrometer (MS) – Agilent 5973 or 5975 Mass Selective Detector (MSD) or equivalent set in scan mode. This system is capable of scanning from 29 to 300 amu every 1 second or less, using 70 eV.
- 5.11 Gas Chromatograph (GC) – Agilent 5890 or 6890N series or equivalent.

- 5.12 GC/MS interface – Agilent GC/MSD interface or equivalent equipped with a heater sleeve and a heater sensor to monitor and maintain interface temperature.
- 5.13 GC Column – 60 m, 0.52 mm, 1.0 μ m film thickness silicon coated, Restek® Rtx-1 or equivalent.
- 5.14 Data system – Agilent Windows ChemStation or equivalent is used for data acquisition and processing. This system is capable of continuous acquisition and storage of mass spectral data obtained throughout the run. The processing software allows for data to be plotted as total ion current abundance or extracted ion current abundance versus time and is equipped with a 129,000 analyte library from the National Institute of Standards and Technology (NIST) for mass spectra identification.

6.0 Reagents and Standards:

- 6.1 Carrier Gas – UHP Hydrogen or Helium
- 6.2 Sorbent tubes – A suitable sorbent must be chosen based on the physical properties of the analytes of interest. Carboxen X is the optimal sorbent choice when sampling 1, 3-Butadiene. Uptake rates should be verified for the sorbent used when the tubes are used for passive sampling unless they are available in relevant international standards or peer reviewed publications.
- 6.3 Gas phase standards – Static or dynamic atmospheres of certified calibration gases, accurate to $\pm 10\%$ or better, may be used to prepare calibration tubes or validate passive sampling uptake rates. Changes in room temperature and atmospheric pressure can change the mass spiked onto the TD tube when spiking with gas phase standards. When calculating the mass spiked onto tubes used for performing an initial calibration, the room temperature and atmospheric pressure must be recorded and included in calculating the mass of each standard. When preparing CCV standard tubes, the analyst must verify that any change in the room temperature and atmospheric pressure do not cause the spiked mass to differ from the initial calibration standard by more than 3%. If the CCV standard concentration changes by more than 3% from the initial calibration standard, the new CCV concentration must be used in any subsequent analyses/calculations. Gas standards should be spiked onto calibration tubes using an appropriate gas-tight syringe for each tag amount. Each sorbent tube should be left connected to the flow of gas for 2 minutes after standard introduction. Alternatively, gas standards may be prepared using a Thermal Desorber with appropriate volume gas loops for each level.
- 6.4 Liquid Stock Standards – Liquid stock standards may be purchased from approved vendors at specified concentrations or may be prepared from neat materials. Purchased stock standards will have an expiration date assigned by the manufacturer and are stored according to manufacturer recommendations. Prepared liquid stock standards will be assigned a 1 year expiration date and should be stored $\leq 6^\circ\text{C}$. Liquid stock standards may be used to prepare working standards which may then be used to spike the calibration standard tubes.
- 6.5 Liquid working standards prepared for spiking calibration standard tubes must be stored at $\leq 6^\circ\text{C}$ and discarded after two weeks from preparation. The solvent used

must be pure, <10% of the minimum analyte levels, and not interfere chromatographically with the analytes of interest. Prepare the calibration standard tubes as follows:

- 6.5.1 Precise 0.5 to 2 μ L aliquots of liquid standard are introduced to the sampling end of blank sorbent tubes in a flow of carrier gas using a capillary syringe and unheated injector.
- 6.5.2 Each standard tube is purged with carrier gas for five minutes after spiking.
- 6.5.3 Each standard tube must be sealed with long term storage caps immediately after being spiked unless they are to be analyzed immediately. Calibration tube standards expire after 30 days and must be stored in the same manner as samples.
- 6.6 GC/MS Tuning Standard – A certified cylinder containing 4-Bromofluorobenzene (BFB) at a known concentration, such that the loop used to load the standard results in an on-column concentration of 50 ng or less.
- 6.7 Internal Standards – A certified cylinder containing Benzene-d₆, Toluene-d₈, and Bromofluorobenzene at known concentrations, such that a 5 mL load results in on-column masses of approximately 20 to 50 ng.

7.0 Sample Preservation, Storage, and Handling:

- 7.1 Store samples in clean glass jars, metal cans or rigid, non-emitting polymer boxes with long term storage caps.
- 7.2 Sample tubes must be inspected for damage, lose or missing storage caps, or any other problem prior to analysis. Any problems must be documented and tubes are not to be analyzed unless directed by the customer. Tubes which will not pass leak check due to damage on the very ends of the tube may be analyzed if the damage can be mitigated with micro-mesh or similar material to allow the leak test to pass.
- 7.3 Sample tubes must be analyzed within 30 days of the end of sample collection.
- 7.4 Samples must be stored at or below 23°C. If a refrigerator is used for storage, it must be clean and free of organic solvents.

8.0 Calibration:

- 8.1 Instrument Performance Check (Tuning):
 - 8.1.1 Prior to the analysis of calibration standards, blanks or samples, analyze the BFB standard to verify acceptable mass spectrometer performance. The injection of BFB begins the 24 hour analytical clock.
 - 8.1.2 Either a blank tube or a continuing calibration tube containing <50ng of BFB is analyzed. Process the BFB analysis by averaging three scans (the scan prior to the peak apex, the peak apex and the scan following the peak apex) then subtracting one scan prior to the elution of the BFB peak.
 - 8.1.3 The criteria listed in Table 2 in Appendix A must be met before analysis of blanks and samples may begin. If any of the ion abundance criteria are not met, retune the mass spectrometer and repeat the BFB analysis.

8.1.4 If instrument performance criteria are still not met, perform maintenance such as cleaning the ion source or baking the ion source for at least 8 hours using the bakeout program available in the software.

8.1.4.1 The use of hydrogen as a carrier gas is known to cause protonation of the mass 95 BFB product ion which may result in an elevated response for mass 96.

8.1.4.2 If multiple injections of BFB meet all other tuning criteria and mass 96 response is stable and less than 14%, calibration and sample analysis may begin. The following note should to be added to the narrative. "The BFB tune exhibited high bias for the relative response of m/z 96. The use of hydrogen as a carrier gas is known to cause protonation of the m/z 95 BFB product ion resulting in an elevated response for m/z 96. All other BFB tuning criteria have been met for this analysis."

8.2 Initial Calibration:

8.2.1 A spiked tube multipoint calibration, minimum 5 levels, is performed at least yearly. One of the calibration levels must be the same as the daily continuing calibration. See Table 3 in Appendix B for General GC/MS Operating Conditions.

8.2.2 Discrete tube preparations are performed for each level. Desorbing, splitting, and recollecting to prepare another level is not acceptable. Calibration standards must be analyzed using the same analytical conditions as the field samples.

8.2.3 Enter the mass in ng for each analyte into the calibration table when new standards are prepared. Upon analysis of the initial calibration, update each calibration level with the analyte response. The software then calculates the average response factor (RF) and percent Relative Standard Deviation (%RSD) for each analyte.

8.2.4 The software also calculates the mean Response Factor, \overline{RF} , the Relative Retention Time (RRT), and the Relative Standard Deviation (RSD) for all target analytes over the range of the initial calibration. The response factor for each target analyte is calculated using the equation in section 11.1.

8.2.5 Tabulate the area response of the primary ion for each internal standard and calculate the mean area response. Calculate the mean Retention Time (RT) for each internal standard over the range of the calibration.

8.2.6 Repeat the initial calibration after major changes are made to the instrument including ion source cleaning or repair, column replacement, anytime the mass spectrometer is vented, or if the continuing calibration acceptance criteria cannot be met.

8.3 Acceptance criteria for initial calibration:

- 8.3.1 The %RSD of the RF for each analyte must be $\leq 30\%$. If this criterion is not met, maintenance may be required prior to analysis of a new initial calibration.
- 8.3.2 The results of the analysis of each analyte in each calibration must be within 30% of its tag value.
- 8.3.3 The RRT for each analyte at each calibration level must be within ± 0.06 RRT units of the mean RRT for that analyte.
- 8.3.4 If these criteria are not met, maintenance may be required prior to analysis of a new initial calibration or a new preparation of the calibration standards may be needed.

8.4 Initial Calibration Verification (ICV):

- 8.4.1 Analyze an ICV after the acceptable analysis of an initial calibration. The ICV standard should be prepared using a second source of reference materials.
- 8.4.2 Results of the analysis of the ICV standard must be within 30% of its tag value. If this criterion is not met, prepare and analyze a fresh standard. If reanalysis fails, check the instrument for problems. If necessary, analyze a new initial calibration.

8.5 If sufficient time remains on the 24 hour analytical clock after the acceptable initial calibration and ICV analyses, samples may be analyzed. If not, analyze a CCV/BFB instrument performance standard to start a new 24 hour analytical clock.

8.6 Continuing Calibration Verification (CCV):

- 8.6.1 Analyze a daily CCV containing a passing BFB injection. The percent difference (%D) between the analyte RFs in the CCV and corresponding average RF from the initial calibration must be $\leq 30\%$. The internal standard area responses for the beginning CCV must not differ by more than $\pm 40\%$ from of the average area responses of the most recent initial calibration.
- 8.6.2 Analyze a CCV after a maximum of 10 field samples and at the end of the sequence. The percent difference (%D) between the analyte RFs in the CCV and corresponding average RF from the initial calibration must be $\leq 30\%$. The internal standard area responses for the CCV must not differ by more than $\pm 40\%$ from of the area response of the most recent daily CCV.
- 8.6.3 The CCV for a subsequent set of samples may be used as the final CCV for a previous analytical sequence, provided the same analytical method is used and the subsequent set of samples is analyzed within 4 hours of last CCV.
- 8.6.4 For CCVs that fail the method internal standard response criteria, if the RFs are in agreement with the CCVs with normal responses, there was probably a bad injection which would not affect sample results and the data can be reported with appropriate narration if a recollect run of the CCV passes both RF and response criteria.

- 8.6.5 If the criteria in sections 8.6.1 or 8.6.2 are not met, perform maintenance and/or prepare a new calibration standard and reanalyze the continuing calibration. If maintenance and new standards fail to correct the problem, analyze a new initial calibration.

9.0 Procedure:

9.1 Tube conditioning:

- 9.1.1 Freshly packed or newly purchased Carboxpack X tubes need to be conditioned at between 315°C (our instrument desorption temperature) and 400°C (the temperature limit for Carboxpack X) under a stream of inert gas, flowing between 50 and 150 mL/min for at least 2 hours prior to field use. All other tubes need to be conditioned for at least 30 minutes prior to field use.
- 9.1.2 Unused/spare tubes received with field samples shall not be put into the conditioning queue until the analyst has verified that all field samples for the particular job have been loaded (or are available for analysis).
- 9.1.3 Tubes may be conditioned using the thermal desorber provided the unit has a tube conditioning mode in which the effluent from contaminated tubes is directed to vent without passing through key parts of the sample flow-path such as the focusing trap.
- 9.1.4 Tubes may be conditioned using a dedicated conditioning apparatus provided it is leak tight to prevent air ingress, allows precise and reproducible temperature selection ($\pm 5^\circ\text{C}$), offers a temperature range at least as great as that of the tube conditioning temperature, and supports inert gas flows of 50-120 mL/min through each tube.
- 9.1.5 Freshly packed or newly purchased tubes must be analyzed individually to demonstrate they are free of contaminants and interference. All other conditioned tubes must be demonstrated to be free of contaminants and interference by analyzing 10% of the conditioned tubes selected at random from each batch.
- 9.1.6 Blanked tubes should be processed using the response from the Daily CCV to ensure accurate levels are calculated compared to actual sample tubes. The contribution peaks should be included in the area.
- 9.1.7 Background contamination must be < 2.5 ng.
- 9.1.8 If tubes contain unacceptable levels of background contamination, repeat the conditioning and recertification process for that entire box of cleaned tubes (including untested tubes).
- 9.1.9 Sample tubes in which the catch weight exceeds the calibration limit must be marked after analysis and individually blank checked after reconditioning.
- 9.1.10 Tubes must be reconditioned if not used within 30 days of conditioning.

9.2 Pre-desorption System Checks and Procedures:

9.2.1 Ensure all sample tubes, blanks, and standards are at ambient temperature before removing them from the storage container.

9.1.1 Remove the long-term storage caps from the tubes and replace with analytical caps.

9.2.2 Load the tubes on the tray and enter the analytical sequence using the Turbomatrix software used by the automated tube desorber (ATD).

