

## AMBIENT AIR QUALITY MONITORING TECHNIQUES AND QUALITY ASSURANCE



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## Sources of Air Pollution

### Natural

- Forest Fire
- Volcanoes
- Dust storms

### Man made

- Domestic
- Industrial
- Vehicular
- Non point source

## Classification of Air Pollutants

Primary Pollutants (emitted in to the atmosphere directly from identifiable sources)	Secondary Pollutants (Those formed as a result of reactions among two or more pollutants)
Suspended Particulate Matter Sulphur dioxide Nitrogen dioxide Hydrocarbons Carbon monoxide Metals	Ozone Formaldehyde Peroxy Acetyl Nitrate (PAN)

## Typical Sources of some Air Pollutants

Air Pollutants	Major Sources
Sulphur Dioxide (SO <sub>2</sub> )	Fuel combustion, power station, industrial processes, chemical processes, diesel vehicles, solid waste disposal, smelters
Nitrogen Oxide (NO <sub>x</sub> )	Transport (road, rail, passenger and commercial), fuel combustion, power station, industrial boilers, chemical processes, waste incinerators, smelters
Particulate Matter (SPM, RSPM-PM <sub>10</sub> , RSPM-PM <sub>2.5</sub> )	Fuel combustion, power station, construction activities, industrial processes, diesel vehicle exhaust, re suspended road dust, domestic refuse burning, domestic wood
Carbon Monoxide (CO)	Transport, combustion, industrial processes, solid waste disposal, refuse burning
Ozone (O <sub>3</sub> )	Secondary pollutants formed during photochemical reaction

## Typical Sources of some Air Pollutants

Organic compounds	Transport, oil based fuel combustion sources, chemical processes, solvent use, waste incinerator, vaporization of fuel
Benzene	Petrol combustion products, petrol filling stations, chemical process
Polynuclear aromatic hydrocarbons (PAH)	Fuel combustion, industrial emission
Volatile organic compounds (VOC)	Transport, solvents (especially used in industrial and domestic sector)
Trace metals	Fuel combustion, chemical process, transport, metal production and finishing operation, product manufacture
Lead (Pb)	Lead additives in gasoline, soil originated particles
Cadmium	Fuel combustion, metal production process, transport

### -Site selection for rural and remote sites

- Selection of sampling sites is a critical factor in monitoring.
- Sampling sites should be located in areas suitable for the purpose.
- They should properly represent the area in question.

### -Criteria for Monitoring Sites

- Land use in the vicinity of the sites is likely to remain in almost the same condition for several decades.
- The samples should represent the area in question.
- Consideration of the topographic features and meteorological conditions should be taken into account.

### Minimum Distance to Emission Sources

- Regions *within 50 km* of large pollution sources should be excluded as remote sites.
- Regions *within 20 km* of large pollution sources should be excluded as rural sites.
- Regions *within 500 m* of main roads should be excluded as remote and rural sites.

### Local criteria

- An open, flat, grassy area far enough from trees, hills and other obstructions. No objects should be within a few meters of the collector, and no object should shade the collector.
- The top of an obstruction as viewed from the collector should be less than 30 degrees above the horizon.
- Regions within 100 m of emission sources (waste disposal sites, incinerators, parking lots, open storage of agricultural products, domestic heating) should be excluded.

### Site selection

- Intake points of automatic instruments should be **5 to 10 meters from the ground** if no obstructions are located around the sites.
- They should be around **3 meters higher** than the height of the buildings if buildings or other obstructions are located around the sites, or the intake points are on the buildings.

### Microscale Considerations for Site Selection

- Obstructions to local wind flow (avoid nearby buildings, walls or forests)
- Logistical factors such as site access, site security, availability of utilities
- Consistency with monitoring objectives

### Measurement parameters

- The first priority parameters for air concentration monitoring are **NO<sub>2</sub>** (urban), **SO<sub>2</sub>**, **O<sub>3</sub>**, and **NO**, and particle mass concentration. For particle mass concentration, it is recommended to start with a **10 μm cut-off**.

