PM CEMS CALIBRATION

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INTERNATIONAL CENTRE FOR
SUSTAINABLE CARBON

PRESENTATION OUTLINE

- Objective & Acceptance of CEMS
- Monitoring & Calibration Approach
- Testing Procedure
- Regulatory Requirements

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Responsible for Manufacturing, Order Execution, NABL Calibration, QA & QC, Training

INTERNATIONAL CENTRE FOR SUSTAINABLE CARBON

Technology Collaboration Programme by iea

CEMS REQUIREMENT?

Compliance

Reference Standard

(country specific)

In order to protect public health, vegetation & property

Necessity

Health

High efficiency of work force

Process

High efficiency of system

ACCEPTANCE OF CEMS

A CEMS to be used at installations covered by CPCB direction shall have to be proven suitable for its measuring task (parameter and composition of the flue gas) by use of the procedure equivalent to Indian standards . It shall prove performance in accordance to the set performance characteristics during the field-testing.

The performance testing procedures involve all concerned including plant operator, vendor and testing laboratories. The Regulator has to inspect the installation and collect information. The comments on this information are essential tool to qualify the installation for further performance testing.

contd…

ACCEPTANCE OF CEMS

Field-testing is a procedure for the determination of the calibration function and its variability and a test of the variability of the measured values of the CEMS compared with the data quality objectives specified. The performance tests are performed on suitable CEMS that have been correctly installed and commissioned.

A calibration function is established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). The variability of the measured values obtained with the CEMS is then evaluated against the required criteria to satisfy the Data Quality Objective

PERFORMANCE SPECIFICATION FOR PM CEMS

S.No.	Specification	Tolerance ranges/values
1	Zero Drift between two servicing intervals	≤ ± 2 % of Full Scale range
2	Reference point Drift between two servicing intervals	≤ ± 2 % of Reference value range
3	Analyzer's Linearity	The difference between the actual value and the reference value must not exceed ±2 percent of full scale (for a 5 point check).
4	Performance Accuracy	≤ ± 10 % of compared Reference measurement

WHY CEMS CALIBRATION?

Is PM CEMS capable of providing dust concentration directly ?

STACK EMISSION MONITORING/CALIBRATION APPROACH

- Manual Measurement

It may be used where a sample is extracted on site and analyzed later in a laboratory. Samples may be obtained over periods of several hours, or may be so-called spot samples or grab samples, collected over a period of seconds to a few minutes.

PM CEMS to be calibrated at three operational loads & triplicate samples at each load, against isokinetic sampling method at the time of installation & thereafter.

HOW TO OBTAIN RELIABLE & COMPARABLE RESULTS

- Measurement section & site are available to enable representative sample to be taken.
- Measurement objective & plan are available before it is carried out.
- Sampling strategy is specified in the plan to meet the measurement objective.
- Report of the results is produced which includes all relevant information.

REQUIREMENTS AS PER CPCB GUIDELINES

- Construction of chimney shall adhere to CPCB publication, Emission Regulation Part III unless otherwise specified by CPCB or SPCB or PCC.
- All measurement ports into the stack as per CEMS requirements.
- PM monitoring system to be installed at a distance of atleast 8d downstream & 2d upstream from any flow disturbance.
- CEMS devices shall be installed at least 500 mm below the port hole designed for manual sampling.

IMPORTANCE OF REPRESENTATIVE SAMPLING

- Whichever monitoring technique, method or equipment is chosen, the fundamental principle of sampling must be adhered to.

- This principle is that a small amount of collected material should be a representative sample of the overall character of the material.

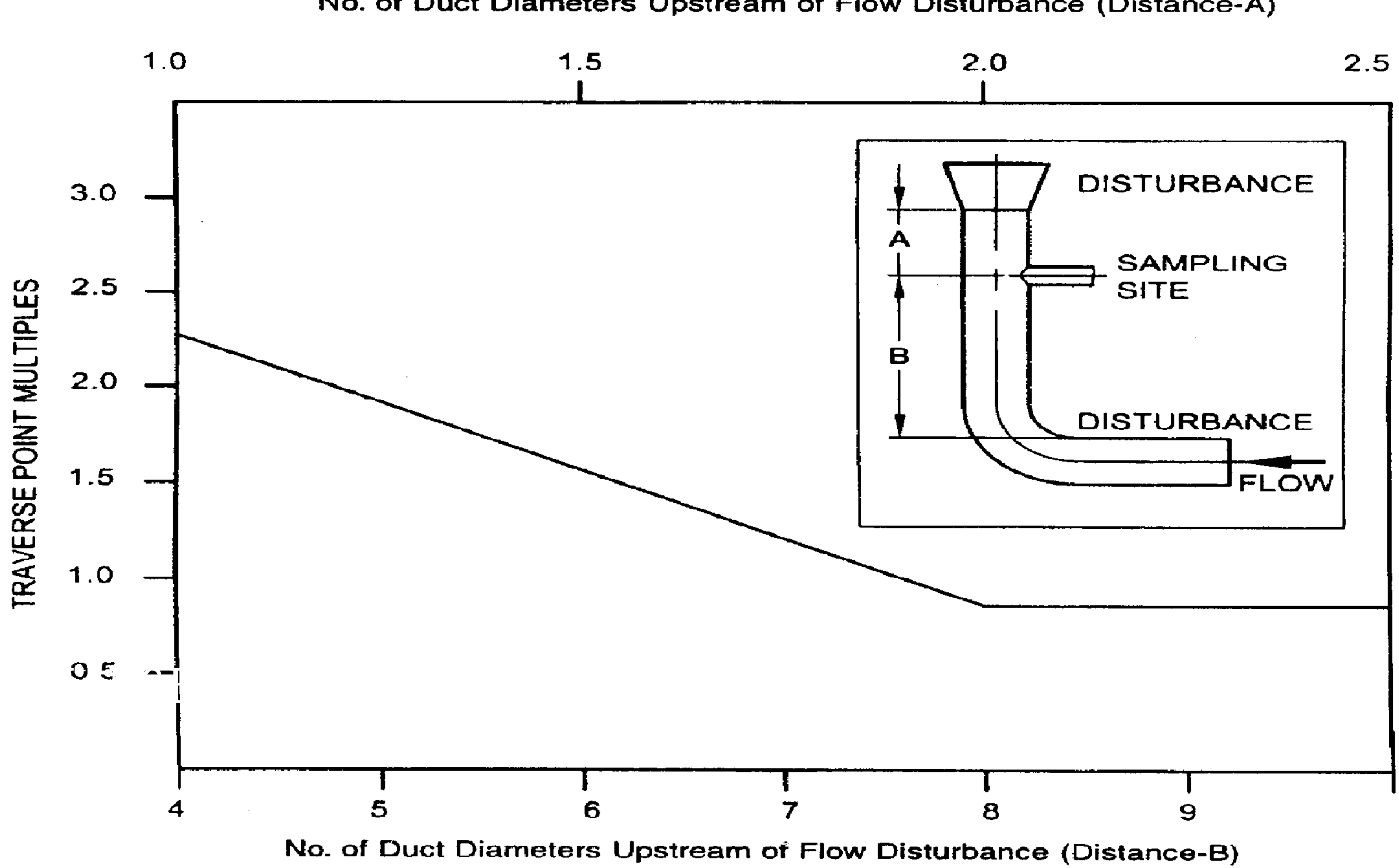
- The number and location of sampling points that need to be taken to make up a representative sample depends on how homogeneous the bulk material (the stack gas) is.

