TEFUGEN
Technologies for Future Generation

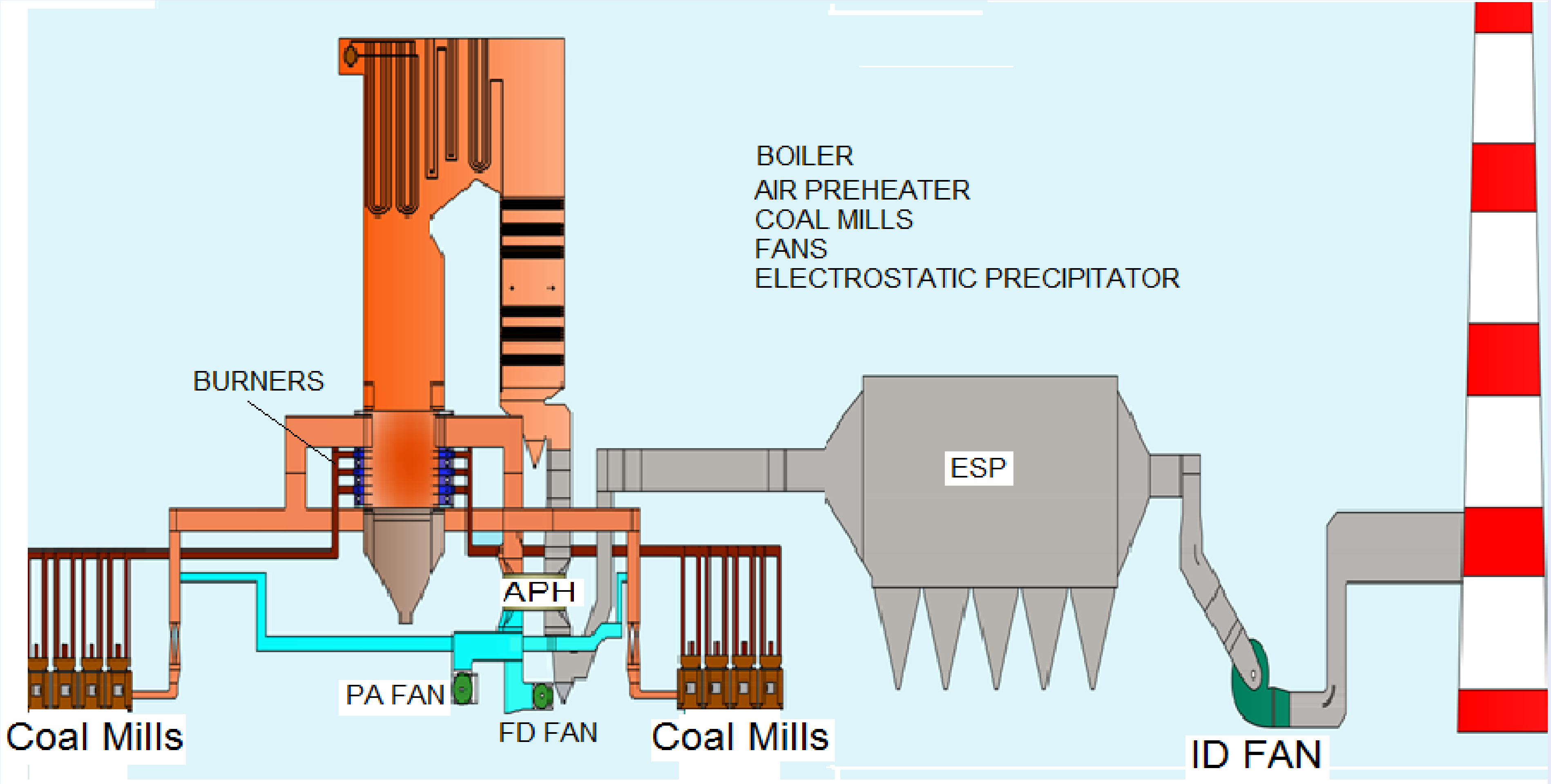
GEECO

8th International Seminar -2023

TESTING OF BOILER AND AUXILIARIES FOR PERFORMANCE IMPROVEMENT

By
R. Balasubramanian
Boiler Consultant
TEFUGEN

BOILER AND AUXILIARIES



Testing of Boilers and Auxiliaries

TEFUGEN
Technologies for Future Generation

Performance Guarantee Test

Test conducted by the supplier, to prove the guarantees agreed as per the contract.

Performance Evaluation Test

Test conducted by any contractor appointed by customer to asses the present condition of equipment.

- **Checking of actual performance against specified performance.**
- **Comparing changes in performance over time with specified performance**
- **Comparing performance under various operating conditions.**
- **To accommodate present fuel availability to meet out design condition**

Performance Test Code (PTC)

Test procedures including sampling methodology developed as standards for each and every equipment individually.

ASME , BS

PERFORMANCE TESTING

Performance Testing is an effective tool which provides

- **Vital information base for evaluation of performance measures.**
- **Positive approach for continuous improvement.**
- **Cost optimization**
- **Adhering Pollution control norms**
- **Methods to improve operating and maintenance practice of the system**
- **Energy efficient equipment at the time of replacement**

OBJECTIVE

TARGET AREA FOR IMPROVEMENT

TARGET AREA FOR IMPROVEMENT

↑

DEVIATION FROM THE BEST EFFICIENCY POSSIBLE

PERFORMANCE CORRECTED TO DESIGN INPUT CONDITION

CONDUCTING PERFORMANCE TESTING

↑

BEST POSSIBLE OPERATING CONDITION

OPTIMISE THE INPUT PARAMETERS OF THE EQUIPMENT

Optimize the input parameters with best possible operation

Optimize the input parameters with best possible operation

Boiler and Auxiliaries efficiency reduces with time due to

- **Deterioration in combustion behaviour**
  - Variations in input condition
    - Changes in coal properties
    - Operating the unit as per OEM guide lines even with present coal
      - OEM guide lines are based on Design coal
- **Deterioration due to ageing, poor maintenance**
  - heat transfer surface ineffective and fouling

There is a need for ***Boiler compatibility analysis with different coal*** to enhance the Boiler and auxiliaries performance.

- Input / output parameters of Boiler and AuxilIries are inter related.
- Optimise the input parameters are very much essential.

Boiler Compatibility analysis of different coal

Boiler compatibility analysis

1. Boiler configuration & Type of Firing
2. Auxiliaries capacity availability.
3. Present operating condition & compared with predicted performance.
    - Parameters
    - Coal analysis
    - Ash analysis
    - Boiler Efficiency
        - Unburnt Losses – Bottom ash and fly ash
        - Dry Gas Loss – Flue Gas Exit Temperature
4. Slagging condition
5. Pollution condition
    - SPM
    - Sox
    - Nox
    - Co

Coal Combustion

Type of Firing

- **Pulverised coal Firing**
  - **Tilting Tangential corner firing**
  - **Wall firing**
    - Front wall
    - Opposite wall
- Bed firing
  - Stoker
  - Fluidised bed combustion
    - AFBC
    - CFBC

COAL TYPES AND CONSTITUENTS

TYPES:-

- Anthracite
- Bituminous
- Lignite

PROPERTY & CONSTITUENTS

- HGI

Proximate **Ultimate** **Analysis:-**

Proximate

- Moisture %
- VM %
- *FC %*
- **Ash %**
- **GCV**

Ultimate

Surface Moisture
Inherent Moisture
Carbon
Sulphur
Hydrogen
Nitrogen
Oxygen
Ash
GCV

Analysis:-

Coal analysis
ARB
ADB
AFB

Ash analysis.
LOI
Minerals (Acid & base)

EFFECT OF COAL CONSTITUENT

TEFUGEN
Technologies for Future Generation

MOISTURE ↑	Drying Limitation *(Hot PA temperature)* (Arching, bridging in bunkers, & conveying chutes and Reduces Boiler Efficiency;
GRINDABILITY INDEX HGI ↓	Reduced Mill output and Boiler load
ASH ↑	Reduced Mill output and Boiler load
VOLATILE	Dictates Ignition Energy
LOW VOLATILE	Difficult to Burn, Furnace stability Low
REACTIVITY ($\frac{FC}{VM}$)	< 1.5 easy to burn ≥ 1,5 upto 2 moderate and > 2 difficult to burn
GCV ↓	Reduced mill output, mill efficiency, Boiler Load
SLAGGING AND FOULING TENDENCY	Heavy and sticky Furnace deposits and blockages in convective zones.

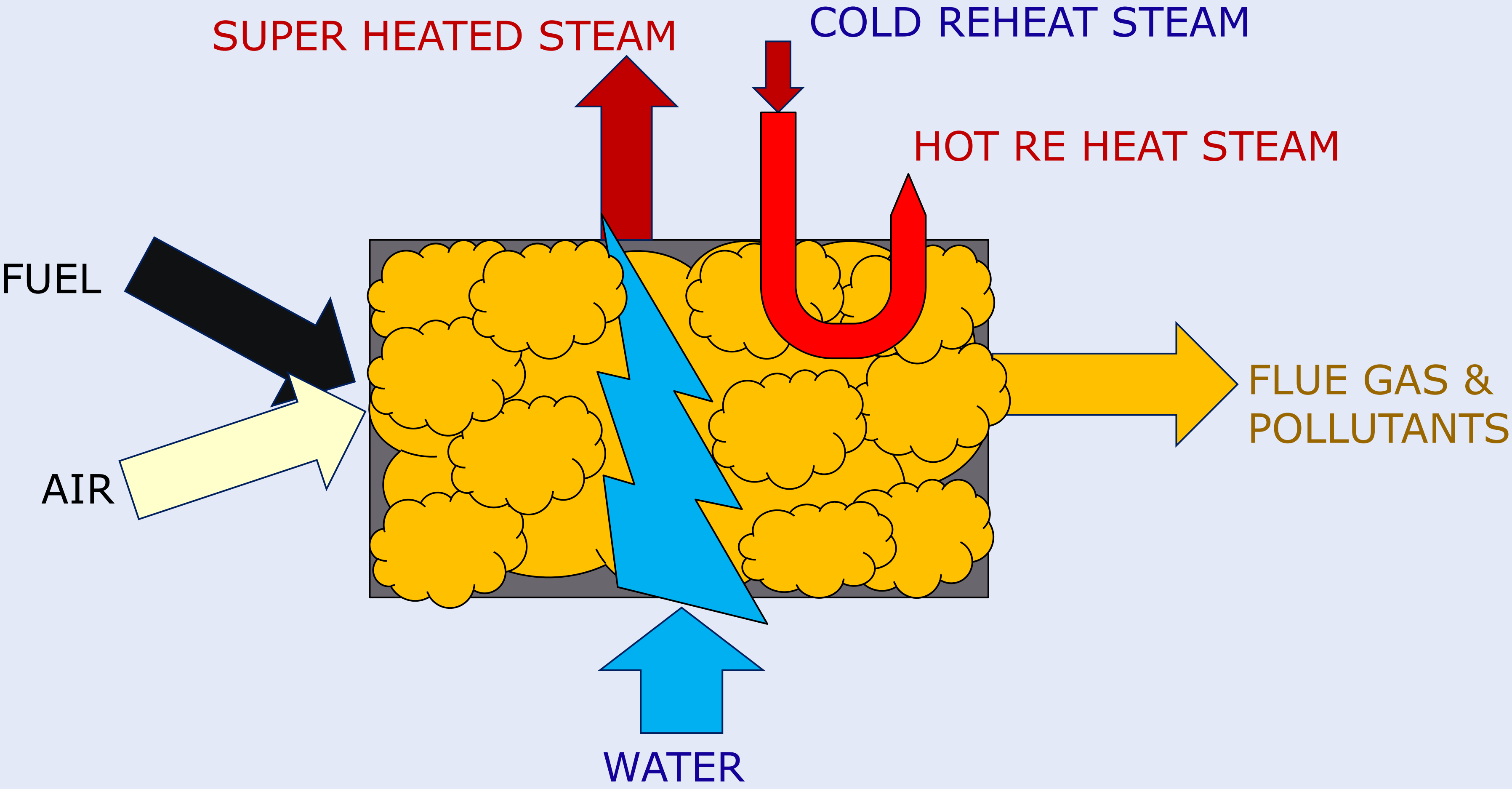
BOILER
PERFORMANCE FACTORS

1. Achieving Rated Parameters

2. Maximum Efficiency(Reducing losses)

BOILER SYSTEM

TEFUGEN
Technologies for Future Generation



Boiler parameters as Predicted

Ensure INPUT PARAMETERS	Acheive OUTPUT PARAMETERS
Feed water Flow Pressure Temperature	**Super heated (SH) steam** Flow Pressure Temperature SH Spray (minimum)
CRH Flow Pressure Temperature	**HRH** Flow Pressure Temperature RH Spray (Minimum tends to 0

Boiler parameters as Predicted

INPUT PARAMETERS As required.	OUTPUT PARAMETERS As minimum as possible
Air Flow Distribution Temperature	Solid unburnts Flue gas Flow Temperature Unburnts as CO Pollution Parameters Nox Sox
Fuel Flow Distribution Condtion Temperature	
Without any slagging tendency	

