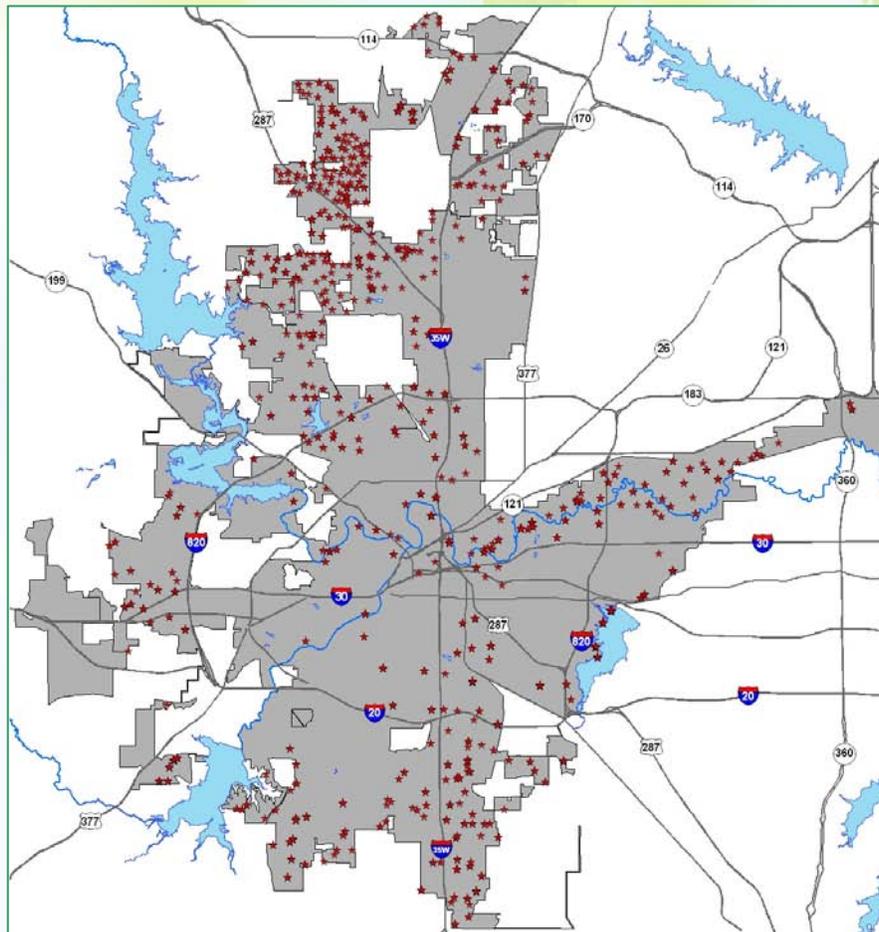


# City of Fort Worth Natural Gas Air Quality Study Revised Final Point Source Test Plan



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## INTRODUCTION

The focus of the Point Source Testing task is to characterize hydrocarbon emissions from natural gas point sources located within the Fort Worth City limits. This characterization will be accomplished through a detailed point source testing plan as explained below. While surveying all 500+ point source locations (wells, well pads, compressor stations, gas processing stations, gas gathering stations, and treatment and disposal facilities) would be desirable, it may not be feasible given time and resource constraints. However, the proposed plan (outlined below) attempts to survey, at a minimum, 75% of the existing point sources. The bulk of this testing will be conducted in the late summer to early fall months when elevated ambient temperatures can be expected.

To accomplish this, we propose to deploy two point source sampling teams, each fully equipped with the necessary sampling instrumentation. Specifically, we will perform the following sub-tasks:

- 1) Survey a minimum 75% of the existing natural gas emission point sources with FLIR infrared (IR) cameras;
- 2) Conduct screening, with a Thermo Environmental TVA 1000B analyzer (TVA), of all camera-detected emissions, and of a subset of minor emission points (those where the camera did not detect any emissions) following the procedures of EPA Method 21<sup>1</sup>;
- 3) Perform on-site emission rate testing of all camera-detected emissions with the Bacharach High-Flow<sup>®</sup> Sampler (HiFlow Sampler), as well as of a subset of the minor emission points detected with the TVA;
- 4) Collect selected samples of emissions for Air Toxic and Methane analysis in evacuated Summa<sup>™</sup> Canisters to determine compound specific emission rates;
- 5) Collect site parameter field data;
- 6) Calculate point source emissions;
- 7) Quality assure equipment and sampling and analytical procedures; and
- 8) Perform all tasks in a safe manner and in accordance with the Point Source Project Safety Plan.

At the conclusion of the field studies, we will prepare draft and final reports to the City summarizing the point source testing results, as well as provide all information used to generate emissions (spreadsheets, video footage, equipment characteristics, etc.).

### 1.0 TASK 1 – NATURAL GAS POINT SOURCE EMISSION INVENTORY

The objective of this sub-task is to survey point source equipment at natural gas facilities and to survey for hydrocarbon emissions during different stages of well development. Specifically, we will use the IR Camera to survey:

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<sup>1</sup> Federal Register. Vol. 65, No. 201. Tuesday, October 17, 2000. Rules and Regulations. Method 21 – Determination of Volatile Organic Compound Leaks. A copy of Method 21 is provided in the Appendix.

- Active well pads including valves, connectors, separators, dehydrators, pneumatic controllers, pressure relief devices, emergency vents, lift compressors, fracture-blowback tanks, pumps, process piping, tank batteries and all other major equipment items located with the boundaries of the each well pad;
- Line Compressor stations including the compressors and all valves, connectors, seal vents, pressure relief devices, storage tanks, separators, process lines, dehydrators, control devices, closed vent systems and all other major equipment items located within the battery limits of each compressor station;
- Processing facilities including all associated valves, connectors, vents, pressure relief devices, separators, dehydrators, fractionation towers, process lines, closed vent systems, storage tanks, control devices and all other major equipment items located with the battery limits of each processing facility;
- Well development activities such as drilling, fracking and completion;
- Active saltwater evaporation facilities including all valves, connectors, vents, pressure relief devices, storage tanks, separators, process lines, and other major equipment items located within each saltwater evaporation facility during times of normal operation. The point source sampling team will communicate with the operator of these facilities to ensure access and that units are operating normally while surveying is in progress;
- Water treatment, recycling, and disposal units including all valves, connectors, vents, pressure relief devices, storage tanks, separators, process lines, and other major equipment items located within each water treatment facility and
- Gathering stations under City control including all valves, connectors, metering equipment and piping within the boundaries of the each gathering station.

Natural gas transmission lines will not be included in the point source survey unless located within the battery limits of any of the above facilities. We have presented approximate counts and the estimated number of target sources for each source type in Table 1.

**Table 1. Point Source Estimated Counts and Survey Targets**

<b>Point Source Type</b>	<b>Count</b>	<b>Target #</b>
Active Well Pads	489	75% = 367
Active Compressor Stations	13	75% = 10
Processing facility	1	1
Well Development (drilling, fracturing & completion)	1 drilling, 1 fracking, 1 completion	3
Saltwater treatment facility	1	1
Water recycling units	2	2
Gathering stations	None	0
<b><i>Estimated Point Sources Target</i></b>		<b>384</b>

As previously stated, ideally we would like to capture all natural gas facilities within the City. However, this goal may not be feasible due to time and resource constraints. Therefore, we are proposing to survey, at a minimum, 75% of the active well pads and 75% of the compressor stations randomly selected from the entire population of well pads and compressor stations. We will also survey wells at different stages of development such as drilling, fracking and completion in order to identify hydrocarbon emissions that may be associated with these activities. Based upon information provided by the City, we will also survey at least one gas processing facility (if such a facility can be identified for survey), at least one saltwater treatment facility, and up to two water recycling facilities. It is our understanding that there are no natural gas gathering stations with the City of Fort Worth that are not included in the Active Compressor Station count in Table 1.

We feel that the information gathered from the proposed number of point sources will provide a wealth of information in characterizing emissions from the total population of these sources. Additionally, scientifically defensible and statistically robust surrogates can be developed to estimate emissions from facilities which were not surveyed.

The random selection of well pads and line compressors to be surveyed will be performed in a manner designed to ensure that each well pad and each compressor station has an equal chance of being selected:

- 1) Using a random number generator, each well pad and each line compressor station will be assigned a unique identification number;
- 2) The population of well pads and the population of line compressor stations will be ordered numerically according to the random number assigned to them;
- 3) The first 75% of the numerically ordered well pads and the first 75% of the numerically ordered line compressor stations will be selected for the IR Camera survey; and

- 4) To create efficient survey routes, the two survey sets will be combined and ordered by geographical location.

Sources not included in the first 75% will be used as surrogate sites to be substituted for a site that can not be accessed for any reason. Following the selection of the point sources to be surveyed, the City will be gridded into equal area sectors with an alphanumeric identifier applied to each sector. Individual sector survey maps of the point sources will then be created using the Fort Worth GIS dataset, and each sector will be assigned to one of the two point source sampling teams. The sector survey maps will identify each point source to be visited, and will contain any descriptive or spatial information available from the City's GIS data or other sources. The two point source sampling teams will work in adjacent sectors to facilitate communications, to provide each other with equipment and manpower support as necessary, and for safety reasons.

Equipment surveys will be performed by Level I and Level II Thermographers using FLIR IR<sup>®</sup> cameras (IR Cameras). All emissions detected with the IR Camera will be video recorded. Emission points will also be photographed with a digital camera to aid in their identification. The advantage of using the IR Camera is that it is able to scan large areas rapidly in real time and visually detect larger emission sources (i.e. where concentrations are greater than 10,000 ppmv). It is ideal for sensing emissions from equipment in natural gas service since it readily responds to methane, the largest constituent of natural gas, as well as ethane, propane, and butane. Another advantage of the IR Camera is that the operator can effectively use this technology at a distance of up to 50 feet from the source of interest.