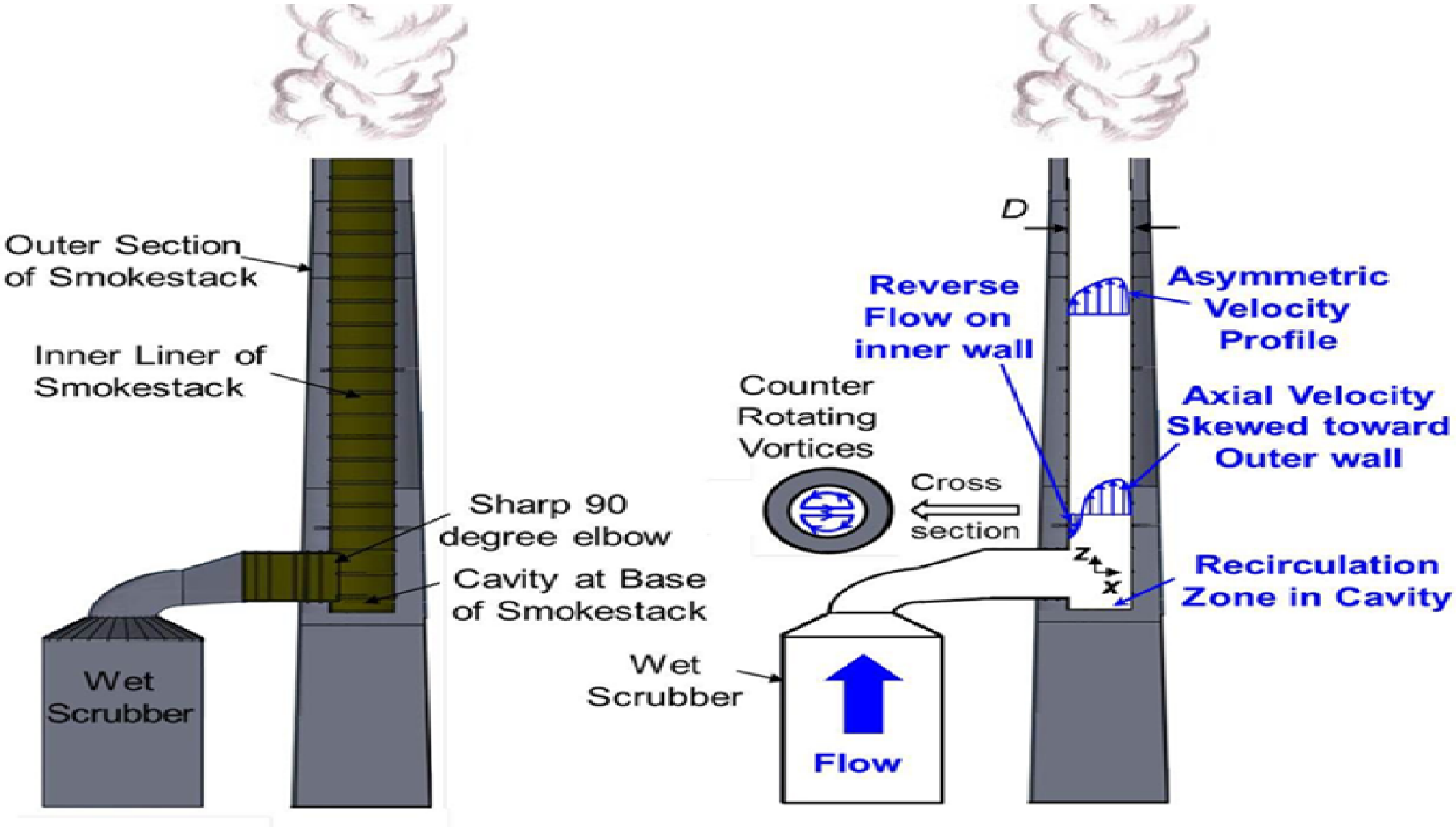
WHERE TO CARRY OUT EMISSION MEASUREMENTS

- It requires defined flow conditions in the measurement plane i.e. an ordered & stable flow profile without vertexing & back flow so that velocity & mass concentration of the measured component in the waste gas can be determined.

