Evaluation of Historical Methods for Determination of Total Volumes Collected in RETS/REMP Air Monitoring Applications with Currently Available Technology

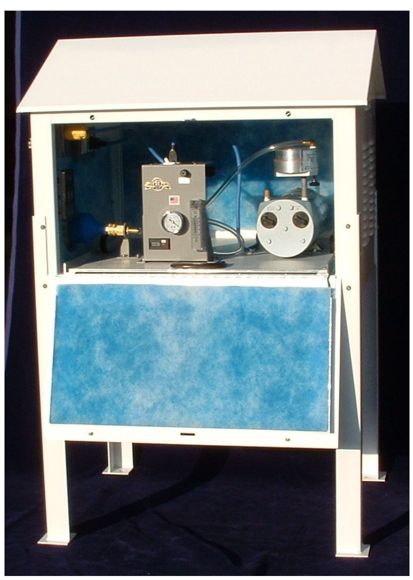
Historically, RETS/REMP air monitoring programs have utilized a variety of assembled components to achieve the ultimate goal of sampling ambient air for radioactive particulate matter and gaseous radioiodine species. One of the main objectives is to determine the total sample volume that has been passed through the particulate and/or charcoal filter.

The typical basic components utilized in these air monitoring systems of traditional designs are listed in Table A below.

TABLE A
Basic Components

Component	Type
Vacuum Pump:	Oilless Carbon Vane Pump
Flowmeter:	Variable area rotometer
Flow Regulator:	Constant flow regulator that automatically adjusts for filter dust loading
Elapsed Time Meter:	Electromechanical or electronic timer
Volume Totalizer:	Dry gas test meter

These components have been purchased individually and assembled locally inside an aluminum enclosure such as the well recognized "doghouse" enclosure utilized by the majority of nuclear utilities.



Alternatively, complete packages containing several or all of these components, including the weatherhouse enclosure; have been available from various USA suppliers. Optional items installed in these RETS/REMP air monitoring systems include the items listed in Table B.

TABLE B
Optional Features Employed in RETS/REMP Environmental Air Monitoring Systems

- Thermostatically controlled fans
- GFCI protection
- Multiple receptacle strips
- Light fixtures
- Heat Lamps
- Small heaters
- External gooseneck
- Removable base plates where all components are mounted to facilitate exchange of components

These systems have done the job over the years with some sacrifice on the part of accuracy and reliability of data.

Today RETS/REMP type air monitoring systems can be obtained with several of the advances in electronics that have become available over the past 15 years such as small powerful and relatively inexpensive microprocessors, surface mount electronics, low power digital displays, etc.

Air monitoring systems with current technology generally employ the following components:

- Vacuum pump
- Flow regulator
- All purpose microprocessor controlled electronic control center
- One or more of the options listed in Table B above

These all purpose electronic control centers generally provide several or all of the following features listed in Table C.

TABLE C

- Digital display of data values utilizing LCD, LED or VFD displays
- Accurate flow sensor
- Very accurate elapsed time meter
- Very accurate determination of flowrate corrected to STP
- Very accurate volume totalization corrected to STP
- Measurement of air flow temperature
- Absolute pressure measurement (usually at entry to flow sensor)
- Auto shut-off on time, selectable by operator
- Auto shut-off on volume, selectable by operator
- Data export capability through RS232
- Data storage
- Programmability by operator of periodic sampling intervals
- Data acquisition, data management and report software
- Capability for real time interaction with field instrument (some additional hardware required)

Some of the above features are more sophisticated than others and apply to applications requiring more frequent, more detailed operator intervention and/or access to the field instrument from a distant location.

The pros and cons of the traditional systems vs. the current technology systems are examined below in Table D.