GasFindIR Camera

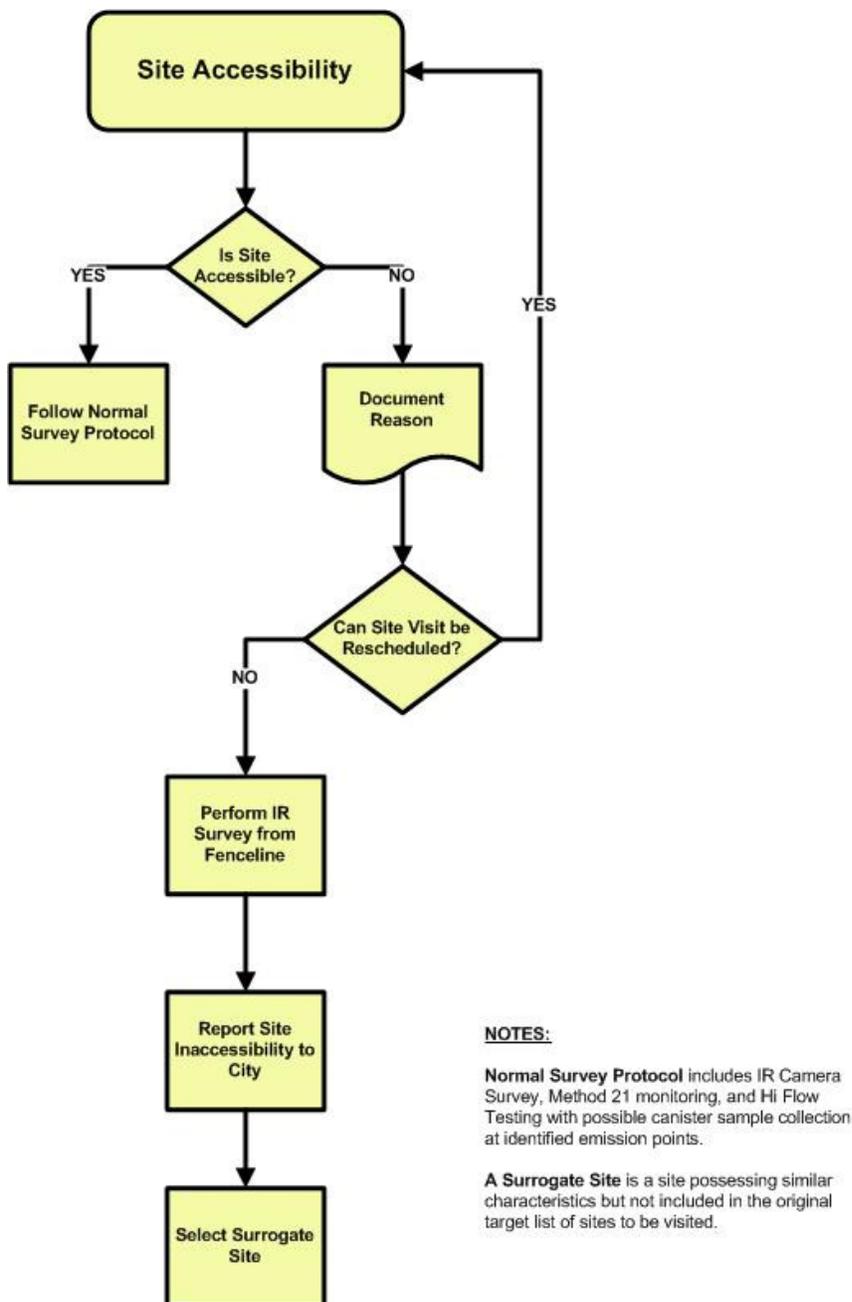
Testing at a typical well pad consisting of 4 to 5 separate wells and a small battery of storage tanks can be accomplished in about 2 hours. A large compressor station can require 4 to 8 hours. A gas processing station may take up to 8 hours to complete sampling. We also anticipate that there may be situations in which the operator may not be able to perform an infrared camera survey right next to the equipment. For instance, the site entrance may be locked, the owner/operator may deny access, or there may be safety concerns restricting access. In these situations, the Thermographers will:

- Fully document the reasons why the equipment could not be directly accessed;
- Arrange to re-visit the site at another time when access can be allowed; and
- If access can not be obtained to the site, attempt to image the facility's equipment from a safe vantage point at the facility's boundary and then select a similar surrogate site for testing. Similarly, if the site shuts down during a survey the survey will be discontinued and considered for re-scheduling.

Should emissions be detected from a facility to which a point source sampling team is unable to enter, the emission stream will be video recorded and the City will be promptly notified of the existence of an emission source to which there is restricted access.

Figure 1 illustrates the process that will be followed in dealing with site accessibility issues.

**Figure 1 - Site Accessibility Flow Chart**



While the IR Camera excels at detecting larger emission sources, it is limited in several important aspects:

- It does not reliably detect minor emission points (i.e. emissions that are less than 10,000 ppmv).
- It cannot quantify the emission concentration in ppmv.
- It cannot provide data on the emission's mass release rate (lb/hr or ton/yr).
- It cannot speciate the emissions. It is unable to determine, for instance, the proportion of methane, propane, ethane, benzene, or xylene in an emission plume.

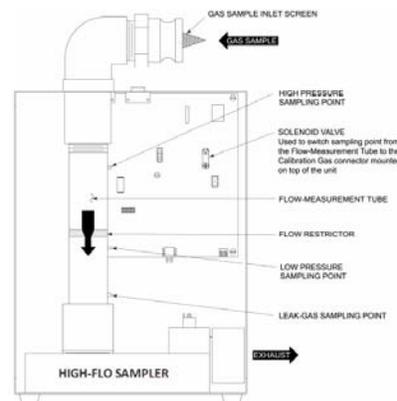
Therefore, the IR Camera is only one of several tools that will be used by the point source sampling teams. Minor emission points, defined as those with emissions below the detection limit of the IR Camera, will be identified with the previously mentioned TVA, which is a portable, battery-powered hydrocarbon analyzer. The TVA will also be used to quantify pollutant concentrations from the larger emission sources found with the IR Camera. Once emission sources have been identified by either the IR Camera or the TVA, mass emission rates will be measured directly using the HiFlow Sampler, and speciation of emissions will be determined through selective collection and analysis of Summa Canister samples.

The TVA is a portable hydrocarbon monitor with a screening range extending from 0.5 ppmv to 50,000 ppmv. The analyzer uses a flame ionization detector (FID) to sample and measure gases. Concentrations in ppmv can be read on both the hand held probe and on the instrument sidepack. The response of the TVA to different hydrocarbons is determined by the response characteristics of the FID and by the gas species used to calibrate the instrument. The unit is factory calibrated with methane. Since methane is the largest constituent of natural gas, continued methane-calibration of the TVA is appropriate for this project. Thus all concentrations detected by the TVA are reported as methane. Since the TVA is portable, operators can take measurements as close to the equipment as possible. However, we do anticipate that at some sites, using this technology may not be possible due to access limitations.



TVA 1000B

The HiFlow Sampler is a portable, intrinsically safe instrument designed to determine the rate of gas leakage from components in natural gas service. A component's leak rate is measured by sampling at a high enough flow rate to ensure that all of the gas emitted from the component will be captured. The HiFlow Sampler calculates the resulting leak rate as percent methane concentration per cubic feet/minute by



accurately measuring the flow rate of the sample stream and the natural gas concentration within that stream. Emissions from a component are drawn into the unit through a flexible 1.5 inch inner diameter hose. An assortment of hose-end attachments are available to provide a means of capturing all the gas that is being emitted. Sample flow rate is measured as the pressure differential developed as the gas passes through a fixed orifice, and sample concentration (as methane) is measured by an on-board combustible gas sensor with a range of 0.05% (500 ppm) to 100% gas by volume.

A Summa Canister is an evacuated six liter metal canister used to collect an instantaneous emission sample for subsequent laboratory analysis. The Summa Canisters for this work will be provided by a laboratory (TestAmerica in Austin, Texas) in a pre-cleaned, evacuated (typically 27 inches Hg vacuum) condition. A canister sample is collected by simply holding the Summa Canister directly in the emission stream of the source being sampled and opening the canister control valve. The canister fills in less than 30 seconds. The canister valve is then closed and the canister is prepared for shipment back to the laboratory.



SUMMA  
Canister

The Summa Canister sampling is used to provide speciation of the compounds emitted, while the previously discussed HiFlow Sampler and TVA will be used to quantify emission concentrations and actual emission rates. To limit the number of samples that would need to be taken and the time needed to accomplish the work, the Summa Canister sample will be collected at the HiFlow Sampler's output port in order that the HiFlow Sampler's operating parameters can be applied to the calculation of a speciated emission rate. This procedure can be accomplished without compromising the integrity of the samples collected.

At the laboratory, the contents of the Summa Canister will be analyzed by the following two analytical methods:

- Analytical Method TO-15: The TO-15 analysis as written by the EPA in support of the Clean Air Act refers to a specific 63 compound list of regulated hydrocarbon compounds.
- Analytical Method D 1946: Since methane is not one of the analytes included in the TO-15 compound list, Method D 1946 will also be performed on the canister sample to provide the methane concentration of the collected sample. Method D 1946 also provides the sample's oxygen, nitrogen, and carbon monoxide concentrations.

Copies of the analyte list for each analytical method are provided in Appendix A.

By using the FLIR IR Camera, HiFlow Samplers, TVA's, and Summa Canisters, and the EPA specified sampling technologies, we will be able to identify, characterize, and quantify the

emission rates from all emission sources and speciate what is being emitted at those emission points.