## Measurement instruments and monitoring interval

- For routine monitoring of the air concentration, **automatic instruments** are commercially or conventionally available for SO<sub>2</sub> (such as ultraviolet fluorescent (UVF) method), NO (such as chemiluminescence detection (CLD) method), O<sub>3</sub> (such as ultraviolet photometric method and CLD method) and PM10 (such as β-ray absorption method and TEOM method) to obtain one-hour averaged values.
- Chemical/Gravimetric method

## Ambient Air Monitoring Methods and Equipment

- Selection will be determined by the Aim of the Survey
- If only average concentration values of pollutants in low and **“smoothly” polluted areas** are required, then **non sophisticated** but trustworthy equipment is recommended.
- If **retracking** to emitting source and / or assessment of impact is intended, then sophisticated, **high temporal resolution** equipment might be necessary.

## MONITORING METHODS

- **Detector Tubes**
- **Passive / Diffusive Sampling**
- **Wet Chemical**
- **Continuous Monitoring**
  - **Point sampling**
  - **Open Path**

## DETECTOR TUBE

### ADVANTAGE

- **Quantitative**
- **Provides instant value**

## Passive Sampling

### ADVANTAGES

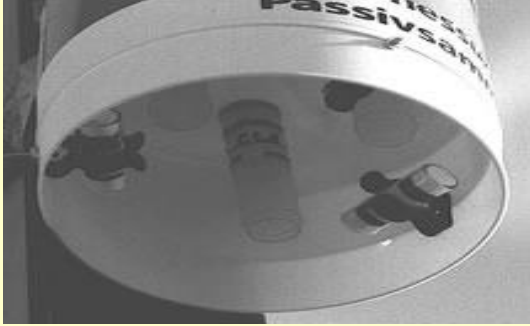
- Provides average values for a certain period of time usually between one week and one month
- Method requires no power supply for the sampling
- Method recognized as low cost of sampling as compared to other techniques
- Ideal for survey applications either in remote areas or assessment of personal exposure
- Samples can be collected from any part of the country and shipped to laboratory for analysis

## PASSIVE SAMPLING

### DISADVANTAGE

- **Peaks not available**
- **Co-relation with meteorological parameters not possible**

### Diffusion Tubes with Field Protection Shelter



### Sampling and measurement Techniques of air pollutants (Wet Chemical Methods)

Parameter	Technique	Instrument
SPM/RSPM	Gravimetric	HVS/RDS
SO <sub>2</sub>	Colorimetric	Spectrophotometer
NO <sub>2</sub>	Colorimetric	Spectrophotometer
Ozone	Colorimetric	Spectrophotometer
Metals	Spectroscopy	AAS
PAH	Chromatography	Gas Chromatograph
BTX	Chromatography	Gas Chromatograph

### State-of-the-Art “Wet” Chemical

#### Advantages

- low costs
- simple equipment
- normal laboratories’ performances sufficient
- accepted as basic reference methods
- internal calibration possible
- automatic integration of sampling period
- any chemically reactive component detectable
- small power required

### State-of-the-Art “Wet” Chemical

#### Disadvantages

- simplicity of equipment may lead to “easy handling”
- calibration of sampling system absorption solutions and analytical procedures are necessary, “Ring Test” required
- “normal” laboratory performance must yield maximum accuracy
- integration results in loss of short-time-event-tracing
- higher risk of “non-reliability” by contamination
- universality is also the crux as to interferences

### High Volume Sampler (HVS)



## Conclusion

No beauty but reliable reasonable  
and nearly always feasible

### Measurement of VOCs in Ambient air using Canister sampling method

Canister :

- It is made of stainless steel and is electro polished from inside.
- It is commercially available.