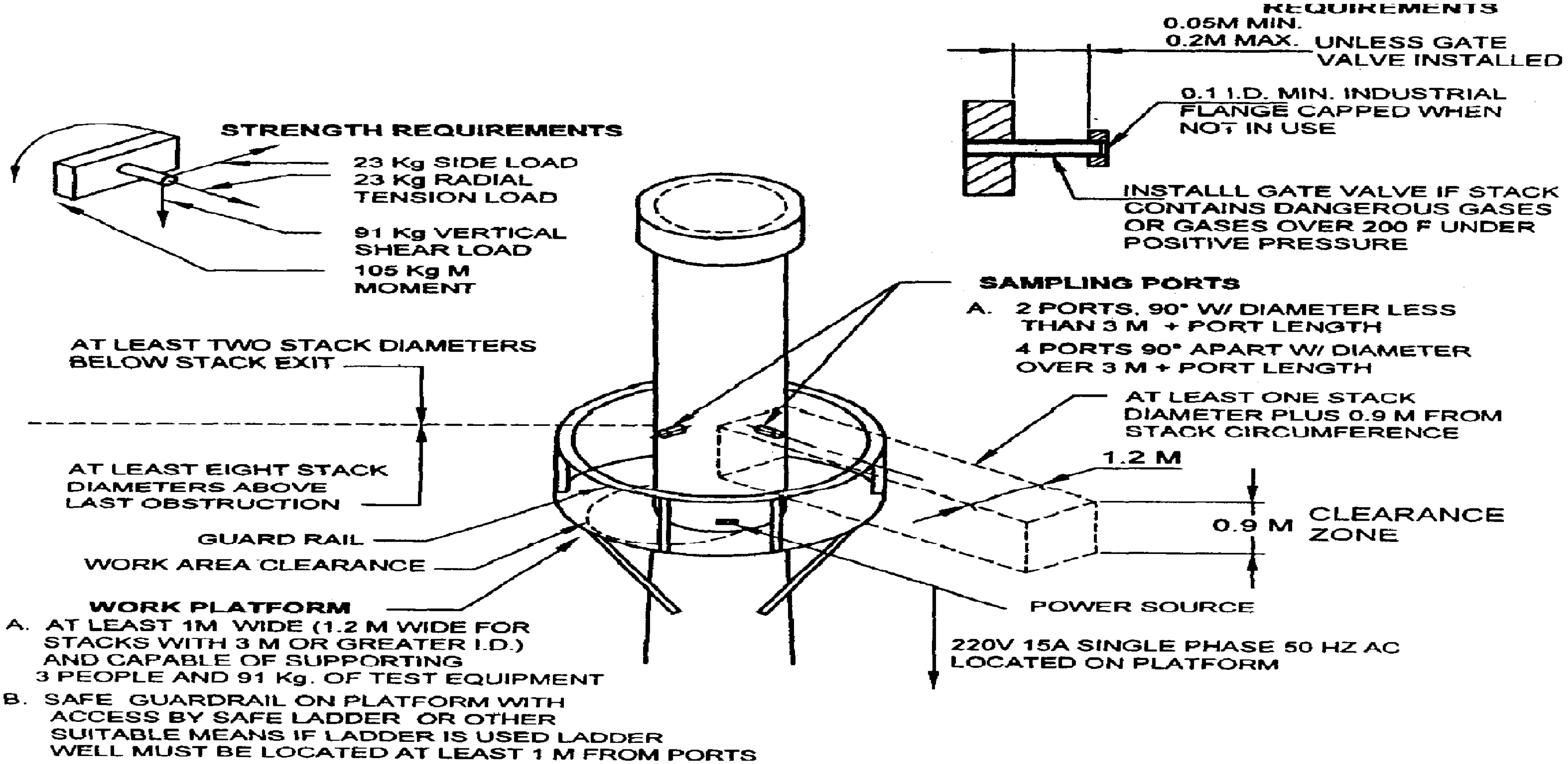
- It requires appropriate measurement ports & working platforms.

- Compliance regulations & official requirements shall be considered.

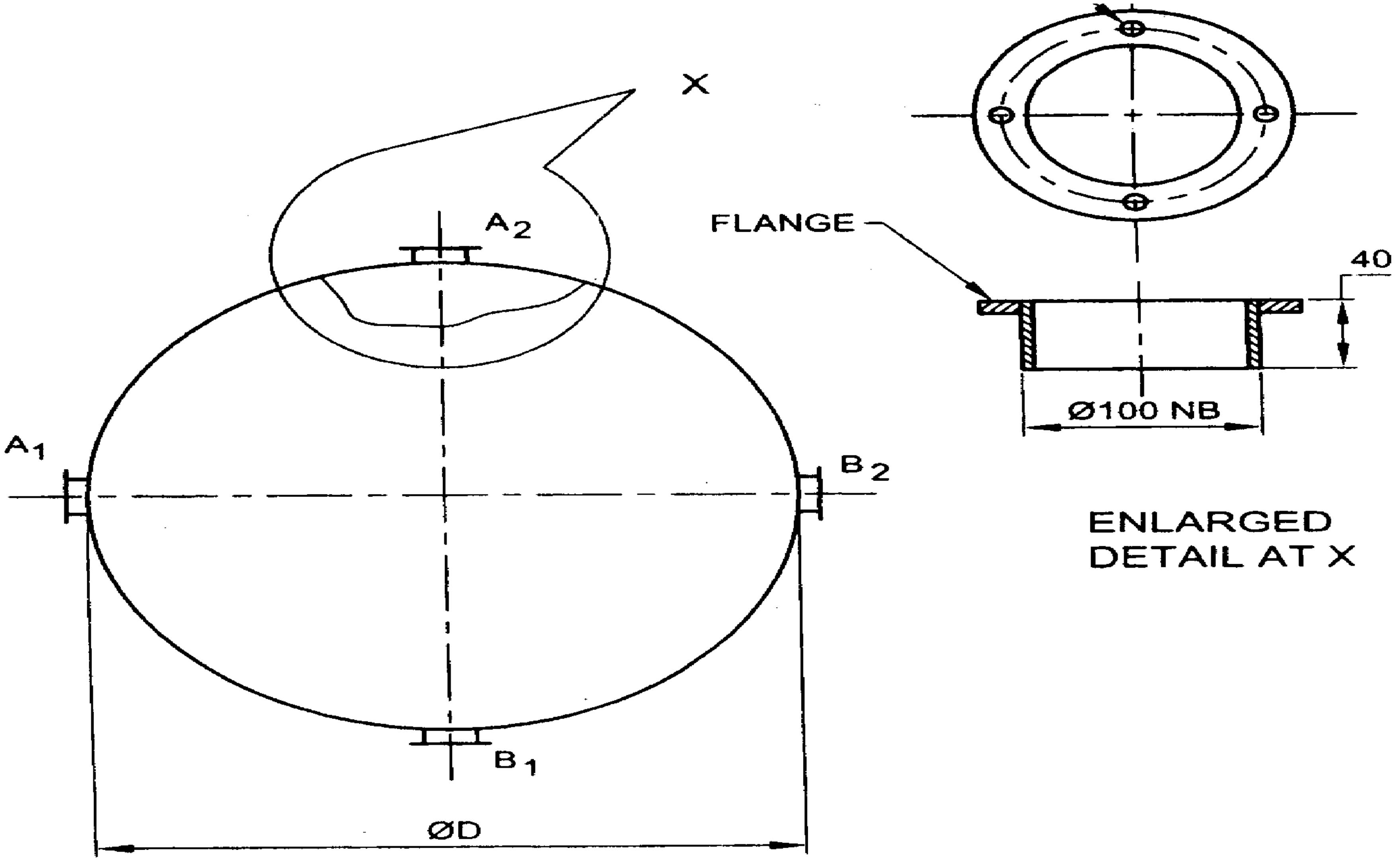

No. of Duct Diameters Upstream of Flow Disturbance (Distance-A)
1.0
1.5
2.0
2.5
TRAVERSE POINT MULTIPLES
3.0
2.5
2.0
1.5
1.0
0.5
DISTURBANCE
A
SAMPLING
SITE
B
DISTURBANCE
FLOW
4
5
6
7
8
9
No. of Duct Diameters Upstream of Flow Disturbance (Distance-B)