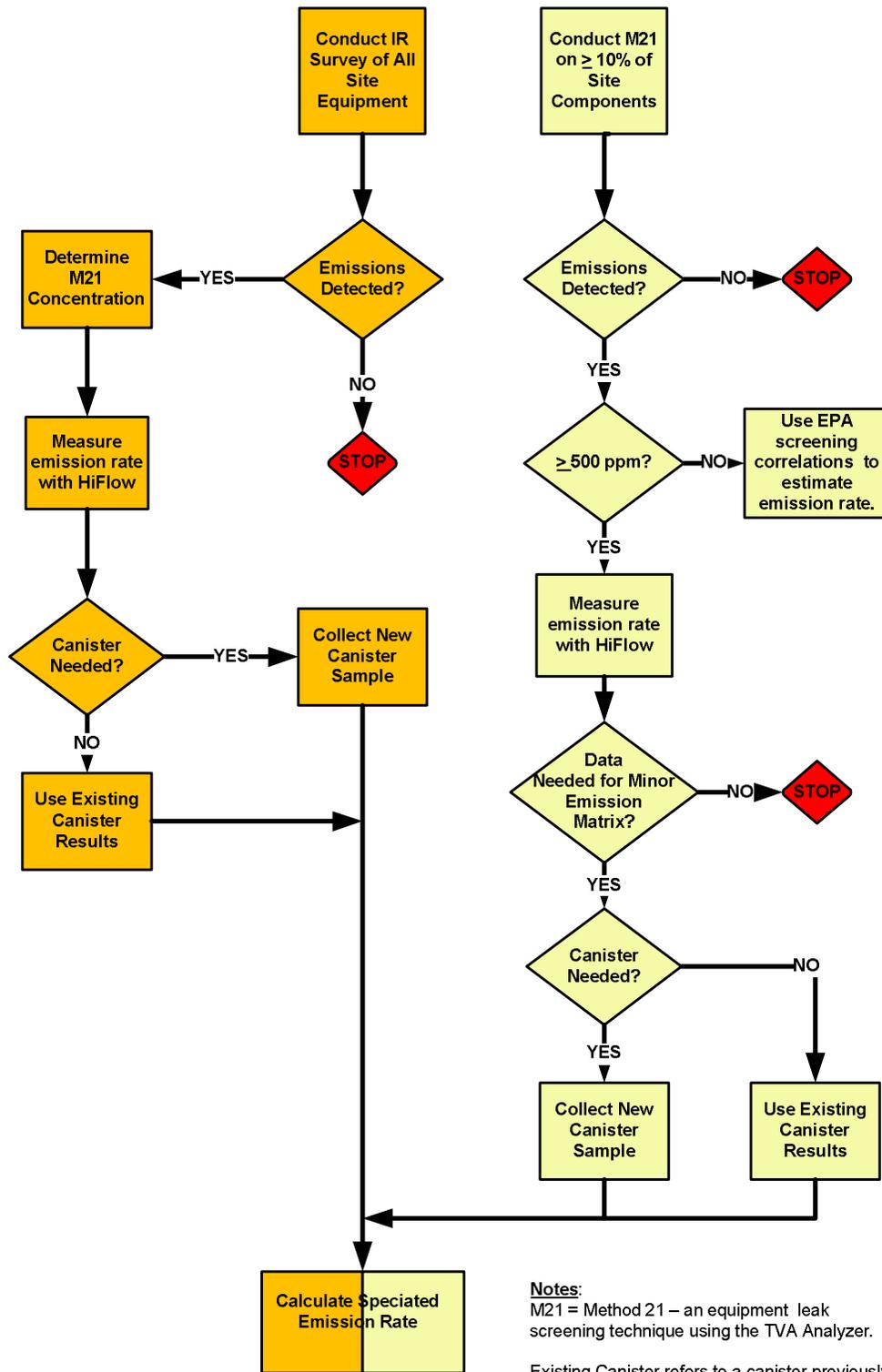
## **2.0 TASK 2 – POINT SOURCE SAMPLING METHODOLOGY**

The sampling methodology will follow the same steps at each point source:

- Perform an IR Camera emissions survey of all equipment within the facility limits to identify all large emission sources;
- With the TVA, obtain concentration measurements of all emission points identified by the IR Camera;
- Collect emission rate data with the HiFlow Sampler from all emission sources identified by the IR Camera;
- Screen a subset of minor emission points with the TVA;
- Collect emission rate data with the HiFlow Sampler on a selection of minor emission points identified by the TVA;
- Collect a canister sample according to the canister sample collection protocol described below;
- Speciate emissions;
- Document all sample collection data; and
- Calculate point source emissions.

Details on each step of the sampling methodology are provided in the following subsections. A flow chart illustration of the sampling methodology is provided in Figure 2.

Figure 2 - Sampling Methodology



**Notes:**  
 M21 = Method 21 – an equipment leak screening technique using the TVA Analyzer.

Existing Canister refers to a canister previously collected at the same site.

HiFlow Sampler is a direct emission measurement device.

### **2.1. Perform an IR Camera emissions survey of all equipment within the facility limits to identify all large emission sources**

Each facility included on the point source target list (see Table 1) will be thoroughly surveyed for emissions with the IR Camera. This will include all stationary equipment found at the site during the survey, but will not include mobile sources such as truck diesel engines. The IR Camera operator will begin the survey at one corner of the facility's boundary and work in a logical, ordered manner through the entire facility. Whenever possible, equipment will be viewed from several angles to ensure that no emission point is overlooked. Fixed ladders, stairs, and portable ladders will be used to reach elevated positions. All camera-detected emissions will be video recorded.

### **2.2 With the TVA, obtain concentration measurements of all emission points identified by the IR Camera**

All emissions from accessible sources that are detected by the IR Camera will be further tested with the TVA to determine their screening value. Point source screening will be conducted on all facility stationary equipment. The screening value is a measure of the hydrocarbon concentration from a leaking component in units of parts per million by volume (ppmv). The procedures for collecting screening measurements will follow US EPA Method 21 protocols<sup>2</sup>. Since the camera sees only large emission sources (i.e. > 10,000 ppmv) the concentration of some emission points will likely exceed the upper range of the TVA (50,000 ppmv or 5% by volume) resulting in a possible flame-out of the analyzer.<sup>3</sup> In these instances, we will use a 10:1 dilution probe with the TVA in order to quantify emissions above 50,000 ppmv.

### **2.3 Collect emission rate data with the HiFlow Sampler from all emission sources identified by the IR Camera**

The HiFlow Sampler will be used to measure the emission rate, expressed as percent methane per cubic foot per minute, from all accessible sources that have been identified by the IR Camera. Since each HiFlow Sampler run takes only 3-8 minutes, this provides a very quick and economical way to directly measure emission rates from these sources.

### **2.4 Elevated and Inaccessible Emission Points**

While virtually all points are accessible to the IR Camera, this is not true for the TVA, the HiFlow Sampler, or for canister sample collection since these all require the operator to be close to the emission point. The methodology for dealing with these "difficult to monitor" components will be as follows:

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<sup>2</sup> EPA Method 21 Determination of Volatile Organic Compounds Leaks. 40 CFR, 60 Appendix B.

<sup>3</sup> A TVA flame-out can occur when the sample concentration is sufficiently high to prevent sufficient air from reaching the detector burner assembly. As a result, the hydrogen flame is extinguished and the analyzer must be re-lit.

- For “just out of reach” components, the TVA probe, the HiFlow sampler tubing and the canister will be equipped with extensions long enough to enable the tester to access these points. This approach should work for emission points on small storage tanks where the emission point is located on the other side of the access platform. It should also enable access of piping vents that extend up to 10 feet above ground level.
- For higher components, stepladders will be used, if necessary, in combination with probe extenders. This should enable testing of the majority of elevated components.
- Provided roof access is available, the vents at large compressor stations should be capable of being tested from the roof level.
- If an identified emission point is elevated so high that it cannot be safely accessed by any of the above methods then several alternatives will be discussed with the City:
  - Use of a man lift and operator to provide the point source crew with access to the emission point.
  - Exclusion of the source from the survey altogether and replacement with an alternative accessible source.
  - In lieu of direct measurements, use EPA emission factors to estimate the mass emissions from the point source.

## **2.5 Screen a subset of minor emission points with the TVA**

For each of the two point source sampling teams, while one inspector is surveying the facility with the IR Camera, the second inspector will conduct a selective screening of components with the TVA following EPA Method 21 procedures. The purpose of this screening step will be to identify equipment emissions that are below the detection threshold of the IR Camera (i.e. emissions < 10,000 ppm). Since the cumulative emissions from these minor emission points can possibly equal or exceed emissions from a major emission point, it is important that they be considered in a facility’s overall emission profile.

A typical wellpad or compressor station can contain hundreds to thousands of components, so it is not feasible from a time perspective to test each component. Instead, the second inspector will attempt to screen as many components as possible with the TVA while the IR Camera survey is being conducted and the site characterization data collected. Given an average screening rate of 250 components/hour, we expect that at a minimum 10% of the total number of a facility’s components will be screened with the TVA for minor emission points. In most cases, this percentage should be considerably higher.

Screened components will be randomly selected from the following component types: valves, connectors, and other components, including pumps, compressors, pressure relief devices, open ended lines, pipelines, etc.

## **2.6 Collect emission rate data with the HiFlow Sampler on a selection of minor emission points identified by the TVA**

While emission rate data will be collected with the HiFlow Sampler on all of the larger accessible emission points detected with the IR Camera, the number of minor emission points to be tested with the HiFlow Sampler will be based upon the requirements for developing unit

specific screening correlations as specified in EPA's *Protocol for Equipment Leak Emission Estimates*<sup>4</sup>. These requirements are defined in Section 2.3.4 of the Protocol:

*"In developing new correlations, a minimum number of leak rate measurements and screening value pairs must be obtained according to the following methodology. First, equipment at the process unit is screened so that the distribution of screening values at the unit is known. Then, mass emissions data must be collected from individual sources that have screening values distributed over the entire range. The criteria for choosing these sources are as follows. For each equipment type (i.e., valves, pumps, etc.) and service (i.e., gas, light liquid, etc.), a random sample of a minimum of six components should be chosen for bagging from each of the following screening value ranges:*

*Screening Value Range (ppmv)*

*1 - 100*

*101 - 1,000*

*1,001 - 10,000*

*10,001 - 100,000*

*> 100,000."*

Two types of units will be considered in this case: natural gas components in wet gas service, and natural gas components in dry gas service. Natural gas well sites that produce water and hydrocarbon liquids (i.e. condensate) in addition to the gas are considered to be in wet service, and wells that produce only water and gas are considered to be in dry service.

Since components with emission concentrations of 10,000 ppm and above (i.e. components with emissions sufficient to be detected by the IR Camera) will have already been selected for emission rate testing, additional emission rate testing would only be needed in the three categories below 10,000 ppm (i.e. 1-100, 101-1,000, and 1,001-10,000 ppmv). However, since the HiFlow Sampler cannot reliably detect emission rates at concentrations less than 500 ppm, we will conduct HiFlow Sampler emission rate testing on components falling within the following two concentration groupings: 500-1,000 ppm and 1,001-10,000 ppm. Table 2 defines the proposed HiFlow Sampler test matrix for components with screening values between 500 – 10,000 ppmv.