### Personal Sampling Pump And Sorbent Tube



### Need for Automatic Monitoring System

- Continuous Information Flow
- Warning at critical period
- Accuracy and precision of information
- Minimise Human Error

### Continuous Instruments

#### A Glimpse on Physics Behind

- NDIR Absorption : carbon monoxide
- UV / VIS / IR Absorption : ozone, hydrocarbons
- UV Fluorescence : Sulphur dioxide
- Chemiluminescence : nitrogen oxides, ozone
- FID : hydrocarbons
- Beta ray absorption, light scattering, TOEM : SPM
- Particle size analysers : impactors, particle counters etc.
- GC - FID, PID : Benzene, Toluene, Xylene

### Continuous Instruments

#### Advantages

- low response times less than 1 min
- high selectivity
- high temporal resolution in non-stop coverage
- good stability under normal conditions
- intermittent calibrations and zero checks automatically or manually triggered

### Continuous Instruments

#### Disadvantages

- high costs in investment and maintenance
- **all**, as to "high tech" application in field (non-Laboratory-conditions)
- **calibration** methods, systems and units required; science of their own; "Ring Tests" absolutely necessary
- highly qualified personnel required for service, calibration checks, data acquisition etc.
- integration requires computerization
- ambient conditions, e.g. dust, shocks, condensation may cause serious problems

## On Line Measurement of BTEX



This technique for measurement of air pollutants (VOCs) in the ambient air provides real time/instant data.

## Conclusion

**Powerful, but expensive and requiring endeavour and endurance** besides enthusiasm

## OPEN PATH

### ADVANTAGE

- Many parameters with same instrument
- Average concentration for the path length
- Less moving parts

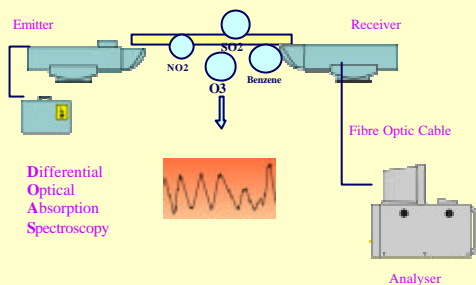
### DISADVANTAGE

- Effect of environmental conditions
- Calibration not easy

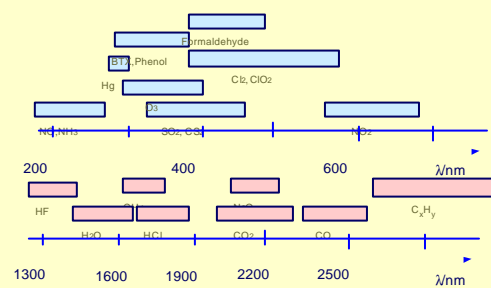
Continuous air quality monitoring using open path monitoring device



## Open Path Monitoring DOAS Technique



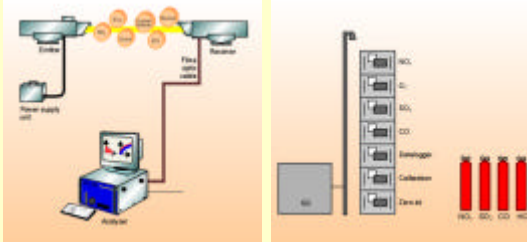
## Wavelength Intervals



## Open Path (DOAS) vs Conventional

Path average, no sampling

Point average, gas sampling and treatment



## Certified materials and certified samples (Traceability)

- In order to assure the reliability of measurements, the certified solution and certified materials that were certified for traceability should be used.
- Standard weights for analytical balance
- Absorbance and wavelength filters for spectrophotometer
- Chemical standards

## Importance of QA/QC activities

- Considering the significance of possible future problems regarding acid deposition, it becomes increasingly important to obtain accurate and precise data on acid deposition.
- However, informed decisions cannot be made on the basis of unreliable data, and therefore certain levels of data quality should be assured.
- A monitoring system without adequate QA/QC runs the risk of not being able to control the quality of data, and not being able to assure accuracy and precision.
- QA/QC has thus become essential part of all measurement systems because it requires especially high international comparability of data.

## Objectives of QA/QC program

- The objectives of this QA/QC program are to obtain reliable data which can be comparable with other networks by ensuring data accuracy, precision, representativeness and completeness in monitoring.

## Coverage of QA/QC programs

- QA/QC programs should cover the whole process of monitoring activities, starting from sampling activities to the end, reporting.
- All the related organizations need to implement QA/QC activities.

## Definition of QA/QC

- **Quality control (QC):** the routine use of procedures designed to achieve and maintain a specified level of quality for a measurement system
- **Quality Assurance (QA):** a set of coordinated actions such as plans, specifications, and policies used to assure that a measurement program can be quantifiable and produce data of known quality
- QA is quality control for QC.

