Title: Standard Operating Procedure for Zero-Air Generators		
Procedure No: SOP-041	Revision No: 1.1 March 22, 2011	Page No.: 1 of 9

1. INTRODUCTION AND SCOPE

Continuous ambient air analyzers require multipoint calibrations on a routine monthly basis and after major maintenance is completed. This procedure describes the role of Zero-Air Generators in supplying pure, dry air as a source of calibration standard. This Standard Operating Procedure details two alternate Zero-Air sources: Perma Pure Inc.'s Zero-Air Generator (ZAG), and Advanced Pollution Instrumentation's (API) Zero-Air Module.

This method adheres to the requirements of the current Air Monitoring Directive (AMD) drafted by Alberta Environment in 1989. In some cases the limits and specifications exceed the requirements of the current AMD and subsequent amendments. It should be considered that the current and any future amendments or drafts of the AMD will be used as the benchmark for requirements and criteria for ambient air monitoring practices conducted in the Province of Alberta. Information used to write this procedure was also taken from sources identified in the reference section.

2. PRINCIPLE OF THE METHOD

The principle of this method uses alternate systems to introduce high purity, particle free, dry air as a source of calibration standard. This is done by bringing ambient air into a Zero-Air source, where it is compressed and then purified using a combination of membranes, adsorbents, and filters.

