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GUIDELINES FOR EVALUATION & SELECTING PORTABLE ANALYZERS FOR COMBUSTION EMISSION MEASUREMENT

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The Institute of Clean Air Companies, the nonprofit national association of companies that supply stationary source air pollution monitoring and control systems, equipment and services, was formed in 1960 to promote the industry and encourage improvement of engineering and technical standards.

The Institute's mission is to assure strong and workable air quality policy that promotes public health, environmental quality, and industrial progress. As the representative of the air pollution control, industry the Institute seeks to evaluate and respond to regulatory initiatives and establish technical standards for the benefit of all.

Guidelines for Evaluating and Selecting Portable Analyzers for Combustion Emissions Measurement

Date Adopted: September 2007

SUMMARY:

This document provides guidance in evaluating and selecting Portable Analyzers for Combustion Emissions measurements. It includes an example bid specification and a bid evaluation form with supporting discussion. Issues addressing applications such as probe locations, monitoring feasibility, and flue gas (sample) composition associated with the measurement process have been omitted, as they are site and process specific.

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1. BACKGROUND

The ICAC Emissions Measuring Division prepared Guidelines for Evaluating and Selecting Portable Analyzers for Combustion Emission Measurement (PACE-1) to ease the process of purchasing a portable emission analyzer, and to help customers specify and obtain analyzers, which best meet, their needs.

2. OBJECTIVES AND SCOPE

The objective of ICAC-PACE-1 is to assist a user of a Portable Analyzer for Combustion Emissions (PACE) to prepare a specification for specifying and collecting information necessary to solicit and analyze bids from PACE suppliers.

3. DEFINITIONS AND TERMS

3.1 CTM-034
Conditional Test Method 34 is a draft method for the Determination of O_2, CO_2 and (NO and NO_2) for Periodic Monitoring

3.2 Data Recorder
A digital recorder, computer, or strip chart recorder for logging measurement data from the analyzer output.

3.3 EPA ETV Verified
Independent third party testing performed in accordance with the US EPA Environmental Technology Verification (ETV) program.

3.4 Interference Compensation
Is a method used to remove or neutralize compounds that interfere with the selective operation of the sensor. The analyzer or user should have a means to determine when interference compensation is operating correctly and in accordance with the manufacturer's recommendations.

3.5 Interference Gas
Every sensing technology will respond to the target gas and may also respond to other "interfering gases". Portable analyzers for combustion emissions should be designed to address these potential interferences. Knowing the complete stack gas stream composition helps to identify potential issues.

3.6 Instrument Drift
The drift of an analyzer refers to the deviation over time of the measured value from the true value. Zero drift describes the difference that an analyzer exhibits during analysis of a gas with zero concentration of the constituent gas. Span drift refers to the change in reading over time shown by the analyzer when subjected to a calibration gas or standard having a known concentration.

3.7 Instrument Response Time
The response time of an instrument is usually specified as the time required for the instrument to show a 90 percent response to a 100 percent concentration step change.

3.8 LCD
Liquid Crystal Display

3.9 LED
Light Emitting Diode

3.10 PACE
Portable Analyzer for Combustion Emissions is a device that incorporates all the hardware necessary to extract and condition stack gases and measure discrete gas constituents. Primary gases measured and categorized by this document may include O_2, CO_2, CO, NO, NO_2, SO_2, and H_2S. Analyzer designs and technology vary between manufacturers and their principles of operation may sometimes differ, therefore it is recommended that the PACE be verified by a recognized 3rd party-testing agency (*e.g.* U.S. EPA's ETV, SCAQMD, or TÜV).

3.11 Particulate Filter
Particulate filters are located before the inlet of the analyzer used to prevent accumulation of particulate material in the measurement system. Filters should be fabricated of materials that are non-reactive to the gas being sampled.

3.12 Probe
The device inserted into the stream of flue or exhaust gas used to extract a sample. The sample probe is the direct interface for extractive sampling.

3.13 Measurement Sensor
A device that produces an electrical output that is proportional to the concentration of gas being measured. There are several sensor technologies available in portable gas analyzers including: Electrochemical (EC) sensor, non-dispersive infrared bench sensor (NDIR), chemiluminesence sensor (CLD), Fourier Transform Infa Red (FTIR) galvanic cell sensor.

3.14 Moisture Removal System
Moisture Removal systems fall into two general categories, active and passive. Active moisture removal systems rapidly force moisture from the sample gas streams and continuously remove this condensation to prevent absorption of NO_x and SO_2. Different technologies, such as Peltier Chiller Systems and Permeation Dryer systems force the moisture from the sample stream. The moisture removal system should not degrade the accuracy of the measurement. Unproven passive moisture removal systems are not acceptable for NO_x or SO_2 testing as there may not be adequate removal of moisture from the gas stream and there may be excessive contact between the condensate and sample gas stream. Typical passive systems are called condensate traps or moisture traps.