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<sup>4</sup> United States Environmental Protection Agency. *Protocol for Equipment Leak Emission Estimates*. EPA-453/R-95-017. November 1995.

**Table 2. Minor Emission Point Testing Matrix**

Service	Screening Concentration (ppmv)	Component Type	Stream Phase	# HiFlow Sampler Tests		
Dry Gas	1-500	All	Gas	0		
		500-1,000		Valve	6	
				Connector	6	
	Other			6		
	1,001-10,000	Valve		6		
		Connector		6		
		Other	6			
	Wet Gas	1-500	All	Light Liquid	0	
			500-1,000		Valve	6
					Connector	6
		Other			6	
		1,001-10,000	Valve		6	
Connector			6			
Other			6			
Wet Gas		1-500	All	Gas	0	
			500-1,000		Valve	6
	Connector				6	
	Other	6				
	1,001-10,000	Valve	6			
		Connector	6			
		Other	6			
	Wet Gas	1-500	All	Light Liquid	0	
			500-1,000		Valve	6
					Connector	6
		Other			6	
		1,001-10,000	Valve		6	
Connector			6			
Other			6			
<b>Total HiFlow Sampler Tests of Minor Emission Points</b>				<b>144</b>		

Since emission points < 500 ppmv are outside the range of the HiFlow Sampler, EPA emission factors will be used to determine emission rates for components with concentrations below this threshold. Alternatively, if the City desires to quantify emission rates below 500 ppm, the blow-through bagging method as described in EPA's *Protocol for Equipment Leak Emission Estimates*<sup>5</sup> can be performed as an option.

<sup>5</sup> United States Environmental Protection Agency. *Protocol for Equipment Leak Emission Estimates*. EPA-453/R-95-017. November 1995.

## **2.7 Collect a Summa Canister sample at each site where an IR Camera detected emission is identified**

If emissions are detected with the IR Camera at a natural gas site, two sampling activities will always be performed: 1) the emission concentration will be measured with the TVA and 2) the emission rate will be measured with the HiFlow Sampler. In addition, a Summa Canister sample will be collected whenever the following three conditions are met:

1. The emission rate from the HiFlow Sampler (in cubic feet per minute) is greater than or equal to the third quartile leak rate value of all previous HiFlow samples (i.e. leak rate is greater than 75% of all previously measured emission rates).
2. Less than three canister samples have been collected from a similar component at other sites.
3. Less than three canister samples have been collected in the general geographical region. Geographical regions will be defined as the north, east, south, and west quadrants of the City of Fort Worth as well as any particular region in which the characteristics of the natural gas are substantially different from other regions (for instance, regions with wet gas and regions with dry gas).

If all of these conditions are not met, a canister sample will not be required; however a canister sample may still be collected at the discretion of the surveyor.

Based on previous studies, it is not expected that emissions will be detected by the IR camera at each point source site, however it will remain uncertain until the completion of the point source survey exactly how many facilities will have one or more detectable emission sources requiring a canister sample collection. The proposed point source budget allows for the collection of forty-five (45) canister samples, including duplicates. If, as the point source effort evolves, it becomes evident that additional canisters will be necessary, the point source team will inform the City in advance that a modification to the sampling plan will need to be considered. Each Summa Canister sample will be collected at the HiFlow Sampler's output port in order that the HiFlow Sampler's operating parameters can be applied to the calculation of a speciated emission rate. A unique sample number, based upon the site the sample is taken, the team taking the sample, and the date of sampling, will be given to each Summa Canister sample. That number will be shown on all documents that track the sample from collection to laboratory analysis and finally to data reporting.

All Summa Canisters will be dispatched, either by personal pickup by a member of the sampling teams or via express shipping, from the laboratory in Austin with a Chain of Custody (COC) sheet attached to it to document who and when the canister was released and to who and when. This COC will follow the canister through every change of possession until the canister returns to the laboratory for analysis. No canister will be moved or accepted without the proper COC document release. In Fort Worth, the unused canisters and their COC documentation will always be under lock and key. The keys will be held by the sampling team leaders. Each COC form will be retained and filed for verification of COC purposes. All COC forms will be spot checked by the QA/QC manager periodically throughout the study and provided to the QA/QC

manager at the end of the study for inclusion into the data validation review process before any data is approved for release. This entire COC process is explained in more detail in Section 3.

If more than one emission source is detected at the same facility with the IR Camera, a uniform natural gas composition will be assumed within the facility so that a second canister sample should not be necessary. A concentration measurement with the TVA will be made of all additional emissions detected by the camera as well as emission rate measurement with the HiFlow Sampler. However, the speciation data from the first canister's analysis will be applied to the other emission sources at that facility. If there is evidence of non-homogeneity, as might be the case with storage tank emissions for instance, more than one Summa Canister may need to be collected at a single site. This will be determined upon receipt of laboratory analysis data for the canisters and may require revisiting some sites.

## 2.8 Speciate emissions

The HiFlow Sampler provides an emission rate as percent methane. It can not determine the levels of ethane, propane, benzene, xylene, or any other specific compounds present in the emission plume. In order to precisely identify an emission's composition, the collection of an emission sample via a Summa Canister, and the subsequent analysis of that sample by gas chromatography, is necessary. As described above, canister sample collection and analysis will be used to speciate emissions into specific compounds, such as benzene.

The collection and analysis of Summa Canister samples is expensive. To minimize project costs, every effort will be made to complete the minor emission point test matrix, as shown in Table 2, at those point source facilities where an emission source has been previously identified with the IR Camera and a Summa Canister sample already collected. At these facilities, the point source sampling teams will attempt to identify components needed to complete the minor emission point test matrix so that that the existing emission speciation information from the one Summa Canister can be applied to them. In those instances where the minor emission point test matrix can not be speciated using existing Summa Canister data, additional canister samples will be necessary.

## 2.9 Document all sample collection data

Electronic data forms stored on hand-held Archer field PCs will be used to record all important data parameters related to the point source test effort. Alternatively, pre-formated paper forms may be used. It is critical to the success of this project that all necessary point source data be collected during each site visit and archived properly. This information will include site characterization data, IR Camera-detected emission data, emission rate testing data, canister collection data, and modeling information. At the conclusion of each day's point source testing, data stored on the Field PCs will be downloaded to computer spreadsheets and backed up on dedicated hard drives.



Archer Field PC

**Site Characterization Data** – It is important that each point source facility

that is visited be fully characterized and documented. To accomplish this, the following facility information will be collected at each site visit:

- Facility Name/ID;
- Owner/operator information;
- Physical location information (address, GPS coordinates, facility boundaries);  
Note: GPS data will be collected using handheld devices manufactured by Garmin or equivalent and these devices are factory calibrated and are not user adjustable. GPS locations will be read at the entrance to the facility;
- Information on activities taking place during the point source testing (i.e., drilling, fracturing, completion, production, etc.);
- Description of major equipment at site with digital photographs and layout sketches;
- Facility Throughput (cubic feet/day);
- Wet gas/dry gas classification information;
- Site operational status; and
- Valve, connector and other component counts.

If a site has stationary or non-road diesel or natural gas-fired engines such as commonly found at drilling or fracking sites and at compressor stations, we propose to collect engine operating parameters, including engine make, model, size, and operating data (hours of operation) and contact the equipment manufacturer to obtain emission factors for typical emissions such as NO<sub>x</sub>, PM, CO, SO<sub>2</sub>, hazardous air pollutants, etc. In lieu of engine vendor data, U.S. EPA published emission factors may be used to estimate emissions.

***IR Camera-detected Emissions*** – The following information will be documented for each emission source identified by the IR Camera:

- Timestamp;
- Equipment ID/Description;
- Equipment Size;
- Camera ID/Operator ID;
- Detection Distance (feet);
- Screening Value (ppm);
- Video File Name;
- Ambient temperature (°F), wind information, relative humidity (%); barometric pressure (kPa), and cloud cover (%) obtained on-site using a hand-held weather meter;
- Ambient lighting;
- IR background;
- Maximum siting distance and
- Comments. The comments field will be used to provide information relevant to detected emissions or environmental conditions that might affect the sensitivity of the camera. For example any abnormal conditions such as a missing tank hatch cover or an open-ended line would be noted in this field.

A digital camera photograph will be taken of each point source equipment item from which emissions are detected by the IR Camera.

In addition, all emissions detected with the IR Camera will be video recorded and saved as digital video files. These video files will subsequently be processed using Windows Movie Maker™ software. Processing of raw video files will consist of adding a title slide with a timestamp and descriptive information followed by a digital photograph of the emission source. Some editing of the IR Camera video may be performed to improve quality of presentation. The completed video recording will then be saved with a descriptive filename as a Windows Media Video file (\*.wmv) and copied on CD media. The questionable or abnormal IR Camera videos will be copied and delivered to the City in a timely manner.

**Emission Rate Measurements** -- The following information will be collected when emission rate measurements are made with the HiFlow Sampler:

- Equipment ID/Description/Equipment Size;
- Operator ID;
- Pre-Test Screening Value (ppm);
- HiFlow Sampler ID;
- HiFlow Sampler Sample ID; and
- HiFlow Sampler Result (% \* cfm).

**Canister Samples** – The following will be collected for each Summa Canister sample:

- Canister ID#;
- Canister Sample Number;
- Canister Initial Vacuum (inch-Hg);
- Canister Sample Start Time (HH:MM:SEC);
- Canister Sample Stop Time (HH:MM:SEC); and
- Canister Final Vacuum (inch-Hg).

**Modeling Information** – To assist with the modeling of receptor impacts of point source emissions, specific information about each point source will be collected by the point source sampling teams including:

- Vent and Stack Information – release height (ft) above ground, gas temperature, gas velocity (ft/sec), stack diameter; Note: laser distance finders will be used to measure stack heights of emission sources as well as heights of other emitting equipment and emission siting distances so long as this equipment is safely accessible to such measurements.
- Fugitive fixed point releases – release height above ground;
- Area sources information – release height above ground, geometry, width (ft), length (ft);
- Tank information – Roof height above ground (ft), Tank diameter (ft);
- Locations and dimensions of structures adjacent to emission points; and

- Nearby traffic conditions.