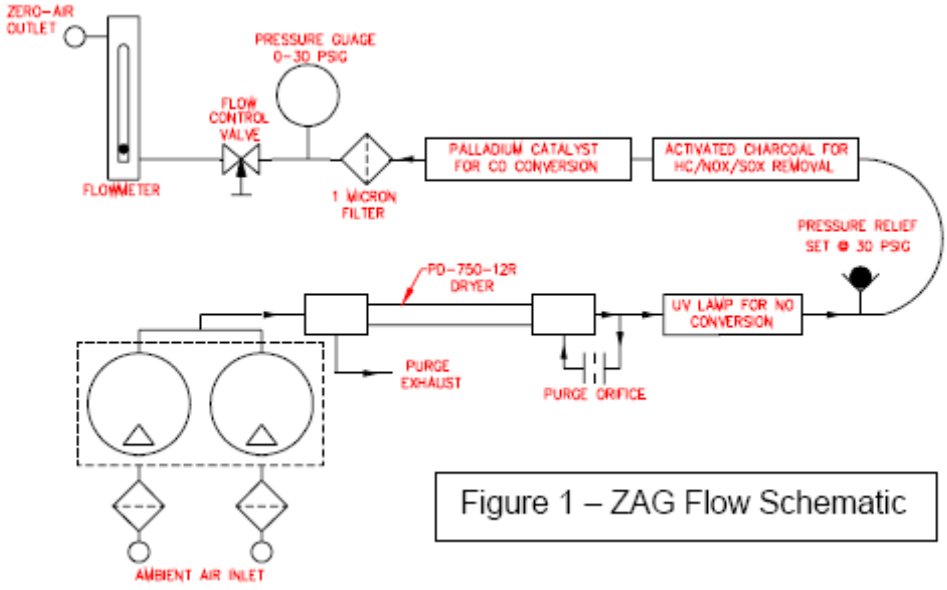

Figure 1 – ZAG Flow Schematic

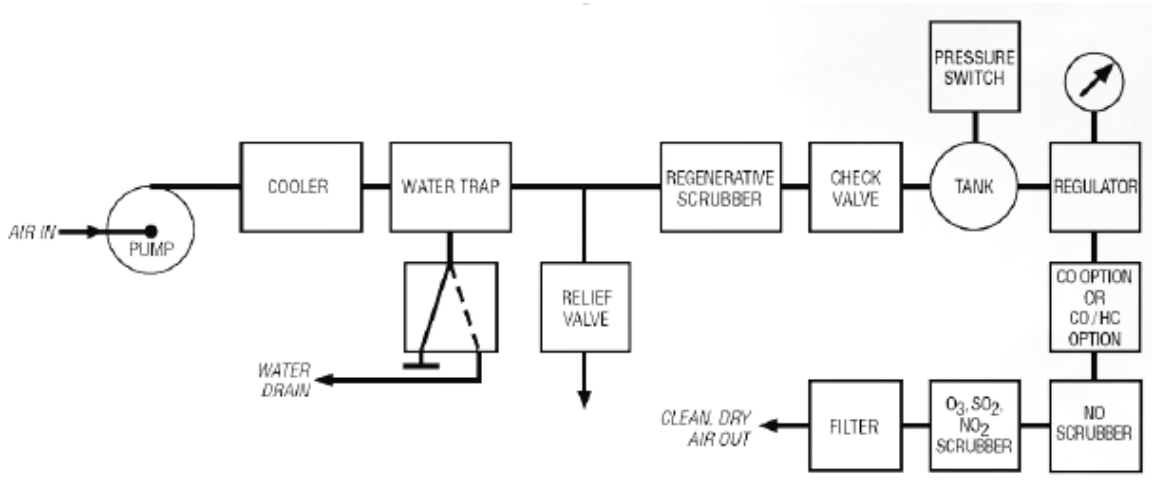

Figure 2 – API Model 701 Flow Schematic

Both zero-air systems are capable of the following outputs:

- Perma-Pure ZAG – 18 SLPM @ up to 30 PSIG.
- API – 10 SLPM @ 30 PSIG.

The API Zero-Air System is capable of cleaning the air stream to allow the following maximum output concentrations:

- SO2 < 0.5 ppb.
- NO < 0.5 ppb.
- NO2 < 0.5 ppb.
- O3 < 0.5 ppb.
- CO <0.025 ppm (requires optional scrubber).
- Hydrocarbons <0.02 ppm (requires optional scrubber).

MEASUREMENT RANGE AND SENSITIVITY

Not applicable

3. EQUIPMENT AND APPARATUS

Zero-air is supplied in this method by either of the following systems:

- Perma Pure Inc. Zero-Air Generator (ZAG) Model ZA-750-12.
- Advanced Pollution Instrumentation (API) Model 701 Zero-Air Module.

4. INTERFERENCES

It is not recommended that the API 701 be used to generate air at a flow rate greater than 10 LPM. The internal CO scrubber is not as efficient at the higher flow rates (e.g., 20 LPM); therefore, caution should be taken when exceeding 10 LPM. Decreased scrubber efficiency presents itself as an increased CO analyzer baseline. An external Hopcalite or Carulite scrubber can be added to the API 701 to remove any CO not eliminated by the scrubber at higher flow rates (USEPA).

5. PRECISION AND ACCURACY

Not applicable

6. SITE REQUIREMENTS

Zero-air generation is part of the calibration process; all calibration equipment should be set up inside a temperature controlled structure to avoid influence of temperature drift. It is also recommended to not set up equipment outdoors due to effects of the weather, i.e. rain, wind, dust, temperature, etc. The zero-air source should be set up so the controls and display are easily accessible.

7. INSTALLATION REQUIREMENTS

ZAG

1. Place the ZAG on a level, dry surface.
2. Check to make sure the power switch is in the 'off' position.
3. Plug the unit into a standard 110V electrical outlet.
4. Open the flow control knob fully (turn knob counter-clockwise).
5. Connect the calibration gas line to the ¼" tube compression fitting located on the top panel of the generator.
6. Turn the power switch to the 'on' position.
7. Adjust the flow control valve to the desired air output. Maximum capacity is 18 litres per minute.
8. High purity air is introduced within minutes of start-up.

API

1. Turn on the front panel POWER SWITCH.
2. The front panel POWER light should come on.
3. The cooling fan should start immediately.
4. The compressor should start after a few seconds delay. The delay is to allow the control board to measure the local line frequency.
5. After 30 to 60 seconds, the front panel pressure gauge should read 30 psig.
6. The Model 701 then produces clean dry air.