Controllable Losses

Carbon loss → LOI in Fly Ash

Carbon loss → LOI in Bottom Ash

Dry gas loss

Fuel moisture loss

H2 moisture loss

Air Moisture loss

Heat in Fly ash loss

→ Function of Flue gas Exit Temperature

Mill Rejects loss → Mill condition, mill air flow and temperature

UNBURNT

High LOI in bottom Ash

- PC fineness - high retension at 50 mesh (> 1)
- Fuel un even distribution amongst the burners
- Insufficient Air for suspension firing

High LOI in Fly Ash

- PC fineness – passing through 200 mesh (< 70%)
- Primary air velocity high.
- Secondary air velocity Low
- Secondary combustion

FLUE GAS TEMPERATURE HIGH AT APH OUTLET

TEFUGEN Technologies for Future Generation

- **High excess air than necessary**
- **High tempering air Flow.**
- **Improper combustion / Secondary combustion**
- **More furnace draft than necessary**
- ***Feed Water Temperature***
- High Air ingress
- Dirty furnace
- Non operation of wall soot blower
- Condition of APH baskets / Elements

FLUE GAS TEMPERATURE HIGH AT APH OUTLET

TEFUGEN Technologies for Future Generation

AIR INGRESS TO THE SYSTEM IS NOT MEASURED AND IT IS BYPASSING THE APH

Un-Known air ingress points:-

- Expansion bellows
- Peep holes / Man holes
- Tapping points
- Bottom & Eco ash hopper
- Burner block
- Purge air to the mill coal pipes.
- LRSB / Wall soot blower openings
- Furnace roof, pourable / castable refractory area

Known air ingress points:-

- Scanner cooling air
- Gun cooling air
- Ignitor cooling air
- Mill seal air

Air flow through APH (SA sector)= Total secondary air flow – Air ingress flow

FLUE GAS TEMPERATURE HIGH AT APH OUTLET

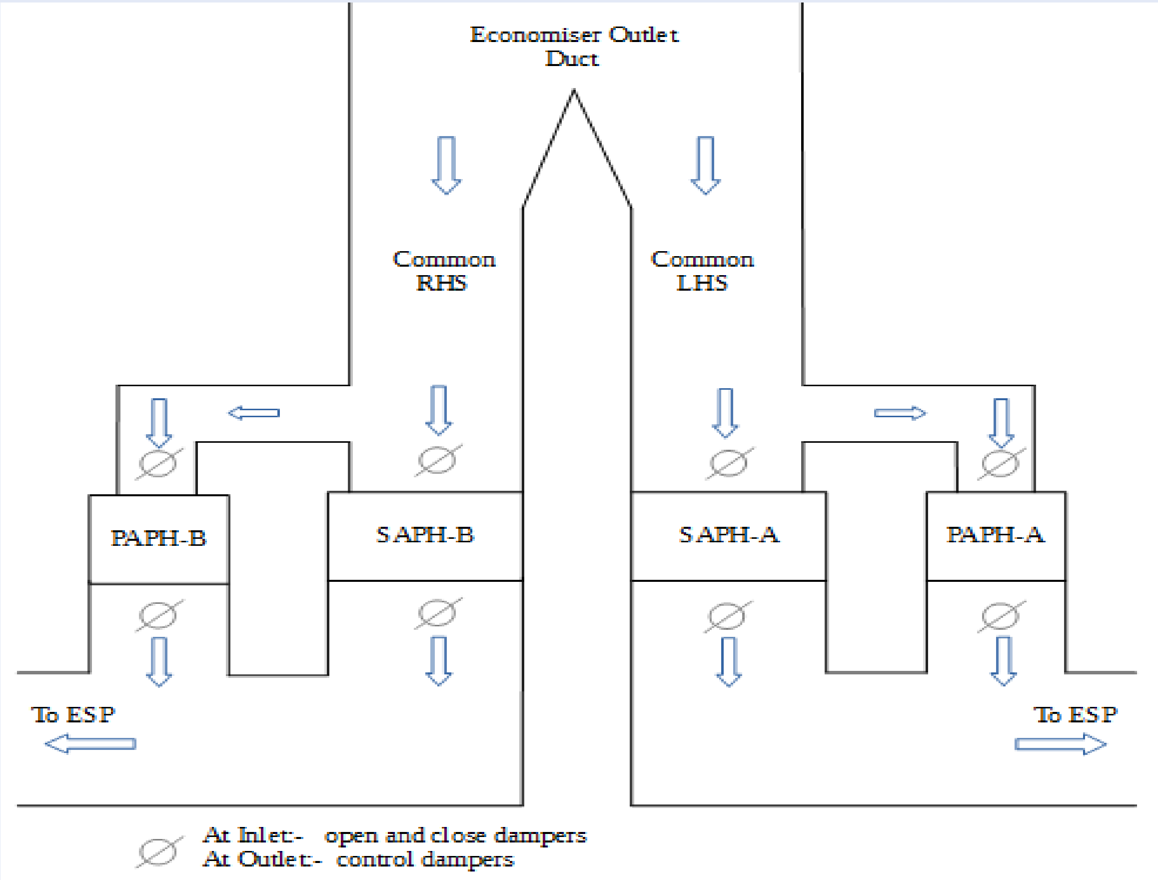
TEFUGEN
Technologies for Future Generation

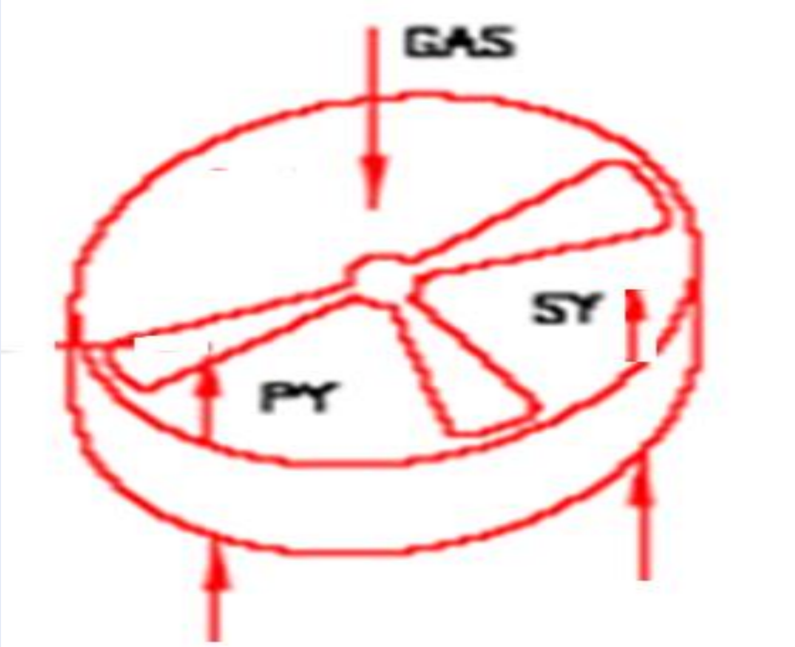
High Tempering Air

- Constituents of Coal
  - Moisture
  - VM
  - GCV
- Very high Primary air temperature than required
  - Primary sector opening in tri sector design
  - Improportionate of flue gas for 4 APH bisector Design
  - High Choking in PAPH than SAPH for 4 APH bisector design
  - Less Primary air flow through Primary sector of APH
- Number of mills in service is higher than required
- Mill outlet temperature not maintained as per VM content.

Air flow through APH (PA sector)= Primary air flow – Tempering air flow

Four – Bisector APH Vs Two – Tri Sector APH





FLUE GAS TEMPERATURE HIGH AT APH OUTLET

TEFUGEN
Technologies for Future Generation

Incomplete combustion / Secondary cmbustion

Fuel

- Fineness
- Distribution
- Temperature
- High PA flow/ Velocity

Air

- Low Secondary air velocity
- Un equal Secondary air flow in Burner / Nozzles
- Insufficient air flow in combustion zone

Optimisation

Understanding the type of coal being fired and type of firing , making proper operational adjustments on

Fuel preparation and Air Regime will

- *Achieve the Boiler parameter as predicted*
- *Reduce*
  - Unburnt carbon in bottom ash / fly ash
  - Flue gas exit temperature
- **Improves the efficiency of**
  - **Boiler**
  - **Air Preheaters**
  - **ESP**
  - **Fans**

Input Parameters Optimisation

optimisation Involves

- Adjustments / Measurements on
  - Excess air requirements based on Fuel property
  - Pulveriser settings
  - Burner Setting
  - Primary and Secondary Air distribution

EXCESS AIR - Concept

Volatiles in fuel are the combustibles in gaseous forms which will burn quickly and supply ignition energy for the solid combustibles.

High VM% and Low FC/VM **(VM>35% and FC/VM < 1.5)**

- This coal will burn very fast and creates rapid combustion leads to generate high temperature in combustion zone.
- This high temperature inprove the evoparation capacity.
- This high temperature increases the formation of Nox.
- **Low excess air (15 to 20%) operation and optimised air staging** is required to reduce rapid combustion and formation of Nox.

Low VM% and high FC/VM **(VM<25% and FC/VM > 1.5)**

- This coal burns slowly and requires high residence time for complete combustion.
- Leads to secondary combustion
- Generates low temperature only during combustion
- **High excess air (20 to 25%) is required to ensure complete combustion**

EXCESS AIR - Concept

Very high excess air operation increases the losses and formation of Nox.
Low excess air operation leads to incomplete combustion

Optimised excess air requirement is based on

- Coal property
- Operating condition
  - CO Level
  - Slagging condition (AFT, Ash constituents, Reducing atmoshphere etc)
  - Nox Level
  - Secondary combustion based on SH and RH spray
  - Flue gas exit temperature

Optimised excess air along with suitable air staging is essential to ensure

- Complete combustion & heat releases in appropriate zone
- Achieving low Nox and low CO level.
- Achieving improvements on Effiency (Reduced Losses)

Optimisation

Pulveriser settings

Numbers of Pulverisers required

Fuel distribution

Consistent PC fineness

Mill outlet temperature

Optimum Primary air

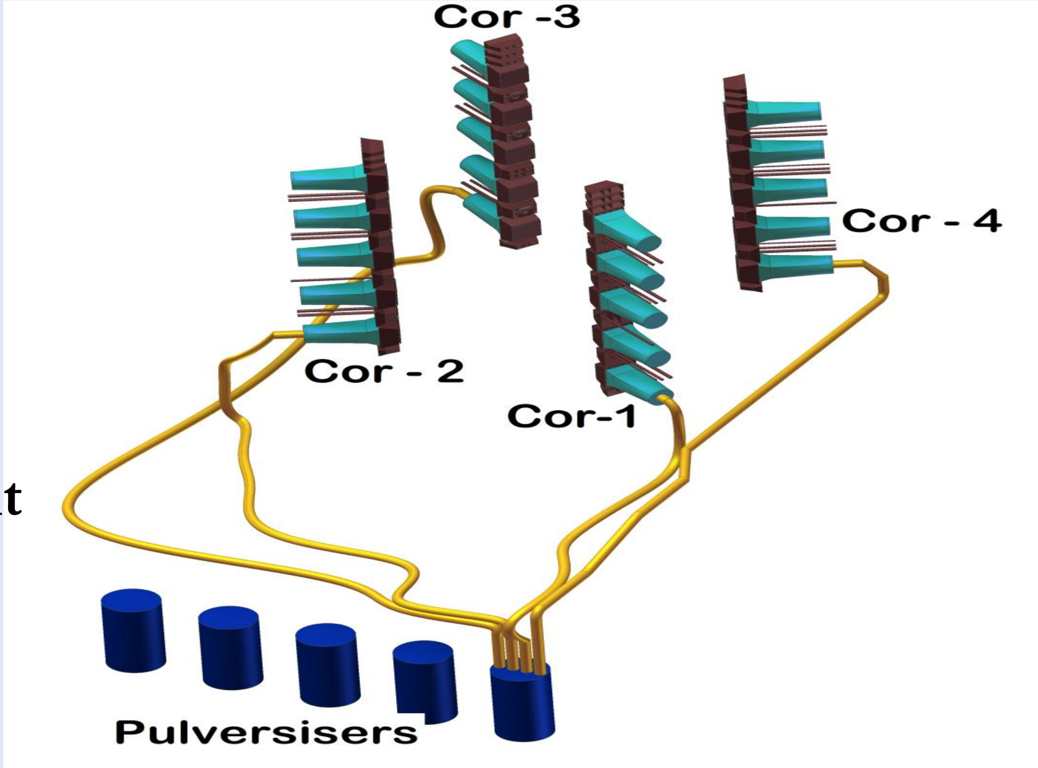
- **Minimum Coal air mixture velocity**
- **Ensure Minimum rejects**
- **Without any coal pipe chocking**

Combustion optimisation

Fuel

Fuel distribution

- It is necessary to equalise the flow with in 5 %
  - This is done by flow measurement in each pipe.
  - Clean air flow/Dirty air flow test



optimisation

PC Fineness.

- 50 mesh --- retention < 1%
- 200 mesh --- pass through > 70%

- Maintain desired mill outlet temperature as per VM% & FC/VM > 1.2 to 1.5
  - VM 20% – 25% MOT 80 - 85°C
  - VM 25% – 30% MOT 70 – 75°C
  - VM 30% - 35% MOT 65 – 70°C
  - VM > 35% MOT 65°C

Air Distribution

- Keep mill air flow just above the settling velocity.
    - Air fuel ratio --- 1.8 to 2.0 max.