## Calibration of HVS

### Requirements for calibration of HVS

- Roots meter
- Top Loading Orifice Kit
- Soap bubble apparatus/meter

### Why to Calibrate

- Calibration of HVS is necessary to establish traceability of field measurement to a primary standard via flow rate transfer standard
- The most common flow rate transfer standard used for calibration of flow of HVS is orifice method
- As air pollutants concentration is expressed as mass per unit volume of air, the accuracy of flow measurement is very important

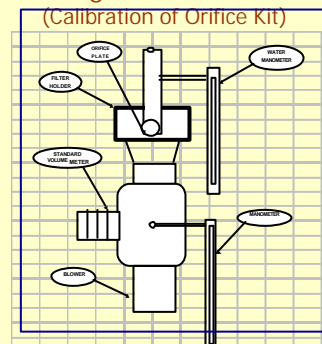
### When to Calibrate

- Single point Calibration
  - Once in a month
- Multi point Calibration
  - When sampler is first installed
  - Every six months
  - After major repair work
  - When a one point calibration check deviates by more than  $\pm 7\%$  from the calibration curve

### What to Calibrate

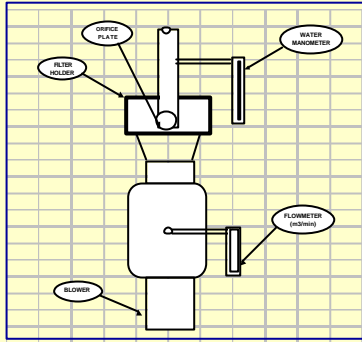
- Flowmeter / Manometer
- Rotameter

### Flow Diagram of Roots Meter (Calibration of Orifice Kit)

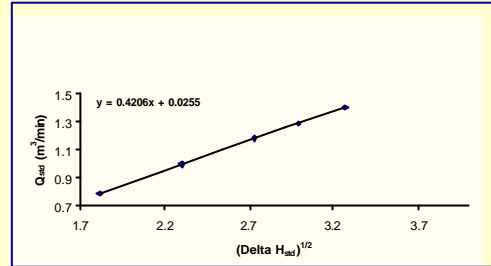




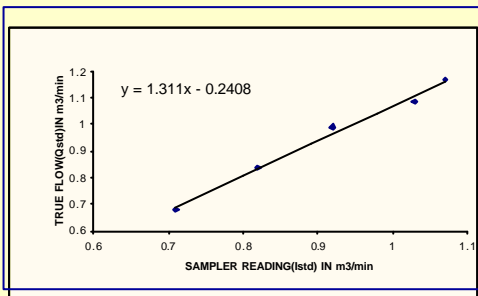
### Flow Diagram of calibration of HVS



### Calibration Graph for Orifice Kit



### Calibration Graph for HVS



### Hierarchy of Calibration

Static Dilution /UV Photometry(Ozone)

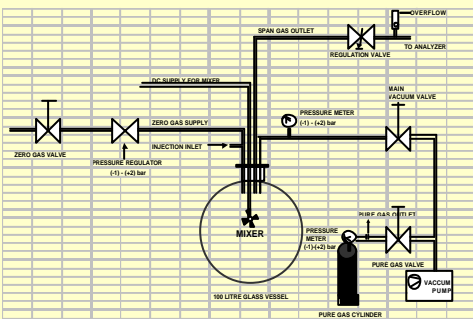


Permeation system

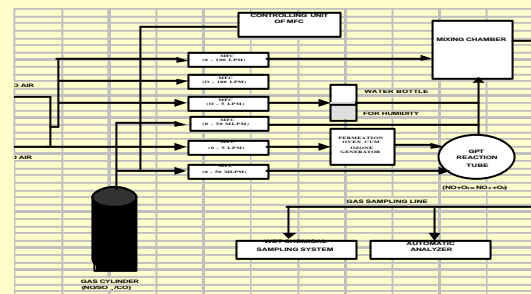


Wet chemical techniques

### STATIC VOLUMETRIC DILUTION



### DYNAMIC DILUTION SYSTEM (RING TEST FACILITY)



## On-Going QA/QC Activities

- Daily automatic calibration checks
- Manual calibrations every 2 weeks
- Linearity checks
- Flow rate checks
- Visual check of met sensors
- Daily checklist