9.2.3 Create a sequence table in Agilent ChemStation software mirroring that of the ATD.

9.2.4 The ATD performs system integrity checks prior to desorption of each tube.

9.2.4.1 Any tube which fails the tube leak test should not be analyzed by the ATD but resealed and stored intact on the autosampler tray. The ATD will continue to test and analyze subsequent tubes. Note that the GC/MS will acquire the next tube in the ATD sequence as if it were the original tube thus unsynchronizing the ATD sequence from the GC/MS sequence.

9.2.4.2 The sample flow path is leak tested without heat or gas flow applied to the sample tube. If a leak is detected, the analytical sequence should be terminated.

9.3 Sample Dry Purge:

9.3.1 Before loading on the ATD, sample tubes may be dry purged with inert gas at ambient temperature for approximately one hour to remove moisture from the tube. They are purged with the sampling sides down (Arrow pointing down). See SOP - 226.

9.3.2 Before analysis after loading on the ATD, tubes are dry purged with 30cc/min of carrier gas passing into the tube from the sampling end for 4 minutes to remove any remaining water vapor.

9.4 Sample Analysis:

9.4.1 An analytical sequence should consist of the following elements in order:

9.4.1.1 A Passing BFB/CCV standard – see Appendix B - or BFB followed by Initial Calibration and ICV

9.4.1.2 Method Blank (MB)

9.4.1.3 Field Blank (FB)

9.4.1.4 Field Samples – up to ten

9.4.1.5 Field Blank (if available)

9.4.1.6 CCV

9.4.1.7 Additional Field Samples – up to ten

9.4.1.8 Closing CCV

Note that BFBs or System Blanks may be injected as needed for diagnostic purposes.

- 9.4.2 Internal standard addition is performed automatically using the ATD. A fixed volume loop is used to introduce the standard to each tube prior to desorption. Benzene-d6 or Toluene-d8 are used to quantitate target concentrations.
- 9.4.3 Each tube should be purged to vent with carrier flowing in the direction of sample desorption to remove oxygen prior to heating.
- 9.4.4 Desorb each tube using the same instrument conditions used to calibrate the system.
- 9.4.5 The internal standard area responses for each sample analysis must not differ by more than $\pm 40\%$ from the area responses of the daily beginning CCV. Flag sample results for analyses that do not meet the response criteria.
- 9.4.6 The internal standard retention times must not vary by more than 20 seconds from the retention times of the internal standard in the daily beginning CCV.
- 9.4.7 Analyzed tubes must be resealed with long-term storage caps after the completion of the analytical sequence.
- 9.4.8 Report results in ng, $\mu\text{g}/\text{m}^3$, and ppbv for each analyte, unless otherwise directed by the client. 'E' Flag any result that exceeds the calibration range of the instrument in the data report and associated narrative.
- 9.5 Record all information associated with instrument calibration and sample analysis on the instrument log book pages.
- 9.6 Record any instrument maintenance in the instrument's maintenance logbook.
- 9.7 Interferences:
 - 9.7.1 Contamination may occur in the sampling system if tubes are not properly conditioned before use.
 - 9.7.2 Interferences in tubes samples may result from improper use or from contamination of: (1) the tubes due to poor manufacturing practices, (2) the tube conditioning cleaning apparatus, and (3) the sampling, shipping or analytical system.
 - 9.7.3 If benzene-d6 is used as an internal standard, a small amount of benzene contribution from the standard will elute on the front of the native benzene. This contribution will be less than the method MDL. The peaks will only be manually integrated if the native benzene from the sampling is not completely included in the area. The internal standard contribution will be integrated out of the peak at the request of the client if the results will affect the clients sampling frequency and will be noted in the narrative.
 - 9.7.4 Attention to the following details will help to minimize the possibility of contamination of tubes.
 - 9.7.4.1 Tubes should be manufactured using high quality stainless steel, preferably deactivated, and new tubes should be conditioned at the lab regardless if they were conditioned by the manufacturer. The

conditioning apparatus, sampling system, and analytical system should be assembled of clean, high quality components.

9.7.4.2 Tubes should be stored in a contaminant-free location and should be capped tightly during shipment.

9.7.5 Significant contamination of the analytical equipment can occur whenever samples containing high VOC concentrations are analyzed. This in turn can result in carryover contamination in subsequent analyses. Closely examine the sample analysis following the high concentration sample for the presence of carryover. If carryover is suspected, data should be qualified in the report narrative.

10.0 Quality Control:

10.1 Method Blank:

10.1.1 The Method Blank is a conditioned blank tube analyzed daily prior to sample analysis but after an acceptable initial or continuing calibration. One Method Blank should be analyzed for a batch of up to 20 field samples or at least once per 24 hour analytical sequence.

10.1.2 The Method Blank must not contain target analytes at concentrations greater than 2.5 ng.

10.1.3 The internal standard response and retention time criteria in sections 9.4.5 and 9.4.6 must be met. If not, perform clean-up procedures on the analytical system and analyze another method blank. If the samples were already run prior to discovering method blank.

10.2 Field Samples should be flagged with a "P" or "Pc" if Field Duplicates results are not within 30% of the concentration of their respective collocated samples.

10.3 Desorption efficiency and compound recovery for the TD method must be demonstrated at instrument setup and after the analytical system is recalibrated. Compound recovery must be greater than 95% for replicate analyses of the same sample tube. Following an initial calibration and ICV acquisition, analyze the high CCV point at 3-1 no-Recollect with internal standard. Immediately rerun the same tube 2-1 using no-Recollect with internal standard. Quantitate the amount of each target, if any, from the second run. This must be less than 5% of the amount originally spiked on tube for the initial run.

11.0 Data Analysis and Calculations:

11.1 Calculate the response factor (RF) for each analyte in the calibration using the following equation:

$$RF = \frac{Area_C}{Area_{IS}} \times \frac{Amt_{IS}}{Amt_C}$$

Where:

$Area_c$ = Area of analyte

Amt_C = Amount of analyte in ng

Amt_{IS} = Amount of Internal Standard in ng

$Area_{IS}$ = Area of Internal Standard (IS)

- 11.2 The instrument software is capable of tabulating each calibrated analyte's response factor at each standard concentration. The software then calculates the average RF and percent RSD. The following equation is used to calculate the % RSD:

$$\%RSD = 100 \left(\frac{SD}{\overline{RF}} \right)$$

Where:

SD = Standard deviation

\overline{RF} = average response factor

- 11.3 Calculate the %D between the average RF from the initial calibration and the corresponding RF from the continuing calibration using the following calculation:

$$\% D = \left(\frac{|\overline{RF} - RF_{concal}|}{\overline{RF}} \right) \times 100$$

Where:

\overline{RF} = Average RF from initial calibration

RF_{concal} = RF from continuing calibration

- 11.4 Calculate sample results in ng for each analyte of interest using the following equation:

$$\text{Concentration (ng)} = \frac{A_A \times IS_C}{A_{IS} \times RF}$$

Where:

A_A = Area of quantitation ion of target analyte

IS_C = Internal Standard mass in ng

A_{IS} = Area of quantitation ion of Internal Standard

RF = Response factor from the daily CCV

- 11.5 Concentrations for detected target analytes are calculated using the following equation:

$$C_c = \frac{m_{meas} \times 10^6}{U_{NTP} \times \left[\frac{T_{ss}}{298} \right]^{\frac{1}{2}} \times t}$$

Where:

C_c = concentration of target compound at normal ambient temperature and pressure in $\mu\text{g}/\text{m}^3$

m_{meas} = Measured mass of target analyte in μg

t = Exposure time in minutes

$Untp$ = Diffusive uptake rate (sampling rate) in mL/min unadjusted.

T_{ss} = Average field temperature (K) over sampling period

$$\text{Conc. (ppbv)} = \frac{C \times 24.45}{MW}$$

Where:

C = Concentration of target analyte in $\mu\text{g}/\text{m}^3$

MW = Molecular weight of target analyte

24.45 = Specific molar volume of an ideal gas at 25°C and 760 mmHg

11.6 Calculate Analytical Precision for Duplicate Field Samples using the following equation:

$$\text{Field Precision (\%)} = \frac{([F1 - F2])}{\bar{F}} \times 100$$

Where:

$F1$ = A measurement value (mass) taken from one of the two field replicate tubes used in sampling.

$F2$ = A measurement value (mass) taken from the second of two field replicate tubes used in sampling.

\bar{F} = The average of $F1$ and $F2$.

12.0 Method Performance:

Method performance is demonstrated through MDL studies and demonstrations of capability performed by the analyst. Follow procedures detailed in SOP ENT027, for determining MDLs. Follow the procedures detailed in SOP ENT005, for performing demonstrations of capability.

13.0 Pollution Prevention and Waste Management:

Expired liquid stock standards and any waste generated during standard preparation must be disposed of in the appropriate waste container using the guidance in SOP ENT 023.

14.0 References:

- 14.1 Method 325B, Volatile Organic Compounds from Fugitive and Area Sources: Sampler Preparation and Analysis. Federal Register, Vol. 80, No. 230, Tuesday, December 1, 2015.
- 14.2 McClenny et al., 24h diffusive sampling of toxic VOCs in air onto Carbopack X solid adsorbent followed by thermal desorption/GC/MS analysis – laboratory studies. J. Environ. Monit., 2005, 7, 248-256.

15.0 Tables, Diagrams, and Flow Charts:

- 15.1 Appendix A: Table 1: Target Analyte List
- 15.2 Appendix A: Table 2: Instrument Performance Check criteria
- 15.3 Appendix B: Table 3: GC/MS Operating Conditions
- 15.4 Appendix C: Table 4: 325B Data Flags
- 15.5 Appendix D: Table 5: Acceptance Criteria and Requirements for All Runs

Revision History:			
Revision#	Date:	Author:	Comments:
3.0	04/19/2019	Glenn Graham	Updated to reflect new Internal Standard and to clarify requirements and remedial actions for requirement failures. Listed Enthalpy exceptions to the method requirements.
2.0	6/20/18	Glenn Graham	Updated to reflect EPA ALT-122 concentration calculations. Removed System Blank and separate BFB requirements.
1.0	12/1/15	C. Thrasher; A. Pope	Updated per published method
0.0	09/04/13	David Berkowitz	

Appendix A

TABLE 1: Target Analyte List:		
Analyte Name	Quantitation Ion	CAS Number
1,3-Butadiene	54	106-99-0
Benzene (Cyclohexatriene)	78	71-43-2
Toluene (Methyl benzene)	91	108-88-3
Ethylbenzene	91	100-41-4
m-/p-Xylene		108-38-3
(1, 3 & 1, 4-Dimethylbenzene)	91	106-42-3
o-Xylene (1, 2-Dimethylbenzene)	91	95-47-6
Internal Standards		
Benzene-d6	84	1076-43-3
Toluene-d8	98	2037-26-5
4-Bromofluorobenzene	95	460-00-4

TABLE 2- Tune Acceptance Criteria	
MASS	TO-15 Ion Abundance Criteria
50	8 to 40% of mass 95
75	30 to 66% of mass 95
95	Base Peak, 100% Relative Abundance All ion abundances must be normalized to the 95 mass
96	5 to 14% of mass 95 (if using hydrogen as the carrier gas)
173	<2% of mass 174
174	50 to 120% of mass 95
175	4 to 9% of mass 174
176	93 to 101% of mass 174
177	5 to 9% of mass 176

Appendix B

TABLE 3. GENERAL GC/MS OPERATING CONDITIONS		
Chromatography	Column	Rtx-1 (60m x 0. 52-mm x 1.0 µm film thickness)
	Carrier Gas	UHP grade Hydrogen (1.8 mL/min set by ATD650)
GC Temperature Program	Initial Column Temperature	40°C
	Initial Hold Time	5.0 minutes
	Program	10.0°C/minute to 130°C, hold for 0.0 min; 20.0°C/minute to 280°C
	Final Hold Time	4.50 minutes (may be extended)
Mass Spectrometer	Mass Range	35 to 300 AMU
	Scan Time	5.26 scans/second
	EI Condition	70eV
	Mass Scan	EI full scan
ATD650 Conditions	Valve Temp:	250°C
	Transfer Line Temp:	225°C
	IS Loop Volume:	5cc
	Dry Purge:	30cc/min for 4.0min
	Column flow:	1.8cc/min UHP Hydrogen
	Outlet split:	8.0cc/min
	Percent Sample Inj:	18.4%
	Tube Desorb:	50cc/min for 8 min @ 325°C
	Rate of Heating:	40°C/sec.
	Focusing Trap:	Trap: -10°C Desorb: 330°C for 8 min Rate: 40°C/sec. Flow during desorb: 1.8cc/min
Note: The GC/MS operating conditions presented in the Table 3 are an example. Actual instruments conditions may vary as the instrument is optimized.		