LOCATION OF SAMPLING SITE – EMISSION PATTERN



TYPICAL SAMPLING PROVISION



POSITION OF SAMPLING PORTS IN A CIRCULAR STACK

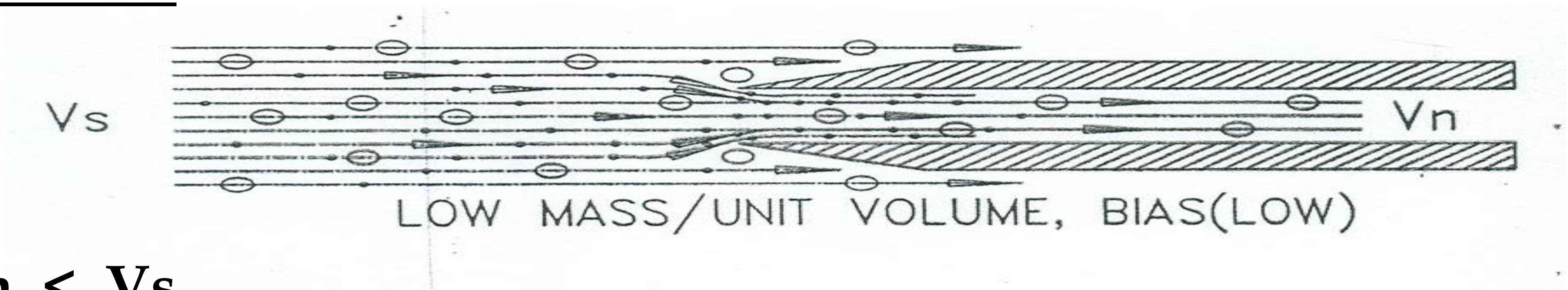
ISOKINETIC SAMPLING

- Due to the wide range of particle sizes normally present in process emission streams, it is necessary to sample isokinetically to ensure that a representative sample of the particulate emission is obtained.
- It is achieved through maintaining desired flow rate through nozzle & sampling at appropriate multiple points.

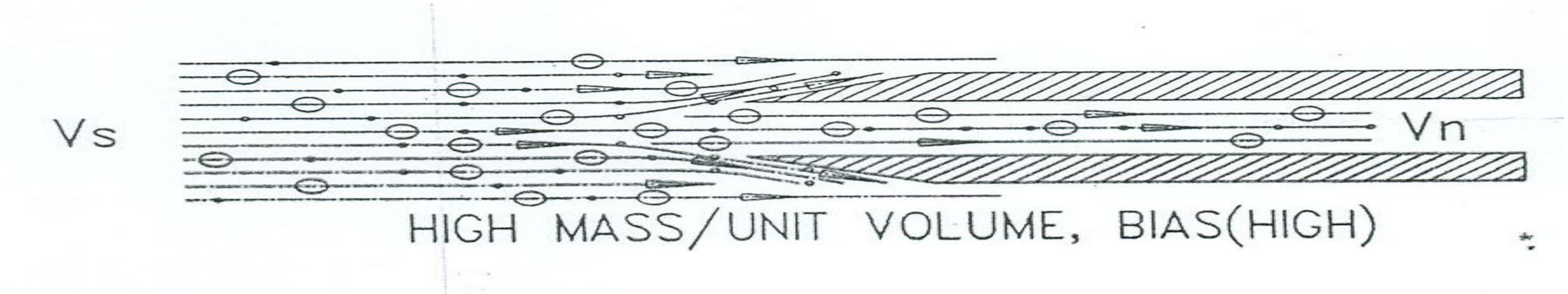
- Sometimes with limited access to sampling lines, sampling points & poor positioning of sampling plane one is forced to estimate/assume certain measurements.

ISOKINETICITY

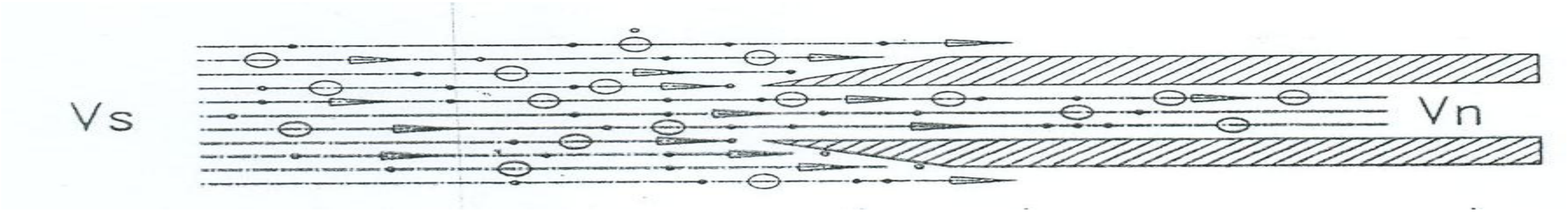
Vn > Vs



Vn < Vs



Vn = Vs



Sl. No.	Range of Stack Diameter M	Total No. of Traverse	Number of Traverse	
			Plane 1	Plane 2
(1)	(2)	(3)	(4)	(5)
i)	ID up to 0.3	4	4	---
ii)	ID>0.3 up to 0.6	8	8	---
iii)	ID>0.6 up to 1.2	12	12	---
iv)	ID>1.2 up to 2.4	20	10	10
v)	ID>2.4 up to 5.0	32	16	16
vi)	ID > 5.0	52	26	26

SITES WHICH MEET SPECIFIED CRITERIA.
FOR RECTANGULAR DUCT/STACK CALCULATE EQUIVALENT DIAMETER 2LH/(L+H)
NUMBER OF TRAVERSE POINTS INCREASES IN CASE OF INAPPROPRIATE LOCATION OF SAMPLING POINT.

