ELECTROSTATIC PRECIPITATOR PERFORMANCE IN OLD BOILERS IN INDIA – CAUSE & SUGGESTED REMEDIAL MEASURES

V.Hariharan
ESP Consultant

K.Sivaraman
Boiler Consultant

I.0: INTRODUCTION : Pollution control norms for particulate emission are becoming very stringent and even older power plants undergoing renovation & modernisation Schemes (plants generally older than 25 years) are required to meet a very stringent specific particulate matter (particulate) emission level of 50 milli gram (mg) / Normal Cubic Meter(N.Cu.M). To meet this stringent particulate emission criteria, it is essential that all new & retrofit Electro-static Precipitator (ESPs) are

i) Conservatively sized (to provide regulation compliant specific particulate matter emission under all projected / possible operating conditions) & properly laid-out

ii) Designed with latest technological features for the best particulate removal efficiency, lowest specific particulate matter emission (as per statutory needs) - in conjunction with optimum (minimum 50%) power consumption for the Electrostatic Precipitator.

iii) Correctly set-up in the field (mechanically & electrically) for the optimized operation of the ESPs

iv) Promptly & efficiently maintained – for sustained performance, to meet required outlet particulate emission

1.1: On top of ESP centered factors (outside the purview of this paper), there is a large influence from the up-stream boiler that changes the duty conditions imposed on the ESPs w.r.to volumetric flue-gas flow rate & its composition, the flue gas temperature, the inlet dust burden along with its chemical composition & its characteristics, the (non) uniform gas flow & dust flow distribution between the (ESP) passes and last but not the least, the proper up-keep and maintenance of the boiler furnace & 2nd pass roof ceiling, up-stream gas ducts with expansion joints & the Air Preheater (APH)s. At times, ESP ash hoppers ash handling system (non) performance also plays a part on the performance of the ESP (occurs sporadically on old boilers as well as new boilers), causing tripping of the affected field(s) on under voltage - on account of significant ash build-up in the connected hopper(s). On rare occasions, this has lead catastrophic ESP structural collapse as well. Refer Table - 01

1.2: Coming to the point “as operating ESP (more than 15 years) performance & its’ short-fall ”, while Electrostatic Precipitator design, set-up &

maintenance related factors affect the performance of a sizeable number of ESPs, the boiler related issues affect the performance of almost all the operating ESPs. This paper adopts a holistic approach in dealing with all mentioned factors (mainly boiler related as well as boiler-turbo-generator Unit related) that influences the specific particulate matter emission level from Electrostatic Precipitators of old boilers / old boiler- turbo-generator units and suggests ways & means to deal with them – for getting the enhanced performance, both from the boilers as well as the ESPs (a poorly performing boiler / BTG unit will certainly cause the Electrostatic Precipitator to perform at sub-optimum level). Hence, ESP performance is a combined boiler cum ESP issue that must be viewed & addressed holistically by all connected groups (the boiler designer & builder, ESP designer & builder, the consultant to the project, the respective commissioning groups of boiler & ESP, owner's / plant operator's boiler maintenance group, ash handling system maintenance group & ESP maintenance group), for getting the best specific particulate matter emission performance from the existing / retrofit ESPs. This paper mainly deals with ESPs associated with old boilers / BTG units in India (which is a power / energy starved country, where-in, enough planned down-time of the unit is not provided - at the correct time - for its' proper up-keep) where-in, availability of boiler / BTG unit is given more importance than environmental cleanliness and the efficiency at which these units are generally subjected to run, for most part of their later operating life (age 15 to 30 years) - until these are subjected to a renovation & rejuvenation program..

2.0: BOILER & COAL CAUSED ESP OPERATING POINT DEVIATIONS :