Appendix C

TABLE 4. 325B Data Flags	
CODE	Definition/Explanation
ND	The analyte was not present above the Method Detection Limit.
J	Estimated Value - The analyte was detected between the Method Detection Limit and Reporting Limit.
B	Compound present in field blank(s) greater than 1/3 the compliance limit or measured target analyte
E	Concentration exceeds calibration range
S	Saturated peak
P	Field duplicate(s) exceed 30%RPD
Pc	Field duplicate(s) exceed 30%RPD, concentrations of both sample and duplicate are near reporting limit.
Pl	Field duplicate(s) exceed 30%RPD, lab injection error noted
I	Internal Standard recovery outside acceptance limits
M	Matrix interference present for primary ion, alternative quantitation procedure used.
H	Sample was analyzed outside of method hold time
L	Recovery of bracketing CCV(s)exceeded acceptance limits (Apply to sample results)
D	Sample duration outside 14 + 1 days
Fe	Field Error (missing diffusion screen cap, other documented issue on COC)
Te	Tube Error (Sample tube received with leaky sorbent, bent, or missing or loose storage caps)
X	Case Narrative

Appendix D

TABLE 5. Acceptance Criteria and Remedial Actions

Initial Calibration	1)	Calibration standard tubes may be stored for no longer than 30 days and should be refrigerated if there is any risk of chemical interaction or degradation.	Recondition and re-spike any tubes past the 30-day mark.
	2)	Each TD/GC/MS system must be calibrated using at least five concentrations that span the monitoring range of interest.	
	3)	Each GC/MS system must be recalibrated with a full calibration curve following corrective action that involves venting the MS or performing maintenance that will make the response factor criteria unachievable.	
	4)	Recalibration Yearly or when CCV criteria cannot be met.	
	5)	The %RSD of the RF for each analyte must be $\leq 30\%$.	a) Remake failing level if obvious instrument or prep issue. b) Otherwise perform maintenance/tuning and run newly prepared initial calibration curves tubes.
	6)	The results of the analysis of each analyte in each calibration level must be within 30% of its tag value.	a) Remake failing level if obvious instrument or prep issue. b) Otherwise perform maintenance/tuning and run re-prepared initial calibration curves tubes.
	7)	RRT for target peaks ± 0.06 units from mean RRT	Perform maintenance and rerun initial calibration.
ICV	1)	An ICV should be run with each ICAL	
	2)	Results of the analysis of the ICV standard must be within 30% of its tag value.	a) Remake ICV tube and re-inject. b) Perform maintenance and re-ICAL the instrument.
	3)	ICV must be from a second source.	

BFB Tune Check	1)	Must meet the performance criteria listed in Table 2 of Appendix A of the 325B SOP with the exception of m/z 96. M/z 96 percentage of m/z 95 may be excepted up to 14% of m/z 95 due to protonation from the use of hydrogen.	a) Retune and or perform maintenance and rerun BFB tune. b) Document any exceptions for protonation in the job narrative.
	2)	If a BFB tube and a CCV are both run, the BFB tune must be reported from the tube run closest in time to the samples.	
	3)	Required at the start of each sequence and valid for 24 hour from time of injection.	
	4)	BFB tune check percentages may not be rounded to the nearest whole digit for the purpose of passing BFB.	
	5)	Ending CCVs do not need to be injected within the BFB clock provided no maintenance or tuning is performed between the last sample and the CCV injection and there is no more than a four hour time lapse.	

CCV	1)	The Internal Standard response of the Daily CCV must be at or within $\pm 40\%$ of the average of the ICAL Internal Standard responses.	a) Perform maintenance / tuning and rerun the Daily CCV. b) b) If the Daily CCV will not pass, run a new ICAL.
	2)	The Internal Standard response of the remaining CCVs must be at or within $\pm 40\%$ of the Daily CCV Internal Standard response.	a) Perform maintenance/tuning and rerun the CCV and affected sequence/sequences starting with a new Daily CCV. b) If the RFs are in agreement with the CCVs with normal responses, there was probably a bad injection which would not affect sample results and the data can be reported with appropriate narration.
	3)	The percent difference (%D) between the analyte RFs in the CCVs and corresponding average RF from the initial calibration must be $\leq 30\%$.	Perform maintenance/tuning and rerun the CCV and affected sequence / sequences starting with a new Daily CCV.

4)	An additional CCV must be run at the end of every ten field samples (not including field blanks) and to close out the sequence. This analysis may be outside of the 24hr BFB clock if all samples are within the clock.	a) Perform maintenance/tuning and rerun the CCV and affected sequence / sequences starting with a new Daily CCV. b) If samples must be reported using a failing bracketing CCV, flag samples for possible invalidation.
5)	The CCV for a subsequent set of samples may be used as the final CCV for a previous analytical sequence, provided the same analytical method is used and the subsequent set of samples is analyzed within 4 hours of last CCV.	

Method Blank	1)	Internal Standard (IS) area response $\pm 40\%$ and IS Retention Time (RT) ± 0.33 min. of most recent daily calibration check.	
	2)	<2.5 ng per VOC targeted compound or 3 times the LOD, whichever is greater.	a) Repeat analysis with a new blank tube. b) Check system for leaks, contamination. c) Analyze an additional blank.
	3)	One Method Blank run per each twenty field samples.	
Field Blank	1)	Internal Standard (IS) area response $\pm 40\%$ and IS Retention Time (RT) ± 0.33 min. of most recent daily calibration check.	a) Inspect chromatogram for signs of possible moisture issues and perform an additional nitrogen purge if needed before running recollect. b) If moisture is not the issue, proceed with a recollect analysis after performing maintenance as deemed necessary. c) If responses still are not met, flag field blank for possible invalidation.
	2)	<2.5 ng per VOC targeted compound or < 1/3 of the field sample level.	If criteria are not met, flag samples less than three times the field blank level.

Duplicate	1)	Duplicate samples must agree within 30%.	a) Duplicates that exhibit signs of moisture should be re-analyzed after additional nitrogen purging if deemed necessary. b) A poor injection leading to failure for a duplicate and/or its corresponding sample should result in a recollect analysis of the affected tube.
	2)	If Duplicates do not match according to method criteria, samples from the associated job should be flagged with a P or Pc flag.	Pc flag data sets for which the duplicate samples do not agree within 30 percent and the concentrations of both tubes are near reporting limit.

Sample	1)	Internal Standard (IS) area response $\pm 40\%$ and IS Retention Time (RT) ± 0.33 min. of most recent daily calibration check.	a) Inspect chromatogram for signs of possible moisture issues and perform an additional nitrogen purge if needed before running recollect. b) If moisture is not the issue, proceed with a recollect analysis after performing maintenance, if deemed necessary. c) If responses still are not met, flag sample for possible invalidation.
	2)	Sampling time for tubes must be 14.0 \pm 1.49 days	Flag samples that are outside the criteria.
	3)	Target peaks that have saturated the detector should have their results "S" flagged.	The saturation should be documented in the narrative for the job.

Blank Checked Tubes	1)	Internal Standard (IS) area response $\pm 40\%$ and IS Retention Time (RT) ± 0.33 min. of most recent daily calibration check.	a) Rerun the failing tube to verify it is blank. b) Run another tube from the same batch in place of the tube with failing IS response to verify the batch is good.
	2)	One tube analyzed for each batch of tubes cleaned or 10 percent of tubes whichever is greater. Tubes must be verified to be < 2.5 ng of benzene before use of the box of tubes for sampling is permitted.	Failure of a tube triggers the reconditioning of all non-verified clean tubes from that tube's oven batch.

3)	100% of new tubes must be verified to be < 2.5 ng of benzene after initial conditioning and before use.	Failure of a tube triggers the recleaning and reanalysis of that tube until the tube passes the 2.5 ng limit.
4)	Blanked tubes should be processed using the Daily CCV response factors and the response for benzene should include the contribution from the benzene-d6.	

Standard Operating Procedure – Collection and Analysis of Summa Canister

STANDARD OPERATING PROCEDURE

SOP Title: Summa Canister Sampling
Document Number: 928ET-772315-SP-1
Revision Number: R1

Implementation Date: September 9, 2020
SOP Owner (Department): AQS
SOP Approval: Austin Heitmann, CPM

Summa Canister Sampling Standard Operating Procedure:

1. Remove canister from box.
2. Check plug on canister is on tight
3. Confirm the valve on the canister is closed
4. Remove the plug from the inlet of the canister and reserve for after sample collection. If there is an additional fitting attached to the valve, make sure to hold the hex below the plug still with a ½" wrench to remove the plug. Failure to do this may cause the canister to lose vacuum.
5. Remove the cap from the bottom of a sample regulator. (Note: There is a removable graphite/vespel ferrule on this fitting – take care to make sure it is not lost when removing.)
6. If the ferrule falls out, place the ferrule on the tubing stub of the regulator with the taped end facing the connection to be made.
7. Connect the regulator to the sample canister. Tighten the nut on the regulator ¼ turn past finger-tight. Make sure to hold the hex of the additional fitting still (if present) with a ½" wrench to ensure that it's snug.
8. Check and note if the needle is not on zero on the vacuum gauge.
9. Ensure the inlet nut on the inlet filter to the regulator is on and tight.
10. Mount the canister on a tripod (same tripod as a continuous monitor, if applicable) approximately 4-7 feet off the ground.
11. Open the valve on the canister and note the vacuum in the canister. The canister has acceptable vacuum if the gauge reads between 23-28 InHg – please add or subtract any zero offset noted.
12. Allow the regulator to equilibrate for 30 seconds then close the valve on the regulator.
13. To check for leaks, observe the vacuum gauge for 30 seconds to make sure the needle does not move toward zero.
14. If leaking repeat steps above after tighten the fittings an additional 1/8 of a turn. Do this systematically one at a time starting at the canister and moving toward the inlet of the regulator.
15. When ready to sample remove the nut from the inlet of the regulator and open canister. Record sampling information on the COC – Sample ID, Can #, Regulator #.
16. When finished sampling each canister, make sure 2 to 10 InHg of vacuum remains in canister. Note this value on the COC.
17. Close the canister valve
18. Remove regulator from canister
19. Replace nut on top of canister and tighten ¼ turn past finger-tight
20. Replace cap on the bottom of the regulator and plug at inlet. Tighten both ¼ turn past finger-tight.

Enthalpy Analytical Standard Operating Procedure

Determination of Volatile Organic Compounds (VOCs) by EPA Method TO-15

Enthalpy SOP #	ENT200	Revision #	8.0
Author	Denese Adcock	Date Written	January 27, 1998
Revised by	T. Denese Daniels	Date Revised	October 22, 2019

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Laboratory Director/designee Approval: *[Signature]*Approval Date: 10-23-19Quality Assurance Coordinator/designee Review: *[Signature]*Review Date: 10/23/19Effective Date: 11/12/19

1.0 Scope and Application:

This document describes the procedures for sample preparation, analysis, and QC of volatile organic compounds (VOCs) in ambient air samples. Whole air samples are collected in Summa canisters; Restek TO-15 or SilcoSteel, and Entech Silonite or non-silonite canisters (15, 6, 3, and 1.29 liter sizes) at pressures above or below atmospheric pressure. Table 1 contains the list of compounds that may be determined using this SOP.

2.0 Summary of Method:

The samples are analyzed using a cryogenic concentrator and a gas chromatograph equipped with a mass spectrometer. Sample analysis begins by collecting the sample onto a cryogenically cooled trap. The sample is desorbed and refocused at the head of the analytical column for enhanced chromatographic resolution.

It is the responsibility of the qualified analytical staff of Enthalpy Analytical, LLC (Enthalpy) to follow the procedures set forth in this SOP.

3.0 Definitions:

- 3.1 Initial Calibration (ICAL) – Analysis of a multipoint calibration that spans the monitoring range of interest and is used to determine the sensitivity and the linearity of the GC/MS response for the target compounds.
- 3.2 Initial Calibration Verification (ICV) – Analysis of a standard prepared from a second source or lot, or second preparation of calibration material. The ICV or Second Source standard (SS) is used to verify the initial calibration.
- 3.3 Laboratory Control Sample (LCS) – Analysis of the ICV standard or a second injection of a calibration standard analyzed at a concentration that falls within the instrument's calibration range.
- 3.4 Continuing Calibration Verification (CCV) – Analysis of a mid-level calibration standard used to verify the instrument meets calibration acceptance criteria.