- Sec. Air distribution at required elevation is very important
    - Avoid / reduce all unwanted location
    - Follow the recommended wind box damper settings. (Fuel type)
    - Check and ensure the same position of SADC's
    - Ensure equal air flow in every working Burners.(Wall firing)
    - Maintain secondary air at operating burners with optimum SAD opening and Wind box pressure.

- Check all peep holes, furnace opening, bottom ash hopper sealing to avoid air ingress

- Change the air setting and tune combustion with coal quality change

Air Regime Setting

OFA & Top AAD opening (OFA, EE)
Reducing Nox control
Reducing SH/RH spray and temperature

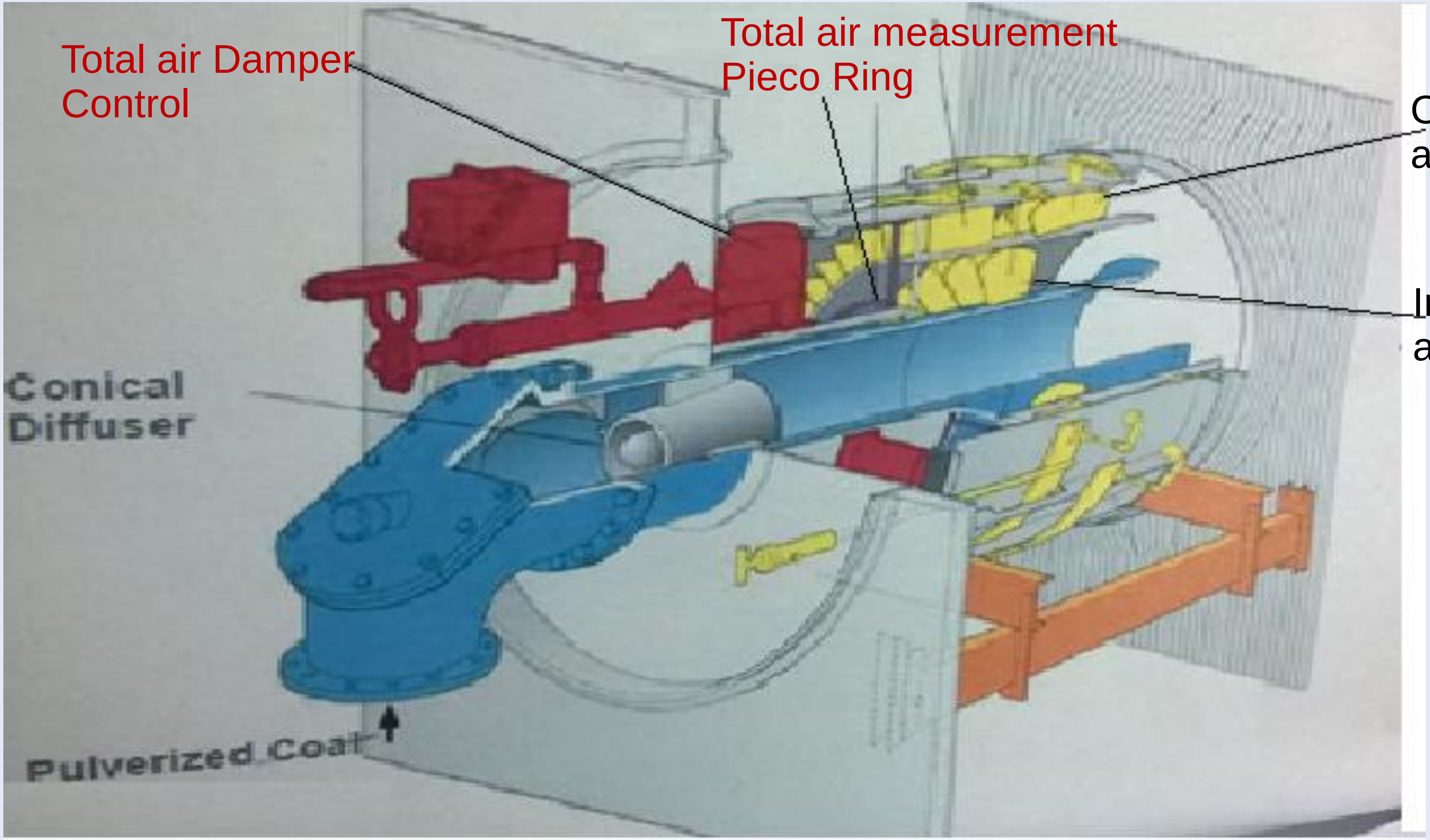
Modulating AAD opening (AB, BC etc)
Ensured adjacent AAD opening for each coal stream
Maintain atleast 25% opening in all condition

FAD opening depends on VM% (A,B,C etc)

Bottom AA opening generally 50% opening.
Full opening for Reducing slagging, SH/RH spray and temperature.
Improved suspension firing and reducing Bottom Ash LOI
30- 50% opening to increase SH/RH temperature and to reduce Nox

Slagging & clinkering.
Split mill operation / More no off AAD opening with low WB Dp
High excess air operation / avoid reducing atmosphere condition
Ensure desired Fuel fineness and Fuel air mixture temperature
Almost equal loading of fuel in each Burner.

FRONT WALL FIRING DAMPER SETTINGS



FRONT WALL FIRING DAMPER SETTINGS

1. **The General Air Damper** :-
   - Balancing the air flow entering from wind box into each burner to ensure all the burners work with equal air flow.
2. **Inner secondary air swirler angle**
   - To apportion the total secondary air into secondary air and tertiary air
3. **Outer secondary air swirler angle**
   - To change the swirling effect to increase the rapid combustion rate.
4. **Tertiary air swirler angle**: -
   - To change the swirling effect of secondary combustion.

1. CO (Carbon monoxide)

Based on Fuel property and combustion behaviour

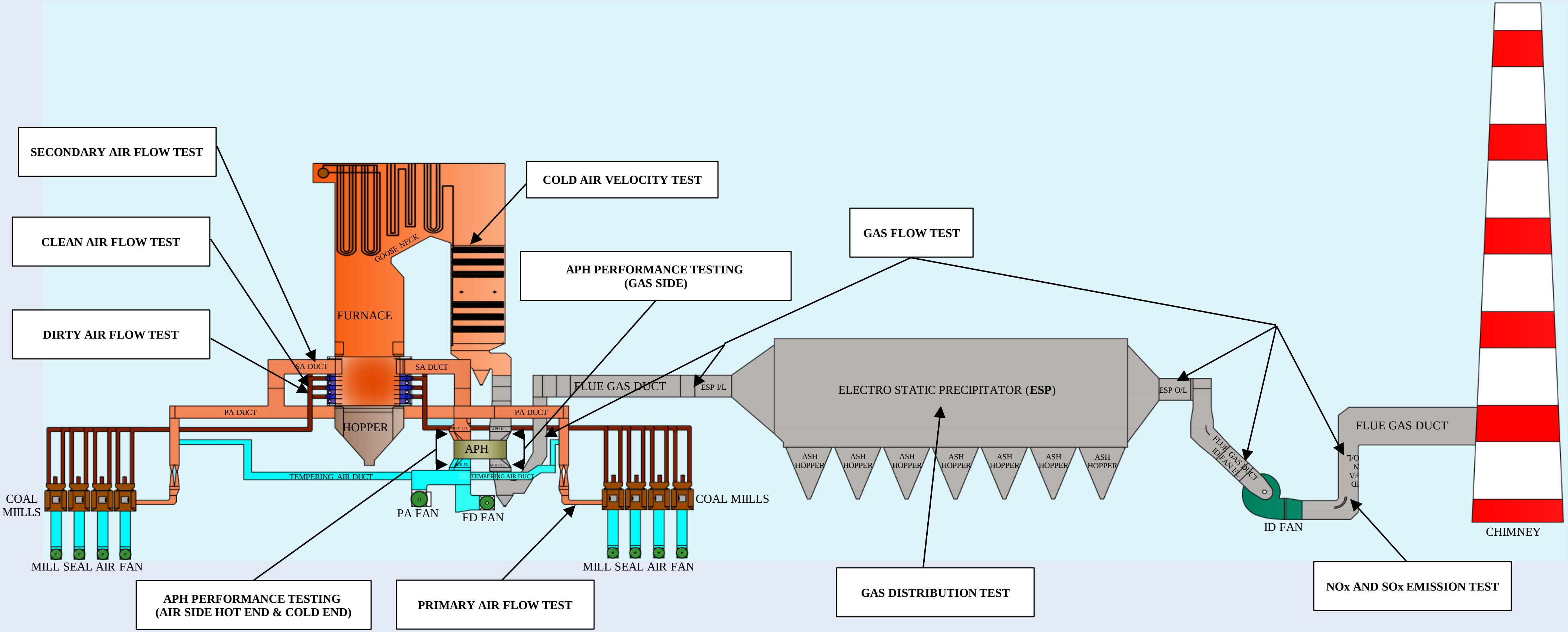
To reduce CO ensure complete combustion in appropriate zones

2. Nox

- Based on Nitrogen content through Fuel and Air
- Generated within the flame profile
- Very high cocentration of N2 and O2 (Rapid combustion)
- High Excess O_2 and high Flame Temperature
- Fuel rich flame.

- Adopting Nox reduction technique
  - Low excess air operation
  - Suitable air staging
    - Avoid rapid combustion
    - Ensure Low flame temperature profile with sluggish combustion

PERFORMACE TESTING



PERFORMACE TESTING

TEFUGEN
Technologies for Future Generation

EQUIPMENT	OBJECTIVE OF THE TEST
Boiler with APH	Boiler efficiency = 100 – Total losses
Air Pre Heater separately	Air Leakage, Air side efficiency, Gas side efficiency, X-Ratio
Fans	Fan efficiency Based on Pressure drop and Flow measurements
Pulveriser	Evaluation of Hot air flow through mills and Fineness
Electrostatic Precipitator	ESP efficiency based on dust concentration and gas flow.

TO ENHANCE THE PERFORMANCE OF BOILER & AUXILIARIES

TEFUGEN
Technologies for Future Generation

TYPES OF TEST	OBJECTIVE OF THE TEST
Cold Air VelocityTest	To assess the erosion pattern of pressure parts coils in second pass
Secondary Air Flow Test	Assessing the Left/Right air flow to ensure equal air flows in service Burners
Clean Air Flow Test Dirty Air Flow Test	Establishing equal flow / velocity of air fuel mixture in all coal pipes to improve combustion behaviour.
Iso-Kinetic sampling	To evaluate Pulvrised fuel Fineness.
Primary Air Flow Test	To assess the air flow through mills
Flue Gas Flow Test	Assesing the equal flow through duct branches to reduce the pressure drop and to improve the ESP and ID fan performance.
Flue Gas Analysis Test	To assess the Nox, Sox and Co content.
Gas Distribution Test	Establishing equal gas flows within ESP which improves efficiency
Air in leakage Test	Evaluavation of air ingress with in ESP

Boiler Performance Testing

Parameters for Boiler and APH evaluation test together.

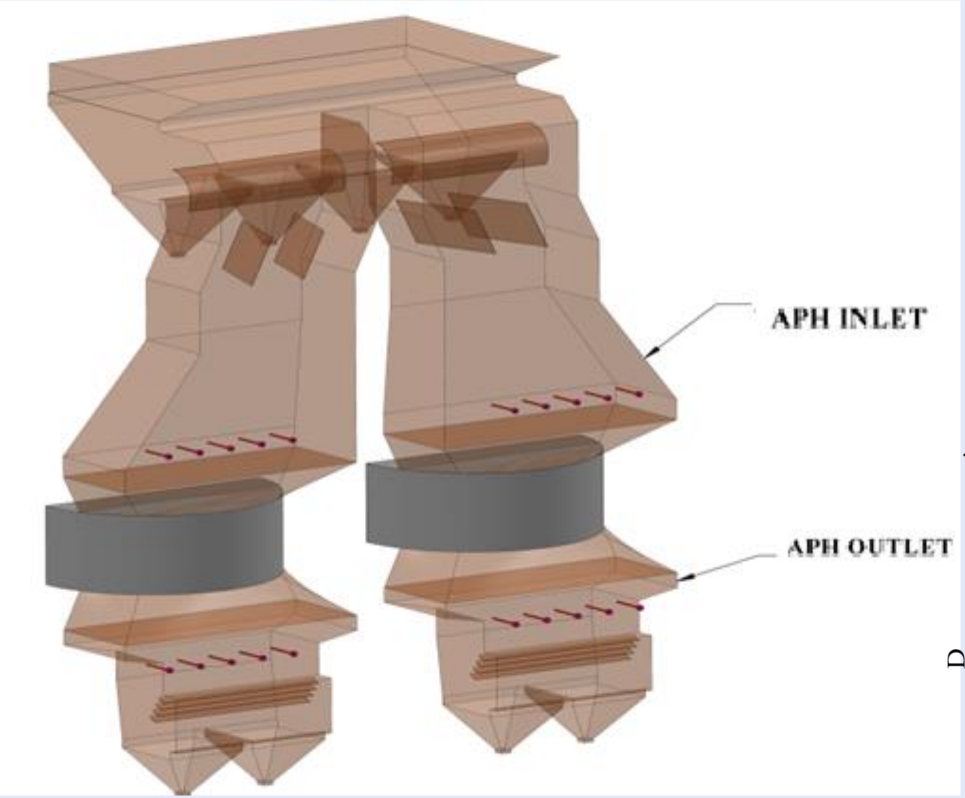
1. **Parameters Measured in grid pattern at APH inlet & outlet**.
   Oxygen
   Carbon dioxide
   Carbon monoxide
   Temperature
   static Pressure