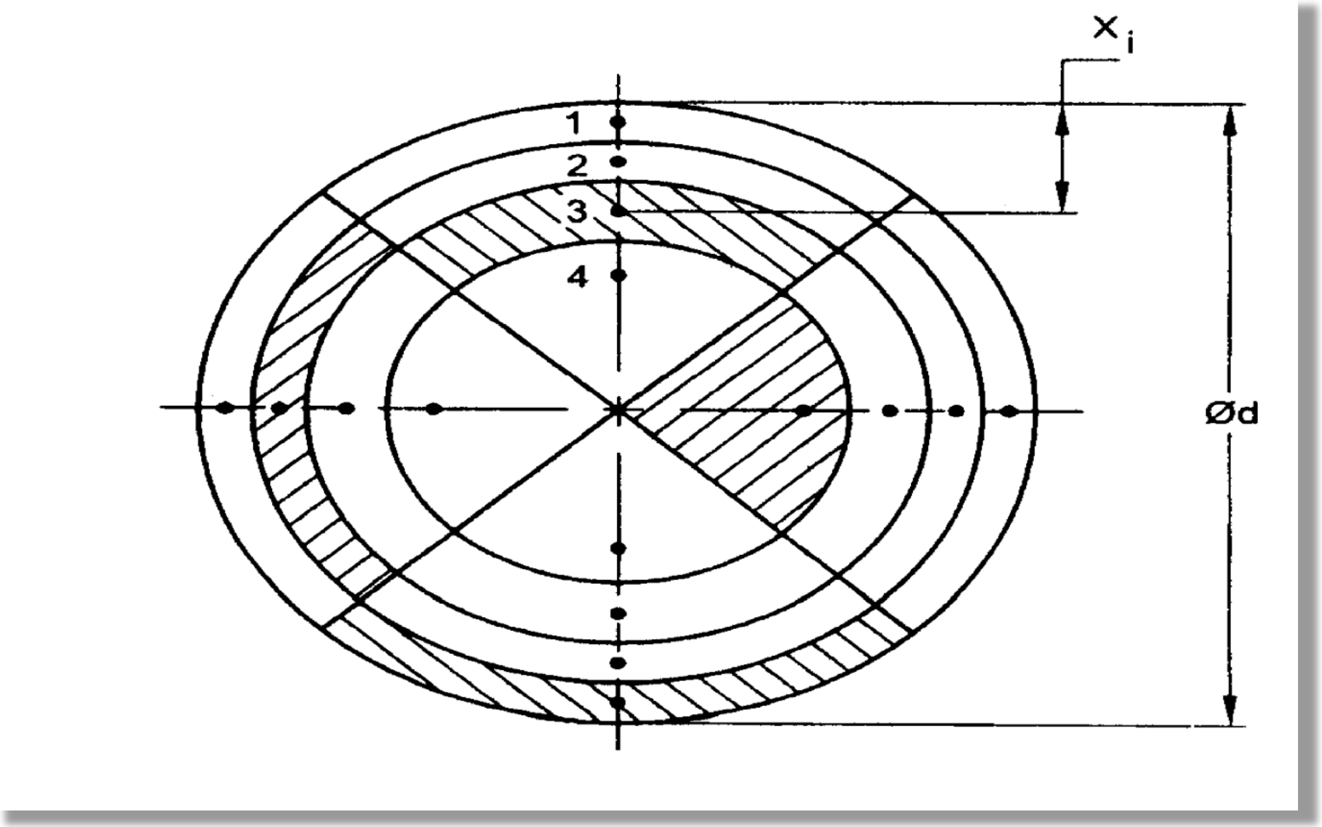
Number of Traverse Points

LOCATION OF TRAVERSE POINTS

- Location of traverse points on diameters of cross sections of circular stacks

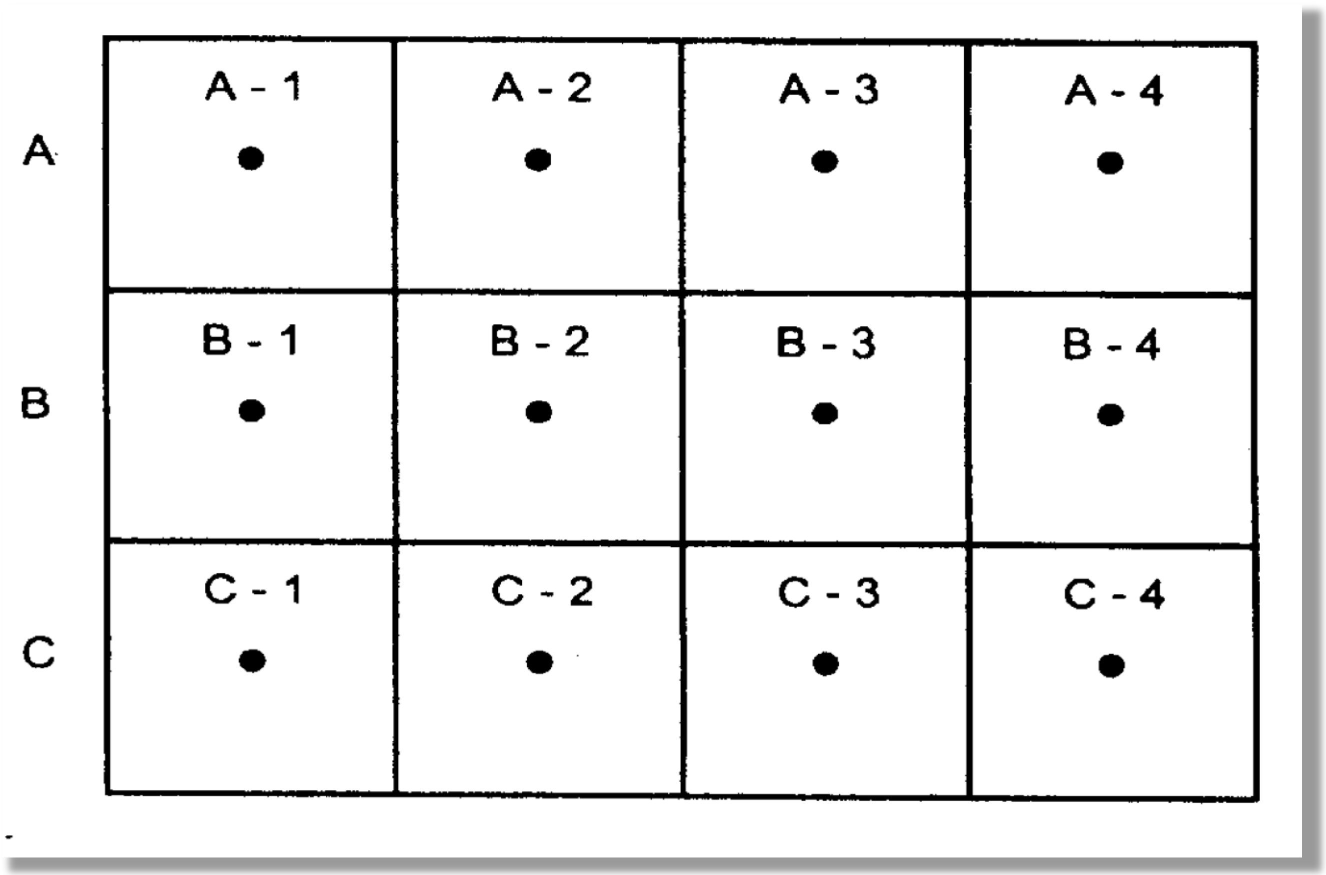
Traverse Point Number on a Diameter	Percent of Stack Diameter from Inside Wall to Traverse Point Number of Traverse Points on a Diameter											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.3	2.5	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.7	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.5	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.5	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.3	67.7	34.2	25.0	20.1	16.9	14.6	12.9	1.6	10.5
6			95.6	80.6	65.8	35.5	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.5	36.6	28.3	23.6	20.4	18.0	16.1
8				96.7	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.1	23.0
10					97.5	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.5	32.2
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.9	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9
19										96.1	91.3	86.9
20										98.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8