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## Quality Assurance

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## Quality Assurance for AQM Networks

- Systems audits
  - Operating procedures
  - Calibration procedures
  - Maintenance procedures
- Performance audits
  - Flow rate checks
  - Reference standards for continuous monitors and met equipment
  - "Blind" standards for off-site laboratories
- Data quality review
- Develop corrective action plans

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## Data Management

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## Data Management for Networks

- Data acquisition
- Data reduction
- Data validation
- Data analysis

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## Data Acquisition

- Automatic data polling
- Review for outliers
- Preset software alarms w/telephone notification
- Daily data polling
- Loading into permanent database (e.g., Oracle)

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## Data Handling

**Data Reduction** = Manipulation of raw data to create intermediate products such as averages, minimum values, maximum values, and standard deviations

**Data Validation** = Systematic review of measurement data for outlier identification, error detection, reasonableness, or exceedance of acceptance criteria. Data validation identifies suspect data whereas QC activities prevent bad data from being collected.

**Data Analysis** = Interpretation of data to identify data trends, understand underlying causes of pollution events, relate concentration to meteorological conditions, etc.

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## Data Validation

- Level I** - Validity checks of raw monitoring data
- Level II** - Independent evaluation of results
- Level III** - Review to identify data outliers and anomalies

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## Acceptance Criteria

- Routine check and review procedures
- Tests for internal consistency
- Tests of consistency of data with previous data sets
- Tests of consistency with data collected under similar conditions

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## Reporting of Monitoring Data

- Total number of samples
- Percent data capture
- Mean, median, minimum, and maximum values
- Detection limits (DL's)
- Frequency above and below DL's
- Number of exceedances
- Upwind versus downwind

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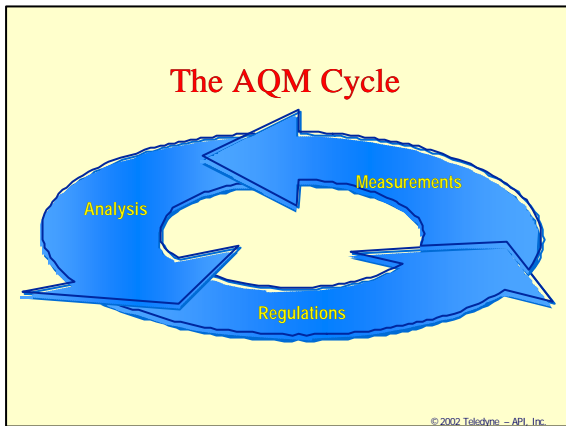
## Measured data

- **The units** to be used for SO<sub>2</sub>, NO/NO<sub>2</sub> and O<sub>3</sub> should be ppb, and that for PM should be µg/m<sup>3</sup>.
- For automatic instruments, SO<sub>2</sub>, NO/NO<sub>2</sub> and O<sub>3</sub> should be expressed **one digit under decimal**, and PM should be expressed by integral numbers (e.g., 15.3 ppb for SO<sub>2</sub> and 52 µg/m<sup>3</sup> for PM).

## Reporting of Meteorological Data

- Hourly averages for all parameters
- Summary wind roses
- Percent data capture
- Summary of atmospheric stability
- Mean value and range for each parameter

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**CENTRAL POLLUTION CONTROL BOARD, DELHI**  
**NATIONAL AMBIENT AIR QUALITY STANDARDS**