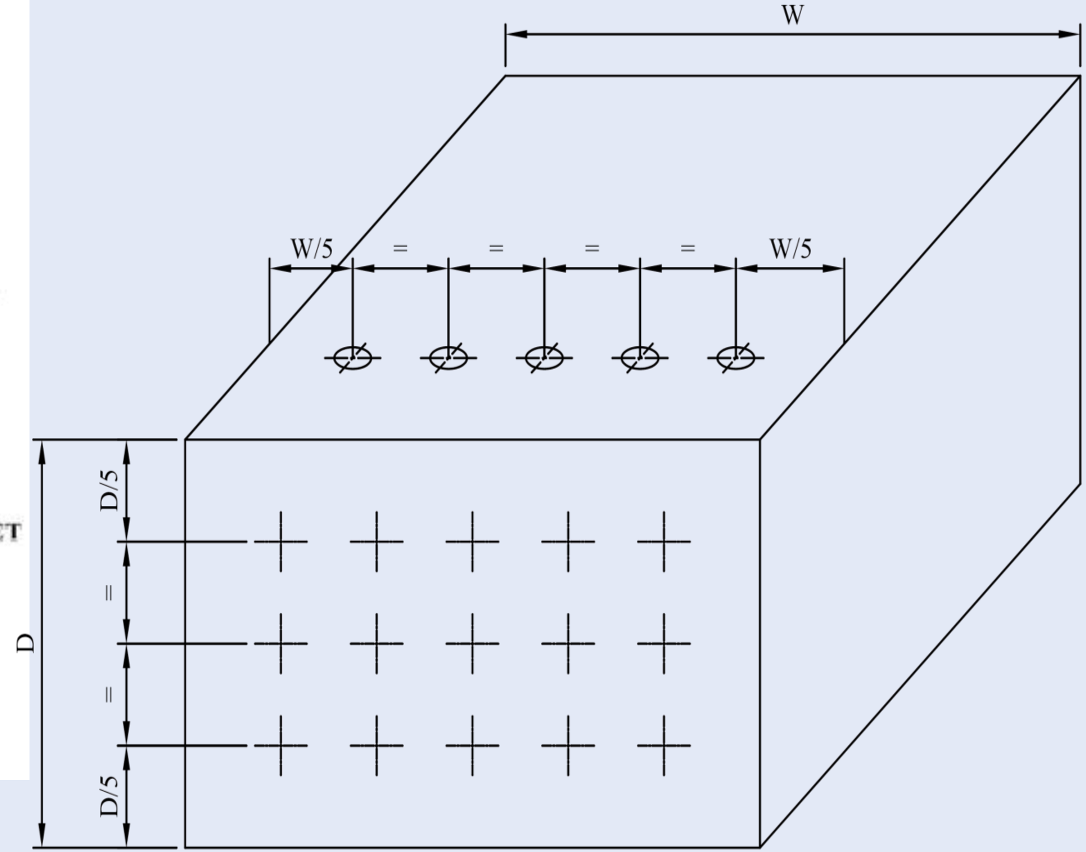
2. **Raw Coal sampling**

3. **Ash Sampling**
   Bottom ash
   Fly ash (Economiser , APH and ESP)

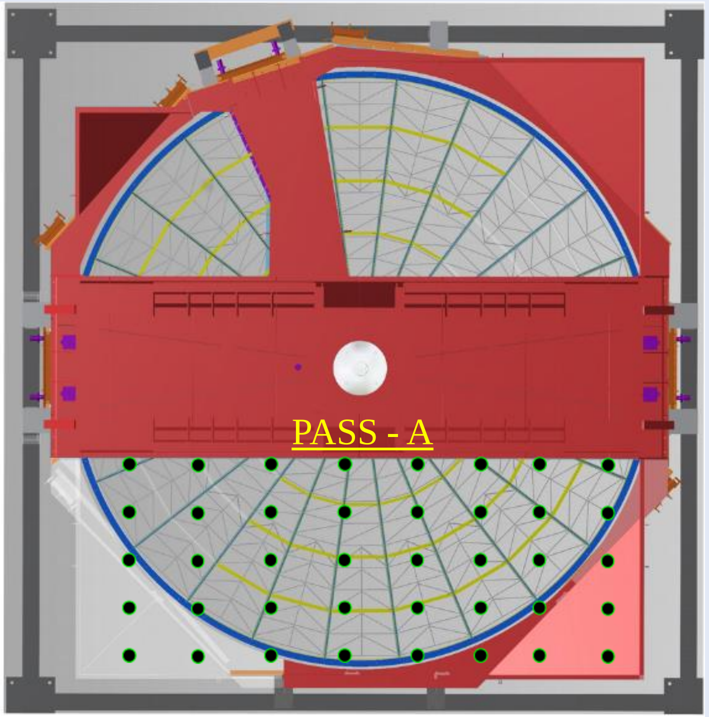
4. **Mill rejects sampling and rejects quantity per hour**

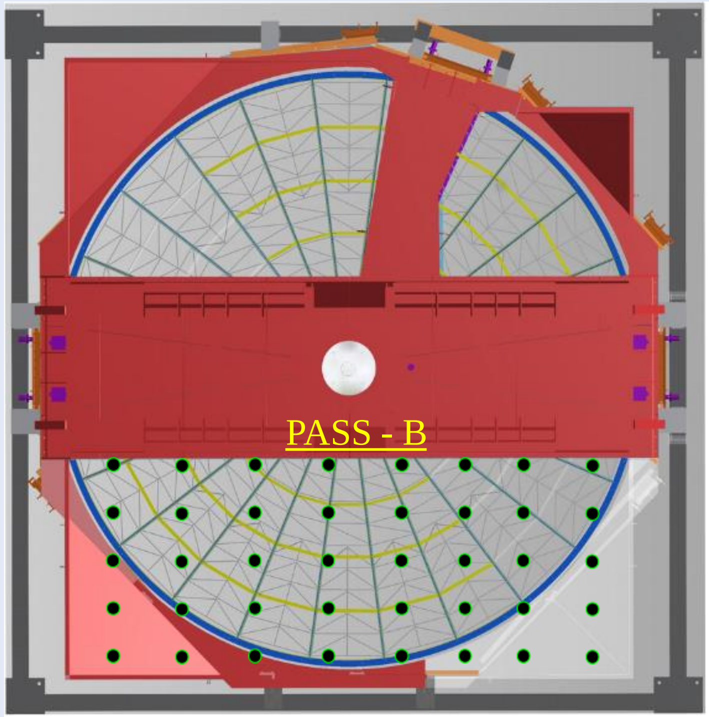
Boiler and APH performance Testing





GRID MARKING:



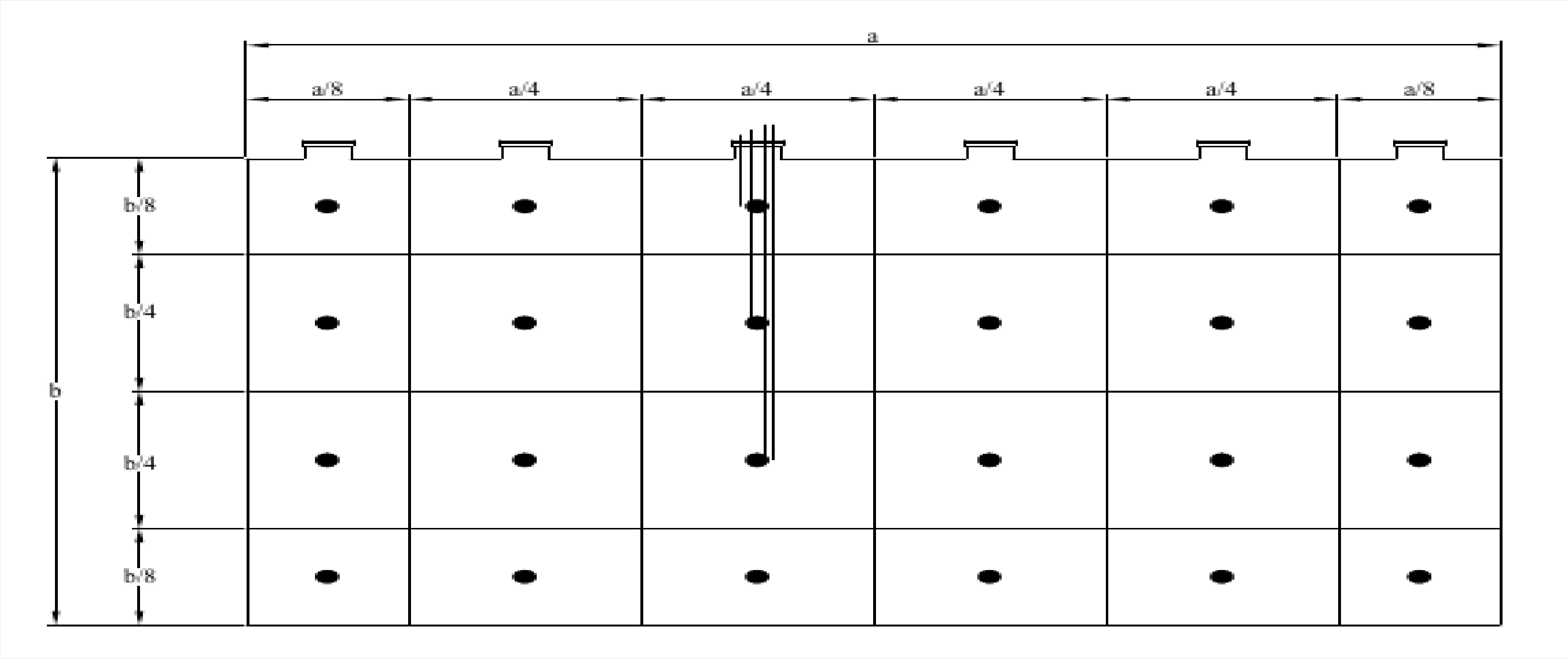


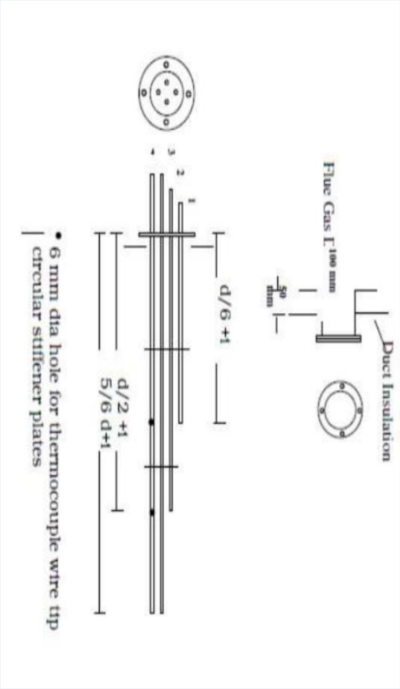
8	7	6	5	4	3	2	1		← PORTS →		1	2	3	4	5	6	7	8

DEPTHS ↑
1
2
3
4
5

Note: Ports and Depths will be decided with respect to duct size

Boiler and APH performance Testing – Grid pattern measurement (TYP)





Boiler performance testing

Derived parameters for Boiler losses.

Based on Gas analysis **(** O_2, CO_2, CO, Static pressure, Temperature and coal analysis)

- ✓ **Weight of gas flows**
- ✓ **Weight of air flow**
- ✓ **APH air Leakage**

Based on coal analysis

- ✓ **Weight of Total moisture**
- ✓ **Moisture due to Hydrogen**

Based on Ambient condition (Temperature and Relative humidity**)**

- ✓ **Weight of Air moisture**

Based on Loss on ignition from ash analysis

- ✓ **Weight of unburnt (Bottom ash +Fly ash)**

Boiler Losses calculation
Basic principle.

$$\text{Carbon loss} = \frac{Uc \times Cv \text{ of carbon}}{GCV}$$

$$\text{Dry gas loss} = \frac{Wd \times cpg\,(Tg - Ta)}{GCV}$$

$$\text{Moisture loss} = \frac{Wm \times Sh}{GCV}$$

Sh = 1.88 x (Tg-25) +2442+4.2x(25-Ta)

$$\text{Heat in ash loss} = \frac{Wa \times cpa \times (Tg - Ta)}{GCV}$$

$$\text{Mill Rejects loss} = \frac{Wr \times gcv \text{ of rejects}}{GCV}$$

Uc	**Wt of un burnt carbon**
Cv	Calrific value of carbon
Wd	wt. of Dry gas
Cpg	specific heat of gas
Wm	weight of moisture
Sh	sensible heat of water vapour
Cpa	specific heat of air
Tg	Exit gas Temperature
Ta	Ambient air Temperature
Wr	Weight of rejects /kg of coal
GCV	Calorific value of coal

AIR PREHEATER PERFORMANCE FACTORS

TEFUGEN
Technologies for Future Generation

1.Air heater Leakage

- Increases fan power for all fans; ID,FD & PA
- Quenches the flue gas and shows low flue gas exit temperature
    - Misleads the Boiler operator

2.Air side efficiency Dictates effectiveness of APH Heating surface (93%)