Some of this information may be obtained on-site, while other data may need to be obtained by follow-up contact with the owner or operator. Other information will be obtained through direct measurement.

All field data will be downloaded and reviewed for completeness on a daily basis. Field data will be archived on a hard drive and backed up on a separate hard drive system. If any site data is lost due to an equipment failure or incomplete due to operator error, that site will be re-surveyed at the next earliest opportunity.

## 2.10 Calculate Point Source Emissions

Equipment mass emission rates for emissions detected either by the IR Camera or through Method 21 screening procedures will be measured directly by the HiFlow Sampler. Speciated emission rates will be calculated using the analytical results of selected Summa Canister samples collected at the HiFlow Sampler exhaust port.

The HiFlow Sampler provides an emission rate expressed as percent methane per cubic feet/minute. Since the Summa Canister sample will be collected at the exhaust port of the HiFlow Sampler, a compound specific emission rate can be calculated based upon the operating parameters of the HiFlow Sampler and the analytical results from the canister analysis.

For example, if the HiFlow Sampler detects a 5% methane emission at a flow rate of 8 cubic feet/minute, and an analysis of a Summa Canister sample collected at the exhaust of the HiFlow Sampler yields a 50 ppm benzene concentration, then the benzene emission rate can be calculated as:

$$E.R. = \frac{C \times MW}{24.45} \times FR \times 7.7E-7$$

Where:

E.R.	=	Emission Rate (lb/hour)
C	=	Concentration (ppm)
MW	=	Molecular Weight
24.45	=	Molar Volume @ 25°C and 1 atmosphere
FR	=	Flow Rate (ft <sup>3</sup> /min)
7.7E-7	=	Units Conversion Factor.

In the above example, a 50 ppmv benzene Summa Canister concentration measured at a flow rate of 8 ft<sup>3</sup>/min would correspond to a benzene emission rate of 9.84 E-4 lb/hour, using 78.11 g/mol as the molecular weight of benzene.

The combined emission rate results for camera-detected emissions, plus smaller emissions detected by Method 21 screening, will be used to develop average component emission factors that can be used to estimate future emissions from facility build-up through simple component counts. The collected data should also be sufficient to develop more refined screening correlation equations specific to Dry Gas and Wet Gas facilities. Screening correlations will allow accurate point source emission calculations to be derived from the screening data collected during this proposed study, as well as from future screening studies.

## **2.11 Characterization of Emissions From Well Development Activities**

There is interest in characterizing emissions generated during the various stages of well development, especially drilling, fracking, and completion operations. The point source sampling teams will rely upon the City to provide information about planned well development activities such as drilling, fracking, and completion and will modify its survey schedule as needed to include site visits while these activities are in progress. For example, when it is learned that drilling is to occur at a particular site, one of the point source teams will break away to survey with the IR camera for emissions related to the drilling operation. This survey will include all drilling equipment as well as the well itself. A similar approach will be used for fracking and well completion activities so that the entire well development process can be characterized.

While conducting a survey with the IR camera during well development activities should be straightforward, it is expected that the nature of those activities, being highly variable from site to site and from operator to operator, may prevent direct emission testing until a full assessment of the process and emission points has been made. This assessment will need to occur once we have had the opportunity to witness these events, discuss options with the City as to how they may be tested, and formulate a testing plan. However, every effort will be made to collect HiFlow Sampler measurements and canister samples from identified well development emission sources, but in the event that this is impractical, emissions will be estimated using process knowledge, data from the operators, and publically available emission factors.

Drilling, fracking, and well completion activities can each take days, sometimes weeks. Upon learning of the planned extent of each activity at a particular site, the point source team will make brief visits several times during each activity so that multiple emissions surveys during each stage of the well development process can be performed. This procedure will require close coordination and communication between the point source team, the City, and the well developer.

The point source sampling teams will work with the well operator and with the City so that the IR camera survey and the collection of emission measurements can be performed effectively and safely.

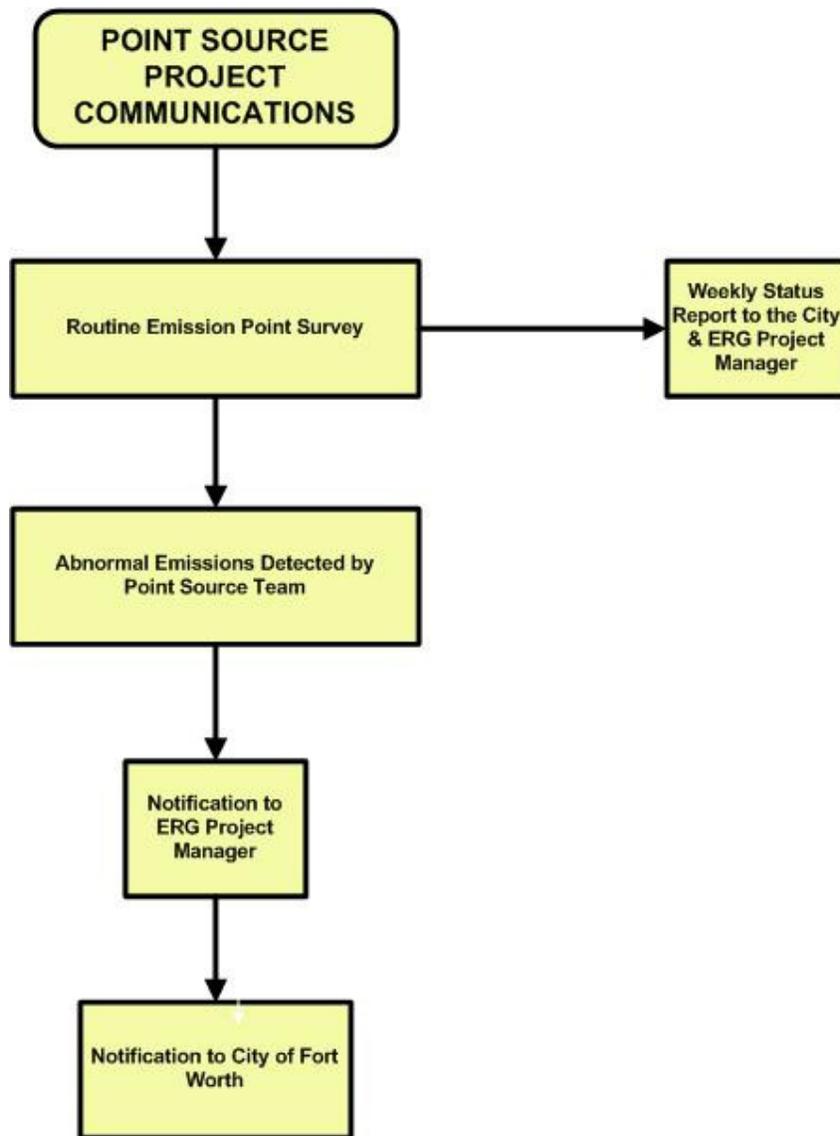
## 2.12 Point Source Project Communications for Abnormal Samples

Information about all detected emission points that appear excessive or abnormally high will be provided to the ERG Project Manager, Mike Pring, shortly after discovery so that the City may be informed of a potential issue. This information will include:

- A copy of the completed point source data form providing location information, equipment description and other important details about the abnormal emission point such as an open hatch, warped gasket, etc.;
- A digital photograph of the emission point; and
- A copy of the IR video.

The ERG Project Manager will then distribute some or all of this information to the City.

Information on the progress of the point source effort will be provided to the ERG Project Manager on a weekly basis (each Monday) in the form of an email memorandum summarizing the point sources visited the previous week and the number of emission points detected. Any additional information will be provided upon request. Figure 3 summarizes the communication of excessive or abnormally high emission point information from the point source team to the ERG Project Manager.

**Figure 3 - Excessive or Abnormal Emission Communication Process**

### 2.13 Weather Delays

Weather delays are likely to occur during the course of the point source testing and will be handled as follows. In the case of thunderstorm activity, we will wait for the storm to subside. If the forecast does not call for timely return to acceptable weather, we will attempt to find a potential sampling site where there is no threat of weather delay and continue to work. If weather prohibits, we will return to the field office and carry out necessary data review, logging, and verification activities as well as preparing for the return to the field.

Wind affects IR imaging in both a positive way and in a negative way. A light wind causes movement of an emission plume which aids greatly in its detection. A strong wind,

however, can quickly cool down an emission plume thereby weakening its imaging contrast. More importantly, a strong wind can change the emission's appearance from a rising, billowing plume, to a thin laminar flow running parallel to the ground or piping. The latter condition makes the emission extremely hard to see. In general it is not good practice to perform IR imaging in winds greater than 30 mph as smaller emissions that may have been readily picked up in light wind conditions may go undetected under the heavier wind conditions. Should winds approach this high level during the IR surveying, the project team will move to another area of the City where winds perhaps are not as high, or suspend surveying until lighter winds prevail.

## **2.14 Task 2 Deliverables**

A draft and final report providing detailed information concerning the results of the point source testing effort will be delivered to the City at the conclusion of the field activities. The report will contain the following sections:

- Executive Summary;
- Project Methodology;
- Facility Characterizations;
- Project Results;
- Project Quality Control Activities and Results; and
- Problems Encountered and Exceptional Events.

## **3.0 TASK 3 - POINT SOURCE QUALITY ASSURANCE/QUALITY CONTROL**

The objective of this task is to ensure that all quality assurance/quality control (QA/QC) procedures are followed and all testing equipment is working properly. The following specifies the responsibilities of the QA/QC reviewer, and specifies the equipment calibration procedures to be employed by the point source sampling teams.

### ***QA/QC Reviewer***

Mr. Arthur Bedrosian will serve as Quality Control reviewer of the point-source survey effort. Mr. Bedrosian's responsibilities will include the following:

- Oversight of the survey program for conformance with this plan, any relevant standards and instructions;
- Checking identification and completeness of project documentation;
- Checking for appropriate use of forms, logs or formats;
- Ensuring that all equipment is properly referenced and calibrated;
- Checking that equipment meets specifications; and

- Random inspection of field activities to ensure they are being performed in accordance with the procedures listed in this project plan and that instrument calibration records are complete and indicate that instruments are in a state of control during use.