2.1 Gas Volumetric Flow rate

An ESP will operate best when the gas volume keeps the velocity in each and every ESP domain within a typical range of 0.9 to 1.2 meters per second (M/Sec). ESP Designers usually work on an average value for gas velocity from the given gas flow data and derive the needed cross section of the precipitator, taking care of the localized variances with-in any given gas flow pass. However, bulk flow variation / velocity variation between the various passes of the precipitator is generally not addressed - either by the ESP designer or by the boiler designer. The essence of the average gas velocity concept is to optimize the treatment time and to reduce the particulate escape through re-entrainment, while rapping. These losses (particulate escape) tend to increase rapidly above certain critical limiting velocity because of the drag forces on the particles. This critical velocity is a function of gas volumetric flow rate & its density, collecting plate geometry, precipitator size, and other dust particle related factors, such as particle size, dust resistivity, etc. Figure 1 illustrates the effect of higher-than-optimum gas volume, using an outlet loading of 25 mg / normal cubic meter (N.Cu.M) as the base point. A gas volume flow of 10.0 % over design increases the outlet loading by 50 percent, to 37.5 mg / N.Cu.M. Similarly a gas volume flow of 20.0 % over the design increases the outlet dust loading by 120 percent, to a value of 55mg / N.Cu.M. Hence, it becomes essential to design any new / retrofit ESP, for the worst gas flow condition that can be expected / fore-seen

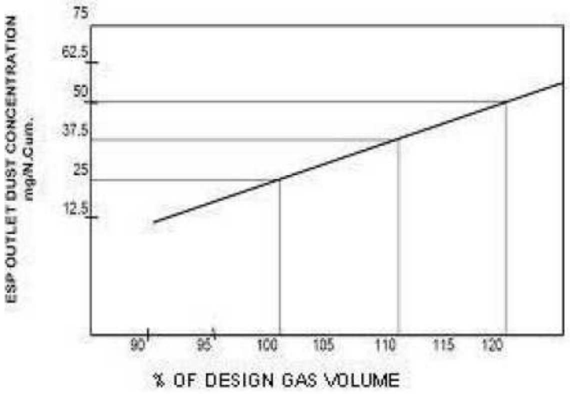

Fig I : Effect of ESP Flow Rate Variation on ESP outlet Dust (SPM) Emission

2.1.1: The gas volumetric flow rate thru' the ESP can increase on account of the following factors:

2.1.1.1: Coal quality deterioration: Coal quality deterioration [Gross Calorific Value (GCV) - Higher Heating Value (HHV) - deterioration can be as severe as from an original design HHV of typically 4000 K.Cal / Kg. to an operating coal HHV of 3200 K.Cal / Kg.) (25.0 % reduction in HHV or 25.0 % increase in coal quantity needed for any given heat content), higher coal ash content - Original design ash content in the vicinity of 32 % can go as high as 40 % or even higher, resulting in and as fired coal ash load of higher than 125.0 kilo gram per million kilo calories (Kg/M.K.Cal) of coal heat content – as against an original design coal ash load of 80.0 Kg/M.K.Cal coal heat content (> 56.25 % increase in the specific ash content of coal) and / or higher total moisture in the as fired coal of about 12.0 % or greater as compared to the original design coal total moisture of around 8.0 % (a total moisture quantum of higher than 37.5 Kg in the fired coal as compared to the original design coal moisture quantum of 20.0 Kg/M.K.Cal .of coal heat content, a 87.5 % increase in the specific moisture content of the coal)] typically leads to 3.0 % – 5.0 % increase in flue-gas weight, for a given operating boiler capacity [this accounts for gas flow rate increase due to increase in coal total moisture content as well as gas flow rate increase due to increased fuel (coal) heat input, to account for marginally lowered boiler efficiency].

2.1.1.2: Increase in air in-leakage thru' boiler setting, flue-gas duct work & gas duct expansion joints – loss of component integrity (in-adequate maintenance and / or in-sufficient time for doing proper maintenance). This cause typically leads to 5.0% to 10.0 % increase in flue-gas weight / volumetric flow rate on all those older units, which are periodically over-hauled but are yet to under-go Renovation & Modernisation scheme (Table -02, Plant-A : Air leakage between Sl.No. 01 & Sl.No. 02 clearly shows this).