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- 3.5 Order Acknowledgement Form (OAF) – A written confirmation sent to the client confirming receipt of samples, requested analyses, quantity, and pricing.
- 3.6 Method blank or humid blank is a humidified zero air (or nitrogen) canister analyzed per 24 hour sample batch or clock.
- 3.7 Limit of Quantitation (LOQ) – The concentration of the low standard included in the calibration curve also referred to as reporting limit (RL).
- 3.8 Limit of Detection (LOD) – The smallest quantity or concentration of an analyte that can be identified as being present in the sample with a 99% confidence level. Also referred to as Detection Limit (DL).
- 3.9 Duplicate precision (Replicate precision) – the precision determined from the analysis of two injections from the same sample canister. The precision is calculated as the absolute value of the difference between the canister analyses divided by the average of their value reported as a percentage.
- 3.10 MS-Scan – Mass spectrometric mode of operation in which gas chromatography (GC) coupled with mass spectrometry (MS) programmed to scan

4.0 Safety:

Appropriate personal protective equipment (including a lab coat, gloves and safety glasses) should be worn when performing this procedure as deemed necessary.

5.0 Equipment and Supplies:

- 5.1 Mass Spectrometer (MS) – Hewlett-Packard 5971, 5973, or 5975 Mass Selective Detector (MSD) or equivalent set in scan mode. This system is capable of scanning from 29 to 300 amu every 1 second or less, using 70 eV.
- 5.2 Gas Chromatograph (GC) – Hewlett-Packard 5890 or 6890N series or equivalent.
- 5.3 GC/MS interface – Hewlett-Packard GC/MSD interface or equivalent equipped with a heater sleeve and a heater sensor to monitor and maintain interface temperature.
- 5.4 GC Column – 60 m, 0.32 mm, 1.0 μ m film thickness silicon coated, Restek® Rtx-624 or equivalent.
- 5.5 Concentrator – Entech 7100A Preconcentrator or equivalent; it utilizes a 3-stage concentration to eliminate water vapor without loss of polar VOCs.
- 5.6 Electronic Mass Flow Controller – Coastal Instruments 0-100-cm³/min or equivalent. The mass flow controller is capable of maintaining a constant flow for both carrier and sample gas. It also can provide analog output that monitors flow anomalies.
- 5.7 Data system – Hewlett-Packard Windows ChemStation, MassHunter or equivalent used for data acquisition and processing. This system is capable of continuous acquisition and storage of mass spectral data obtained throughout the run. The processing software allows for data to be plotted as total ion current abundance or extracted ion current abundance versus time and is equipped with a 129,000 compound library from the National Institute of Standards and Technology (NIST) for mass spectra identification.

- 5.8 Summa canisters 6L, 15L, 3L, and 1.29L – Restek TO-15 or SilcoSteel, and Entech Silonite or non-silonite.

6.0 Reagents and Standards:

- 6.1 GC/MS Tuning Standard – A certified cylinder containing 4-Bromofluorobenzene (BFB) at a known concentration, such that a 50 mL load results in an on-column concentration of approximately 10 ppbv.
- 6.2 Internal Standards – A certified cylinder containing 1,4-Difluorobenzene, Bromochloromethane, and Chlorobenzene-d₅ at known concentrations, such that a 50 mL load results in on-column concentrations of approximately 10 ppbv.

NOTE: The internal standards and tuning standard may be purchased as a single certified cylinder and used for both tuning and internal standards which are introduced during each analytical run.

- 6.3 Calibration standards – Certified 1ppm stock calibration gas cylinders are purchased. Working gas standards are prepared in 6L canisters using gastight syringes to inject the standards into the canister and diluting with nitrogen to appropriate concentrations to calibrate the instrument, generally 20ppbv and 1ppbv. These standards are analyzed at various load volumes to create a calibration curve typically ranging from 0.04 ppbv to 30 ppbv. When performing analyses for the New Jersey Department of Environmental Protection (NJDEP) the low point of the calibration shall be 0.4 ppbv. Data not submitted for NJDEP compliance may have a calibration range of 1.0 ppbv to 20 ppbv. Client requested reporting limits will determine calibration curve range.
- 6.3.1 A clean canister is evacuated to <50mtorr and humidified with approximately 50 to 75µL of DI water for preparation of the TO-15 standard.
- 6.3.2 Prepare the calibration standards using the “Summa from gas stock” tab in the “GasPhaseStandards” excel workbook. The “GasPhaseStandards” excel workbook is located on the server at Enthdc02\Data\Documents\Sheets - VALIDATED\LAB. Enter the following information into the spreadsheet:
- 6.3.2.1 “mL” = the volume of cylinder gas used
- 6.3.2.2 “ppbv” = the concentration of certified cylinder gas
- 6.3.2.3 “Bar (in. Hg)” = the ambient barometric pressure
- 6.3.2.4 “Temp. (F)” = the ambient temperature
- 6.3.2.5 “Canister volume (L) – Canister size (6L, 3L, 15L, etc.)
- 6.3.2.6 “Vol.” = the volume of the canister
- 6.3.2.7 “Gauge Pressure (mmHg)” – the final pressure of the prepared canister standard
- 6.3.2.8 The mL of certified standard and the Gauge Pressure is adjusted to obtain the desired standard concentration. See Table 2 for an example of a TO15 Standards Prep Spreadsheet.
- 6.3.3 TO-15 prepared standards are assigned an expiration date equal to or less than the expiration of the stock standard from which they were made.

6.3.4 Standard canisters are allowed to sit for a minimum of 4 hours (overnight if time permits) before being analyzed. This provides necessary time for a layer of water to form on the surface of the canister displacing VOCs from the surface and forcing them back into the gas phase.

6.3.5 Prepare an ICV standard in a clean canister following the same procedure in sections 6.3.1 and 6.3.2, using different gas standard cylinders and/or gas volumes. The ICV standard may also be analyzed as an LCS

7.0 Sample Preservation, Storage, and Handling:

7.1 Samples are stored in the ambient secure sample storage area, prior to and after analysis.

7.2 TO-15 VOCs are stable in canisters for up to 30 days after collection per method criteria.

8.0 Calibration:

8.1 Instrument Performance Check (Tuning):

8.1.1 Prior to the analysis of calibration standards, blanks or samples, analyze the BFB standard to verify acceptable mass spectrometer performance. The injection of BFB begins the 24 hour analytical clock.

8.1.2 A 50 mL sample load of the certified tuning standard is analyzed. Process the BFB analysis by averaging three scans (the scan prior to the peak apex, the peak apex and the scan following the peak apex) then subtracting one scan prior to the elution of the BFB peak.

8.1.3 The criteria listed in Table 3 shall be met before analysis of standards, blanks and samples may begin. If any of the ion abundance criteria are not met, retune the mass spectrometer and repeat the BFB analysis.

8.1.4 If instrument performance criteria are not met, perform maintenance such as cleaning the ion source.

8.1.4.1 The use of hydrogen as a carrier gas is known to cause protonation of the m/z 95 BFB product ion resulting in an elevated response for m/z 96. This is seen most often after source cleaning, filament replacement or venting of instrument for troubleshooting purposes.

8.1.4.2 If the elevated response of m/z 96 is less than 14% analysis may begin; however, a statement about protonation of the product ion m/z 95 shall be included in the narrative.

8.2 Initial Calibration:

8.2.1 A humidified canister multipoint calibration, a minimum of 5 levels, is performed. One of the calibration levels shall be the same as the daily continuing calibration. See Table 4 for General GC/MS Operating Conditions.

8.2.2 Canisters containing target analytes, usually at 20 ppbv and 2 ppbv are prepared. The 20 ppbv canister is diluted and analyzed at various concentrations between 1 ppbv to 30 ppbv with internal standards that are introduced prior to trapping the standard. The 2 ppbv canister is diluted and analyzed at various concentrations between 0.04 ppbv and 1 ppbv. A canister

prepared at a different concentration may be used for the low levels of the calibration curve.

- 8.2.3 Analyzing a 500 mL aliquot of the 20 ppbv standard canister is an undiluted analysis, resulting in a concentration of 20 ppbv. Analysis of a 750 mL aliquot of the 20 ppbv standard canister is a 1.5-fold concentration, resulting in a concentration of 30 ppbv. Analysis of a 50mL aliquot of the 20 ppbv standard canister is a 10-fold dilution, resulting in a concentration of 2 ppbv.
 - 8.2.4 Enter each analyte concentration into the calibration table when new standards are prepared. Upon analysis of the initial calibration, update each calibration level with the analyte response. The software then calculates the average response factor (RF) and percent Relative Standard Deviation (%RSD) for each analyte.
 - 8.2.5 The software also calculates the mean Relative Response Factor (RRF), the Relative Retention Time (RRT), and the Relative Standard Deviation (RSD) for all target compounds over the range of the initial calibration. The response factor for each target compound is calculated using the equation in section 11.1.
 - 8.2.6 Tabulate the area response of the primary ion for each internal standard and calculate the mean area response. Calculate the mean Retention Time (RT) for each internal standard over the range of the calibration.
- 8.3 Acceptance criteria for initial calibration:
- 8.3.1 The %RSD for each analyte shall be $\leq 30\%$, with 2 exceptions $\leq 40\%$. If the criteria are not met, maintenance may be required prior to analysis of a new initial calibration.
 - 8.3.2 The RRT for each analyte at each calibration level shall be within ± 0.06 RRT units of the mean RRT for that analyte.
 - 8.3.3 The area response at each calibration level shall be within 40% of the mean area response for each internal standard.
 - 8.3.4 The retention time of each internal standard in each initial calibration standard shall be less than 20 seconds from the average retention time of that internal standard over the range of the initial calibration.
- 8.4 Initial Calibration Verification (ICV):
- 8.4.1 Analyze an ICV after the acceptable analysis of an initial calibration. The ICV standard should be prepared using different cylinder gas volumes and final gauge pressure than those used to prepare the initial calibration standard. The ICV is analyzed at a concentration within the initial calibration range.
 - 8.4.2 Results of the analysis of the ICV standard shall be within 30% of its tag value. If this criterion is not met, prepare and analyze a fresh standard. If reanalysis fails, check the instrument for problems. If necessary, analyze a new initial calibration.

- 8.4.3 If sufficient time remains on the 24 hour analytical clock after the acceptable initial calibration and ICV analyses, samples may be analyzed. If not, analyze the BFB instrument performance standard to start a new 24 hour analytical clock and analyze a CCV standard.
- 8.5 Daily/Continuing Calibration Verification (CCV):
 - 8.5.1 A mid-level standard, usually 5ppbv, is analyzed at the beginning of the analytical sequence, after the acceptable analysis of BFB.
 - 8.5.2 The percent difference (%D) between the analyte RFs in the CCV and corresponding average RF from the initial calibration shall be $\leq 30\%$. If this criterion is not met reanalyze the CCV. If reanalysis of the CCV fails to meet the criterion, perform maintenance and/or prepare a new calibration standard and reanalyze the continuing calibration. If instrument maintenance and new standards fail to correct the problem, analyze a new initial calibration.
- 8.6 Sample analysis may begin once the analytical system has meet BFB and initial or continuing calibration acceptance criteria.

9.0 Procedure:

- 9.1 Canister Preparation (see SOP ENT089, for canister cleaning procedures):
 - 9.1.1 All sample canisters used for low level TO-15 analysis are cleaned to at least 0.2 ppbv and tagged as TO-15 clean. Cleanliness is verified through the GC/MS analysis of the cleaned canister.
 - 9.1.2 All sample canisters undergo a 24 hour leak check in which the pressure should not vary more than 13.8 kPa (± 2 psig or 103mmHg) over the 24 hour period. The canister leak check information is recorded in the Canister Leak Check binder.
 - 9.1.3 All sample canisters are stored pressurized after they have been determined to be leak free and at the appropriate cleanliness level. Before being provided to the customer for sample collection, the canisters are evacuated to less than 50mtorr and the temperature and pressure are recorded on the Tank Pressurization Form.
- 9.2 Sample Preparation:
 - 9.2.1 The pressure of each canister is checked prior to analysis using a pressure gauge and the reading is recorded in mmHg.
 - 9.2.2 Check the OAF for the analyses required to determine the appropriate gas for pressurizing the canisters.
 - 9.2.3 Check the requested MDL to determine the level of pressurization needed to minimize tank dilution values. If the canister pressure is below atmospheric pressure, pressurize the canister using zero air, unless fixed gas analysis is also required for that canister.

- 9.2.4 Document the type of gas used to pressurize the canister as well and the final pressure in mmHg. (Canisters are usually pressurized to approximately 700 mmHg).

NOTE: For samples requiring analysis for both Method TO-15 and ASTM D-1946, pressurize the canisters with helium only.

- 9.2.5 The Entech concentrator is equipped with a vacuum pump that will allow samples received at ambient pressure to be analyzed without additional pressurization.
- 9.2.6 Pressurizing the canister introduces an additional dilution factor increasing the minimum detection limit (MDL).
- 9.2.7 Initial and final canister pressures, temperature and Pbar are recorded on Tank Pressurization forms in addition to client name, project number, client sample ID, canister number, analysts initials and the date.