Mr. Bedrosian will report any quality control concerns to the Point Source Project Manager, Mr. David Ranum, who will be responsible for addressing them.

### ***Quality Control Actions***

The following quality control actions will be performed by the point source sampling teams as part of their daily work routines. The purpose of these actions are to maximize the capture of valid data and to assure that each day's data is comparable to any other day's data.

1. ***IR Camera Daily Demonstration*** – The following procedures will be implemented each day prior to using each IR Camera for emission surveying:
  - The camera will be turned on and allowed to cool down (cool down time is approximately 6 minutes).
  - Following cool down, the camera will be taken outside and allowed several minutes to equilibrate to ambient conditions.
  - After the equilibration period, several non-uniformity corrections will be performed.
  - The camera daily demo (daily demonstration) will then be conducted. This demonstration will be performed at two mass flow rates: a low rate equivalent to approximately 5 grams propane/hour, and a high rate equivalent to approximately 25 grams propane/hour, with a video recording made of each result. The distance from which the camera operator is able to see the propane plume (*i.e.*, the sighting distance) will be recorded for each mass flow rate together with ambient temperature, wind speed, relative humidity, barometric pressure, cloud cover, and ambient lighting conditions. This daily demo procedure is the procedure commonly used to “calibrate” the camera’s performance so the video recordings made that day can be compared to this measured level of performance.
2. ***TVA Calibration and Drift Checks*** – The TVA analyzers will be calibrated daily prior to field use with certified  $\pm 2\%$  accurate calibration gases equipped with demand-flow regulators. Both TVAs will also be performance tested (response time, precision, flow rate) at the start of the project and, if needed, every 3 months thereafter. Four gas standard concentrations will be used for the daily calibrations: 0, 500, 1,000, and 10,000 ppmv methane-in-air. Drift checks will be performed using the 500-ppmv standard, at mid-day and at end-of-day. Calibration and drift check acceptance criteria will be  $\pm 10\%$  of each calibration gas certified concentration. Any responses outside the acceptance criteria will require either re-calibration or trouble shooting and repair of the analyzer. A

check of the 10:1 dilution probe will be performed with the high span gas each time prior to its use and the resulting dilution factor recorded.

3. ***HiFlow Sampler Calibration*** – Both HiFlow Samplers will be calibrated each day prior to use. For calibration of the background sensor, a 2.5% methane standard will be used. To calibrate the Gas Sample sensor, a 100% methane standard will be used. Both gas standards will be equipped with Demand Flow Regulators to assure steady and consistent flow rates.
4. ***Summa Canister Sample Collection QC Procedures*** – To ensure that canisters contain sufficient volume and do not leak, the vacuum of each Summa Canister will be checked and documented prior to sampling. Canisters with a vacuum of < 25 in. Hg. will not be used. A residual vacuum of 5 -10 in. Hg. will be left in the canister following sample collection. This value will be documented. Appropriate chain-of-custody procedures will be followed for all Summa Canister samples and each team member will be held accountable for following these procedures. This means keeping an accurate written record to track the possession, handling, and location of the canisters from collection through analysis. Canisters in possession of the point source sampling teams will be kept in a secure area with access restricted to authorized personnel only. The following chain-of-custody guidelines will be observed:
  - a. Only persons associated with the project will be allowed to handle the canisters.
  - b. Strict documentation of the transfer of canisters and data from person to person will be kept on chain-of-custody forms.
  - c. Written canister documentation will always be legible and made with permanent ink.
  - d. Canister serial numbers will be recorded on the chain of custody documentation.

Canisters will be identified by numbered metal tags and with preformatted shipping tags will be used to document important canister information. A bound field logbook will be kept by each project team to document each canister sample collection event. The field logbook will contain the following information:

- Sample location;
- Time/date of sample collection;
- Total number and type of sample containers;
- Method of sample collection, and equipment used;
- Physical description of sample;
- Name of sampler(s);
- Related field screening results; and
- Any other pertinent observations.

While Field, Trip, and Ambient blanks are customary in ambient air canister sampling, they are less of a consideration in point source sampling due to the high concentrations involved. No Summa Canister blanks are planned for the point source sampling effort. Field duplicates are second samples collected in the field simultaneously or near-simultaneously with the primary sample at the same location. The results of the duplicate sample may be compared with the primary sample to provide information on consistency and reproducibility of field sampling procedures. Field duplicates will be collected at a 5% rate (i.e. 1 duplicate per 20 canister samples).

**5 Analytical QC Procedures** -- The following is a listing of the Analytical QC procedures that will be followed to assure sample capture and analysis integrity. These procedures are typically used before field deployment of equipment and as part of sample analysis in the laboratory. While this information is highly technical, we have provided it so readers of this sampling plan can see that state of the art procedures will be applied to assure that the analysis of the sampled data is performed in keeping with full compliance of scientific integrity so the captured data can withstand all levels of scrutiny.

- **Method Blank** – This is a control sample prepared using a well-characterized blank matrix (e.g., UHP nitrogen) and using the same reagents used for the samples. As part of a QC batch, it accompanies the samples through all steps of the analytical procedure. The Method Blank is used to monitor the level of contamination introduced to a batch of samples as a result of processing in the laboratory. One Method Blank is processed with each preparation batch.
- **Canister Blank Check** – Before any canister is sent into the field for sampling, each canister is blank-checked using EPA Method TO-12. Source level canisters must have a total non-methane hydrocarbon concentration of less than 20ppbV-C to pass acceptance criteria.
- **Instrument System/Blank** – An instrument blank or system blank may be analyzed as a diagnostic tool to check for contamination, but is not routinely part of an analytical batch for the purposes of data reporting.
- **Laboratory Control Sample/Laboratory Control Sample Duplicate** – The laboratory control sample (LCS) and laboratory control sample duplicate (LCSD) are prepared using a well-characterized blank matrix (e.g., UHP nitrogen) that is spiked with known amounts of representative analytes. A LCS is processed with each preparation batch. As part of a QC batch, the LCS accompanies the samples through all steps of the analytical process. The LCS is used to monitor the accuracy of the analytical process independent of possible interference effects due to sample matrix. Ongoing monitoring of the LCS results provides evidence that the laboratory is performing the method within acceptable accuracy and precision guidelines. The LCS recovery for the representative analytes must be within established control limits.

- **Surrogates** – Surrogates are organic compounds which are similar in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples. For example, compounds such as 2-bromo-1,1,1-trifluoroethane; fluorobenzene; toluene-d8; 1,4-dichlorobutane; and 4-bromofluorobenzene are the surrogates typically used for Modified Method TO-14A and Method TO-15. Surrogates are injected into the canister at the end of the cleaning process. Surrogate spike recoveries help to measure the effects of both the matrix and the analytical process on accuracy.
- **Internal Standards** – Internal standards are added to each analytical standard, blank, and sample. The acceptance criteria for each internal standard's area for every analysis must be  $\pm 50\%$  recovery of the internal standard area from the continuing calibration standard. The acceptance criteria for each internal standard's retention time in every analysis must be within  $\pm 20$  seconds of the internal standard retention time from the continuing calibration standard.
- **Instrument Performance Check** – Prior to analysis of samples and blanks, each gas chromatograph/mass spectrometer (GC/MS) system must pass instrument performance criteria. Hardware tuning is checked daily to establish that the system meets the standard mass spectral abundance criteria.
- **Initial Calibration** – An initial calibration curve (ICAL) containing a minimum of five concentration levels is analyzed to determine the linear working range of the system for each compound. The dynamic range is generally 0.2 ppbV to 10 ppbV for most analytes. The retention time (RT) shift for each of the internal standards at each calibration level must be within  $\pm 20$  seconds of the mean retention time over the initial calibration range for each internal standard.
- **Calibration Curve Fits** – An average response factor (RF) and percent relative standard deviation (%RSD) are calculated for each target analyte. Method TO-15 has an allowance that up to two target analytes may have an  $RSD \leq 40\%$ . The average response factors derived from the initial calibration are used to quantitate results.
- **Initial Calibration Verification (ICV/ICB)** – The initial calibration verification (ICV) is a second source standard of analytes and is analyzed just after the initial calibration. For each analyte, a percent recovery (%R) is calculated using the average response factor.
- **Continuing Calibration Verification (CCV/CCB)** – Every 24 hours of operation, a mid-range continuing calibration verification (CCV) standard of analytes is analyzed to verify the ICAL average RF. The CCV is routinely analyzed at a concentration matching the midpoint of the ICAL. The percent difference (%D) of the CCV RF from the ICAL average RF is calculated for each compound. In general, %D must be within  $\pm 30\%$ , with exceptions for ethane, 1, 2, 4-trichlorobenzene, and hexachlorobutadiene ( $\pm 50\%$ ).

- 6 ***Equipment Malfunctions*** -- If major point source test equipment, such as the IR camera, the HiFlow Sampler, or the TVA 1000B analyzer malfunctions and cannot be easily repaired, it will be returned to the vendor for an expedited repair. In the meantime, it will be replaced with rental equipment of the same make, manufacturer, and operational specifications.
- 7 ***Point Source Test Plan*** -- Each point source team member will be required to thoroughly review this plan to ensure that the correct survey, sampling methodologies as sample handling chain of custody procedures are observed throughout the term of the study.

#### 4.0 PROJECT SAFETY

Project safety is important to the City, to the Contractor, and especially to the point source sampling team members. A Point Source Project Safety Plan will be drafted specific to this project. Each point source sampling team will be required:

- To keep with them a signed copy of the project safety plan;
- To hold daily safety toolbox meetings to review specific project hazards, either encountered or anticipated;
- To have an emergency first aid kit readily available; and
- To have all required PPE as specified in the project safety plan.

The designated project safety will be responsible for ensuring that the project safety plan is implemented and followed by all project team members.

