Gas Well Drilling and Production:

Air Quality Discussion

City Council Work Session III
November 23, 2010

Overview

1. Air Quality Testing
   - Arlington
   - Tests by Others
   - Operator Testing
2. Presentation by Weston Solutions
   - What to Test
   - Testing Options
   - Pros and Cons of Testing Options
3. Questions/Direction

Air Quality Testing: Arlington

1. City reliance on TECQ for air quality testing, monitoring and conformance.
2. Some air quality data exists from tests performed by others.
3. Majority of tests identify emissions over a defined period of time (e.g., 24 hours) and average the levels over that time frame.

Air Quality Testing: Arlington

1. TCEQ tests Arlington wells on an on-call basis and their 2009 VOC study included 1 Arlington site.
   a) Carrizo's UTA Drill Site on UT Arlington's campus.
      Finding: no measured concentrations of the 22 target compounds exceeded TCEQ long-term or short-term screening values.
2. Barnett Shale Energy Education Council's (BSEEC) ambient air quality study included 1 Arlington site.
   a) XTO's Rose Drill Site at 8101 U.S. 287 Highway.
      Finding: harmful levels of benzene and other compounds are not being emitted from natural gas sites in the study area.

Air Quality Testing: Tests by Others

1. Fort Worth, TX – currently performing air quality tests to analyze 50 percent of natural gas facilities.
   Finding: study is ongoing and will likely finish early 2011.
2. Flower Mound, TX – performed air sampling tests in January 2010.
   Finding: concentrations consistent with ambient levels reported in similar urban environments and previously in Flower Mound.
3. Dish, TX – ambient air monitoring analysis at seven locations August 17 to 18, 2009.
   Finding: Many chemicals identified in laboratory results at several locations tested were found to exceed TCEQ's ESL's.

Air Quality Testing: Tests by Others

1. TCEQ – 6 AutoGC monitoring sites in DFW area
   Finding: ongoing monitoring with live data available online.
2. Southwestern PA Marcellus Shale Short-Term Ambient Air Sampling Report – PA DEP
   Finding: even though constituents of natural gas and other associated target compounds were detected, the screening results found during the 5-week study, did not indicate a potential for major air-related health issues associated with the Marcellus Shale natural gas activities.
3. Sublette County Winter Ozone Forecast – WY DEQ
   Finding: high ozone concentrations unusual for a rural environment, especially during winter months. WDEQ issued Health Advisories on February 2 and 3, and operators instituted various temporary measures to reduce activities that generate emissions of air pollutants.

Air Quality Testing: Operator Actions

1. Extended third-party analysis to identify the gas make-up.
2. Evaluate planned production and calculate site emissions.
3. Compare EPA and TCEQ's promulgated regulations to determine permitting requirements.
4. Utilize automated control and monitoring for producing wells.
5. Various operators report that they regularly visit each well, inspect the equipment for leaks or any other problems, and ensure the well site is operating safely.

City of Arlington

Options for Gathering Natural Gas Exploration and Production Emissions Data

23 November 2010

an employee-owned company

Overview of What to Test - Options and Ways to Test

1. **Area Wide Emissions –**
   - **Analytes include organic compounds, formaldehyde, oxides of nitrogen, mercaptans (odor issues).**
   - **Use canisters, gas chromatographs, or open path instrument and collect meteorological data.**

Test Options (Continued)

2. Point Source Emissions-
   - Leaks – FLIR camera, handheld organic analyzers, compile data from required GHG mandatory monitoring.
   - Components –Testing to develop site specific emission factors. Gas handling equipment, test for methane, benzene, and other organics. Engines, compressors, gas fired equipment, test for oxides of nitrogen, carbon monoxide and for formaldehyde.

Test Options (Continued)

3. Site Wide Emissions
   - Test using open path instruments, canisters, gas chromatographs.
   - Same compounds as site wide.
   - Collect wind data also.

Options

1. Area Wide – TCEQ-type approach with ambient air stations.
2. Point Source - Individual component contributions and emission factor calculations. Individual tests of storage tanks, dehydrators, engines, etc.
3. Site Wide - Individual well site or other source contributions.

Area Wide Pros

Conducting stationary long-term monitoring to assess the influence of oil and gas activity on VOC concentrations.

PROS:

- Ambient stations can be set up with gas chromatographs for VOCs, ambient analyzers for oxides of nitrogen (NOx) and carbon monoxide (CO), and canisters for VOCs.
- Meteorological data can identify areas contributing to elevated concentrations.

Area Wide Pros (Continued)

- Auto-GC and ambient monitors perform continuous, near-real-time monitoring.
- The data can be viewed real time on a created website.

Area Wide Cons

- Costly to set up and maintain
- Hard to track specific emissions from individual sites
- Sampling grid is required to adequately monitor

Point Source Pros

- Individual sources can be tested for emissions. Wellhead vents, storage tank vents, open-ended lines, etc. can be tested for organic compound emissions. Analytes would include methane, benzene, mercaptans, and total organics.
- Engines, generators, and other gas-fired equipment can be tested for formaldehyde, CO, and NOx.

Point Source Pros

- Individual emission factors can be developed using representative well sites.
- Storage tank (lb voc/lb condensate) emission factors, well workover and start-up emission factors, and other relevant emission sources can have emission factors developed.