3.15 NO_x (NO+ NO_2)
The nomenclature used to designate nitric oxide and nitrogen dioxide. Nitric Oxide (NO) is insoluble in water and is a non-reactive gas, whereas Nitrogen Dioxide (NO_2) is highly soluble and extremely reactive with many compounds. Therefore, conditioning the sample with a well designed moisture removal system is required for high accuracy measurements.

3.16 Sensor Temperature Indicator
A temperature measurement device (*e.g.* thermocouple, thermistor, or equivalent) to monitor the sensor temperature to ensure the sensor operates within its normal linear range. The temperature may be measured at the surface, within the sensor, or in close proximity to the sensor such that it indicates the operating temperature of the sensor.

3.17 Sample line
The sample line tubing is used to transport the sample gases from the probe to the analyzer. The sample line should be proven not to degrade the accuracy of measurement.

3.18 Sample Conditioning System
A component necessary for accurate emission testing of NO_x (NO + NO_2), SO_2 & H_2S. It is a system that has the ability to eliminate particulates and sample moisture, and remove the condensate from the sample stream. The sample conditioning system should be proven to not degrade the accuracy of the measurement. The system may include any or all of the following components:

- Filter(s)
- Moisture removal system
- Flow control
- Pressure control
- Temperature control
- Sample pump

3.17 Sample Flow Rate Indicator
A device such as an electronic meter, rotometer, or equivalent used to measure the sample flow rate through the analyzer. This device is recommended because in some sampling situations analyzers can experience drift with changes in sample flow rate. Most recognized test methods require flow rate monitoring. Alternatively the analyzer meeting the requirements of CTM-034 which have been tested for the effects of varying sample flow rate are acceptable.

3.18 SQAMD
South Coast Air Quality Management District

3.19 Temperature Compensation
An electronic method of establishing accurate sensor output characteristics at defined operating temperature ranges. Temperature compensation may be locked at analyzer initialization or compensated dynamically.

3.20 Transport System Response Time
System response time includes the time to transport the sample to the instrument plus the instrument response time, therefore the length of the sample transport lines should be minimized to provide faster response.

3.21 TÜV
TÜV Rheinland Group is an international company that is certified as a Nationally Recognized Testing Laboratory (NRTL) and documents the safety and quality of new and existing products, systems, and services.

3.22 UL
Underwriter's Laboratories Inc. is chartered as a not-for-profit organization to establish, maintain, and operated laboratories for the examination and testing of devices, systems, and materials to determine their relation to hazards to life and property, and to ascertain, define and publish standards for these items.

3.23 U.S EPA
United States Environmental Protection Agency

4. BUYER'S RESPONSIBILITY

Purchasing a portable analyzer for combustion emissions measurements requires planning and foresight. The buyer must define specifications for the PACE, and these specifications influence the overall cost and performance of the system. The specification serves as the basis for buying a system configured to meet the monitoring application.

A PACE specification extends beyond a simple list of instrument specifications. Development of a bid specification may require input from multiple disciplines including mechanical, electrical, instrumentation, and environmental engineering to ensure that the instrument satisfies the applicable regulatory requirements.

The purpose of the instrument specification is to help the buyer not only secure quotes from vendors, but also to be informative to the supplier, and useful as an evaluation tool when selecting a supplier. An instrument specification should address the following topics:

4.1 Purpose
The purpose should be a brief statement defining the equipment followed by a brief explanation of the application and the installation site. For example, *XYZ Corporation* will use a portable analyzer for combustion emissions to monitor NO_X ($NO + NO_2$) emissions from a natural gas engine for compliance with a periodic monitoring permit (*Anywhere, USA*).

4.2 Scope
The scope section should clearly identify the combustion source characteristics such as the type of equipment to be tested, the measurement parameters, the normal reporting range, the maximum and minimum concentrations the analyzer will be exposed to, the maximum and minimum ambient temperature conditions the analyzer will operate in, the maximum sample temperature range the probe will be exposed to, the necessary insertion depth for the sample probe, as well as any extraordinary over or under pressures at the sample location. The desired equipment list should also identify the desired data strategy (*e.g.*, internal data logging, computer interface, analog output, strip chart recorder) and necessary ancillary equipment such as calibration gases or regulators etc. Refer to Appendix 1 for the sample analyzer configuration guide.