**APPENDIX A - TO-15 AND D1946 ANALYTICAL  
METHOD INFORMATION**

## TestAmerica Austin

### Analytical Method Information

#### TO15\_Source in Air (TO-15)

**Preservation:** Store sealed at STP

**Container:** Passivated Canister

**Amount Required:**

Analyte	MDL	Reporting Limit	Units
Propylene	0.00326	0.0200	ppmv
Chlorodifluoromethane	0.00112	0.0200	ppmv
Dichlorodifluoromethane	0.00159	0.0200	ppmv
Chloromethane	0.00119	0.0200	ppmv
1,2-Dichloro-1,1,2,2-tetrafluoroethane	0.00128	0.0200	ppmv
Vinyl chloride	0.00234	0.0200	ppmv
1,3-Butadiene	0.00300	0.0200	ppmv
Butane	0.00160	0.0200	ppmv
Bromomethane	0.00263	0.0200	ppmv
Chloroethane	0.00397	0.0200	ppmv
Vinyl bromide	0.00283	0.0200	ppmv
Isopentane	0.00232	0.0200	ppmv
Trichlorofluoromethane	0.000840	0.0200	ppmv
Acetone	0.00434	0.0200	ppmv
n-Pentane	0.00189	0.0200	ppmv
Diethyl ether	0.00437	0.0200	ppmv
1,1-Dichloroethene	0.00208	0.0200	ppmv

Analyte	MDL	Reporting Limit	Units
Methylene chloride	0.00205	0.0200	ppmv
Carbon disulfide	0.00110	0.0200	ppmv
Allyl chloride	0.00289	0.0200	ppmv
1,1,2-Trichlorotrifluoroethane	0.00106	0.0200	ppmv
trans-1,2-Dichloroethene	0.00164	0.0200	ppmv
1,1-Dichloroethane	0.00122	0.0200	ppmv
Methyl tert-Butyl Ether	0.00272	0.0200	ppmv
Vinyl acetate	0.00264	0.0200	ppmv
2-Butanone (MEK)	0.00322	0.0200	ppmv
cis-1,2-Dichloroethene	0.00157	0.0200	ppmv
Hexane	0.00140	0.0200	ppmv
Chloroform	0.00183	0.0200	ppmv
1,2-Dichloroethane	0.000830	0.0200	ppmv
1,1,1-Trichloroethane	0.00155	0.0200	ppmv
Benzene	0.00253	0.0200	ppmv
Carbon tetrachloride	0.00135	0.0200	ppmv
Cyclohexane	0.00269	0.0200	ppmv
Dibromomethane	0.00192	0.0200	ppmv
1,2-Dichloropropane	0.00144	0.0200	ppmv
Bromodichloromethane	0.00137	0.0200	ppmv
Trichloroethene	0.00552	0.0200	ppmv
2,2,4-Trimethylpentane	0.00143	0.0200	ppmv
Heptane	0.00246	0.0200	ppmv

Analyte	MDL	Reporting Limit	Units
cis-1,3-Dichloropropene	0.00211	0.0200	ppmv
4-Methyl-2-pentanone (MIBK)	0.00168	0.0200	ppmv
trans-1,3-Dichloropropene	0.00210	0.0200	ppmv
1,1,2-Trichloroethane	0.00196	0.0200	ppmv
Toluene	0.00321	0.0200	ppmv
2-Hexanone	0.00197	0.0200	ppmv
Chlorodibromomethane	0.00100	0.0200	ppmv
1,2-Dibromoethane (EDB)	0.00139	0.0200	ppmv
n-Octane	0.00187	0.0200	ppmv
Tetrachloroethene	0.00515	0.0200	ppmv
Chlorobenzene	0.00119	0.0200	ppmv
Ethylbenzene	0.00209	0.0200	ppmv
m-Xylene & p-Xylene	0.00467	0.0400	ppmv
Bromoform	0.000940	0.0200	ppmv
Styrene	0.00237	0.0200	ppmv
1,1,2,2-Tetrachloroethane	0.00104	0.0200	ppmv
o-Xylene	0.00163	0.0200	ppmv
1,2,3-Trichloropropane	0.00104	0.0200	ppmv
n-Nonane	0.00183	0.0200	ppmv
Isopropylbenzene	0.00175	0.0200	ppmv
2-Chlorotoluene	0.00207	0.0200	ppmv
n-Propylbenzene	0.00210	0.0200	ppmv
4-Ethyltoluene	0.00246	0.0200	ppmv
1,3,5-Trimethylbenzene	0.00252	0.0200	ppmv

Analyte	MDL	Reporting Limit	Units
1,2,4-Trimethylbenzene	0.00210	0.0200	ppmv
tert-Butylbenzene	0.00190	0.0200	ppmv
Benzyl chloride	0.00177	0.0200	ppmv
1,3-Dichlorobenzene	0.00231	0.0200	ppmv
n-Decane	0.00192	0.0200	ppmv
1,4-Dichlorobenzene	0.00265	0.0200	ppmv
sec-Butylbenzene	0.00199	0.0200	ppmv
4-Isopropyltoluene	0.00255	0.0200	ppmv
1,2-Dichlorobenzene	0.00243	0.0200	ppmv
n-Butylbenzene	0.00194	0.0200	ppmv
n-Undecane	0.00215	0.0200	ppmv
1,2,4-Trichlorobenzene	0.00514	0.0200	ppmv
Naphthalene	0.00629	0.0200	ppmv
n-Dodecane	0.00264	0.0200	ppmv
1,2,3-Trichlorobenzene	0.00549	0.0200	ppmv
Hexachlorobutadiene	0.00196	0.0200	ppmv

**TestAmerica Austin**

7/7/2010

**Analytical Method Information**

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	Blank Spike / LCS %R	Blank Spike / LCS RPD
<b>D 1946_Positive in Air (D1946)</b>								
Preservation:Store sealed at STP								
Container:Passivated Canister								
Amount Required:6000 mL								
Hold Time:30 days								
Oxygen	0.0199	1.00 %(v/v)		25			75 - 135	25
Nitrogen	0.0201	5.00 %(v/v)		25			70 - 130	25
Methane	0.0877	2.00 %(v/v)		25			73 - 133	25
Carbon monoxide	0.0545	3.00 %(v/v)		25			71 - 131	25

## **APPENDIX B - METHOD 21**

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**METHOD 21 - DETERMINATION OF VOLATILE ORGANIC COMPOUND LEAKS**

*1.0 Scope and Application.*

*1.1 Analytes.*

Analyte CAS No.

Volatile Organic Compounds  
(VOC)

No CAS number assigned

*1.2 Scope.* This method is applicable for the determination of VOC leaks from process equipment. These sources include, but are not limited to, valves, flanges and other connections, pumps and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals, and access door seals.

*1.3 Data Quality Objectives.* Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

*2.0 Summary of Method.*

*2.1* A portable instrument is used to detect VOC leaks from individual sources. The instrument detector type is not specified, but it must meet the specifications and performance criteria contained in Section 6.0. A leak definition concentration based on a reference compound is specified in each applicable regulation. This method is intended to locate and classify leaks only, and is not to be  
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used as a direct measure of mass emission rate from individual sources.

*3.0 Definitions.*

*3.1 Calibration gas* means the VOC compound used to adjust the instrument meter reading to a known value. The calibration gas is usually the reference compound at a known concentration approximately equal to the leak definition concentration.

*3.2 Calibration precision* means the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration.

*3.3 Leak definition concentration* means the local VOC concentration at the surface of a leak source that indicates that a VOC emission (leak) is present. The leak definition is an instrument meter reading based on a reference compound.

*3.4 No detectable emission* means a local VOC concentration at the surface of a leak source, adjusted for

local VOC ambient concentration, that is less than 2.5 percent of the specified leak definition concentration. that indicates that a VOC emission (leak) is not present.

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3.5 *Reference compound* means the VOC species selected as the instrument calibration basis for specification of the leak definition concentration. (For example, if a leak definition concentration is 10,000 ppm as methane, then any source emission that results in a local concentration that yields a meter reading of 10,000 on an instrument meter calibrated with methane would be classified as a leak. In this example, the leak definition concentration is 10,000 ppm and the reference compound is methane.)

3.6 *Response factor* means the ratio of the known concentration of a VOC compound to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation.

3.7 *Response time* means the time interval from a step change in VOC concentration at the input of the sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the instrument readout meter.

4.0 *Interferences.* [Reserved]

5.0 *Safety.*

5.1 *Disclaimer.* This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its  
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use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

5.2 *Hazardous Pollutants.* Several of the compounds, leaks of which may be determined by this method, may be irritating or corrosive to tissues (e.g., heptane) or may be toxic (e.g., benzene, methyl alcohol). Nearly all are fire hazards. Compounds in emissions should be determined through familiarity with the source. Appropriate precautions can be found in reference documents, such as reference No. 4 in Section 16.0.

6.0 *Equipment and Supplies.*

A VOC monitoring instrument meeting the following specifications is required:

6.1 The VOC instrument detector shall respond to the compounds being processed. Detector types that may meet this requirement include, but are not limited to, catalytic

oxidation, flame ionization, infrared absorption, and photoionization.

6.2 The instrument shall be capable of measuring the leak definition concentration specified in the regulation.  
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6.3 The scale of the instrument meter shall be readable to  $\pm 2.5$  percent of the specified leak definition concentration.

6.4 The instrument shall be equipped with an electrically driven pump to ensure that a sample is provided to the detector at a constant flow rate. The nominal sample flow rate, as measured at the sample probe tip, shall be 0.10 to 3.0 l/min (0.004 to 0.1 ft<sup>3</sup>/min) when the probe is fitted with a glass wool plug or filter that may be used to prevent plugging of the instrument.

6.5 The instrument shall be equipped with a probe or probe extension for sampling not to exceed 6.4 mm (1/4 in) in outside diameter, with a single end opening for admission of sample.

6.6 The instrument shall be intrinsically safe for operation in explosive atmospheres as defined by the National Electrical Code by the National Fire Prevention Association or other applicable regulatory code for operation in any explosive atmospheres that may be encountered in its use. The instrument shall, at a minimum, be intrinsically safe for Class 1, Division 1 conditions, and/or Class 2, Division 1 conditions, as appropriate, as defined by the example code. The instrument shall not be operated with any safety device, such as an exhaust flame arrestor, removed.

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#### 7.0 Reagents and Standards.