CIRCULAR STACK CROSS SECTION



Example showing circular stack cross section divided into16 equal areas, with location of traverse points

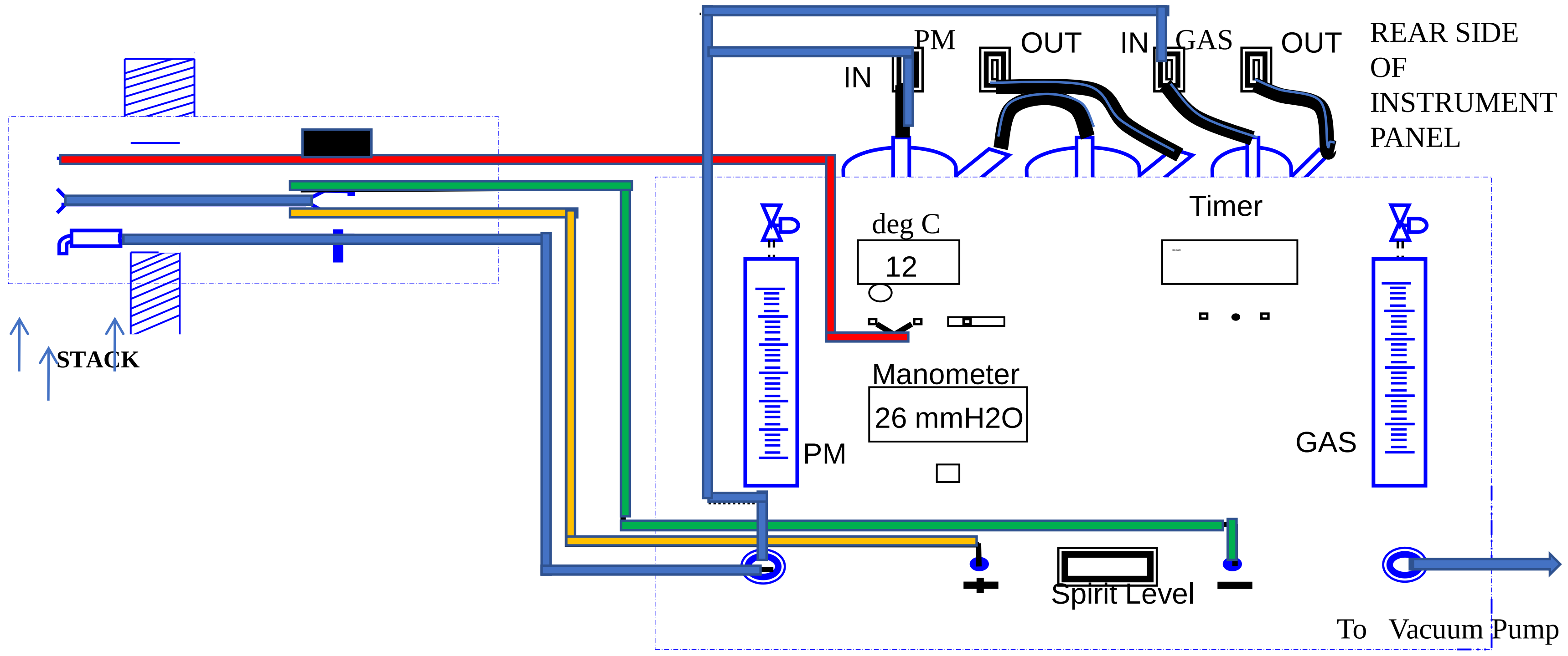
RECTANGULAR STACK/DUCT CROSS SECTION



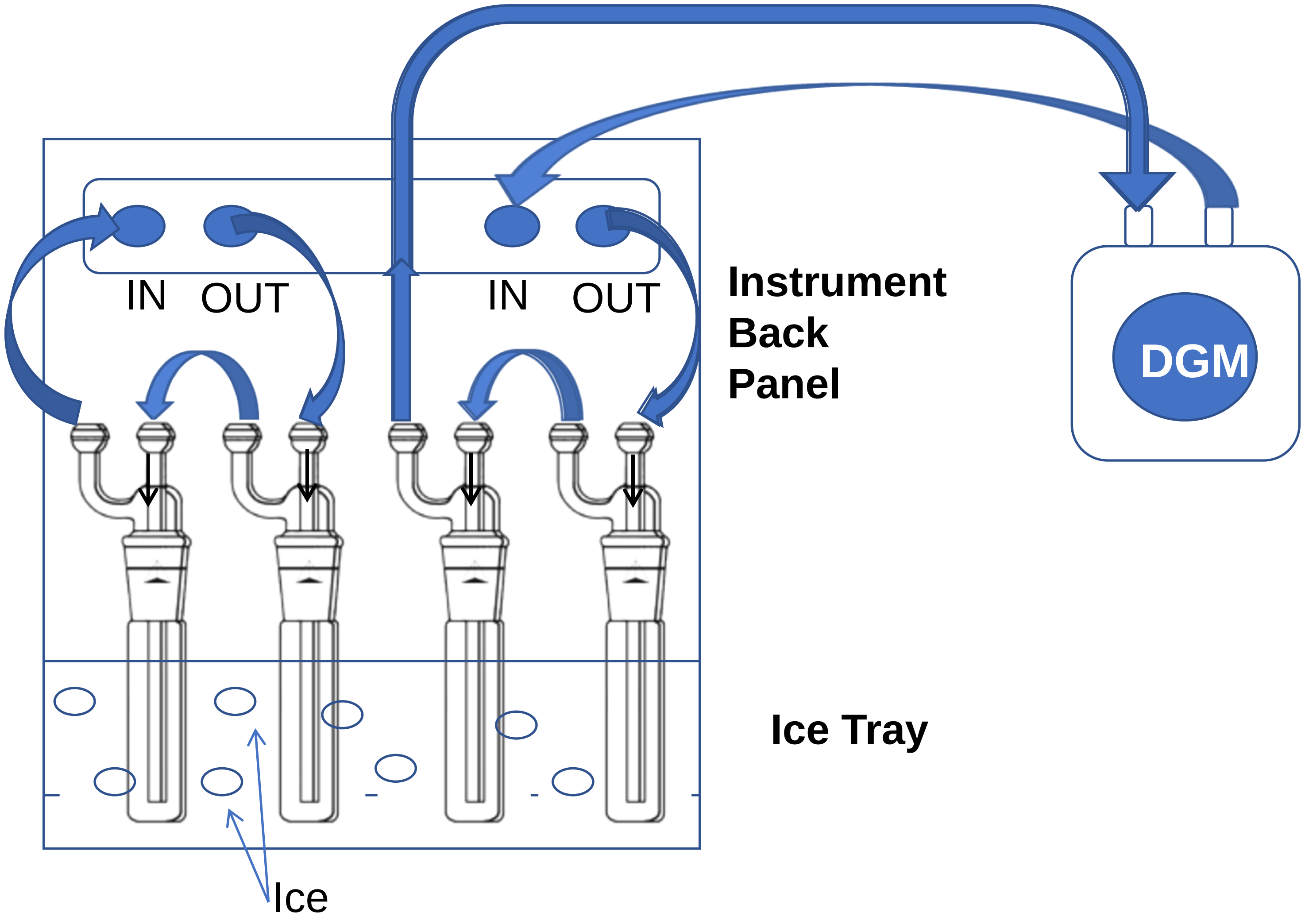
Example showing rectangular stack cross section divided into

12 equal areas, with traverse points at centroid of each other

SYSTEM CONFIGURATION



AIR FLOW INSIDE IMPINGER TRAIN WITH DGM



MEASUREMENT OF TEMPERATURE

- CALCULATION & PROCEDURE FOR STACK SAMPLING
- by inserting thermocouple inside the chimney
- read on the pyrometer
-
- Important
  - Temperature to be noted after it gets stabilised
  - Thermocouple should not touch stack walls
  - Temperature can be taken at one point
  - Thermocouple & pyrometer should be calibrated and must be of the same type
  - Provision should be there to measure temperature of flue gas at metering point also.
-
- Ts – Stack gas temperature in ^0K
- T'a – Temperature at metering point in ^0K

MEASUREMENT OF VELOCITY

- By inserting S-type pitot tube inside the chimney
- Readout on digital manometer for differential pressure

$$V = K \sqrt{\frac{2 \times g \times H \times dm}{ds}} \quad \text{------------------ (1)}$$

where,

V = stack gas velocity in m/s

K = pitot calibration constant

g = gravitational constant = 9.81 m/s^2

H = manometer reading in meter

dm = density of manometer fluid in Kg/m^3

ds = density of stack gas in Kg/m^3 (preferably to be calculated by taking a sample of

MEASUREMENT OF VELOCITY

from GAS LAWS