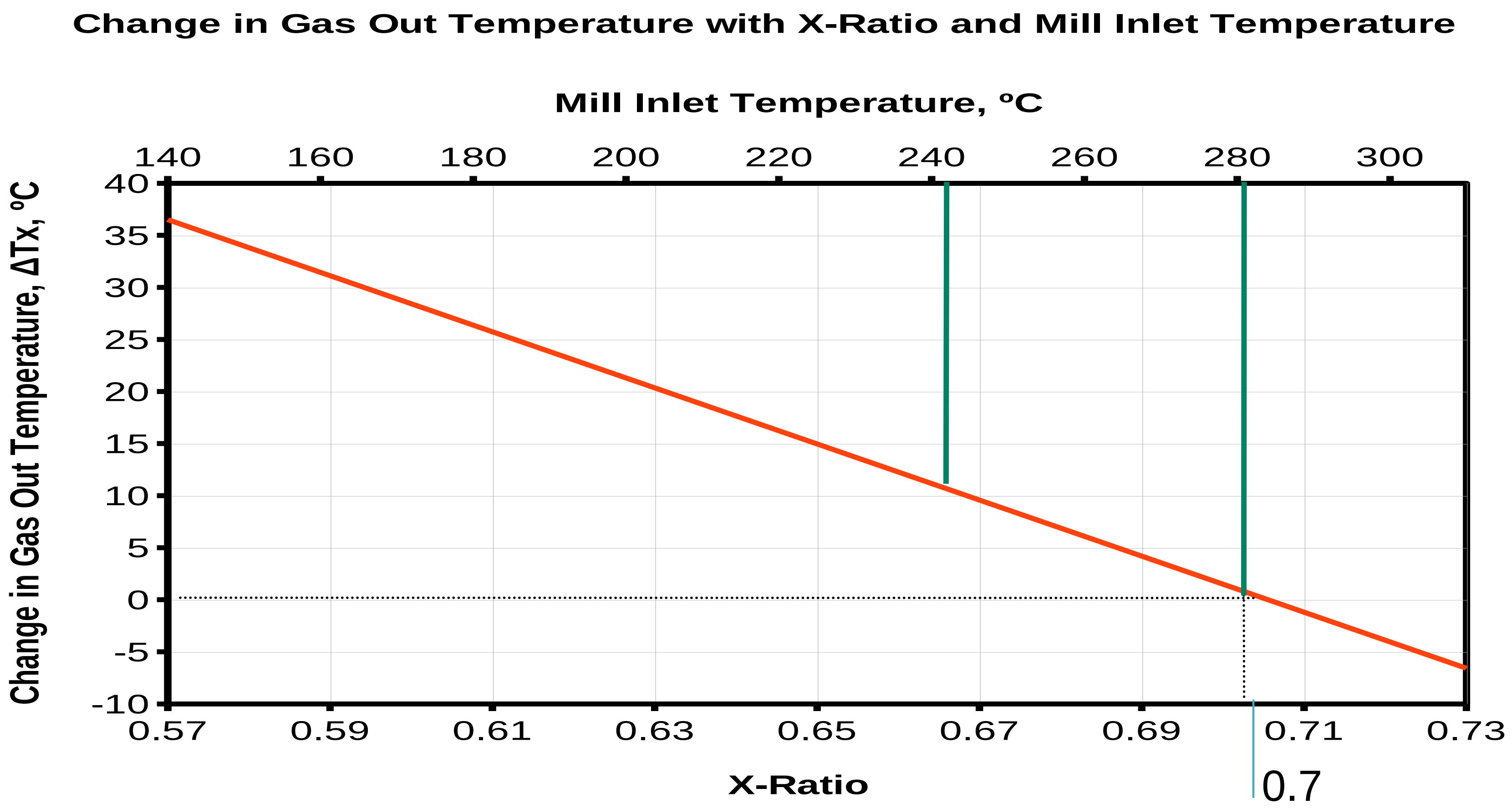
3. Gas side efficiency

4. X - ratio

Operational adjustment based on coal property is required.

5. Higher pressure drop in air and flue gas stream

- Increases fan power for all fans; ID, FD & PA


Change in Gas Out Temperature with X-Ratio and Mill Inlet Temperature
Mill Inlet Temperature, ºC
140
160
180
200
220
240
260
280
300
Change in Gas Out Temperature, ΔTx, ºC
40
35
30
25
20
15
10
5
0
-5
-10
0.57
0.59
0.61
0.63
0.65
0.67
0.69
0.71
0.73
X-Ratio
0.7

APH PERFORMANCE TEST

FORMULA USED:

$$AIR\ LEAKAGE\ by\ O2\ \% = \frac{\left(O_2 out - O_2 in\right) \times 0.9\ x100}{20.95 - O_2 out}$$

$$AIR\ LEAKAGE\ by\ CO2\ \% = \frac{\left(CO_2 in - CO_2 Out\right) \times 0.9 \times 100}{\text{CO2 Out}}$$

APH PERFORMANCE TEST

FORMULA USED:

$$Gas\ Side\ Efficiency = \frac{Gas\ inlet\ temperature - Gas\ outlet\ temperature\_No\ Leakage}{Gas\ inlet\ temperature - Air\ inlet\ temperature}$$

$$TGO\_NL = \frac{AL * cp\ ratio * (Tgom - Tai)}{100} + \text{Tgo measured}$$

$$Air\ Side\ Efficiency = \frac{Air\ outlet\ temperature - Air\ inlet\ temperature}{Gas\ inlet\ temperature - Air\ inlet\ temperature}$$

$$X\ Ratio = \frac{Gas\ side\ Efficiency}{Air\ side\ Efficiency}$$

Fan Performance Testing
(Adopting Flow test procedure)

TEFUGEN
Technologies for Future Generation

Fan testing will be done by measuring

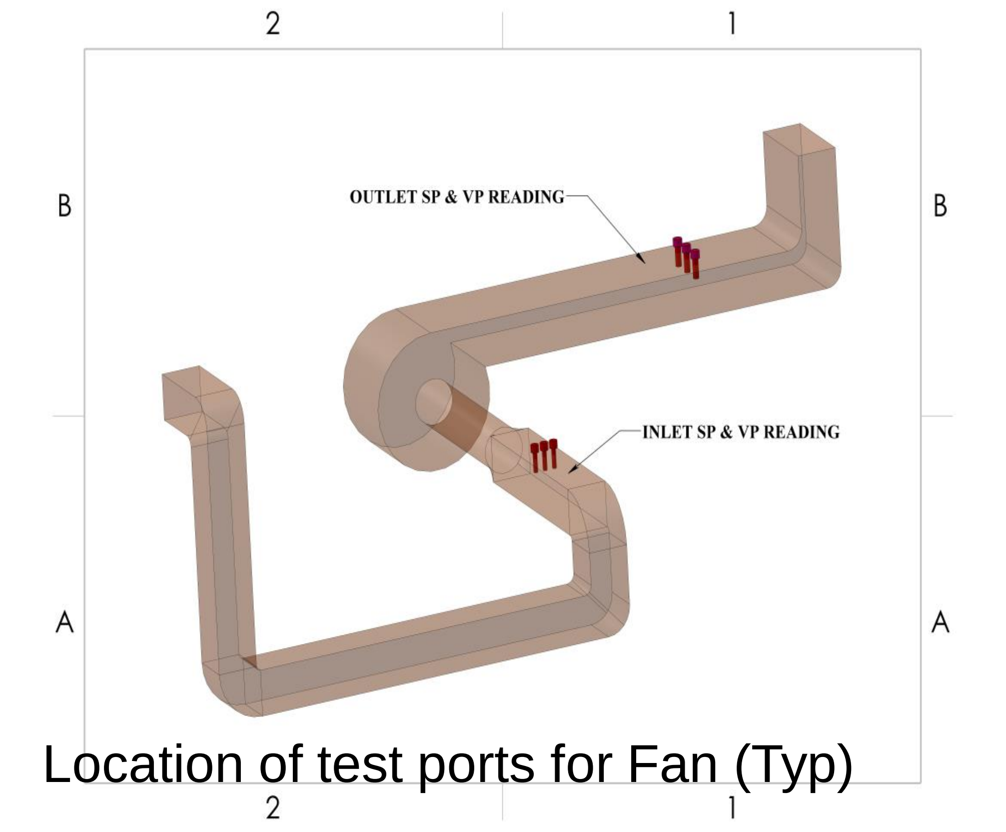
1. Static pressure at inlet and outlet

2. Velocity pressure at inlet and out let

3. Temperature of the medium at in let and outlet.

4. Fan power will be calculated and compared with specified performance and Fan efficiency shall be determined.

5. Identifying the problem area for improvement.



Location of test ports for Fan (Typ)

Fan Performance

Fan shaft Power (KW) = $\frac{Q\ Y\ \rho}{1000\ \eta}$ + Bearing Loss

Fan η = $\frac{\textit{Fan shaft power measured}}{\text{Flow x Total pressure developed}}$

Q=Flow (M3/sec)

Y=Isentropic head (Nm/kg)

ῤ= Density of medium (kg/m3)

η = Fan Effiency.

Isentropic head=Total pressure developed /density

Fan performance factors

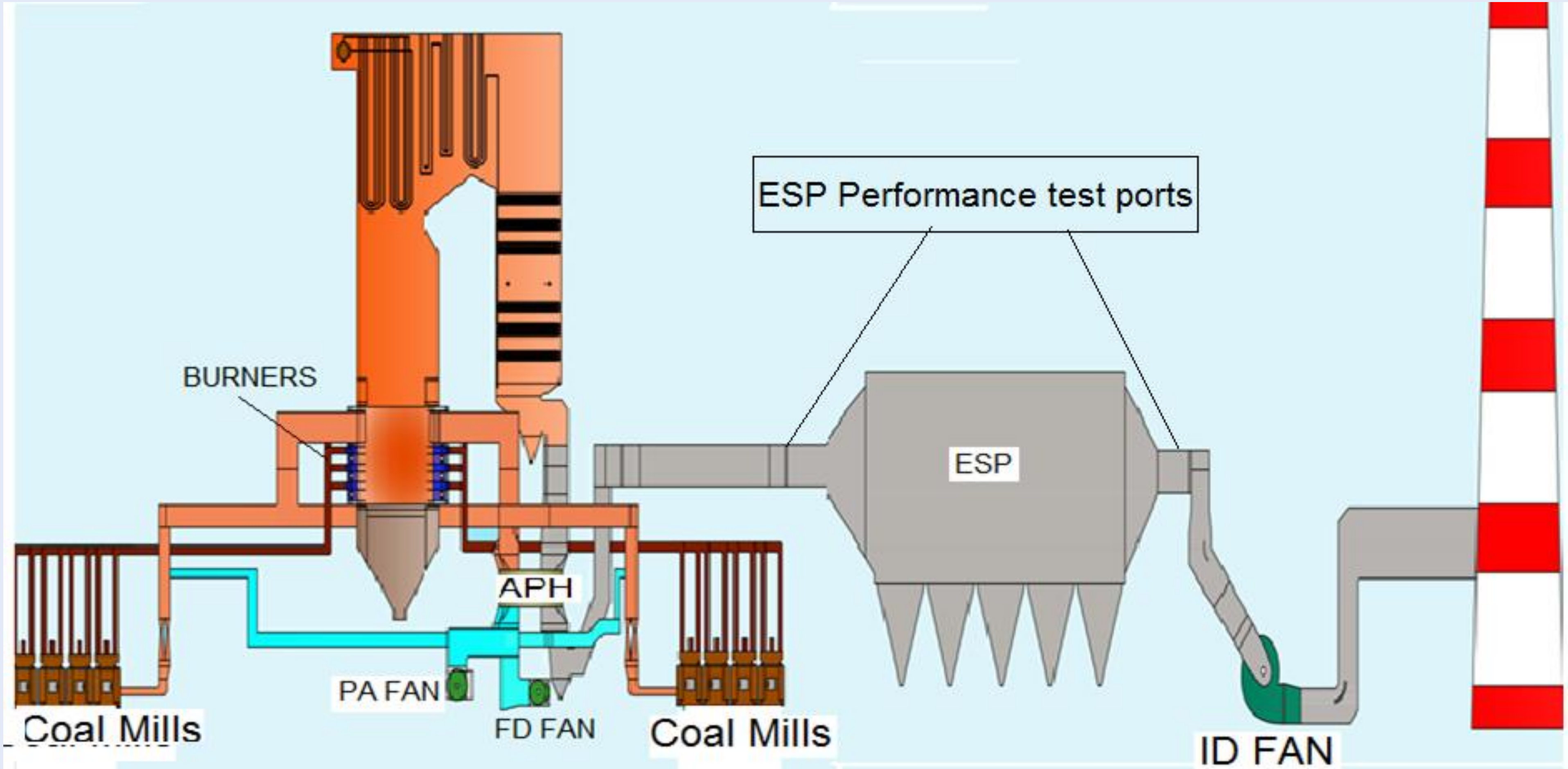
Pressure drop ↑	**Fan Power** ↑
Flow ↑	**Fan Power** ↑

Temperature ↑	**Density** ↓
Density ↓	Flow ↑

Flow, static pressure, temperature, density are inter related.

ESP Performance Testing

ESP Test port location.