9.3 Sample Analysis:

- 9.3.1 Samples are analyzed in the same manner as calibration standards. If the sample is to be analyzed with no instrument dilution factor a 500-mL aliquot of the sample is analyzed. If the sample is expected to be high level, then a smaller sample volume may be analyzed. See section 8.2.2 for an explanation of instrument dilutions.
- 9.3.2 The internal standard area responses for each sample analysis shall not differ by more than $\pm 40\%$ from of the average area responses of the most recent initial calibration.
- 9.3.3 The internal standard retention times shall not vary by more than 20 seconds from the retention times of the internal standard in the continuing calibration standard.
- 9.3.4 The sample may need to be reanalyzed to confirm matrix interference, if the internal standard criteria in sections 9.3.2 or 9.3.3 are not met. Failure to meet internal standard criteria shall be addressed in the data report narrative.
- 9.3.5 The concentration of target compounds in the sample analysis shall fall within the established instrument calibration range. If any target compound concentration exceeds the calibration range, the sample should be diluted and reanalyzed.
- 9.3.5.1 When more than one compound concentration exceeds the instrument's calibration range, dilute the sample based on the highest compound concentration. If any of the compound concentrations saturated the instrument's detector, additional dilutions may be required.
- 9.3.5.2 Dilute the sample in the same manner described in section 8.2.2, until the highest concentrated target compound falls within the instrument's calibration range. Sample volumes of less than 10mL should not be performed using the mass flow controller.

- 9.3.5.3 If a sample volume less than 10 mL is required to bring compounds into the instrument's calibrated range, a loop load approach (0.5mL to 10mL) or a syringe dilution combined with a loop-load may be used. See Table 5 for dilutions analyzed using loop-loads and/or syringe dilution plus loop-loads.
- 9.3.5.3.1 An aliquot of sample may be analyzed using a multi-port valve equipped with nitrogen flow and a loop.
- 9.3.5.3.2 When the valve is in the load position sample is purged through the loop to vent.
- 9.3.5.3.3 When the valve is in the inject position the nitrogen gas flushes the loop, transferring the diluted sample to the Entech preconcentrator trap.
- 9.3.5.3.4 Documentation of loop-loads and syringe dilutions should be recorded in the instrument run log as well as in the sample header information in the miscellaneous / comments field for the diluted sample(s).
- 9.4 Affix the printed analytical sequence tables to the instrument logbook pages. Record all information associated with instrument calibration and sample analysis on the instrument log book pages.
- 9.5 Record instrument maintenance in the instrument's maintenance logbook.
- 9.6 Interferences:
- 9.6.1 Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, all other sampling equipment (e.g., pump and flow controllers) should be thoroughly cleaned to ensure that the filling apparatus will not contaminate samples.
- 9.6.2 Very volatile compounds, such as chloromethane and vinyl chloride can display peak broadening and co-elution with other species if the compounds are not delivered to the GC column in a small volume of carrier gas. Refocusing of the sample after collection on the primary trap, either on a separate focusing trap or at the head of the gas chromatographic column mitigates this problem.
- 9.6.3 Interferences in canister samples may result from improper use or from contamination of: (1) the canisters due to poor manufacturing practices, (2) the canister cleaning apparatus, and (3) the sampling or analytical system. Attention to the following details will help to minimize the possibility of contamination of canisters.
- 9.6.3.1 Canisters should be manufactured using high quality welding and cleaning techniques, and new canisters should be filled with humidified zero air or nitrogen and then analyzed, after "aging" for 24 hours, to determine cleanliness. The cleaning apparatus, sampling system, and analytical system should be assembled of clean, high

quality components and each system should be shown to be free of contamination.

- 9.6.3.2 Canisters should be stored in a contaminant-free location and should be capped tightly during shipment to prevent leakage and minimize any compromise of the sample.
- 9.6.4 Impurities in the calibration dilution gas (if applicable) and carrier gas, organic compounds out-gassing from the system components ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. The analytical system shall be demonstrated to be free from contamination under the conditions of the analysis by running humidified zero air or nitrogen blanks. The use of non-chromatographic grade stainless steel tubing, non-PTFE thread sealants, or flow controllers with Buna-N rubber components shall be avoided.
- 9.6.5 Significant contamination of the analytical equipment can occur whenever samples containing high VOC concentrations are analyzed. This in turn can result in carryover contamination in subsequent analyses. Whenever a high concentration sample is encountered, if possible, it should be followed by an analysis of humid zero air or nitrogen blank to check for carryover contamination. Otherwise, closely examine the sample analysis following the high concentration sample for the presence of carryover. If carryover is suspected, reanalyze the affected sample.
- 9.6.6 In cases when solid sorbents are used to concentrate the sample prior to analysis, the sorbents should be tested to identify artifact formation.

10.0 Quality Control:

10.1 System blank:

- 10.1.1 Prior to sample analysis, a nitrogen system blank may be analyzed to verify that the GCMS system is clean.
- 10.1.2 The system blank should not contain any target compounds at concentrations greater than 3 times the MDL value.

10.2 Method blank:

- 10.2.1 The method blank is a humidified zero air or nitrogen canister analyzed once per 24 hour analytical clock, prior to sample analysis but after an acceptable initial or continuing calibration. Prepare the method blank in a clean canister only used for method blank analysis.
- 10.2.2 The method blank shall not contain target compounds at concentrations greater than 3 times the MDL.
- 10.2.3 The internal standard response and retention time criteria in sections 9.3.2 and 9.3.3 shall be met.

10.3 Laboratory Control Sample (LCS):

- 10.3.1 The LCS is an analysis of the ICV or a second preparation of the initial calibration standard analyzed at a concentration that falls within the range of the initial calibration. Analyze an LCS during each 24-hour analytical clock.
- 10.3.2 The results of the LCS should be within 30% of the tag value, with 3 exceptions within 50% of the tag value.
- 10.3.3 If the LCS fails, reanalyze or reprepare and analyze. If the LCS continues to fail, check the system for problems and restart the sequence.

10.4 Laboratory Duplicate:

- 10.4.1 Analyze one field sample in duplicate per 24 hour analytical clock. A project specific duplicate may be requested by the client.
- 10.4.2 The results of the duplicate analysis should be within 25% of the results of the original sample analysis.
- 10.4.3 In the event there is insufficient sample available for the analysis of a lab duplicate, the LCS should be analyzed in duplicate to fulfill the LD requirements.
- 10.4.4 In the instance no LD is analyzed with the batch sequence a notation should be made in the logbook indicating the reason a duplicate analysis was not performed.

11.0 Data Analysis and Calculations:

- 11.1 Report one result for each analyte, unless otherwise directed by the client. Report the results from the undiluted (or least diluted) analysis that brings the highest concentrated target compound within the calibration range. Report all other target analytes from the undiluted (or least diluted) analysis. Only target compounds that exceed the calibration range in the undiluted (or least diluted) analysis are reported from the diluted analysis.
- 11.2 Calculate the response factor (RF) for each compound in the calibration using the following equation:

$$RF = \frac{Area_c}{Amt_c} \times \frac{Amt_{IS}}{Area_{IS}}$$

Where:

Area_c = Area of compound

Amt_c = Amount of compound in ppbv

Amt_{IS} = Amount of Internal Standard in ppbv

Area_{IS} = Area of Internal Standard (IS)

- 11.3 The instrument software is capable of tabulating each calibrated compound's response factor at each standard concentration. The software then calculates the average RF and percent relative standard deviation (%RSD). The following equation is used to calculate the % RSD:

$$\%RSD = 100 \left(\frac{SD}{RF} \right)$$

Where:

SD = Standard deviation

\overline{RF} = average response factor

- 11.4 Calculate the %D between the average RF from the initial calibration and the corresponding RF from the continuing calibration using the following calculation:

$$\% D = \left(\frac{RF_{AVG} - RF_{concal}}{RF_{AVG}} \right) \times 100$$

Where:

RF_{AVG} = Average RF from initial calibration

RF_{concal} = RF from continuing calibration

- 11.5 If the canister is pressurized prior to analysis, a tank dilution factor is calculated and included in the calculation for "as sampled" analyte concentrations. The following formula is used to calculate tank dilution factors:

$$\text{Tank Dilution} = \frac{\frac{GPF + PbarF}{TempF + 460}}{\frac{GPI + PbarI}{TempI + 460} - \frac{GPP + PbarP}{TempP + 460}}$$

Where:

GPF = Final Gauge Pressure, mmHg

PbarF = Final Barometric Pressure, mmHg

TempF = Final Temperature, degrees F

GPI = Initial Gauge Pressure, mmHg

PbarI = Initial Barometric Pressure, mmHg

TempI = Initial Temperature, degrees F

GPP = Pretest Gauge Pressure, mmHg

PbarP = Pretest Barometric Pressure, mmHg

TempP = Pretest Temperature, degrees F

- 11.6 "As analyzed" concentrations for detected target compounds are calculated using the following equation:

$$\text{Conc. (ppbv)} = \left(\frac{A_A \times IS_C}{A_{IS} \times \overline{RF}} \right)$$

Where:

A_A = Area of the quantitation ion of target analyte

IS_C = Internal standard concentration

A_{IS} = Area of the quantitation ion of the internal standard

\overline{RF} = Average Response Factor from initial calibration

- 11.7 "As Sampled" concentrations are calculated for detected target compounds. If the canister was not pressurized prior to analysis and the sample was not diluted at the instrument, the "As Analyzed" (as calculated in section 11.5) and "As Sampled" concentrations will be the same. If the canister was pressurized prior to analysis or

there was an analytical dilution, the “As Sampled” concentration is calculated as follows:

Conc. “As Sampled” = (Conc. as analyzed) x (Tank Dilution Factor) x (Analytical Dilution Factor)

11.8 Calculate the percent difference (%D) for the Laboratory Duplicate Sample as follows:

$$\%D = \frac{Conc_O - Conc_D}{Avg(Conc_O, Conc_D)} \times 100$$

Where:

Conc_O = original concentration

Conc_D = duplicate concentration

12.0 Method Performance:

Method performance is demonstrated through MDL studies and demonstrations of capability performed by the analyst. Follow procedures detailed in SOP ENT027, for determining MDL values. Follow the procedures detailed in SOP ENT005, for performing demonstrations of capability.

13.0 Pollution Prevention and Waste Management:

Sample canisters are purged and vented into a laboratory fume hood. Refer to SOP ENT023, for waste disposal procedures.

14.0 References:

EPA Compendium Method TO-15, “Determination of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry”, January 1999

15.0 Tables, Diagrams, and Flow Charts:

15.1 Table 1: TO-15 Target Compound List

15.2 Table 2: Example Gas Phase Standards Preparation

15.3 Table 3: Instrument Performance Check criteria

15.4 Table 4: General GC/MS Operating Conditions

15.5 Table 5: Example Loop-load and Syringe Dilution Preparations

Revision History:			
Revision#	Date:	Author:	Comments:
8.0	10/22/19	T. Denese Daniels	Updated definitions, Changed standard expiration date, minor changes to wording for clarity.
7.0	1/30/18	T. Denese Daniels	????
6.0	4/19/17	T. Denese Daniels	Updated definitions; added reference to waste SOP in response to CAF-2016-LDEQ-DEF01b; changed standards prep procedure & added example; added info for loop load dilutions
5.0	8/23/2012	T. Denese Daniels	Periodic review and update
4.0	4/16/2009	Denese Adcock	
3.0	5/07/2007	Ann Morris	

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2.0	3/24/2007	Michael Steven Schapira	
1.0	12/05/2006	L. Goll & D. Adcock	
Original	1/27/1998	Denese Adcock	

TABLE 1: TO-15 Target Compound List:

Compound Name	Quantitation Ion	CAS Number
Propylene	41	115-07-1
Freon 12 (dichlorodifluoromethane)	85	75-71-8
Freon 114 (1,2-dichloro-1,1,2,2-tetrafluoroethane)	85	76-14-2
Chloromethane (methyl chloride)	50	74-87-3
Chloroethene (chloroethylene, vinyl chloride)	62	75-01-4
1,3-Butadiene	39	106-99-0
Bromomethane (methyl bromide)	94	74-83-9
Chloroethane (ethyl chloride)	64	75-00-3
Bromoethene (Vinyl Bromide)	106	593-60-2
Freon 11 (trichlorofluoromethane)	101	75-69-4
Ethanol	45	64-17-5
Acrolein	56	107-02-8
Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane)	151	76-13-1
1,1-Dichloroethene (vinylidene chloride)	61	75-35-4
Acetone	43	67-64-1
Carbon disulfide	76	75-15-0
Isopropyl alcohol	45	67-63-0
Allyl chloride	76	107-05-1
Acetonitrile	41	75-05-8
Methylene chloride (dichloromethane)	49	75-09-2
trans-1, 2-Dichloroethene	61	156-60-5
Methyl tert-butyl ether (MTBE)	73	1634-04-4
Acrylonitrile	53	107-13-1
n-Hexane	57	110-54-3
1,1-Dichloroethane (ethylidene chloride)	63	74-34-3
Vinyl acetate	43	108-05-4
cis-1,2-Dichloroethylene	61	156-59-2
Methyl ethyl ketone (2-Butanone)	72	78-93-3
Ethyl acetate	45	141-78-6
Chloroform (trichloromethane)	83	67-66-3
Tetrahydrofuran	72	109-99-9
1,1,1-Trichloroethane (methylchloroform)	97	71-55-6
Cyclohexane	56	110-82-7
Carbon tetrachloride (tetrachloromethane)	117	56-23-5
Benzene (cyclohexatriene)	78	71-43-2
2,2,4-Trimethylpentane (Iso-octane)	57	540-84-1
1,2-Dichloroethane (ethylene dichloride)	62	107-06-2
n-Heptane	57	142-82-5
Trichloroethene (trichloroethylene)	130	79-01-6
1,2-Dichloropropane (propylene dichloride)	63	78-87-5
Methyl methacrylate	69	80-62-6

TABLE 1: TO-15 Target Compound List:

Compound Name	Quantitation Ion	CAS Number
1,4-Dioxane	88	123-91-1
Bromodichloromethane	83	75-27-4
cis-1,3-Dichloropropene (cis-1,3-dichloropropylene)	75	542-75-6
Methyl isobutyl ketone	43	108-10-1
Toluene (methyl benzene)	91	108-88-3
trans-1,3-Dichloropropene (trans-1,3-dichloropropylene)	75	542-75-6
1,1,2-Trichloroethane (vinyl trichloride)	97	79-00-5
Tetrachloroethene(perchloroethylene, tetrachloroethylene)	166	127-18-4
2-Hexanone (Methyl butyl ketone)	43	591-78-6
Dibromochloromethane	129	124-48-1
1,2-Dibromoethane (ethylene dibromide)	107	106-93-4
Chlorobenzene (phenyl chloride)	112	108-90-7
Ethylbenzene	91	100-41-4
1,1,1,2-Tetrachloroethane	131	630-20-6
m-/p-Xylene (1, 3&1, 4-dimethylbenzene)	91	108-38-3 / 106-42-3
o-Xylene (1,2-dimethylbenzene)	91	95-47-6
Styrene (vinyl benzene)	104	100-42-5
Bromoform	173	75-25-2
1,1,2,2-Tetrachloroethane	83	79-34-5
4-Ethyltoluene	105	622-96-8
2-Chlorotoluene	91	95-49-8
1,3,5-Trimethylbenzene (mesitylene)	105	108-67-8
1,2,4-Trimethylbenzene (pseudocumene)	105	95-63-6
1,3-Dichlorobenzene (m-dichlorobenzene)	146	541-73-1
1,4-Dichlorobenzene (p-dichlorobenzene)	146	106-46-7
Benzyl chloride	91	100-44-7
1,2-Dichlorobenzene (o-dichlorobenzene)	146	95-50-1
1,2,4-Trichlorobenzene	180	120-82-1
Hexachlorobutadiene (1,1,2,3,4,4-hexachloro-1, 3-butadiene)	225	87-68-3
Naphthalene	128	91-20-3
Internal Standards		
Bromochloromethane	130	17060-07-0
1,4-Difluorobenzene	114	460-00-4
Chlorobenzene-d5	117	2037-26-5

TABLE 2 – GAS PHASE STANDARDS PREP

Cyl. ID / Exp Date:	Spectra-65 TO-15 FF-22030 Exp 10/17/18	
Cyl. ID / Exp Date:	Spectra-16 TO-15 CC133334 Exp 6/15/18	
Std Conc.:	20ppbv TO15 (Primary)	
Logbook ID:	GCMSPrepPg378	
Can #(s):	24090	
Prep Date:	1/3/2018	
Exp Date:	2/2/2018	
Prep Chemist:	AJP	
DI H2O Added (uL)	75	
Cylinder #	FF-22030	CC13334
mL	400	400
ppmv	1.00	1.00
Bar (in. Hg)	29.85	29.85
Temp. (F)	73.5	73.5
Total Moles	1.64E-08	1.64E-08
vol (DSL)	19.7	19.7
Vol.	6.00	6.00
Bar (in. Hg)	29.85	29.85
Gauge Press (mmHg)	1,769	1,769
Temp. (F)	73.5	73.5
Total Moles	0.821	0.821
Tank Press (in. Hg)	99	99
Conc. (PPM)	0.02000	0.02000
Conc. (PPB)	20.00	20.00

TABLE 3- TUNE ACCEPTANCE CRITERIA	
MASS	TO-15 Ion Abundance Criteria
50	8 to 40% of mass 95
75	30 to 66% of mass 95
95	Base Peak, 100% Relative Abundance All ion abundances shall be normalized to the 95 mass
96	5 to 9% of mass 95
173	<2% of mass 174
174	50% to 120% of mass 95
175	4 to 9% of mass 174
176	93% to 101% of mass 174
177	5 to 9% of mass 176

TABLE 4. GENERAL GC/MS OPERATING CONDITIONS		
Chromatography	Column	Rxi-624 (60m x 0.32-mm x 1.8 μm film thickness)
	Carrier Gas	5.0 grade Helium (1.5 mL/min at constant pressure)
Temperature Program	Initial Column Temperature	30°C
	Initial Hold Time	3 minutes
		5.0°C/minute to 75°C, hold for 0.0 min; 15.0°C/minute to 120°C, hold for 2.0 min; 70.0°C/minute to 240°C, hold for 8.0 min.
	Program	
	Final Hold Time	5.00 minutes (may be extended)
Mass Spectrometer	Mass Range	29 to 300 AMU
	Scan Time	5.26 scans/second
	EI Condition	70eV
	Mass Scan	EI full scan
Entech 7100 Conditions	Cold trap dehydration method or equivalent	
The GC/MS operating conditions presented in the Table 3 are an example. Actual instruments conditions may vary as the instrument is optimized.		

Table 5 – non-MFC Dilutions (Undiluted Run = 500mL)

Dilution Factor	Loop-Loads
*50	10mL load
*10	5mL load
*250	2mL load
*500	1mL load
*1000	0.5mL loop load
Dilution Factor	Syringe Prep
*2 syr dil	25mLs sample + 25mLs N2
*5syr dil	10mLs sample + 40mLs N2
*10 syr dil	5mLs sample + 45mLs N2
*20 syr dil	25mLs (10*syr) + 25mLs N2
*50 syr dil	10mLs (10*syr) + 40mLs N2
*100 syr dil	5mLs (10*syr) + 45mLs N2
*200 syr dil	25mLs (100*syr) + 25mLs N2
*500 syr dil	10mLs (100*syr) + 40mLs N2
*1000 syr dil	5mLs (100*syr) + 45mLs N2
*2000 syr dil	25mLs (1000*syr) + 25mLs N2
Dilution Factor	Loop Load/Syringe Dilution Prep
5,000	0.5mL loop load of 5 syr dil
10,000	0.5mL loop load of 10 syr dil
20,000	0.5mL loop load of 20 syr dil
50,000	0.5mL loop load of 50 syr dil
100,000	0.5mL loop load of 100 syr dil
1,000,000	0.5mL loop load of 1000 syr dil
2,000,000	0.5mL loop load of 2000 syr dil

Manufacturer's Specification Sheets – PID Analyzers and Meteorological Sensor

WX Series

LAND APPLICATIONS

WX Ultrasonic WeatherStation® Instruments for Land Applications

Delivering a Compact, Affordable Instrument
for Informed Decision-Making

Available Models: 110WX, 150WX, 200WX

Whether you are harvesting crops, operating equipment, preparing for bad weather or responding to a hazardous event; understanding the weather is important. The WX Series allows users to make informed decisions based on site specific information, resulting in improved efficiency, reduced risks and overall cost savings. Various model options are available depending on the application and requirements.

The WX Series WeatherStation Instruments offer a truly best-in-class solution at a better price point compared to any other weather monitoring system on the market today!



FEATURES

- Model 110WX – Measures apparent wind speed and angle, barometric pressure, air temperature, relative humidity, calculated dew point, heat index and wind chill temperature
- Models 150WX and 200WX – Includes all 110WX functionality plus internal compass and GPS (for true wind speed and direction), GPS position, speed over ground, course over ground
- Model 200WX – Best-in-class dynamic stabilization via three-axis compass and three-axis rate gyro
- UV stabilized, compact housing is fully waterproof and resistant to chemicals and sunlight

Product Models to Satisfy Multiple Weather Needs



Now available on iTunes — OnSiteWX
The innovative App for real-time weather data!



110WX



150WX



200WX

	Apparent Wind Model	Apparent & True Wind Models	
	Recommended for Stationary Applications	Recommended for Moving Vehicle Applications	Recommended for Dynamic Moving Vehicle Applications
Apparent wind speed and angle	✓	✓	✓
True wind speed and direction		✓	✓
Barometric Pressure	✓	✓	✓
Ultrasonic wind readings up to 90 mph (78 knots, 40 m/s)	✓	✓	✓
Air temperature plus calculated wind chill	✓	✓	✓
		✓	✓
10 Hz GPS (Position, COG, SOG)		✓	✓
Two-axis solid state compass		✓	
Three-axis accelerometer for pitch and roll		✓	✓
Three-axis solid-state compass with dynamic stabilization: Better than 1° static compass accuracy Best-in-class 2° dynamic compass accuracy			✓
Three-axis rate gyros provide rate-of-turn data			✓
Best-in-class pitch and roll accuracy			✓
Optional field-serviceable relative humidity Calculated dew point Calculated heat index	✓	✓	✓
Output options include: NMEA 0183 (RS422) and NMEA2000® (CAN Bus) NMEA 0183 (RS232) and NMEA2000® (CAN Bus)	✓	✓	✓

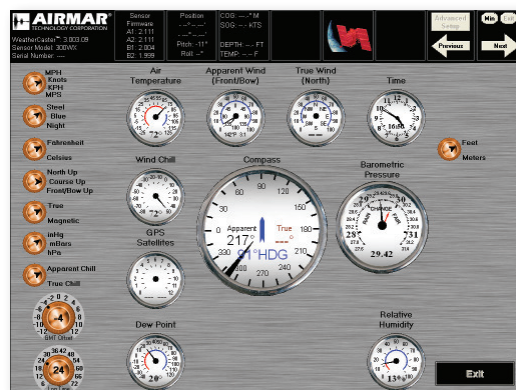
WeatherCaster™ Software

Developer Assistance

- Enable/disable functionality
- Optimize communications bandwidth NMEA 0183 (RS232, RS422)
- Change sampling rate (output interval)

Field Installation Assistance

- Enable/disable functionality
- Sensor orientation
- Compass calibration
- Temperature offset
- Select specific device on a NMEA2000® network
- Alarms for wind speed and barometric pressure
- Altitude offset
- More accurate GPS position in 2D mode
- More accurate BP reading



Achieving Best-in-Class Product Specifications

SPECIFICATIONS

Wind Speed Range:

— 0 knots to 78 knots (0 MPH to 90 MPH, 0 m/s to 40 m/s)

Wind Speed Resolution:

— 0.1 knot (0.1 MPH, 0.1 m/s)

Wind Speed Accuracy @ 0°C to 55°C (32°F to 131°F), no precipitation*:

— Low Wind Speeds:

0-10 knots; 1 knot RMS +10% of reading

(0 MPH to 11.5 MPH; 1.1 MPH + 10% of reading)

(0 m/s to 5 m/s; 0.5 m/s + 10% of reading)

— High Wind Speeds:

10-78 knots; 2 knots RMS or 5%, whichever is greater

(11.5 MPH to 90 MPH; 2.3 MPH or 5%, whichever is greater)

(5 m/s to 40 m/s; 1 m/s or 5%, whichever is greater)

Wind Speed Accuracy in wet conditions**:

— 5 knots RMS (5.7 MPH RMS, 2.5 m/s RMS)

Wind Direction Range: 0° to 360°

Wind Direction Resolution: 0.1°

Wind Direction Accuracy @ 0°C to 55°C (32°F to 131°F), no precipitation*:

— Low Wind Speeds (5° RMS typical):

4-10 knots (4.6 MPH to 11.5 MPH, 2 m/s to 5 m/s)

— High Wind Speeds (2° RMS typical):

>10 knots (>11.5 MPH, >5 m/s)

Wind Direction Accuracy in wet conditions** (8° RMS Typical):

>8 knots (>9.2 MPH, >4 m/s)