If the 701 has been unused for several days, it may take 30-60 minutes to achieve final purity and dryness.

8. OPERATIONAL REQUIREMENTS

ZAG

Airflow proceeds in order through the following components (see Figure 1):

1. *Perma Pure Dryer*

   Water vapor and certain polar organic compounds (i.e. alcohols, ketones) are removed here. A bundle of Nafion® tubes is housed inside the dryer shell. As the wet compressed air flows through the tubes, the water vapor is absorbed through the membrane and carried off by a counter-current purge air flow at a reduced pressure. The driving force for this process, known as permeation distillation, is the difference in partial vapor pressure of water between the product and purge gas flows. In this system, a portion of the dried air is expanded and used as the purge gas.

2. *Ultraviolet Lamp*

   Used for the destruction of bacteria into carbonaceous by-products. The lamp produces approximately 1-3 PPM of ozone (O3), which then breaks down microorganisms into carbon compounds that are removed further downstream. The lamp also oxidizes NO to NO2, which is readily removed by system adsorbents.

3. *Activated Carbon/Alumina Mixture*

   This is a blend of high performance activated carbon and impregnated alumina pellets. This mixture will remove trace quantities of chlorine (Cl2), hydrogen fluoride (HF), hydrogen sulfide (H2S), nitrogen oxides (NOx), ozone (O3), sulfur dioxide (SO2), sulfur trioxide (SO3), and general hydrocarbons (HC). In addition to removing these substances, the mixture changes from purple to brown, indicating the need for replacement.

4. *Carbon Monoxide Catalyst*

   Palladium impregnated alumina pellets are used to convert low levels of CO to CO2. This catalyst is not consumable, and should last for the lifetime of the unit.

5. *1µ Particulate Filter*

   The last stage of purification is the particulate filter. This filter has an absolute retention rating of 1 micron, and a 93% rating for particles down to 0.1 micron. The disposable filter is housed in a transparent plastic housing, allowing easy visual determination of the filter's condition (ZAG).

API

The compressor draws air in from the rear panel bulkhead union and inlet filter. At the compressor outlet, the air is under pressure and hot from the compression. The relative humidity is high as a result of the high pressure.

The air is conducted through the cooling coil where heat is removed by transfer to the cooling fan air. With the pressure still high but the temperature reduced to ambient, the relative humidity is at its highest. At this point, the air is usually supersaturated.

From the coil, the wet air passes through a coalescing filter where the excess water is separated and settles in the bottom of the filter. The controller periodically opens the solenoid drain valve allowing the water to be expelled through a rear panel bulkhead union (drain).

The partially dried air passes a pressure relief valve, set to open at 90 psig., and enters the regenerative scrubber, which removes essentially all the remaining water and a portion of the other contaminants.

The dry air then passes through a check-valve to the storage tank. A pressure switch turns off the compressor when the pressure in the tank reaches a set high value, and turns the compressor on when the pressure reaches a set low value. Thus, when air demand is low, the compressor is turned off and the tank fulfills the demand. The pressure in the tank varies from approximately 35 psig to approximately 75 psig depending on the demand. As the air leaves the tank, its pressure is controlled to 35 psig by an air pressure regulator mounted on the front panel. This maintains a constant pressure at the calibrator inlet and is displayed by the pressure gauge on the 701 front panel.

For a final clean-up, the dry, regulated air enters the specific scrubbers:

First, the optional CO scrubber, where CO is catalytically oxidized to CO2, or the optional Hydrocarbon scrubber where Hydrocarbons and CO are catalytically converted to CO2 and water. Then, the NO scrubber where NO is oxidized to NO2, then, the activated charcoal scrubber where the NO2 is absorbed. Finally, the clean dry air passes through a fine particulate filter and leaves the 701 through the rear panel bulkhead union (Zero Air Out).