ESP PERFORMANCE TESTING

Flow measurement and iso kinetic sampling procedure

1. Gas flow parameters at inlet and outlet of ESP
   - Static pressure
   - Dynamic pressure
   - Temperature

2. Iso kinetic sampling of ash
   - Inlet dust concentration per NM3   (IDC)
   - Outlet Duxt Concentration per NM3 (ODC)

Derived parameters:
- Gas flow at ESP inlet and outlet
- Weight of ash collected at inlet and outlet

$$\textbf{ESP Efficiency} = \frac{IDC - ODC}{IDC.}$$

ESP Performance (SPM)
Based on Boiler Parameters

Gas velocity **:-** **Gas Flow**

Excess air

APH leakage

Duct Air Ingress

Gas Temperature

Boiler & APH performance

Migration Velocity:- *Gas velocity*

Gas flow & Distribution

Gas Temperature

Ash Resistivity

Ash composition

Gas temperature

Treatment Time :- *Gas velocity*

Gas Flow & Distribution

Gas Temperature

Air and Gas Flow test in Ducts.

1. Clean air flow test and dirty air flow test in coal pipes.

2. Hot air, cold air and gas flow test in ducts

3. Hot primary air flow test for pulverisers.

3. Air / Gas Flow testing for fan performance

4. Gas Flow testing for ESP performance.

AIR & GAS FLOW TEST

OBJECTIVE:

- Flow testing is carried out to check the flow / velocity profile in different stream of Air & Gas circuit of Boiler.
- This evaluation will indicate the present condition of flow / velocity profile.

PROCEDURE:

- This test will be conducted during operation at full load condition.
- The measurements shall be taken in with grid pattern to ensure the accuracy of the performance.
- The grid points can be marked with respect to the size of duct.

Flow Test

TEFUGEN
Technologies for Future Generation

Instruments used:

1. Pitot tube
2. Monometer
3. Thermocouple
4. Temperature indicator

Parameters measured

1. Static pressure (st)
2. Dynamic pressure (h)
3. Temperature (T)

$$\text{Velocity} = \sqrt{\frac{2\,g\,h}{\rho}}$$

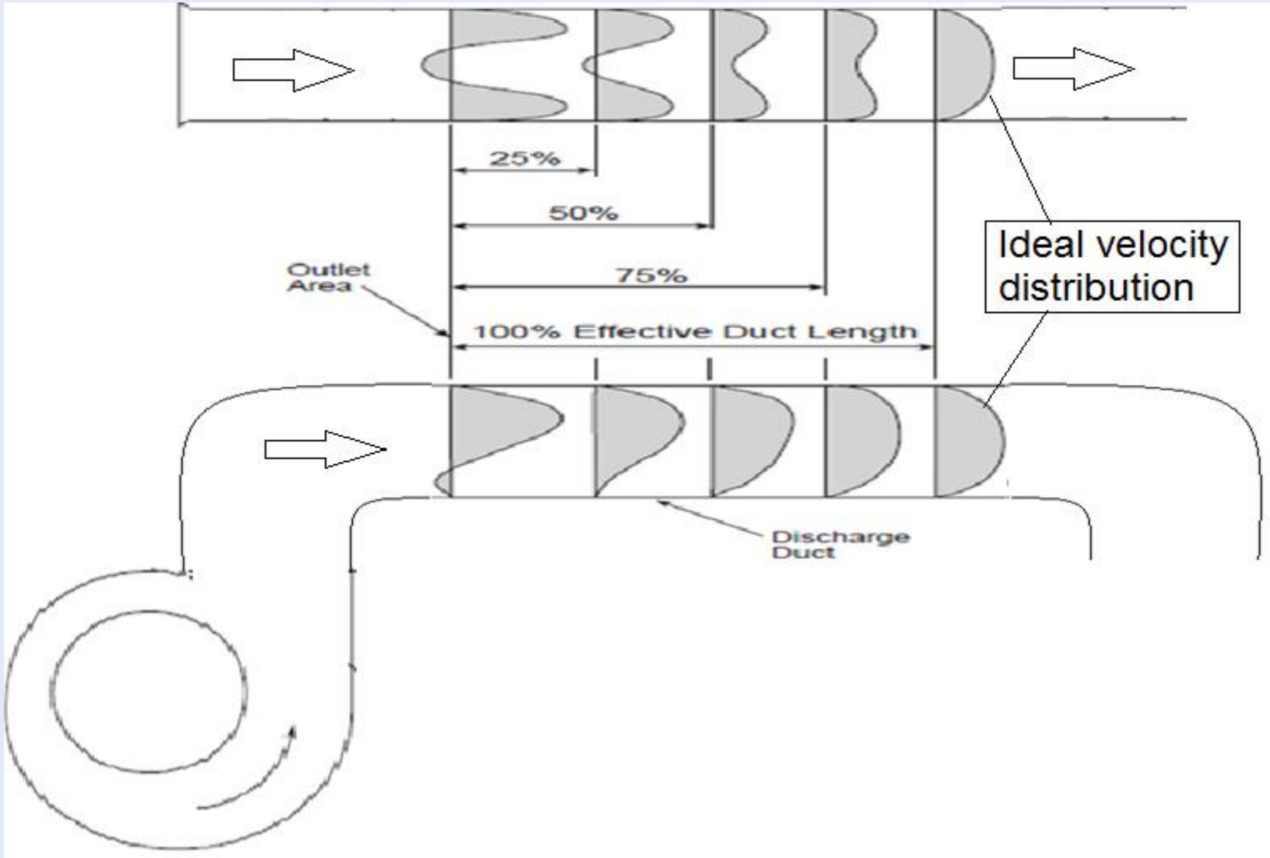
Density (ρ)is proportional to static pressure (st) and inversly proportional to temperature (T).

Flow = Area x velocity

Location of tapping ports
&
Velocity distribution pattern

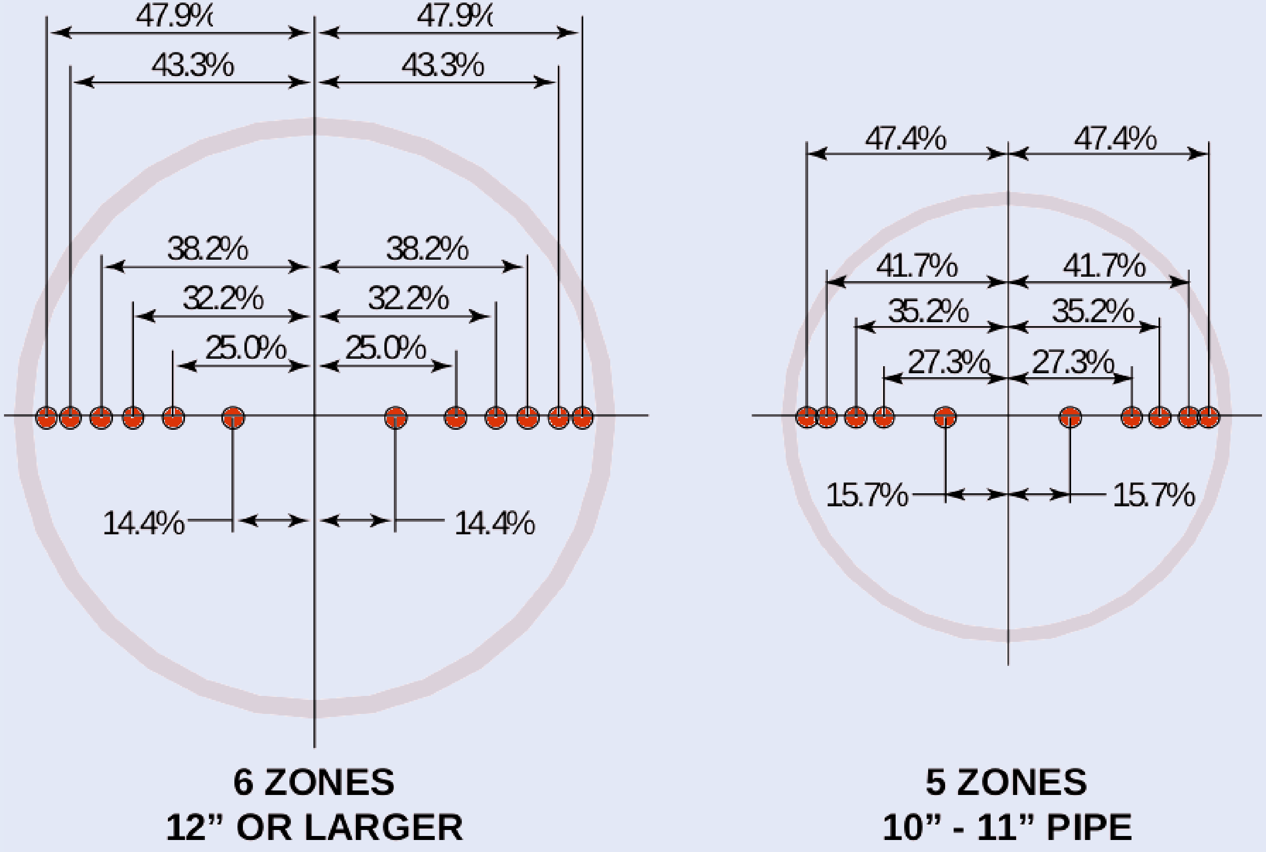
Effective Length	**For flow velocity 15 m/se**
100 %	3 times hydraulic diameter
For every 5 m/sec add one times of hydraulic diameter to get 100 % effective length. Hydraulic diameter $=\frac{2\,ab}{a+b}$	

Medium of flow	Velocity
Air	12-15 m/sec
Flue gas	17-20 m/sec
Air coal mixture	25-30 m/sec