4.3 Documentation
The type and number of documents to be clearly specified (*e.g.* operations manual, calibration certificates, maintenance manual)

A specification developed according to the principles outlined above is provided as Appendix 1. This specification is offered only as a guideline. Site-specific conditions, regulations, and permit conditions will dictate the precise parameters for a given application.

5. QUALIFYING VENDORS

Before writing a specification, the buyer must decide which companies to consider as qualified suppliers. Potential sources of suppliers include the list of ICAC members, ICAC online buyers' guide, as well as other sources which list emission and combustion analyzer manufacturers.

Portable analyzers for combustion emissions manufacturers are specialized companies dedicated to manufacturing analyzers specifically designed for stack gas monitoring applications.

Which type of supplier is best? The answer to this question is dependant on the application and on the buyer's preferences, background, and engineering expertise. The intent of this document is not to specify one type of portable analyzers for combustion emissions supplier, but to provide guidance for narrowing the supplier field to those suppliers best able to meet the application's specific needs.

The buyer should pre-qualify bidders before issuing a bid request. This practice will eventually make the final selection process easier by reducing the number of firms being considered. Criteria for pre-qualification of portable analyzers for combustion emissions suppliers include:

- Experience, size, and resources of the supplier;
- Technical competence, staffing, and inventory of spare parts;
- After-sales support and service;
- Technology expertise,
- End-user references;
- Quality assurance aspects;
- Warranty, and;
- General comfort factors (*e.g.*, rapport with the supplier's personnel).

An important aspect of any monitoring system is its cost. There are two types of costs associated with a PACE: purchase costs, and ownership costs. The initial purchase cost is obvious and easily evaluated. The ownership cost is divided into three areas: 1) Parts replacement. Typical replacement parts are sensors or sensor components, filters and pump related components. 2) Field calibration and the required hardware and/or factory calibration services should be evaluated. 3) The supplier's time commitment to replace parts and perform calibrations. Field replaceable parts verses factory replaceable parts should be a consideration in the bid evaluations.

Considering these topics, portable analyzers for combustion emissions suppliers can be quickly pre-qualified. The pre-qualification process should give the buyer a short list of vendors that, in the buyer's confidence, can supply a portable analyzer for combustion emissions meeting the buyer's specifications and expectations. Exploring the capability and compliance to specifications is left to the evaluation process.

6. EVALUATING THE PROPOSAL

After soliciting quotes from the group of pre-qualified suppliers, the buyer then faces the most important task: evaluating the quotes and selecting the portable analyzers for combustion emissions supplier. A carefully written specification will usually assure that bids will be tailored to the buyer's needs.

Evaluating any quote will require careful comparison of design features and technology of the system, its components, and performance characteristics such as:

- Sample probe and sample line
- Sample conditioning system
- Moisture removal system
- Direct measurement of NO and NO_2
- Temperature compensation
- Display and data output
- Data acquisition / software
- Calibration method and frequency
- Serviceability and method of sensor replacement (If required)
- System performance specifications
- System upgrade capabilities
- Normal expected system maintenance.
- Third party testing (*e.g.* TÜV, UL, ETV)

Commercial terms and conditions also require considerations when appropriate. These should include but not be limited to:

- System warranties and guarantees
- Training
- Payment terms
- Delivery schedule

To make the purchase process easier, the buyer should develop a process that assists, and documents the results of the evaluation. During this process, a set of questions and/or data sheets should be created to summarize each bidder's offer.

Appendix 1 provides a sample specification for portable analyzers for combustion emissions.

Appendix 2 provides an example Bid Evaluation form. The Bid Evaluation form helps to identify those bidders that have included all items, and that have submitted complete information. Reviewing each proposal for completeness can explain major cost differences between vendor bids.

APPENDIX 1- SAMPLE PACE SPECIFICATION

1 Purpose

XYZ Corporation issues this specification to solicit proposals for a Portable Emission Analyzer. The analyzer will be required to monitor gas emissions.

2 Scope of Supply

This specification is for the purchase and delivery of a fully assembled and operational Portable Emission Analyzer as described in this document.

2.1 Components of Portable Analyzer for Combustion Emissions –

2.1.1 Gas analyzers to measure the concentration of the following parameters in stack flue gas: O_2, CO, CO_2, NO, NO_2, SO_2, H_2S.

2.1.2 Analyzer designed to meet the specific application (*e.g.*, boiler, turbine, and, furnace) and or intended purpose or permit condition.