$$ds = \frac{da \times Ta}{Ts}$$

Where ,

Ts = stack gas temperature in ^oK

Ta = ambient temperature in ^oK

da = density of air at temperature Ta

MEASUREMENT OF VELOCITY

- substituting in eq – (1)
-
- V = K 2 x 9.81 x H x dm
- (da x Ta) / Ts
- (taking h in milimeters) & Ta = 273 + 25
-
- = K 2 x 9.81 x h x dm x Ts --------------(2)
- (da x 298) x 1000
- = C h x Ts
- Where,
- C = K 2 x 9.81 x dm

(da x 298) x 1000

MEASUREMENT OF VELOCITY

Important

- orientation of pitot tube
- leakage check
- tip of pitot tube to be protected from bending / deposits
- cleaning of pitot tube from inside
- number of sampling point to be decided on the basis of diameter of stack & location of port hole for representative sample
- calibration of pitot tube is absolutely essential

MEASUREMENT OF ISOKINETIC FLOW RATE

- $Qs = V \times An$ ---------------(3)
- Where,
- Qs – sampling rate in m^3/s
- An – cross sectional area of nozzle in m^2
- V – stack gas velocity in m/sec
- Using $An = \pi Dn^2/4$ for a given nozzle & since stack gas cool down as they pass through the cold box therefore rate of flow indicated by flow meter is to be corrected accordingly, therefore as per GAS LAWS & assuming
- $Q's = \frac{Qs \times Ta}{Ts}$
- Where,
- $Ta = (273 + 25)$
- $Q's$ = Sampling rate indicated by flow meter after normalisation
- Substituting in (3)
- $Q's = \frac{V \times An \times 298}{}$

MEASUREMENT OF ISOKINETIC FLOW RATE

for Q's in lpm

$$= \frac{V \times 60 \times An \times 1000 \times 298}{Ts}$$

Since : V(m/s) x 60 = V(m/min)