Compass Accuracy:

— 1° RMS when level—(150WX only)

— 1° static heading accuracy; 2° dynamic heading accuracy—200WX only

Pitch and Roll Range / Accuracy: ±50° / <1°—150WX & 200WX

Air Temperature Range: -40°C to 55°C (-40°F to 131°F)

Air Temperature Resolution: 0.1°C (0.1°F)

Air Temperature Accuracy:

±1.1°C (±2°F)* @ >4 knots wind (>4.6 MPH wind) (>2 m/s wind)

Barometric Pressure Range:

300 mbar to 1100 mbar (24 inHg to 33 inHg, 800 hPa to 1100 hPa)

Barometric Pressure Resolution: 0.1 mbar (0.029 inHg, 0.1 hPa)

Barometric Pressure Accuracy:

±1 mbar (±0.029 inHg, ±1 hPa) when altitude correction is available

Relative Humidity Range: 10% to 95% RH

Relative Humidity Accuracy*: ±5% units RH

GPS Position Accuracy:

3 m (10') with WAAS/EGNOS (95% of the time)—150WX & 200WX

Operating Temperature Range: -25°C to 55°C (-13°F to 131°F)

Supply Voltage: 9 VDC to 40 VDC

Supply Current (@ 12 VDC):

— (<50 mA) <0.6W —110WX

— (<85 mA) <1.0W —150WX

— (<105 mA) <1.25W —200WX

Weight: 300 grams (0.8 lb)

Communication Interface: NMEA 0183 (RS422 or RS232) and NMEA2000® (CAN bus)***

Mounting Thread Size on Base: 1"-14 UNF or 3/4" NPT

Certifications and Standards:

CE, IPX6 (Relative Humidity/IPX4), RoHS, IEC61000-4-2, IEC60945

IEC60950_1C, IEC60950_22A, EN55022, EN55024, EN15014982

RMS—Root Mean Square

*When the wind speed is less than 2 m/s (4.6 MPH) and/or air temperature is below 0°C (32°F), wind, temperature, and relative humidity readings will be less accurate.

**Wet conditions include moisture, rain, frost, dew, snow, ice and/or sea spray in the wind channel.

***Airmar has made the address claiming modifications to enable compatibility with the ISO 11783 communication protocol for the agriculture industry – that is based on the SAE J1939 protocol.

PART NUMBERS

110WX: 44-820-1-01, RH, NMEA 0183 (RS422) and NMEA2000® (CAN Bus)

110WX: 44-823-1-01, NMEA 0183 (RS422) and NMEA2000® (CAN Bus)

110WX: 44-843-1-01, RH, NMEA 0183 (RS232) and AG (CAN Bus)

150WX: 44-832-1-01, RH, NMEA 0183 (RS422) and NMEA2000® (CAN Bus)

150WX: 44-833-1-01, NMEA 0183 (RS422) and NMEA2000® (CAN Bus)

150WX: 44-834-1-01, RH, NMEA 0183 (RS232) and AG (CAN Bus)

200WX: 44-835-1-01, NMEA 0183 (RS422) and NMEA2000® (CAN Bus)

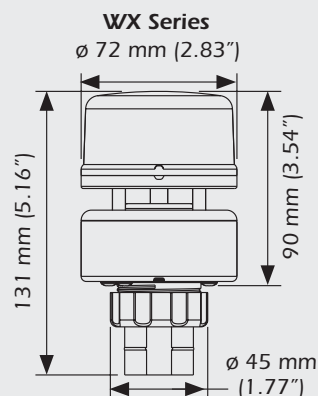
200WX: 44-837-1-01, RH, NMEA 0183 (RS422) and NMEA2000® (CAN Bus)

200WX: 44-847-1-01, NMEA 0183 (RS232) and NMEA2000® (CAN Bus)

* Cables sold separately

RH— Relative Humidity

DIMENSIONS



DATA OUTPUT PROTOCOL

NMEA 0183 Sentence Structure

\$GPD TM..... GPS Datum Reference

\$GPGGA..... GPS Fix Data

\$GPGLL..... Geographic Position—Latitude and Longitude

\$GPGSA..... GNSS DOP and Active Satellite

\$GPGSV..... Satellites in View

\$GPRMC..... Recommended Minimum GNSS

\$GPVTG..... COG and SOG

\$GPZDA..... Time and Date

\$HCHDG..... Heading, Deviation, and Variation

\$HCHDT..... True Heading

\$HCTHS..... True Heading and Status

\$TIROT..... Rate of Turn

\$WIMDA..... Meteorological Composite

\$WIMWD..... Wind Direction and Speed

\$WIMWV..... Wind Speed and Angle

\$WIMWR..... Relative Wind Direction and Speed

\$WIMWT..... True Wind Direction and Speed

\$YXXDR..... Transducer Measurements

NMEA2000® Output Message Structure

59392..... ISO Acknowledgement

060928..... ISO Address Claim

126208..... Acknowledge Group Function

126464..... PGN List

126992..... System Time

126996..... Product Information

126998..... Configuration Information

127250..... Vessel Heading

127251..... Rate of Turn

127257..... Attitude

127258..... Magnetic Variation

129025..... Position and Rapid Update

129026..... COG and SOG, Rapid Update

129029..... GNSS Position Data

129033..... Time and Date

129044..... Datum

129538..... GNSS Control Status

129539..... GNSS DOPs

129540..... GNSS Sats in View

130306..... Wind Data

130310..... Environmental Parameters

130311..... Environmental Parameters

130312..... Temperature

130313..... Humidity

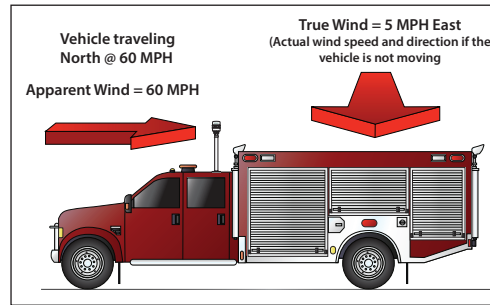
130314..... Actual Pressure

130323..... Meteorological Station Data

Understanding True and Apparent Wind

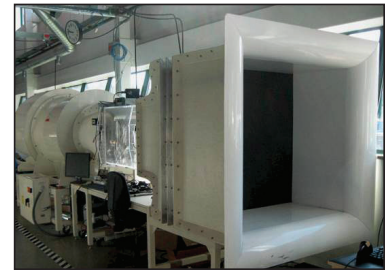
Virtually all mechanical and ultrasonic anemometers report apparent wind speed and direction. The Airmar WX Series is unique because it calculates both true and apparent wind speed and direction. These wind readings are the same if the unit is mounted in a fixed location. However, if the WX Series is mounted on a moving vehicle, the apparent wind is the wind you would feel on your hand if you held it out the window while going down the highway. Since the WX Series has a built in GPS and compass, it calculates the true wind based upon the apparent wind, speed of the vehicle, and compass heading.

True wind information is significant for numerous applications on hazardous response vehicles. True wind speed and direction is also mission-critical. When en route to an emergency situation, first responders can use the true wind readings to predict wind conditions at the disaster site before they even arrive, giving vital information for planning operations and staging apparatus.

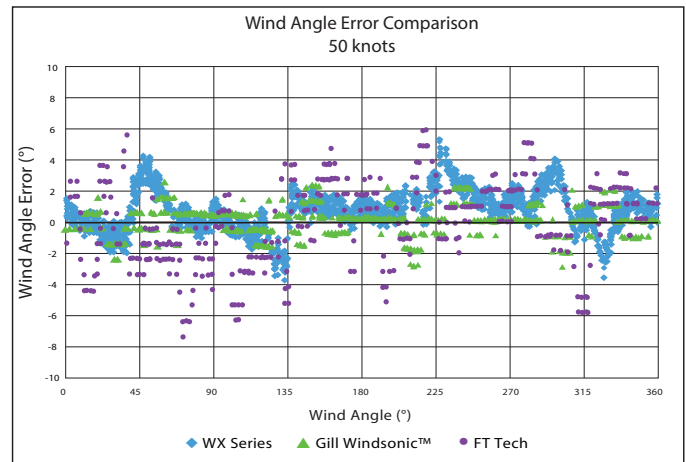
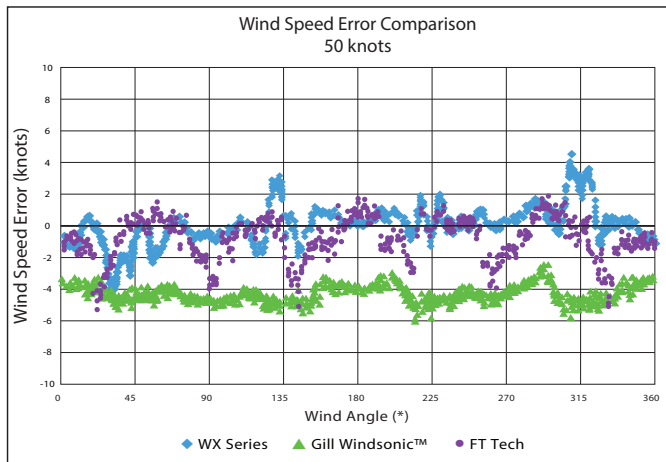


Airmar's WX Series products are the only all-in-one unit to offer true and apparent wind speeds without additional sensors.

Each WeatherStation Instrument is factory calibrated in a wind tunnel at our state-of-the-art facility located in Milford, New Hampshire, USA.



Performing Above and Beyond Competitive Products on the Market



www.airmar.com



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WX_Series_LAND_APP_RA 09/21/15

wind



Model 91000

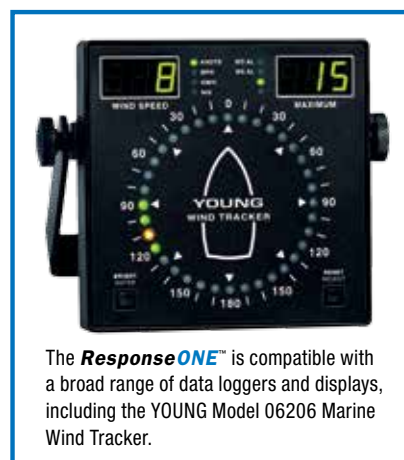
*Response***ONE**[™] Ultrasonic Anemometer

The YOUNG *ResponseONE™* Ultrasonic Anemometer is designed to reliably measure wind speed and direction. The *ResponseONE™* is wind tunnel calibrated and will accurately measure wind speeds up to 70 m/s (156 mph). The high sampling rate of the Model 91000 provides for fast response to changing wind conditions and wind data may be updated as fast as 10 times per second. An easy-to-use Windows setup program is provided with each sensor. The program allows the user to customize device settings such as sampling rates and communication parameters.

The compact IP-66 rated design features durable, corrosion-resistant construction. A variety of useful standard serial output formats are provided including SDI-12, NMEA, and ASCII text. The sensor installs on readily available 1 inch (IPS) pipe and wiring connections are made in a convenient weather-proof junction box. Special connectors and cables are not required. The Model 91000 is available in black or white.

Specifications

Wind Speed	Range:	0 – 70 m/s (156 mph)
	Resolution:	0.01 m/s
	Starting Threshold:	<0.01 m/s
	Accuracy:	±2% or 0.3 m/s (0 – 30 m/s) ±3% (30 – 70 m/s)
	Response Time:	<0.25 seconds
Wind Direction	Azimuth Range:	0 - 360 degrees
	Resolution:	0.1 degree
	Starting Threshold:	<0.01 m/s
	Accuracy:	±2 degrees
Electronic Compass	Range:	0 – 360 degrees
	Resolution:	1 degree
	Accuracy:	± 2.0 degrees
Serial Output (selectable)	Interface:	RS-232, RS-485/422, SDI-12
	Formats:	NMEA, SDI-12, ASCII (polled or continuous)
	Baud Rates:	1200, 4800, 9600, 19200 and 38400
	Wind Units:	m/s, knots, mph, kmph
	Output Update Rate:	0.1 to 10 HZ
Power	Voltage:	10 – 30 VDC
	Current:	7 mA @ 12 VDC typical, 80 mA max
General	Protection Class:	IP66
	EMC Compliance:	FCC Class A digital device, IEC Standard 61326-1
	Dimensions:	22.0 cm high x 13.5 cm wide
	Weight:	0.5 kg (1.1 lb)
	Shipping Weight:	1.4 kg (3.1 lb)
	Operating Temperature:	-40 to +60 °C
	Removable Bird Spikes:	Included



The *ResponseONE™* is compatible with a broad range of data loggers and displays, including the YOUNG Model 06206 Marine Wind Tracker.

CE Complies with applicable CE directives.