2.1.3 Portability of analyzer – Percent self contained, size (W × H × L) weight, sensor technology utilized, calibration stability, calibration capability,
2.1.4 Data Output – Type of data display – for example on-board screen (*e.g.* LCD, LED), printing capability, other output capabilities (*e.g.* analog.
2.1.5 Operating software and/ or Data Acquisition Handling System Software- List of options (*e.g.* tabular, graphic, non-corruptible)
2.1.6 Sample probe length and diameter and maximum temperature specification.
2.1.7 Sample transport line, approximately XX ft. in length.
2.1.8 Sample conditioning system as required to condition and prepare samples for analyzer.
2.1.9 All ancillary components such as: (*e.g.*, filters, printer paper, interconnecting cables), necessary to ensure proper operation of the system
2.1.10 A case designed to transport, house and protect the analyzer and sample lines.
2.1.11 Calibration gases, cylinder regulators, supply manifold and auxiliary devices necessary to perform calibrations if required.

2.2 Documentation
Provide documentation in the form of an operation and/or maintenance manual, recommended spare and consumable spare parts.

3 Application Description

The *XYZ Corporation* plant is located in (*Any City, Any State*). Measurements to make when and where at this plant

3.1 Conditions at Testing Locations
3.1.1 Sampling location port – what type of access, height from ground, port diameter, etc
3.1.2 Ambient Temperatures
3.1.2.1 Extreme minimum temperature: ____ °F
3.1.2.2 Extreme maximum temperature: ____ °F
3.1.3 Ambient dust at sample location: high or low
3.1.4 Relative humidity range: ________ %
3.1.5 Expected elevation: ____ ft. above sea level
3.1.6 Electrical Interference (*e.g.*, radio frequency, microwaves)
3.1.7 Stack conditions (diameter, wall thickness and stack construction)

3.2 Process Conditions –
3.2.1 Combustion Specifications –
3.2.1.1 Type – (Boiler, Burner, engine, etc.)
3.2.1.2 Primary Fuel __________
3.2.1.3 Alternate fuel _________
3.2.1.4 Temperature __________
3.2.2 Temperature Conditions within Flue Gas Stack
3.2.3 Stack temperature _______ °F
3.2.4 Stack pressure_________ inches in H_2O
3.2.5 Range of Stack Gas Stream (expected constituent concentrations)

Pollutant	Min (ppm)	Max (ppm)
CO_2		
CO		
O_2	%	%
NO		
NO_2		
SO_2		
Hydrocarbons		
H_2S		
Moisture	%	%
Dust Loading	µg/scfm	µg/scfm
Other		

3.3 Electrical power – Available as:
- 90 V to 230 V AC, 47 - 63 Hz

4 Design Parameters of Portable Analyzers for Combustion Emissions

4.1 Analyzers
4.1.1 Analyzer Quality
Analyzers provided should meet data quality requirements consistent with the intended purpose or permit condition. It is recommended that EPA ETV verified analyzer or other internationally verifiable bodies (*e.g.*, TÜV) be among the instruments evaluated.
4.1.2 Analyzer Specifications
Analyzers should be capable of satisfying applicable EPA and/or local agency specified performance criteria, if the analyzer will be used to verify environmental emissions compliance.

4.1.2.1 Analyzer- should be equipped with a direct readout display, or an independent remote display. Analyzers should have the capability of displaying concentration in parts per million (ppm) units. At a minimum, discrete error messages indicate:

4.1.2.2 Analyzer malfunction
Measured concentration exceeds predefined limits

4.2 Sample Probe Design

4.2.1 The standard probe should be constructed of materials that are corrosion resistant and chemically inert with respect to the process gases being sampled.

4.2.2 The probe pipe should be fabricated to a length that ensures representative samples are obtained for analysis.

4.2.3 Filters or other suitable methods to mitigate plugging resulting from uptake of particulate matter will be supplied. Replacement of filters should be possible and require minimal effort.

4.3 Sample Line- All sample transport strategies must prevent the absorption and/or loss of sample gas constituents such as NO_x (NO & NO_2) and SO_2. Sample hose should be proven to not degrade the measurement accuracy.

4.3.1 Sample tubes should be appropriately sized to minimize sample transport and lag times.

4.3.2 Overall physical characteristics such as diameter, overall length, bending radius and weight should be minimized to facilitate portability.

Heated sample line (if required by the moisture removal system or agency/ regulatory authority)

Heated sample lines are designed to prevent the condensation of moisture and the loss of sample gas constituents such as NO_x and SO_2 into condensation by maintaining the sample above 250°F and or the dew point. Additionally, the gas transport tube inside a heated sample line is manufactured from materials that prevent absorption of these sample gas constituents. Heating should be consistent with the temperature limitations of the sample line's tube materials. A temperature sensor may be required to monitor or control the heated line. Heated sample lines must be designed to withstand repeated bending and flexing seen in portable applications. See ICAC's EM-4 for more information on Sample Transport Bundles.