Point Source Cons

- Very costly to test all sites and all emission sources

Site Wide Methods

- TCEQ Approach
- Recent Pennsylvania Department of Environmental Protection study
- Site Wide measurement instruments

Site Wide Methods used by TCEQ

- TCEQ monitoring staff collect emissions measurements downwind of the sources, moving around to stay in the plume where emissions would be most concentrated.
- Use hand-held VOC monitors, gas chromatographic monitors mounted in specialized vehicles, infrared cameras that detect VOC emissions invisible to the naked eye, and instantaneous VOC canisters that take samples that are later analyzed in the laboratory.

TCEQ Approach - Pros

- Allows individual site data
- Mobil approach allows travel to sites during upsets, well workovers, startups, etc.
- Perform investigations with passive infrared cameras to focus additional testing and investigations
- Canister samples have low detection limits for organic compounds

TCEQ Approach - Cons

- Sample is from a single point
- Mobil GC and laboratory costs for canister sampling
- Data is only a snapshot

Recent Example of Site Wide Air Study

Southwestern Pennsylvania Marcellus Shale, Short-Term Ambient Air Sampling Report, 1 November 2010

Conducted in response to the increased number of well sites and concerns about the impact of the Marcellus Shale natural gas drilling activities on air quality.

Scope of Pennsylvania Study

- Started short-term, screening level air quality sampling initiative in the southwest region in April 2010
- Project completed in August 2010
- Conducted morning and late evening to correlate with time of most complaints
- Focused on compressor stations, tanks farms, and frac water impoundment

Scope of Pennsylvania Study

- Surveys of the atmosphere were conducted during a 5-week period using the PA DEP Mobile Analytical Unit (MAU) to measure the concentrations of a target list of pollutants associated with gas drilling.
- The MAU used Gas Chromatography/ Mass Spectrometry (GC/MS) and Open Path Fourier Transform Infrared (OP-FTIR or Open Path) samplers to screen for approximately 48 volatile organic compounds (VOCs) including methane and benzene.

Pennsylvania Sampling Goals

1. Screen for ambient air concentrations of target pollutants near certain Marcellus Shale gas drilling operations
2. Assess potential air quality impact
3. Assess any potential health risks from exposure to ambient concentrations
4. Determine whether the scope of the short-term Marcellus sampling initiative should be expanded

Table 1 - List of Target Compounds and PA DEP Sampling Capability

Target CAS#	Compounds	FTIR	Canister	FLIR Camera
95-63-6	1,2,4-Trimethylbenzene	x	x	
71-43-2	Benzene	x	x	x
75-15-0	Carbon Disulfide	x	x	
74-87-3	Chloromethane	x	x	
630-08-0	Carbon monoxide	x		
74-84-0	Ethane	x		x
100-41-4	Ethylbenzene	x	x	x
50-00-0	Formaldehyde	x		
7647-01-0	Hydrogen Chloride	x		
7783-06-4	Hydrogen Sulfide	x		
74-82-8	Methane	x		x
67-56-1	Methanol	x		x
108-38-3	Xylenes	x		
91-20-3	Naphthalene	x		
106-97-8	n-Butane x	x		
110-54-3	n-Hexane	x	x	x
	Nitrogen oxides	x		
74-98-6	Propane	x		x
100-42-5	Styrene	x	x	
108-88-3	Toluene	x	x	x

Open-path FTIR

- In many applications, remote sensing of gas species presence and concentrations offer advantages over established point-sampling and/or laboratory analysis methods.
- Open-path (OP) Fourier Transform Infrared (FTIR) spectroscopy can be used to detect and quantify a wide range of gases simultaneously; eliminating contamination from tubing or sample handling; and operating continuously, to provide real-time data.
- OP-FTIR spectroscopy is being used increasingly as a method for monitoring key carbonaceous greenhouse and tracer species.

Smith, T.E.L., Wooster, M.J. and Tattaris, M.
King's College London, Environmental Monitoring and Modeling Research Group, Department of Geography.

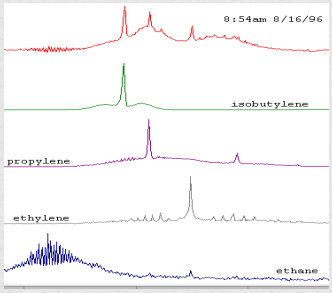
Optical Remote Sensing UV Monitor

UV monitors or FTIR monitors can be used for formaldehyde, benzene, and NOX.

Open Path FTIR

FTIR monitors can be used with and without a reflector.

Compound Identification in a Specific Region



Example Spectra on Top and Calibration Spectra Below

www.fenceline.net

Analysis of FTIR Data Advantages

- The raw spectral data from the FTIR monitors is saved electronically and can be checked later for the presence of other "unknown" or "interfering" chemical compounds
- This means new analytes can be added at a later date and the spectrum re-analyzed

Analysis of FTIR Data Disadvantages

- Weather and wind speed can cause delays
- Limited number of companies equipped to perform work

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Potential Testing Parameters

1. Measurements should be conducted for the following key compounds:
   a) BTEX (benzene, toluene, ethylbenzene, and xylenes)
   b) Formaldehyde (HCHO)
   c) Nitrogen oxides (NOx)
2. Testing should be during different drilling stages.
3. Tests should include all on-site stationary and mobile sources.
4. Tests should clearly and quantitatively distinguish these emissions from upwind fluxes of the measured pollutants, whenever possible.