Pollutant	Time Weighted Average	Concentration in Ambient Air			Method of Measurement
		Industrial Area	Residential Rural and other Areas	Sensitive Area	
Sulphur Dioxide (SO <sub>2</sub> )	Annual Average*	80 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>	15 µg/m <sup>3</sup>	1. Improved West and Gaeke Method 2. Ultraviolet Fluorescence
	24 Hours Average**	120 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>	
Oxides of Nitrogen (as NO <sub>2</sub> )	Annual Average*	80 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>	15 µg/m <sup>3</sup>	1. Jacob & Hochheiser modified (NaOH-NaAsO <sub>2</sub> ) Method 2. Gas Phase Chemiluminescence
	24 Hours Average**	120 µg/m <sup>3</sup>	80 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>	
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m <sup>3</sup>	140 µg/m <sup>3</sup>	70 µg/m <sup>3</sup>	High Volume Sampling (Average flow rate not less than 1.1 m <sup>3</sup> /minute)
	24 Hours Average**	500 µg/m <sup>3</sup>	200 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>	
Respirable Particulate Matter (Size less than 10µm) (RPM)	Annual Average*	120 µg/m <sup>3</sup>	60 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>	Respirable Particulate Matter Sampler
	24 Hours Average**	180 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>	75 µg/m <sup>3</sup>	
Lead (Pb)	Annual Average*	1.0 µg/m <sup>3</sup>	0.75 µg/m <sup>3</sup>	0.50 µg/m <sup>3</sup>	AAS Method after sampling using EPA 2000 Or equivalent filter paper
	24 Hour Average**	1.5 µg/m <sup>3</sup>	1.0 µg/m <sup>3</sup>	0.75 µg/m <sup>3</sup>	
Carbon Monoxide (CO)	8 Hours Average**	5.0 mg/m <sup>3</sup>	2.0 mg/m <sup>3</sup>	1.0 mg/m <sup>3</sup>	Non dispersive Infrared Spectroscopy
	1 Hour Average	10.0 mg/m <sup>3</sup>	4.0 mg/m <sup>3</sup>	2.0 mg/m <sup>3</sup>	
Ammonia (NH <sub>3</sub> )	Annual Average*	100 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>	
	24 Hour Average**	100 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>	100 µg/m <sup>3</sup>	

\* Annual Arithmetic mean of minimum 104 measurements in a year twice a week 24 hourly at uniform interval.  
\*\* 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

NOTE  
1. National Ambient Air Quality Standard - The levels of air quality necessary with an adequate margin of safety, to protect the public health, vegetation and property.  
2. Whenever and wherever two consecutive values exceed the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.  
3. The State Government / State Board shall notify the sensitive and other areas in the respective states within a period of six months from the date of notification of National Ambient Air Quality Standards.

### Remarks

- Without quality control procedures in place, laboratories cannot hope to remain in-control, and without quality assurance procedures in place, they cannot ensure that they are in-control.

### OBJECTIVES OF INTERLABORATORY COMPARISON

- To determine performance of individual laboratories
- Identify problems in laboratories and initiate remedial action related to individual staff performance or calibration of instruments
- Establish the effectiveness and comparability of new test methods and similarly to monitor established methods
- Identify inter-laboratory differences
- Provide additional confidence to laboratory clients

### Inter-laboratory Comparison conducted by CPCB

- At a time 15 laboratories can participate
- Parameters – Sulphur dioxide  
Nitrogen dioxide  
Ozone  
Carbon monoxide
- All participants are required to work with their own set of instruments, chemicals and analysers.
- Duration – 5 Working days - 8 Working days

### EVALUATION OF RESULTS

- Values assigned by pilot laboratory (CPCB) with a set range of tolerance  $\pm 15\%$
- Values assigned by CPCB are based on calibration of automatic analysers employing Static Injection of pure gas (100%)
- Z - Scores (Robust)