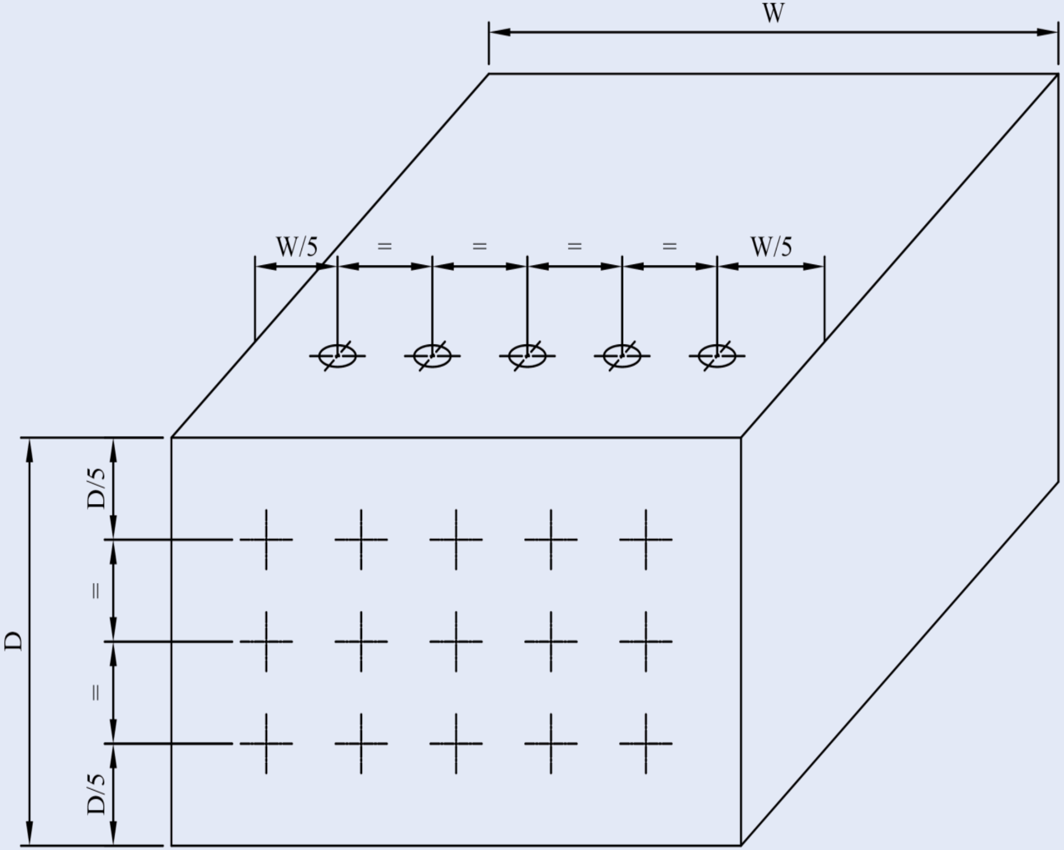


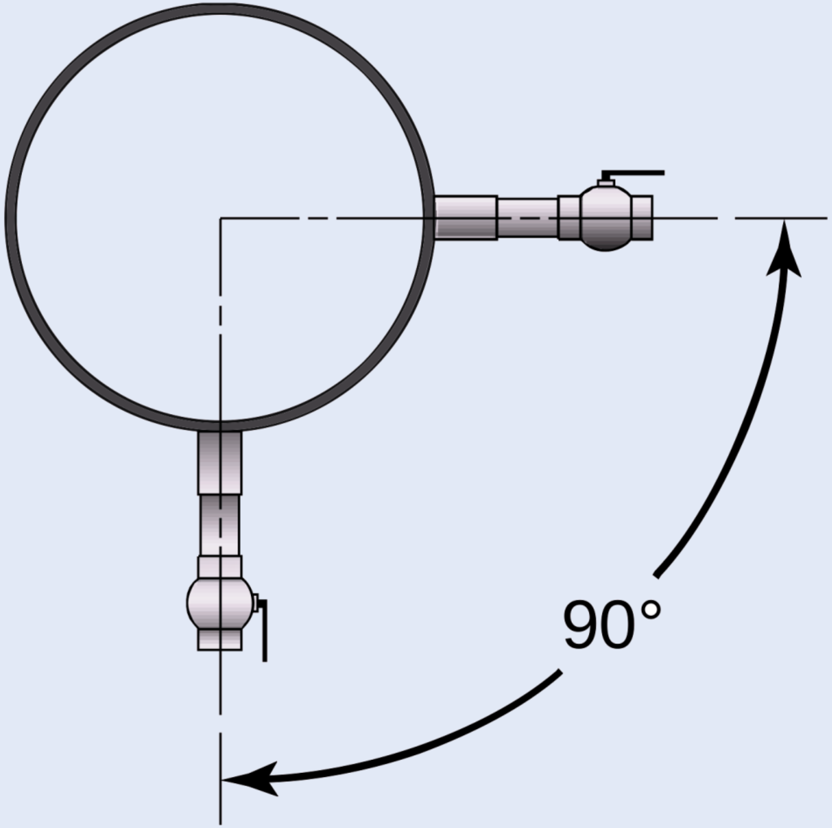
GRID PATTERN FOR CIRCULAR DUCTS

CLEAN AIR FLOW TEST
DIRTY AIR FLOW TEST
ISO KINETIC SAMPLING

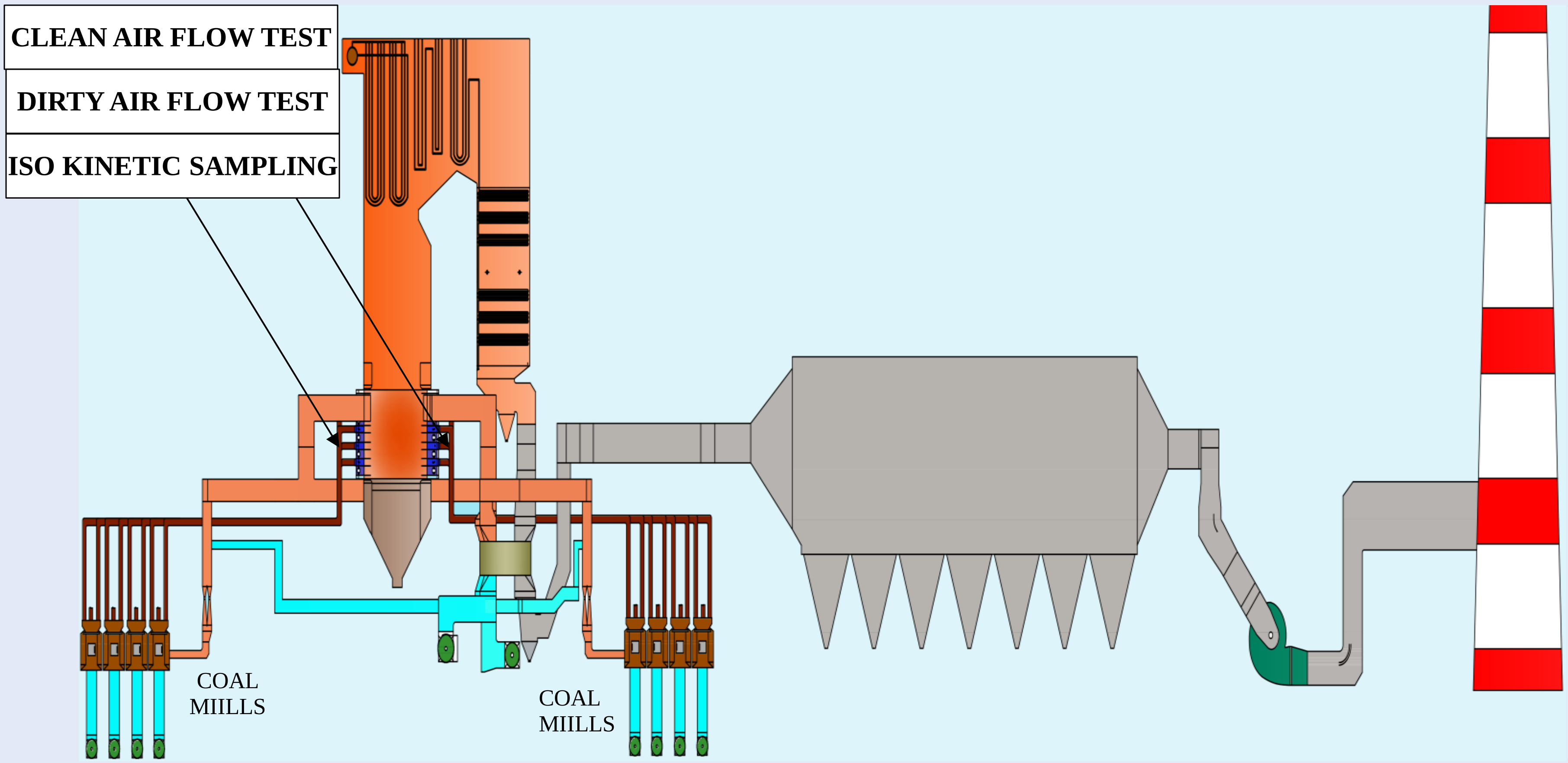


Velocity distribution pattern
Vs
Tapping ports



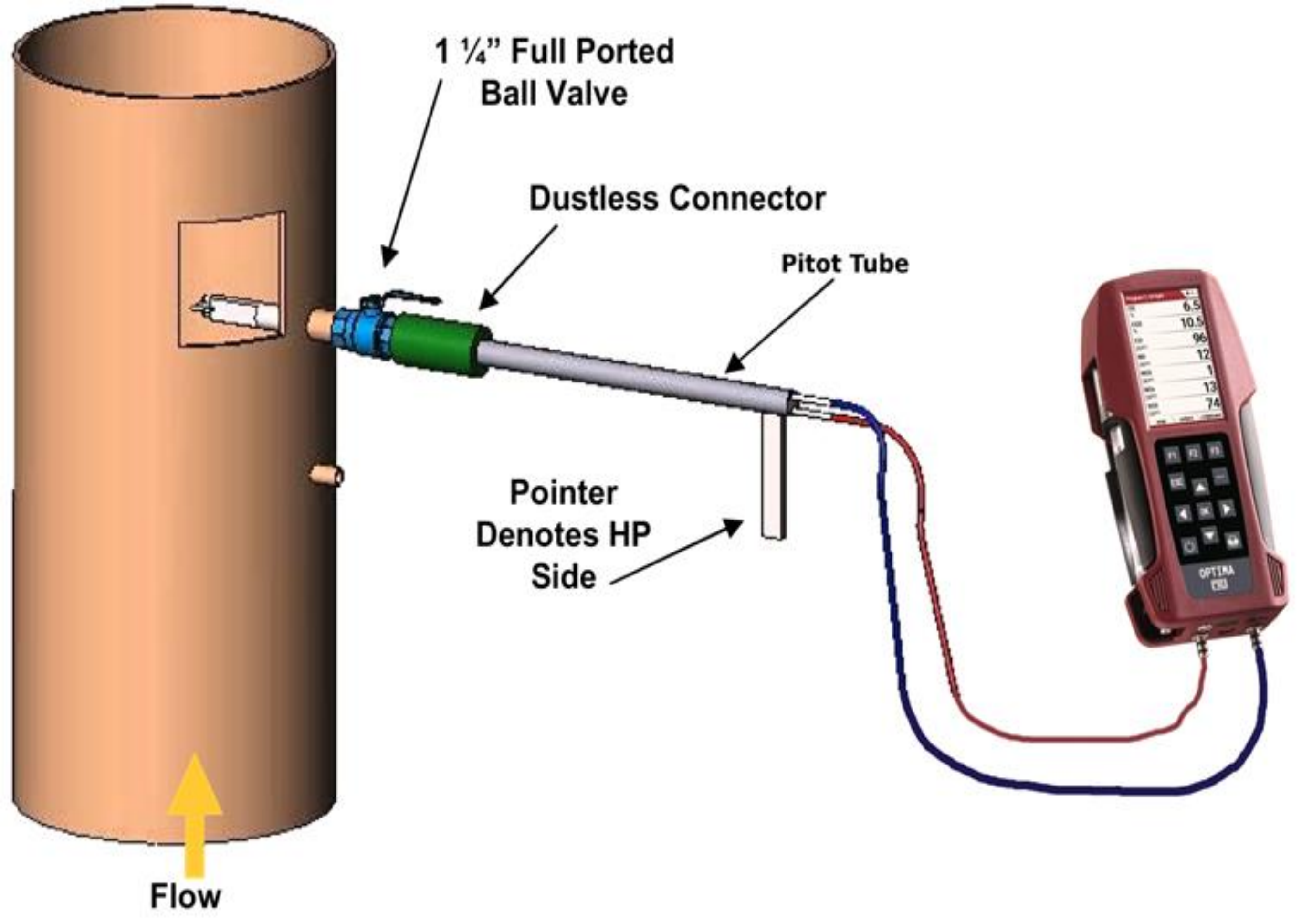


CLEAN / DIRTY AIR FLOW TEST LOCATION
ISO KINETIC SAMPLING



FLOW TEST PORTS

CLEAN AIR FLOW TEST
DIRTY AIR FLOW TEST
ISO KINETIC SAMPLING



CLEAN AIR FLOW TEST

OBJECTIVE:

- To check velocity variation among the coal pipes of a pulverizer
- To ensure correct size orifices are installed in coal pipes
- To establish equal flow in all the coal pipes of pulverizer.
- Ensure the standard deviation of velocity among the coal pipes is with in the acceptable limit of ± 5%.

CLEAN AIR FLOW TEST

PROCEDURE:

- Ensure two tapping points 90 deg apart preferebly nearer to burner
- Clean Air flow tests will be conducted in all mills outlet coal pipes individually with medium of Cold Air.
- The test will be conducted by running primary air fan and pulveriser.
- This test will be conducted normally when the Boiler is under shutdown.
- With respect to Variation in Velocity among the coal pipes the orifice will be adjusted or orifice size will be determined and recommended for further action.

CLEAN AIR FLOW TEST

TEFUGEN
Technologies for Future Generation

PROCEDURE:

◆ FIXED SIZE ORIFICE SYSTEM:

If the deviation is beyond the limit, length of all pipes will be calculated as per the coal pipe layout drawing.

- Based on the difference in length, suitable orifice size as per the standard shall be selected and recommended for correct orifice size.

◆ VARIABLE ORIFICE SYSTEM:

If the deviation is beyond the limit, the orifice shall be adjusted by trial and error method until the velocity deviation is within acceptable limit.

DIRTY AIR FLOW TEST

OBJECTIVE:

- To check coal-air mixture flow/velocity variation among the coal pipes of a pulverizer
- To ensure correct size orifices are installed in coal pipes
- To establish equal flow in all the coal pipes of pulverizer.
- Ensure the the standard deviation of velocity among the coal pipes is with in the acceptable limit of ± 10%.

DIRTY AIR FLOW TEST

TEFUGEN
Technologies for Future Generation

PROCEDURE:

- Dirty Air flow tests procedure will be same as discussed in clean air flow test.
- Instruments will vary to suit air coal mixture as medium of flow.
- Grid marking, Formula used, Tapping points requirements & procedure remains same as clean air flow test.
- Clean air flow test will be done during shutdown of Boiler.
- Whereas Dirty air flow will be carriedout during the Boiler is inservice

ISO KINETIC - PULVERSED COAL SAMPLING

To determine the actual coal fineness of the pulverisers

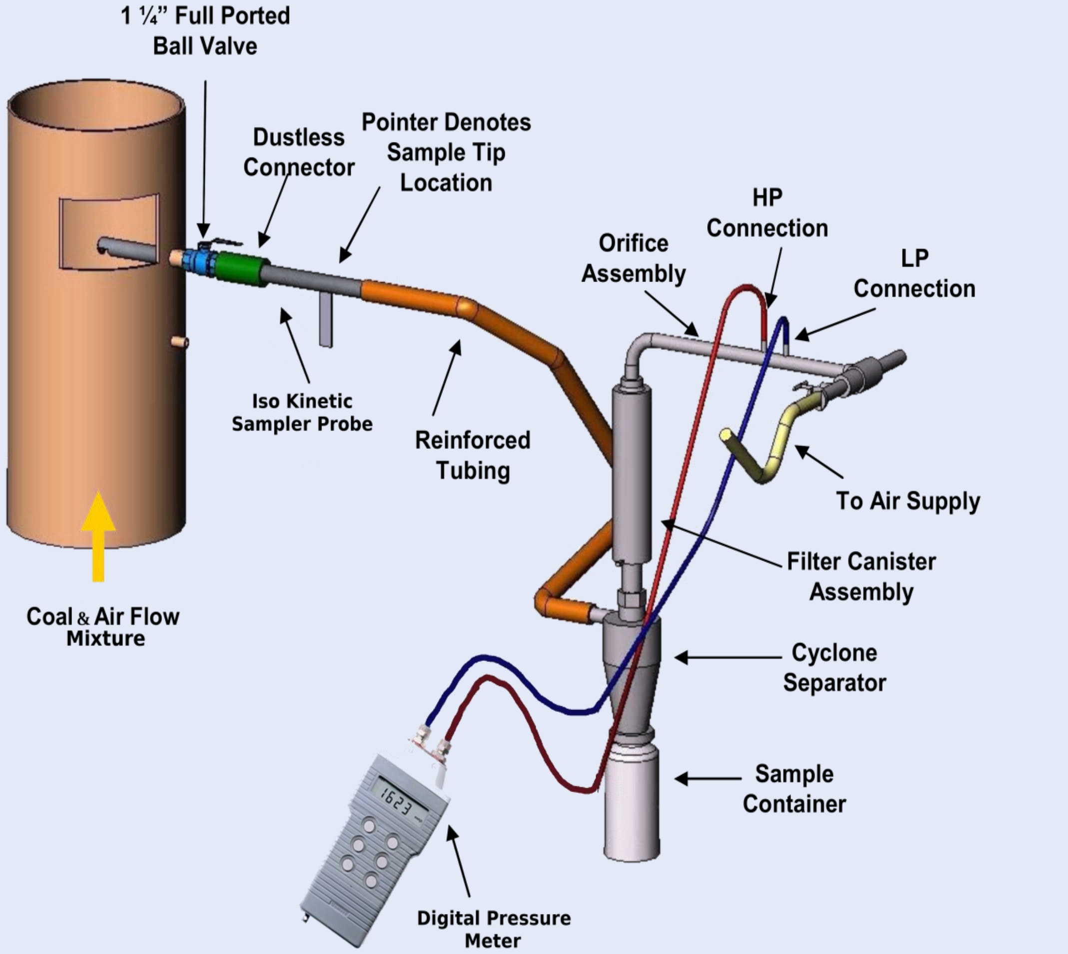
.