TABLE D
Comparison of Traditional RETS/REMP Sampling System Designs with Current Technology Designs

		Traditional Technology	Current Technology
1.	Flow Rate Accuracy	Maximum 5% at time of reading. Easy to make errors reading rotometers. No record of measured flowrate.	2%-4% for long term unattended monitoring applications. Errors are at a minimum in reading a digital display. Flow rate record vs. time is available.
2. (a)	Volume Totalization Accuracy without dry gas test meter	Very poor; usually start plus ending flowrate divided by 2 multiplied by elapsed time recorded by timer or time elapsed between the two readings of the rotometer. The value of flowrates in between readings is not known and results in unknown accuracy.	Excellent; Volume accumulation computed as frequent as once per second or other acceptable frequency are continually summed giving up-to-date volume accumulation on display and at the end of the measurement.
	Volume Totalization Accuracy with dry gas test meter	Marginal; The volumes measured are actual volumes at the temperature and pressure at which the gas flows through the meter at any point in time. Can't compare volumes at different plant sites or at different times at the same plant site.	Volumes collected at one NPP can be compared to volumes collected at any other NPP location, regardless of elevation differences, seasonal differences or short term climatic changes between sites.
(b)	Capability to correct Volumes to a reference temperature and pressure	None; If dry gas meter is used for volume totalizations; it does not correct for pressure changes and unless it is a temperature compensated meter, it does not correct for temperature changes. Volumes reported are actual volumes, which vary from day to night and season to season due to variations in pressure and temperature during the sampling period.	Excellent; Systems can be set to correct incremental volumes to any reference temperature and pressure or even to report actual volume, if desired.
3.	Size Requirements	Dry Gas Test Meter ~ 1540 cubic inches Elapsed Time Meter – negligible	Typical footprint range is approximately 30-144 cubic inches. Additional features implemented by software can be selected without increasing the footprint size.

Comparison of DGTM Volume Totalizer Dimensions with the Dimension of Current Technology Systems

TABLE D (Cont.)

		Traditional Technology	Current Technology
4.	Cost	Less expensive than top of the line electronic units. Comparable in price to electronic units that offer basic features of flowrate, volume totalization, digital displays and RS232 communication port.	Fully programmable units are 70% to 100% greater in cost than traditional technology units. Middle of the line units are comparable in price when you consider the costs of air sampler + timer + dry gas test meter and fittings.
5.	Calibration	Calibration of individual components is required. Calibration of components at different dates is not desirable.	Entire unit can be calibrated at one time as a single component.
6.	Maintenance	Maintenance expertise for various components required; different vendors involved	Single vendor involved provides maintenance service or maintenance instructions.
7.	Legal/Regulatory	Data accuracy is less than desirable. No certainties of operating conditions during unattended periods.	Data record available to determine the operating conditions at any unattended period of time. Greater accuracy of values improves data credibility with regulatory agencies and for use as evidence in legal proceedings.
8.	Calibration of Dry Gas Test Meter	Calibrations performed at pressure conditions that do not bracket the operating pressure range experienced in most RETS/REMP applications.	Calibrations performed for pressure ranges applicable to RETS/REMP system operating conditions. Current technology systems can be calibrated easily over the ranges of absolute pressures to which the monitoring system will be exposed to.

Filter and Flow Rate Impacts on Determination of Absolute Pressure Values at Dry Gas Test Meter (DGTM)

The absolute pressure created at the DGTM is a function of the filter combinations utilized in the sampling station and the flowrate at which the system is operated. To some extent, the piping length and inner diameter of connective piping will cause line losses to further decrease the absolute pressure at the DGTM.

More restrictive filter combinations, higher sample flowrates and larger line losses will lower the absolute pressure at the DGTM measurement point.

Refer to Table E below for a comparison of different filter combinations at two different flowrates. The data illustrates the magnitude of the pressure drop differences between filter combinations operating at 100 LPM and at 30 LPM.

TABLE E

Comparison of Pressure Drop Differences for Different Filter Combinations at Two Different Flowrates

Filter Combination	**Pressure Drop @ 100 LPM**		**Pressure Drop @ 30 LPM**	
	" H_2O	**" Hg**	**" H_2O**	**" Hg**
TE2C + FP47	59.5	4.38	15.0	1.10
TE3C + FP47M	37.4	2.75	8.3	0.6
TE1C + FP47M	34.1	2.51	7.2	0.53
AGZC58 + FP47	96.8	7.13	31.1	2.28
521147	51.8	3.81	13.4	0.98
0.45 µ membrane*	138.6	10.2	55.6	4.1

* Max. flowrate achieved was 80 LPM

Issues Involving the Absolute Pressure Conditions at which DGTM are Utilized in RETS/REMP Monitoring Applications

The range of differences for volume measurements not corrected to a reference temperature and pressure is primarily a function of the pressure drop that the combination of filters create and difference between the actual air sample temperature and a reference temperature such as 70ºF or 25ºC.