7.1 Two gas mixtures are required for instrument calibration and performance evaluation:

7.1.1 Zero Gas. Air, less than 10 parts per million by volume (ppmv) VOC.

7.1.2 Calibration Gas. For each organic species that is to be measured during individual source surveys, obtain or prepare a known standard in air at a concentration approximately equal to the applicable leak definition specified in the regulation.

7.2 Cylinder Gases. If cylinder calibration gas mixtures are used, they must be analyzed and certified by the manufacturer to be within 2 percent accuracy, and a shelf life must be specified. Cylinder standards must be either reanalyzed or replaced at the end of the specified shelf life.

7.3 Prepared Gases. Calibration gases may be prepared by the user according to any accepted gaseous preparation procedure that will yield a mixture accurate to within 2 percent. Prepared standards must be replaced each day of use unless it is demonstrated that degradation does not occur during storage.

7.4 Mixtures with non-Reference Compound Gases.

Calibrations may be performed using a compound other than 1157

the reference compound. In this case, a conversion factor must be determined for the alternative compound such that the resulting meter readings during source surveys can be converted to reference compound results.

*8.0 Sample Collection, Preservation, Storage, and Transport.*

8.1 Instrument Performance Evaluation. Assemble and start up the instrument according to the manufacturer's instructions for recommended warmup period and preliminary adjustments.

8.1.1 Response Factor. A response factor must be determined for each compound that is to be measured, either by testing or from reference sources. The response factor tests are required before placing the analyzer into service, but do not have to be repeated at subsequent intervals.

8.1.1.1 Calibrate the instrument with the reference compound as specified in the applicable regulation. Introduce the calibration gas mixture to the analyzer and record the observed meter reading. Introduce zero gas until a stable reading is obtained. Make a total of three measurements by alternating between the calibration gas and zero gas. Calculate the response factor for each repetition and the average response factor.

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8.1.1.2 The instrument response factors for each of the individual VOC to be measured shall be less than 10 unless otherwise specified in the applicable regulation. When no instrument is available that meets this specification when calibrated with the reference VOC specified in the applicable regulation, the available instrument may be calibrated with one of the VOC to be measured, or any other VOC, so long as the instrument then has a response factor of less than 10 for each of the individual VOC to be measured.

8.1.1.3 Alternatively, if response factors have been published for the compounds of interest for the instrument or detector type, the response factor determination is not required, and existing results may be referenced. Examples

of published response factors for flame ionization and catalytic oxidation detectors are included in References 1-3 of Section 17.0.

8.1.2 Calibration Precision. The calibration precision test must be completed prior to placing the analyzer into service and at subsequent 3-month intervals or at the next use, whichever is later.

8.1.2.1 Make a total of three measurements by alternately using zero gas and the specified calibration gas. Record the meter readings. Calculate the average algebraic difference between the meter readings and the  
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known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

8.1.2.2 The calibration precision shall be equal to or less than 10 percent of the calibration gas value.

8.1.3 Response Time. The response time test is required before placing the instrument into service. If a modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required before further use.

8.1.3.1 Introduce zero gas into the instrument sample probe. When the meter reading has stabilized, switch quickly to the specified calibration gas. After switching, measure the time required to attain 90 percent of the final stable reading. Perform this test sequence three times and record the results. Calculate the average response time.

8.1.3.2 The instrument response time shall be equal to or less than 30 seconds. The instrument pump, dilution probe (if any), sample probe, and probe filter that will be used during testing shall all be in place during the response time determination.

8.2 Instrument Calibration. Calibrate the VOC monitoring instrument according to Section 10.0.

8.3 Individual Source Surveys.

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8.3.1 Type I - Leak Definition Based on Concentration. Place the probe inlet at the surface of the component interface where leakage could occur. Move the probe along the interface periphery while observing the instrument readout. If an increased meter reading is observed, slowly sample the interface where leakage is indicated until the maximum meter reading is obtained. Leave the probe inlet at this maximum reading location for approximately two times the instrument response time. If the maximum observed meter reading is greater than the leak

definition in the applicable regulation, record and report the results as specified in the regulation reporting requirements. Examples of the application of this general technique to specific equipment types are:

8.3.1.1 Valves. The most common source of leaks from valves is the seal between the stem and housing. Place the probe at the interface where the stem exits the packing gland and sample the stem circumference. Also, place the probe at the interface of the packing gland take-up flange seat and sample the periphery. In addition, survey valve housings of multipart assembly at the surface of all interfaces where a leak could occur.

8.3.1.2 Flanges and Other Connections. For welded flanges, place the probe at the outer edge of the flange-gasket interface and sample the circumference of the flange.

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Sample other types of nonpermanent joints (such as threaded connections) with a similar traverse.

8.3.1.3 Pumps and Compressors. Conduct a circumferential traverse at the outer surface of the pump or compressor shaft and seal interface. If the source is a rotating shaft, position the probe inlet within 1 cm of the shaft-seal interface for the survey. If the housing configuration prevents a complete traverse of the shaft periphery, sample all accessible portions. Sample all other joints on the pump or compressor housing where leakage could occur.

8.3.1.4 Pressure Relief Devices. The configuration of most pressure relief devices prevents sampling at the sealing seat interface. For those devices equipped with an enclosed extension, or horn, place the probe inlet at approximately the center of the exhaust area to the atmosphere.

8.3.1.5 Process Drains. For open drains, place the probe inlet at approximately the center of the area open to the atmosphere. For covered drains, place the probe at the surface of the cover interface and conduct a peripheral traverse.

8.3.1.6 Open-ended Lines or Valves. Place the probe inlet at approximately the center of the opening to the atmosphere.

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8.3.1.7 Seal System Degassing Vents and Accumulator Vents. Place the probe inlet at approximately the center of the opening to the atmosphere.

8.3.1.8 Access door seals. Place the probe inlet at the surface of the door seal interface and conduct a

peripheral traverse.

8.3.2 Type II - "No Detectable Emission". Determine the local ambient VOC concentration around the source by moving the probe randomly upwind and downwind at a distance of one to two meters from the source. If an interference exists with this determination due to a nearby emission or leak, the local ambient concentration may be determined at distances closer to the source, but in no case shall the distance be less than 25 centimeters. Then move the probe inlet to the surface of the source and determine the concentration as outlined in Section 8.3.1. The difference between these concentrations determines whether there are no detectable emissions. Record and report the results as specified by the regulation. For those cases where the regulation requires a specific device installation, or that specified vents be ducted or piped to a control device, the existence of these conditions shall be visually confirmed. When the regulation also requires that no detectable emissions exist, visual observations and sampling surveys are required. Examples of this technique are:

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8.3.2.1 Pump or Compressor Seals. If applicable, determine the type of shaft seal. Perform a survey of the local area ambient VOC concentration and determine if detectable emissions exist as described in Section 8.3.2.

8.3.2.2 Seal System Degassing Vents, Accumulator Vessel Vents, Pressure Relief Devices. If applicable, observe whether or not the applicable ducting or piping exists. Also, determine if any sources exist in the ducting or piping where emissions could occur upstream of the control device. If the required ducting or piping exists and there are no sources where the emissions could be vented to the atmosphere upstream of the control device, then it is presumed that no detectable emissions are present. If there are sources in the ducting or piping where emissions could be vented or sources where leaks could occur, the sampling surveys described in Section 8.3.2 shall be used to determine if detectable emissions exist.

8.3.3 Alternative Screening Procedure.

8.3.3.1 A screening procedure based on the formation of bubbles in a soap solution that is sprayed on a potential leak source may be used for those sources that do not have continuously moving parts, that do not have surface temperatures greater than the boiling point or less than the freezing point of the soap solution, that do not have open areas to the atmosphere that the soap solution cannot

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bridge, or that do not exhibit evidence of liquid leakage. Sources that have these conditions present must be surveyed using the instrument technique of Section 8.3.1 or 8.3.2.

8.3.3.2 Spray a soap solution over all potential leak sources. The soap solution may be a commercially available leak detection solution or may be prepared using concentrated detergent and water. A pressure sprayer or squeeze bottle may be used to dispense the solution. Observe the potential leak sites to determine if any bubbles are formed. If no bubbles are observed, the source is presumed to have no detectable emissions or leaks as applicable. If any bubbles are observed, the instrument techniques of Section 8.3.1 or 8.3.2 shall be used to determine if a leak exists, or if the source has detectable emissions, as applicable.

#### 9.0 Quality Control.

##### Section

##### Quality Control

##### Measure Effect

##### 8.1.2 Instrument calibration

##### precision check

Ensure precision and accuracy, respectively,

of instrument response to

##### 10.0 Instrument calibration standard

##### 10.0 Calibration and Standardization.

10.1 Calibrate the VOC monitoring instrument as follows. After the appropriate warmup period and zero

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internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value.

**NOTE:** If the meter readout cannot be adjusted to the proper value, a malfunction of the analyzer is indicated and corrective actions are necessary before use.

##### 11.0 Analytical Procedures. [Reserved]

##### 12.0 Data Analyses and Calculations. [Reserved]

##### 13.0 Method Performance. [Reserved]

##### 14.0 Pollution Prevention. [Reserved]

##### 15.0 Waste Management. [Reserved]

##### 16.0 References.

1. Dubose, D.A., and G.E. Harris. Response Factors of VOC Analyzers at a Meter Reading of 10,000 ppmv for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81051. September 1981.

2. Brown, G.E., et al. Response Factors of VOC Analyzers Calibrated with Methane for Selected Organic

Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81-022. May 1981.

3. DuBose, D.A. *et al.* Response of Portable VOC Analyzers to Chemical Mixtures. U.S. Environmental 1166 Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81-110. September 1981.

4. Handbook of Hazardous Materials: Fire, Safety, Health. Alliance of American Insurers. Schaumburg, IL. 1983.

*17.0 Tables, Diagrams, Flowcharts, and Validation Data.*  
[Reserved]

## **APPENDIX C - 1995 PROTOCOL FOR EQUIPMENT LEAK EMISSION ESTIMATES**

Due to the length of this EPA document as well as formatting issues, we have not included the hardcopy text into this Appendix. Rather, we are providing the EPA website link for use by interested readers.

<http://www.epa.gov/ttnchie1/efdocs/equiplks.pdf>