: $1m^3$ = 1000 litres

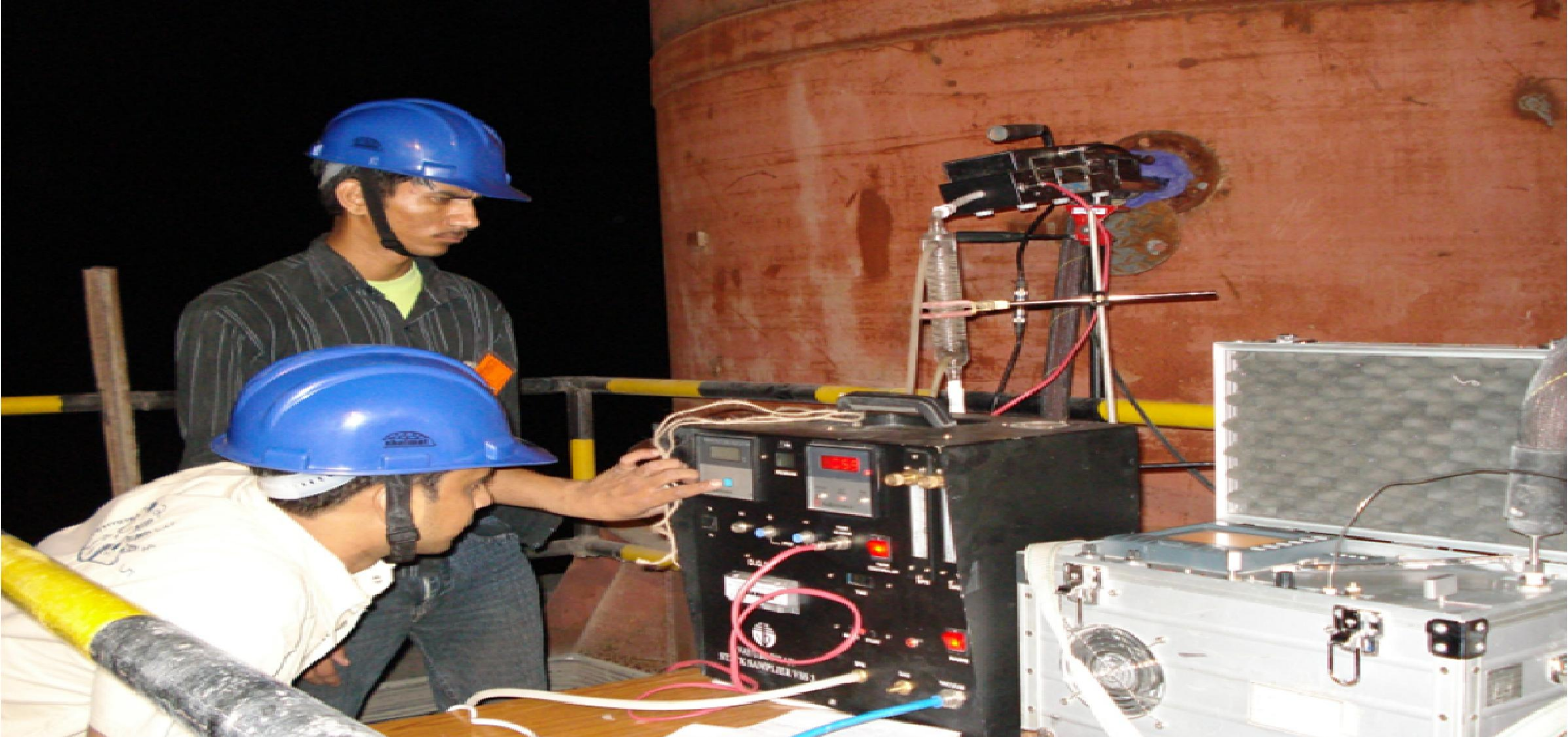
For Sampling select,

- appropriate nozzle on the basis of capacity of rotameter
- appropriate thimble on the basis of temperature
- time period depending upon collecting 2-3 gm of dust or 1000 litre of gas
- flow rate for PM & Gas stream for simultaneous monitoring

Important

- leakage should be zero
- sufficient ice should be kept in ice tray
- orientation of nozzle - handle
- sampling at various traverse points
- pressure drop & temperature at metering point to be recorded

MEASUREMENT OF TRUE FLOW RATE



TYPICAL SAMPLING LOCATION

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REQUIREMENTS – SAMPLING LOCATION & MONITORING

- Site visit prior to monitoring in order to understand physical & logistical situation on site.
- Dimensions of stack(s) & details of monitoring facilities are available.
- Access to stack & adequate work area at sampling position
- Availability of required utilities (electrical, lighting, water, ice)
- Expected velocity profile, temperature, moisture in stack gas.
- Restrictions on using equipment e.g. intrinsically safe areas
- Appropriate measurement equipment (like length of pitot tubes, sampling probe, suitable thimble etc.) for the application
- Competent manpower with knowledge of process & details of monitoring method(s) to be engaged
- Phobia of heights should not be there
- Proper dress, safety shoes, belt , helmet etc. should be available.

REGULATORY REQUIREMENTS FOR CALIBRATION

The continuous Particulate Matter monitoring system (PM-CEMS) shall be calibrated at different operational loads against isokinetic sampling method (triplicate samples at each load) at the time of installation and thereafter, every six months of its operation.

The results from the Particulate Matter monitoring system shall be compared on fortnightly basis i.e. second Friday of the fortnight, at fixed time (replicate sample) starting 10.00 am. with standard isokinetic sampling method.

In case, deviation of the comparison values for 02 consecutive monitoring is more than 10%, the system shall be recalibrated at variable loads against isokinetic sampling method (replicate samples).

Contd…

REGULATORY REQUIREMENTS FOR CALIBRATION

No adjustment of Calibrated Dust Factor (CDF) is allowed unless full-scale calibration is performed for PM CEMS. Change of CDF should be permitted only if it is approved by SPCB/ PCC.

After any major repair to the system, change of lamp, readjustment of the alignment, change in fuel quality, the system shall be recalibrated against isokinetic sampling method. (triplicate samples at each load). It is advised to carry out PM emission monitoring on the day when plant operates, under capacity due to any reason besides the routine monitoring.

The data capture rate of more than 85% shall be ensured.

The data comparison/calibration verification shall be done by laboratories empanelled by CPCB using standard reference methods and at a frequency specified.

If we really want to improve quality of air around us?

Control

EMISSIONS

Regular, Simple,

Accurate Monitoring

&

Calibration

is the key to

Pollution Control

INTERNATIONAL CENTRE FOR SUSTAINABLE CARBON

THANK YOU FOR LISTENING

ANY QUESTIONS?

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