ISO KINETIC SAMPLING

TEFUGEN
Technologies for Future Generation

PROCEDURE:

- The average differential pressure is calculated based on the dirty air velocity traverse.
- The pressure inside the probe is set to the average differential pressure and it is monitored using digital pressure meter.
- Almost same duration of coal sampling in each pipe is maintained and recorded.



ISO KINETIC SAMPLING

TEFUGEN
Technologies for Future Generation

OPTIMUM FINENESS REQUIRED:

- The coal fineness shall be determined by sieve analysis in the Laboratory.
- Retention of particle in 50 Mesh should be below 0.5% of sample weight.
- Passing through of particles in 200 Mesh should be above 75% of sample weight.
- **ADVANTAGES OF OPTIMUM FINENESS**
- Coal fineness below optimum level may cause Poor distribution of coal amongst the coal pipes each Pulveriser.
- Fuel distribution always be achieved with higher coal fineness
- Better fuel balance is always beneficial to boiler performance, emissions characteristics and unburnt losses.

COLD AIR VELOCITY TEST

Methods to resolve isolated erosion of coils in secon pass:-

OBJECTIVE:

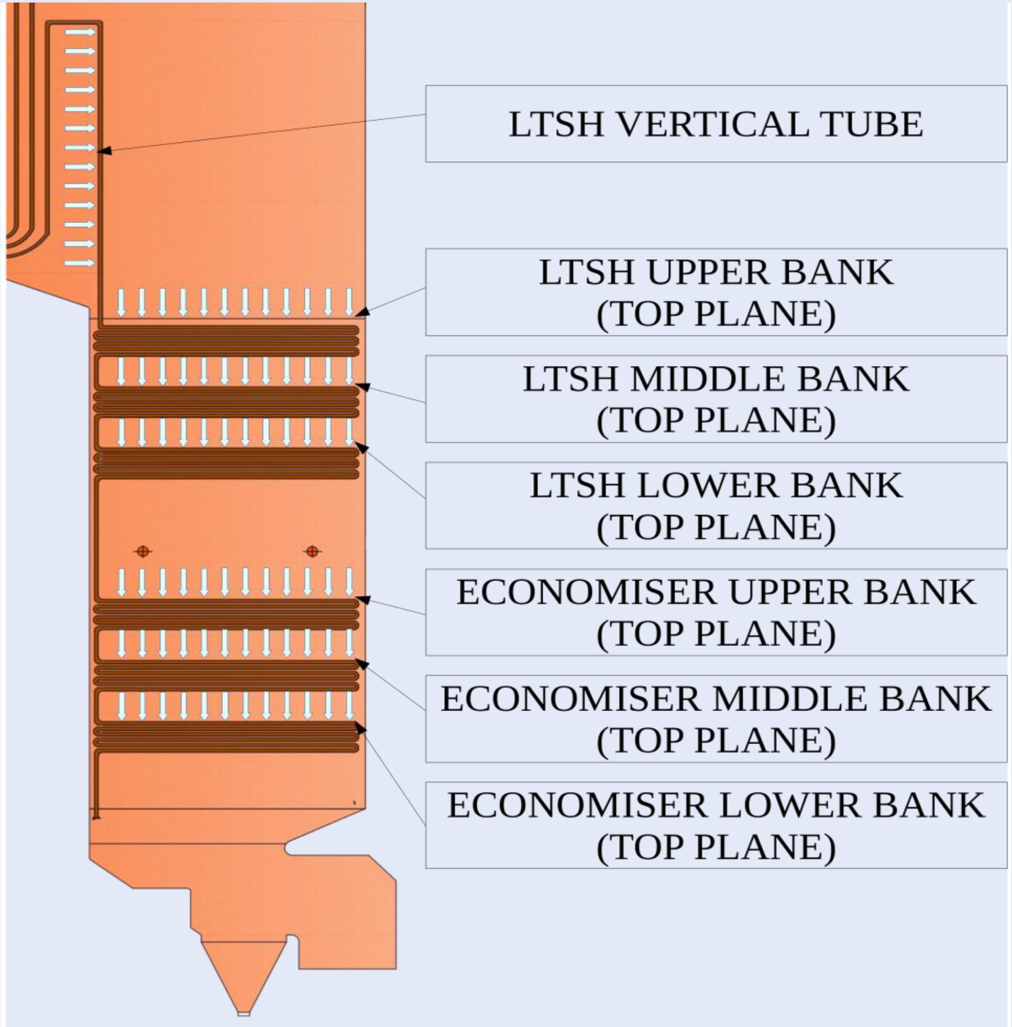
- To assess the flue gas flow pattern of second pass.
- Velocity mapping shall be carried out by conducting Cold Air Velocity Test.
- The uniform pattern of flue gas flow shall be ascertained by the co-efficient of variation (COV) in velocity across the cross section of second pass.

Cold Air Velocity Test (CAVT):-

Gas flow pattern Vs Configuration of second pass of Boiler

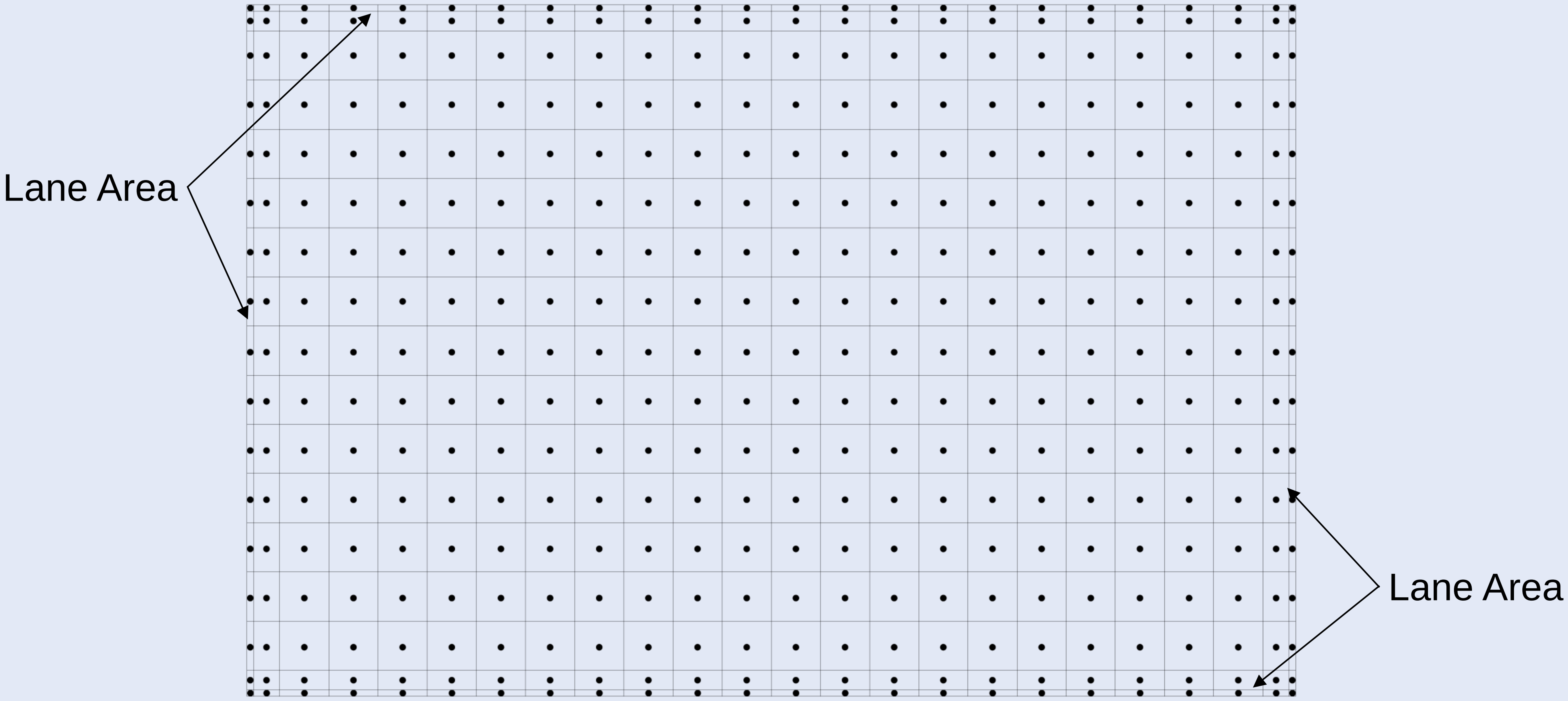
- Gas flow pattern in second pass will not be uniform across the second pass cross section due to the following Boiler gas path configuration.
  - The goose neck provided in first pass is to throw the gas flow up to the roof.
    - To utilise the entire heat transfer surface of Platen SH
  - Always higher gas flow is passing through right side than left side of the Boiler due to the anticlockwise recirculation effects in tangential fired Boilers. Non uniform combustion among the working burners in wall firing boilers.
  - The gas flow path from horizontal pass to second pass is configured to 90 degree. Hence, always gas flow through rear side is higher than front side of the Boiler.
  - Lane gap is provided on all four sides of the bundle coils. (LTSH & Economiser)

COLD AIR VELOCITY TEST LOCATION



COLD AIR VELOCITY TEST

GRID MARKING:



Cold Air Velocity Test in second pass of Boiler (CAVT)

TEFUGEN
Technologies for Future Generation

Phase 1: The velocity mapping will be done for the entire plane of the second pass by using **Hot wire anemometer**. Then average velocity, standard deviation and coefficient of velocity (CoV) will be calculated.

Phase 2: CFD analysis will be done to enhance the velocity distribution in the entire plane of second pass by providing suitable expanded metal screens.

Phase 3: As recommended by CFD analysis, the expanded metal screen shall be procured and installed by end user.

Phase 4: Post testing will be conducted similar to Phase 1 and the velocity distribution will be checked to comply with CoV < 20 % as per standard requirement.

Gas Distribution Test in ESP

Phase 1: The velocity mapping will be done for the entire plane in between first field and second field of the ESP cross section by using **Vane type anemometer** Then average velocity, standard deviation and coefficient of velocity (CoV) will be calculated.

Phase 2: Deflector plate and throttle plate will be re located to achieve flow distribution as per standard < 20 % COV by trial and error method.

CFD technique may also be adopted for re locating the deflector plate and throttle plate to achieve COV < 20%

FLUE GAS ANALYSIS TEST

PROCEDURE:

- This test will be conducted at full load condition.
- The measurements shall be taken in flue gas outlet duct of APH or in ID Fan outlet duct with grid pattern to ensure the accuracy of the performance.

PARAMETERS RECORDED TO ADHERE POLLUTION NORMS:

- **O_2 (Oxygen)**
- **CO_2 (Carbon Dioxide)**
- **CO (Carbon Monoxide)**
- **NO (Nitrogen Monoxide)**
- **NO_2 (Nitrogen Dioxide)**
- **NO_X (Oxides of Nitrogens)**
- **SO_2 (Sulphur Dioxide)**

Input Factors affecting Performance

Performance Test Results will be corrected to specified (Design) performance with changes in following Input parameters

Performance of Boiler & APH together

Ambient

Excess air

Feed water Temperature

Coal constituents

APH performance alone

Air inlet temperature

Gas inlet temperature

Gas inlet flow rate

X- Ratio – (Mass flow ratio)

Input Factors affecting Performance

TEFUGEN
Technologies for Future Generation

Mill Performance

- HGI
- Moisture
- Mill loading and Fineness
- Primary air inlet flow & temperature

Fans Performance

- System resistance and flow

ESP Performance:

- Gas Flow rate
- Gas Temperature
- Inlet dust concentration

Summary:

1. Understanding the present fuel property and tune the system to get maximum efficiency
2. Optimisation of input parameters to meet out design condition is very important.
3. Suitable location of ports and grid points are to be selected to avoid error in measurement.
4. Performance Test Results will be corrected, based on design input
5. Compare the measured performance with specified performance
6. Analyse the deviation and identify the area of improvements
7. Equipment wise suitable operation and maintenance practice to meet out anticipated performance will be proposed.

THANK YOU