4.4 Sample Conditioning System

4.4.1 Conditioning System Components:

4.4.1.1 The sample conditioning system should include an acceptable moisture removal system, if required by the chosen analyzer system.

4.4.1.2 The sample conditioning system should not degrade the accuracy of the measurement.

4.4.1.3 The sample conditioning system should have the capability to condition and control calibration gases identical to the manner in which sample gas is conditioned.

4.4.1.4 The system may be designed to have integrated alarms or diagnostics that monitor operation of the system and provide warning whenever sample conditions exceed operational limits.

5 Documentation

5.1 Operation and maintenance manuals

5.1.1 A minimum of one operation and maintenance manual should be supplied for the Portable analyzers for combustion emissions. The manual should provide:

5.1.1.1 Instructions for operation, system calibration, maintenance, and troubleshooting.

5.1.1.2 A list the recommended spare and consumable components for the system.

APPENDIX 2- SAMPLE PACE BID EVALUATION FORM

Note: Because these example forms encompass a variety of designs and situations, some of the items included may not be relevant in all cases.

Portable Analyzer	Vendor 1	Vendor 2	Vendor 3
Manufacturer			
Model No.			
Sensor type / Range and Response time (s): -			
-O_2 -- / /			
-CO -- / /			
-NO -- / /			
-NO_2 -- / /			
-SO_2 -- / /			
-H_2S -- / /			
-Hydrocarbons -- / /			
-CO_2 (calculated or measured)			
Other (Examples) HCl, HF, Formaldehyde, NH_3:			
Application specific testing requirements			
Boiler or turbine or other (specify)			
Calibration stability/ capability/ required frequency			
Sample Conditioning System:			
-Moisture Removal: Is the moisture removal system required?			
Integrated or Separate sample condition system			
Peltier chiller			
Permeation dryer			
Other			
-Condensate Removal			
None			
Peristaltic pump			
-Sample conditioning alarms			
None			
Type and alarm condition			
Temperature Compensation: -			
-Compensation - upon analyzer start-up/ initialization			
-Dynamic compensation			
-Temperature Control			

Portable Analyzer *Continued from page 9*	**Vendor 1**	**Vendor 2**	**Vendor 3**
Sample Flow Rate monitoring:			
Meets CTM-034 or CTM-030 or other			
-Electronic meter			
-Rotometer			
- Other			
- Other			
Analyzer Operating conditions			
-Maximum operating temperature (°F/°C)			
-Minimum operating temperature (°F/°C)			
-Maximum pump draw (inches W.C.)			
Instrument Alarms / diagnostics			
-List alarm types			
-List diagnostics			
Sensor over-range protection			
-List Sensor & type of protection			
Instrument Outputs			
-Software output			
-Analog output			
-Digital output			
Power requirements -			
DC Power - operating capacity in hours.			
AC power- power range capability			
Physical Characteristics			
Dimensions (H × W × D - inches/mm)			
Weight (lbs./kg)			
Display Screen Type			
Analyzer Case Type			
Case Sealing Rating			
Sample Probe			
What are the design features of the sample probe?			
What is the construction of the probe?			
What is the length of the probe?			
What is the diameter of the probe pipe?			
What is the temperature limitation for the probe?			
What types of filters are used?			
How many filters are used?			
Where are the filters located?			
Can the filters be changed without probe removal?			
What is the porosity of the filters?			

Sample Line	Vendor 1	Vendor 2	Vendor 3
Standard sample lines:			
Will sample line be provided?			
What are the dimensions of the sample line?			
What are the features of the sample line?			
What is the transit time from the probe tip to the analyzer			
What is the composition of the tubing?			
Heated sample lines:			
Does the sample conditioning system require a heated sample line			
What is the length of the heated line?			
What is the inner diameter?			
Is the heat tracing self limiting?			
How is heating monitored?			
What types of fittings and sizes and materials are used?			
What is needed to power the sample line			
What is the weight of the heated line?			
Documentation			
Will system documentation be supplied?			
Operations and Maintenance Manual			
Calibration gas certification reports			
How many copies of documentation will be provided?			
Will an electronic version of the document be provided?			
Will a shipping schedule be provided following receipt of order?			
Training/Service			
Will training be provided?			
Will training documentation be provided?			
Are key components field replaceable?			
Will training, repairs and services, be performed by manufacturer's personnel or supplied by third party personnel?			
Warranties			
What warranties will be provided for the system?			
What is the length of warranty for system components?			
Who is responsible for replacement parts?			
Who is responsible for service to install replacement parts?			

12 NOTES

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