**Results of Inter-laboratory comparison conducted in December 2001**

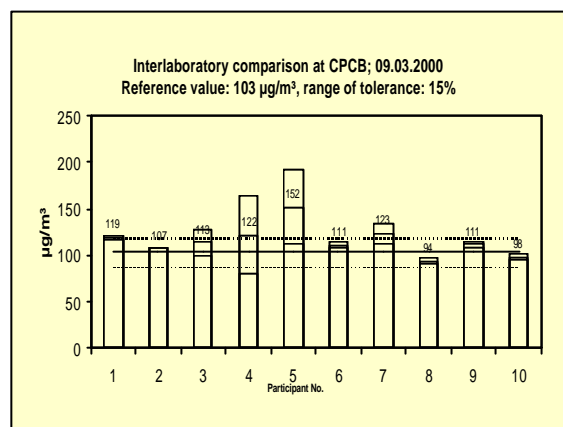
Participant Code	Method	Reference Concentration Nitrogen dioxide ( $\mu\text{g}/\text{m}^3$ )			Reference Concentration Sulphur dioxide ( $\mu\text{g}/\text{m}^3$ )		
		28	79	115	16	39	100
		33*	73	176*	14	40	98
1	Chemical	33*	73	176*	14	40	98
2	Chemical	32	94*	134*	17	41	100
3	Chemical	30	108*	114	15	33*	96
4	Chemical	30	85	88*	17	12*	41*
5	Chemical	34*	107*	128	13*	44	104
6	Chemical	31	90	125	17	42	101
7	Chemical	30	93*	111	16	46*	100
8	Chemical	41*	87	124	14	45	105

9	Chemical	33*	105*	112	14	44	101
10	Chemical	34*	94*	156*	15		90
11	Chemical	31	72	112	16	37	90
12	Chemical	32	79	119	17	43	107
13	Analyser	29	75	112	17	39	96
14	Analyser	-	-	-	16	43	94
15	Analyser	30	77	114	13*	40	103
Average Concentration		32	88	123	15	39	95
No. of Labs exceeding +/- (15%) SRT		5	6	4	2	3	1
Percentage (%) of Labs exceeding +/- (15%) SRT		33	40	27	13	21	7

Note : Values marked with asterisk (\*) denote that the values are exceeding the +/- (15%) Set Range of Tolerance (SRT)

**Interlaboratory Comparison of Nitrogen dioxide  
15.03.2000  
Reference Concentration 103  $\mu\text{g}/\text{m}^3$**

No.	Board	Impinger	I $\mu\text{g}/\text{m}^3$	II $\mu\text{g}/\text{m}^3$	III $\mu\text{g}/\text{m}^3$	arithmetic mean $\mu\text{g}/\text{m}^3$	stand. dev. $\mu\text{g}/\text{m}^3$	stand. dev. %	deviation to setpoint abs.	deviation to setpoint rel. (%)
1	Andhra Pradesh PCB	midjet type	121.1	117.9	119.1	119	2	1	15.9	15
2	Gujrat PCB	midjet type	(8.3)	(29)	107.4	107			4.0	4
3	Haryana PCB	midjet type	98.4	113.6	127.8	113	15	13	9.9	10
4	Madhya Pradesh PCB	midjet type	151.3	92.4		122	42	34	18.4	18
5	Punjab PCB	midjet type	107.3	187.6	160.9	152	41	27	48.5	47
6	Tamil Nadu PCB	midjet type	114.4	108.6	108.6	111	3	3	7.1	7
7	West Bengal PCB	midjet type	127.4	131.8	109.8	123	12	9	19.6	19
8	CPCB I	midjet type	95.8	90.2	95.8	94	3	3	-9.5	-9
9	CPCB II (Saltzman)	fritted type	110.4	108.4	114.2	111	3	3	7.6	7
10	HLUG (Saltzman)	fritted type	(137.8)	99.8	95.8	98	3	3	-5.6	-5



**Interlaboratory comparison of sulphur dioxide, 14.03.2000  
Reference concentration 63  $\mu\text{g}/\text{m}^3$**

No.	Board	Impinger	I $\mu\text{g}/\text{m}^3$	II $\mu\text{g}/\text{m}^3$	III $\mu\text{g}/\text{m}^3$	arithmetic mean $\mu\text{g}/\text{m}^3$	stand. dev. $\mu\text{g}/\text{m}^3$	stand. dev. %	deviation to setpoint abs.	deviation to setpoint rel. (%)
1	Andhra Pradesh PCB	midjet type	52.1	52.1	52.1	52	0	0	-10.9	-17
2	Gujrat PCB	midjet type	44.8	67.1	47.7	53	12	23	-9.8	-16
3	Haryana PCB	midjet type	61.3	61.3	56.9	60	3	4	-3.2	-5
4	Madhya Pradesh PCB	midjet type	69.4	47.5	65.7	61	12	19	-2.1	-3
5	Punjab PCB	midjet type								
6	Tamil Nadu PCB	midjet type	56.8	60.6	53.0	57	4	7	-6.2	-10
7	West Bengal PCB	midjet type	59.3	59.3	59.3	59	0	0	-3.7	-6
8	CPCB I	midjet type	53.0	56.7	60.5	57	4	7	-6.3	-10
9	CPCB II	Muencke type	60.3	62.8	62.8	62	1	2	-1.0	-2
10	HLUG	Muencke type	57.3	57.3	56.1	57	1	1	-6.1	-10