To help me demonstrate the pressure issues, I have obtained data comparing actual volumes obtained using a temperature compensated DGTM to volumes obtained with a microprocessor controlled volume totalizer corrected to 70ºF and 1 atmosphere pressure. The same air stream was passed through the DGTM and the STP correcting air sampler volume totalizer. A photo of the test setup is illustrated on page 9.

The differences in pressure, between the absolute air pressure (value) at the DGTM and a reference pressure, have a greater impact than the differences between the air temperature at the DGTM from a reference temperature.

Table F, on page 10, illustrates the test results comparing the DGTM volume utilizing typical RETS/REMP filter combinations illustrating a range of various pressure drop conditions. The larger the pressure drop across the filters, the greater the deviation of the DGTM actual volume from the reference volume corrected to STP.

Please note that even when the actual volumes determined by the DGTM are corrected to STP utilizing known P and T conditions that the corrected DGTM values differ substantially from the values reported by the instrument that automatically corrects to STP incrementally every second.

These differences can possibly be explained by examining the calibration methods and calibration conditions utilized by manufacturers of DGTM.

I discussed the calibration procedures utilized by Inversys, one of the largest manufacturers of gas meters in the USA. The calibration procedures utilized by the Inversys calibration lab implements a highly accurate Bell Prover calibration instrument which is operated at negative pressure (vacuum). The vacuum condition at maximum flowrate of the DGTM is 7” H_2O.

Good scientific practices always recommend that a measurement instrument should not be used outside the operating range for which it was calibrated. It is possible that DGTM utilized in RETS/REMP applications are being used at absolute pressure conditions outside the range at which these instruments were calibrated even for the least restrictive filter combinations typically utilized in these programs.

This aspect of RETS/REMP monitoring programs may require re-evaluation in order to ensure that the monitoring results being reported are consistent with standard scientific instrument measurement practices applicable to our industry.

Physical Test Setup for Comparing Volumes Determined by DGTM and Current Technology Systems

TABLE F
DRY GAS TEST METER ACCUMULATED VOLUMES AT VARIOUS VACUUM CONDITIONS

B.P. (“Hg)	Pressure Drop (“ Hg)	Flow Rate (LPM)	Filters	DGTM Final Reading	DGTM Initial Reading	DGTM Actual Volume (m^3)	DGTM @ STP (m^3)	DL-1 STP Volume (m^3)	% Deviation @ STP
29.95	4.06	92	TE2C+ FP47	36.38	25.30	11.08	9.59	10.020	-4.29
29.99	10.172	67	A080A047A	76.70	63.10	13.60	9.078	10.001	-9.92
29.99	14.46	54	TE2C+ CI47	63.11	47.80	15.31	7.941	10.001	-20.59
30.14	18.15	44.7	CI47(2)+AGZC58	93.23	77.00	16.23	6.50	10.000	-35.0

Temperature Correction: None made because temperature compensated meter was utilized

Pressure Correction:

$$V_{STP} = V_A \frac{(B.P. - \text{Pressure Drop})}{29.92\text{'' Hg}}$$

V_A = Actual volume
V_{STP} = STP volume @ 1 atm and 70ºF

% Deviation: @ STP

$$\frac{V_{DGTM(STP)} - V_{DL\text{-}1(STP)}}{V_{DL\text{-}1(STP)}} \times 100$$

Conclusion:

Organizations utilizing DGTM for volume totalizations in RETS/REMP air monitoring applications should reexamine their programs. An evaluation of these issues could include one or more of the following items:

(a) Determination of typical absolute pressure values at the inlet to the DGTM for the actual systems employed at the plant sites.

(b) Determination of the calibration conditions for pressure utilized by the manufacturer of the DGTM utilized in the RETS/REMP system at its maximum flow rate through the DGTM

(c) Evaluation of the probable errors in volume determination, obtained with use of the existing DGTM at the typical absolute pressure existing at each DGTM.

(d) Installation of temperature compensated DGTM to limit the measurement issues to the absolute pressures existing at the DGTM

(e) Determination as to whether use of DGTM at pressure conditions outside the range for which the instrument is calibrated is acceptable from a scientific and/or regulatory perspective.

(f) Report all volumes as actual volumes on data sheets and reports unless STP volumes are actually being determined.