Ordering Information

MODEL

ResponseONE™ Ultrasonic Anemometer – White **91000**

ResponseONE™ Ultrasonic Anemometer – Black..... **91000B**



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E-mail: met.sales@youngusa.com
Web Site: www.youngusa.com

SENSIT[®] SPOD

VOC EMISSIONS AND AIR POLLUTANT MONITORING SYSTEM



SENSIT[®] SPOD sensors help detect, locate and continuously monitor air pollutant sources.

MADE IN THE USA
WITH GLOBALLY SOURCED COMPONENTS



Innovative Detection Solutions

www.gasleaksensors.com

SENSIT[®] SPOD

A remote air quality monitoring platform and pollution data management system

The SENSIT[®] SPOD is a low-cost, solar-powered sensor system that combines wind and air pollutant concentration measurements to detect VOC emission plumes and help locate the source of emissions.

With a small footprint, the user-friendly SENSIT[®] SPOD is designed for near-fenceline applications where localized emissions may be present. This Next Generation Air Measurement (NGAM) sensor offers real-time continuous monitoring and direct-reading, without laboratory analysis at a lower cost than traditional methods.

The SENSIT[®] SPOD features solar charging and global cellular integration for remote operation.



SENSIT[®] SPOD includes an Ultrasonic weather station for wind speed, direction, temperature, humidity, and pressure.

Standard Features

- Real-time Continuous Monitoring
- Modular Data Transmission
- Cellular (4G IoT default)
- Local RF (Optional)
- Total VOC Output: (Variable range)
- Auxiliary Port for Automated Sampling
- Solar Compatible with Integrated Battery Backup

Applications

- Fenceline emissions monitoring
- Large-scale outdoor air monitoring
- Community stations



Accessories

- 4 Port Canister Valve Controller
- Canister Pressure Monitors
- 4 Port Sorption Tube Sampler

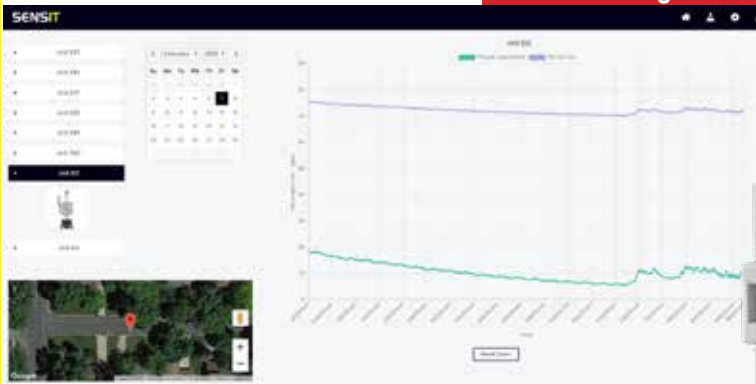
PRODUCT SPECIFICATIONS

Weight	Base unit:
Dimensions	6x8x16" (Fully assembled with anemometer and antenna)
Mounting	Attached mounting flanges
Voltage Requirements	18-24 DC Charging (wired adapter or solar panel)
Current Requirements	2A max current draw when charging
Operating Runtime	2-3 days battery backup
Operating Temp	-20°C to 50°C
Data Outputs	Digital wired output (3.3V TTL - USB) 4G NB-IoT or Cat M1 Wireless SD card data backup

Periodic Maintenance

Periodic cleaning of sensor openings of dust, zero point calibration, and single point span calibration. User replacement of sensors is easily performed as needed.

Data Page



Sampler Page

The screenshot displays the 'Sampler Page' of the SENSIT web interface. It contains several configuration sections: 'Sample Rate' with a dropdown menu, 'Sample Size' with a numeric input field, and 'Trigger Value' with a numeric input field. There are also checkboxes for 'Enable Sampling' and 'Enable Trigger'. The bottom of the page includes a 'Save' button and a 'Cancel' button.

Settings Page

The screenshot displays the 'Settings Page' of the SENSIT web interface. It includes a list of settings on the left, a central satellite map, and a right-hand panel with various configuration fields such as 'Device Name', 'Device ID', 'Device Location', 'Device Type', 'Device Status', and 'Device Settings'. The bottom of the page features a 'Save' button and a 'Cancel' button.





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Valparaiso, IN 46383-8432

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Canary – S

Air Quality Monitoring System

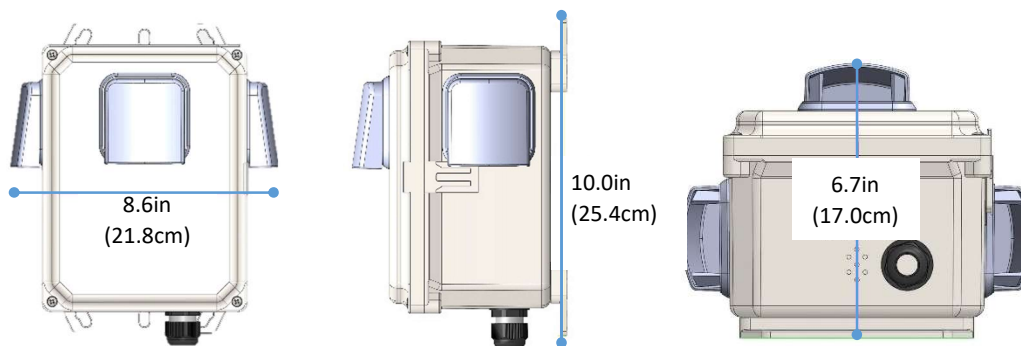


Gen 4 Revised: 12/17/19

I. Introduction

The Canary-S is a continuous solar powered air quality and meteorological monitoring system designed to be class leading in size, reliability, and flexibility. With cellular communication these systems can be placed nearly anywhere to provide measurements on particulate matter, targeted gases, and meteorological data. Multiple units can be deployed to create a network of real-time data integrated into existing customer databases or into Lunar Outpost's platform.

II. Mechanical



A. Physical Properties

See Table 1.

B. Mounting Options

The Canary enclosure allows mounting to either tripods, large diameter poles, or DIN rails.

C. Certifications and Environmental

The Canary enclosure meets the following certifications: UL508A, UL 50, CSA-C22.2 No. 14, NEMA 1,2,3,3R,4,4X,5,6,6P,12,13, UL94V-0 Flame rating, and UL746C-F1 UV and submersion testing. The original enclosure before modification had an IP68 rating. The rating after modification is reduced due to the designed addition of vents for airflow, but the unit maintains protections against inclement weather when mounted correctly. The enclosure is UV-Stabilized Polycarbonate and the units have undergone extensive testing in a variety of outdoor environments to ensure robust functionality. Canary units have an operational temperature range of -20F to 140F (-28.89C to 60C).

Table 1: Physical Properties of air quality monitor

Dimension	Value
Width	8.6 in
Height	10.0 in
Depth	6.7 in
Weight	~4.3 lbs

III. Power

Table 2: Power characteristics of air quality monitor

Battery		Charging	
Chemistry	Lithium-Ion	Solar Panel	12V DC (20W)
Capacity	8000 mAh	Solar Charge Controller	12V DC
Run-time without power input	120 hours* *under proper conditions	Wall Charger	120V AC (US std) input to 12V DC output (24W)

IV. Communication and Data

Canary-S units communicate over commercial cellular bands and data is transmitted to a secure cloud. From the cloud, the data can be routed to the customer's database or Lunar Outpost's custom database. The connection to the cloud is database agnostic, allowing integration with a variety of commercial or custom databases. Table 3 and 4 outline the cellular data connection specifications of two of the cellular modems used in the Canary units.

A. Cellular Communication

Table 3: 2G/3G Cellular Data Connection Specifications

Network	2G/3G HSPA/GSM	Cellular Modem	Ublox SARA-U260
HSPA Bands	850/1900 MHz	GSM Bands	850/1900 MHz

Table 4: 4G Cellular Data Connection Specifications

Network	4G LTE Cat M1	Cellular Modem	Ublox SARA-R410M
LTE Bands	3, 4, 5, 8, 12, 13, 20, 28	2G/3G Bands	None

B. Data

The Canary-S allows for data integration into the platform of choice and puts data ownership and control in the customer's hands. JSON formatting is used for the data unless otherwise requested by the customer. Micro-SD capability allows for data-backups and redundancy storing up to 7 years of data locally.

- **Integrate to client database:** Canary-S data can be routed to a customer's existing database or routed to multiple databases simultaneously.
- **Lunar Outpost's custom database:** Lunar Outpost's custom database is an effective, user friendly platform that allows customers to view, interact with, analyze, and download data.

V. Sensors

Table 5: Base Unit Sensor Specs

Property	Range	Resolution
PM2.5	0~1000 µg/m ³	1 µg/m ³
PM10	0~1000 µg/m ³	1 µg/m ³
Internal Temperature	-40 to 85 °C (-40 to 185°F)	+/-1.5 °C (2.7 °F)
Internal Humidity	0-100% RH	+/-3%
Atmospheric Pressure	300-1250 hPa (mbar)	+/-1.7 hPa (mbar)

Table 6: Optional Sensor Specs

Property	Range	Max Resolution Limit
Total VOC (tVOC)	0 to 50 ppm	1 ppb
Ozone (O₃)	0 to 20 ppm	15 ppb
NO₂	0 to 20 ppm	15 ppb
CO	0 to 1000 ppm	4 ppb
CO₂	0 to 5% volume	1 ppm
H₂S	0 to 100 ppm	5 ppb
SO₂	0 to 100 ppm	5 ppb
CH₄	0 to 50000 ppm	100 ppm
External Temperature	-40 to 80°C (-40 to 176°F)	+/-0.3 °C (0.54 °F)
External Humidity	0-100% RH	+/-2%
Wind Speed	0-75 m/s (0-168mph)	0.01 m/s
Wind Direction	0-360 deg	+/- 2 deg

For more information: info@lunaroutpost.com

Kahuna Ventures Letter



KAHUNA VENTURES
MIDSTREAM PROJECT EXECUTION

January 13 2020

Chad Schlichtemeier
HES Manager
Occidental Petroleum Corp.
1099 18th Street, Suite 1800
Denver, Colorado 80202

RE: Air Monitoring Procedure and Duration Guideline

Dear Mr. Schlichtemeier:

Occidental Petroleum Corp. (Oxy) has asked Kahuna Ventures (KAHUNA) to recommend sampling procedure and duration guidelines for air monitoring in the vicinity of their operations in Northeastern Colorado. This recommendation will allow for Oxy to best compare air sampling results to the Agency for Toxic Substances and Disease Registry (ATSDR) acute inhalation Minimum Risk Levels (MRL), especially the acute inhalation MRL for benzene. The acute inhalation MRL for benzene is 9 parts per billion (ppb). MRLs are derived when reliable and sufficient data exists to determine an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse, non-cancer health effects over a specified duration of exposure. Acute inhalation MRLs are derived for a 1 to 14-day inhalation exposure duration. Additionally, MRLs are generally based on the most sensitive chemical-induced end point considered to be of relevance to humans and ATSDR uses a conservative approach in determining the specific MRL in order to address any uncertainty related to the population considered to be most sensitive (infants, elderly, nutritionally or immunologically compromised). Therefore, it is my opinion Oxy should collect a 14-day air sample to compare to the acute inhalation MRL for benzene (9 ppb) and best assess potential impacts to surrounding populations.

Sampling should follow the US Environmental Protection Agency (EPA) Method 325A—Volatile Organic Compounds from Fugitive and Area Sources. This Method has been established by the EPA to screen average airborne VOC concentrations at facility property boundaries or monitoring perimeters over an extended period of time. The duration of each sampling period is normally 14 days. This method allows for the collection of volatile organic compounds (VOCs) using passive (diffusive) tube samplers (Supelco Radiello 130 passive badges). This method also requires the collection of local meteorological data (wind speed and direction, temperature, and barometric pressure) in order to effectively determine emission sources and potential impact areas.

In addition, Oxy should continuously monitor the sampling locations for Total Organic Vapors (TOCs). This will provide Oxy the data necessary to evaluate potential high emission periods and design further sampling actions.

Oxy can then use data obtained as screening levels for potential impacts to surrounding populations. In the event that the average airborne benzene concentration exceeds the acute inhalation MRL for benzene (9 ppb), additional sampling should be conducted. This additional sampling may include



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evaluation of the continuous VOC monitoring data in order to collect additional samples related to a specific event, such as initial flowback. I would then recommend a 24-hour air sample be collected during this specific event using a SUMMA canister, to further evaluate potential impacts to surrounding populations.

If anyone has questions regarding this guideline, please contact me. KAHUNA looks forward to working with Oxy on any future projects relating to this guideline.

Sincerely,

Jeffrey Citrone, CIH, CSP
Manager Health & Safety Compliance
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