**Inter-laboratory comparison 2000-2001  
SULPHUR DIOXIDE AND NITROGEN DIOXIDE**

Rounds of Proficiency Testing	SULPHUR DIOXIDE			NITROGEN DIOXIDE		
	Reference Conc. ( $\mu\text{g}/\text{m}^3$ )	No. of Labs. Participated	Outliers	Reference Conc. ( $\mu\text{g}/\text{m}^3$ )	No. of Labs. Participated	Outliers
1 (Mar. 2000)	24 (28)	10	8	15 (21)	10	5
	63 (58)	10	2	75 (82)	10	3
	97 (95)	10	3	103 (115)	10	4
	139 (131)	10	Nil	183 (190)	10	2
2 (Feb. 2001)	26 (26)	12	1	15 (21)	12	8
	42 (41)	12	Nil	30 (33)	12	4
	65 (75)	12	2	73 (86)	12	6
	83 (98)	12	2	114 (119)	12	Nil
3 (Mar. 2001)	26 (25)	10	1	19 (19)	10	6
	42 (39)	10	1	24 (30)	10	5
	65 (62)	10	1	71 (74)	10	4
	83 (92)	10	2	117 (108)	10	2
4 (Dec. 2001)	16 (19)	15	2	28 (32)	14	5
	39 (39)	15	3	79 (88)	14	6
	100 (95)	15	1	115 (123)	14	4

Values Given In Parenthesis Denote The Mean Of All Participants

## EVALUATION BASED ON Z –SCORES

### Robust Z- Scores

$$Z = \frac{\text{Result} - \text{Median}}{\text{Normalised IQR (NIQR)}}$$

$$\text{Normalised Inter Quartile Range (NIQR)} = \text{IQR} * 0.7413$$

### Inter Quartile Range :

Is the difference between the lower and upper quartiles. The lower quartile ( $Q_1$ ) is the value below which a quarter of the value lie. Similarly the upper quartile ( $Q_3$ ) is the value in which a quarter of the lie

Median = 104

94, 96, 99, 100,	101, 102,	104, 106, 107,	110, 115, 116,
1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	
Quartile	Quartile	Quartile	
( $Q_1$ )	( $Q_2$ )	( $Q_3$ )	

## ASSESSMENT CRITERIA BASED ON Z SCORE

$Z_i \notin \pm 2 =$  Results are Satisfactory

$\pm 2 < Z_i < \pm 3 =$  Results are Questionable

$\pm 3 \notin Z_i =$  Results Unsatisfactory

## EVALUATION BASED ON Z SCORE (Between Laboratory Z Score of sulphur dioxide)

Participant Code	Reference Concentration (ug/m <sup>3</sup> )		
	1	2	3
97	2.4	5.3	13.9
1	0.27	1.69	3.68
2	1.35	1.18	3.35
3		0.33	3.89
4	0.36	0.67	3.35
5			
6	0.72	0.5	0.29
7	3.33 <sup>nd</sup>	1.18	3.67
8	0.63	0.33	0.15
9	0.89		3.69
10	1.8	0.67	0.75

## CONCLUSIONS

Most of the State Pollution Control Boards have participated in the inter-laboratory comparison for sulphur dioxide and nitrogen dioxide measurements by wet chemical methods

Overall, the results indicate relative consistency in measurements at higher concentration ranges as compared to lower concentrations.

## FUTURE PLANS

To conduct inter-laboratory comparison study for other parameters e.g., Ozone, Carbon monoxide

To conduct interlaboratory comparison by sending standard gas mixtures in canisters or cylinders to different state pollution control boards, public sector undertakings.

**THANK YOU !**