When air usage is high (say 5-20 LPM), the compressor runs continuously. When air usage is low, the pressure switch turns the compressor off until the storage tank pressure drops to 35 psig, then turns the compressor on again.

There is no need for the user to turn off the 701 when air usage is low (API).

CAUTION: Do not operate the 701 without connection to a calibrator for more than a few minutes. Operating without restriction will increase the dew point and cause the scrubbers to become wet and/or shorten the lifetime of the pump.

9. CALIBRATION

There are no calibration procedures for zero-air generators however listed below are maintenance routines that ensure that the instrument operates properly.

ZAG

Routine maintenance on the ZAG consists of periodic carbon replacement and outlet filter replacement. Under normal, intermittent use, the desiccant should last at least six months.

Activated Carbon/Alumina Replacement

The activated carbon canister is located behind the top panel. The top half of the canister is exposed to allow visual inspection of the mixture. As the mixture is used, its color changes from purple to brown. When ¾ of the canister has changed to brown, replace the mixture. The mixture cannot be regenerated and must be discarded.

Replacing the mixture:

1. Disconnect the three (3) air lines by loosening the ¼" compression nuts with a 9/16" wrench. Hold the bulkhead nut with a 5/8" wrench to prevent turning.
2. Remove the four (4) panel screws using a 1/8" Allen wrench and pull the top panel out.
3. Remove the black plug from the bottom of the canister using a 15/16" wrench.
4. Pour the pellets out, tapping the canister lightly to remove any that may remain inside.
5. Re-fill the canister by slowly pouring in the fresh activated carbon/impregnated alumina mixture. Tap the side of the canister while filling to settle the mixture and reduce air pockets.
6. Apply Teflon® tape to the plug and replace in the bottom of the canister tightening fully.
7. Replace the top panel using the panel screws.
8. Re-connect the three (3) air lines to the bulkhead fittings, making sure to re-connect to the proper ports. Once again, hold the bulkhead nuts in place using a 5/8" wrench (ZAG).

API

Cleaning:

1. Occasionally, depending upon the local conditions, check the inside of the 701 for excessive dirt or dust.
2. Particularly, check the cooling fan, cooling coil and compressor fan inlet.
3. Remove any dirt or dust with a vacuum cleaner. Do not use an air jet. This will only redistribute the dirt and will not remove it.

Checking the Tubing:

1. Under the vibration of the compressor, it is possible for some parts of the TFE tubing to abrade against nearby objects. This is most likely to occur with the tubing directly attached to the compressor.
2. Check to see if any signs of abrasion are present, and, if so, re-dress the tubing.
3. If any section of tubing appears to be heavily abraded, remove and replace it (API).

10. APPLICABLE DOCUMENTS

- **EM-041a** Perma Pure Inc. Zero-Air Generator (ZAG). *Model ZA-750-12 Operation and Maintenance Manual – Rev 9/99*.
- **EM-041b** Teledyne Instruments - Advanced Pollution Instrumentation Division (API*). Model 701 Zero-Air Module, Instruction Manual – Rev. E2*. July, 2005.
- **EM-041c** Thermo Scientific (TECO*). Model 111-A2R Zero-Air Supply Including External Air Compressor, Instruction Manual – Part Number 7734*. December 20, 2007.

11. LITERATURE REFERENCES

- U.S. Environmental Protection Agency (USEPA). *Standard Operating Procedures, Environics Series 9100 Computerized Ambient Monitoring Calibration System. Version 0.01 – Draft.*

12. REVISION HISTORY

Revision 0 (new document)

Revision 1.0 – Section 9 – Added caution statement under API 701.
Changed Team Leader to Manager
Added footer

Revision 1.1 - Added Thermo model 111 air supply reference Section 10

13. APPROVAL

Approved by: **Harry Benders** **Date: March 22, 2011**

Title: **Air Monitoring Manager**