2.1.1.3: APH air to gas side leakage increase due to either worn-out / damaged seals of Regenerative Air Preheater (RAPH) or due to eroded and / or corroded tubes of Tubular Air Preheater (TAPH) (due to in-adequate maintenance and / or in-sufficient time for doing proper maintenance). This cause typically leads to 10.0 % to15.0 % increase in flue gas weight / volumetric flue-gas flow rate [over and above the predicted flue-gas flow rate (Typically with zero leakage, in the case of boilers with TAPH and 8.0% to 12.0% leakage, in the case of boilers with bi-sector / tri-sector RAPH, respectively)]. The air in-leakage between Sl.02 and Sl.No.03 of Table-02 clearly indicates this position on Plant A & Plant B. APH air in-leakage is one of the major cause for ESP inlet flue gas flow increase. Table-02 gives the general scenario of air in-leakage along the flue-gas flow path at two plants (Plant-A with TAPH and Plant-B with tri-sector RAPH - the age of both these plants being > 30 years and these units yet to be renovated & rejuvenated under Renovation & Modernisation program). While ESP casing leakages are fairly close to normal, the air in-leakage thru' the boiler setting, and duct & duct / expansion joints are found to be excessive.

2.1.1.4: Turbo-generator (TG) heat rate deterioration due to poorly performing TG plant equipment [other than boiler (as boiler related causes are already covered under 2.1.1.1 to 2.1.1.3 above) and most often seen as issues pertaining to TG cycle heaters and condensers] causes specific flue-gas flow rate to increase abnormally. This can be as high as 50.0 % - 60.0 % in some extreme cases (See table 03). However, maximum flue-gas production is limited by the boiler maximum steaming capacity – but this happens at a lower TG (MW) load. Boiler efficiency degradation (due to coal quality deterioration, poor combustion, increased excess air level and associated increased dry-gas loss) generally contributes typically to about 5.0 % to 10.0 % increase in the gas flow rate over the predicted one; but it is the other causes like gross unit (TG) heat rate increase (due to plant equipment other than the boiler), causes the specific flue gas flow rate [Kilo gram./Sec or Cubic Meter (M^3) / Sec of flue gas flow rate per (MW) of power at Generator terminals] to increase steeply. This aspect is clearly brought-out in Table-03 (on Plant A and Plant B - both with the age > 30 years and yet to be renovated & rejuvenated under Renovation & Modernisation program).

2.1.1.5: Flue gas flow rate im-balance between various passes of the ESP can be as high as 15.0 % to 20.0% from the average flue-gas flow rate thru' the ESP passes. Similarly, dust total burden (Tons Per Hour of dust flow) variations between passes can be as high as 25.0% of the average dust burden per pass. Boilers / Units with all types of firing systems are affected by this characteristic but tangentially fired units are likely to have the maximum pass to pass variations in gas flow rate as well as ESP pass inlet dust burden – due to very nature of firing system configuration & flow dynamics, as the flue gas exits the furnace. Typical anti-clockwise rotation of the fire ball (while looking down from top of the furnace - which is the most often used utility boiler configuration in India) causes ESP inlet right side flue gas flow rate & dust burden to be higher as compared to the left side ESP passes (when TAPHs / RAPHs are in fine working condition). When the APH gets blocked by deposits or when the APH gets corroded / eroded (with one side getting more affected than the other side), then the situation become more complex. The origin of these variations start right from the coal mills (with Pulverised Coal (PC) pipe to Pulverised Coal (PC) pipe. Pulverised Coal flow variations of individual coal mills being as high as 25.0% or even greater from the average). While there are no simple solutions for setting right the dust burden variations between ESP passes it can be at best minimized by minimizing the PC pipe to PC pipe. Pulverised Coal flow variation of individual coal mills – by properly setting-up the mill (concentricity of the center feed raw coal pipe to the classifier cone, uniform angle of all the classifier vanes, unifom air flow passage around the edge of the grinding table,.. etc.) and the PC pipes flow - flow im-balance adjustment / correction devices (fixed area as well as variable area orifices). A perfect PC distribution system at coal mill outlet (for two way / four way / eight way distribution) is rifle distributors but incorporating this on pressurized mills (these are still employed on suction mills with exhausters) calls for more height above the mill to do this distribution and leads to increase in feeder floor elevation, lowest possible coal burner elevation & bunker top elevation (for the same bunker coal carrying capacity) - with associated increased costs of bunker bay structures, bunker feeding coal handling system and boiler (due to height increase). On top of it, the rifle distributor themselves are high maintenance and high pressure drop devices and leads to increased maintenance costs as well as increased aux. power consumption (Primary Air Fan power). The pass to pass variation in gas volumetric flow rate can be adjusted to be near equal – by incorporating flow equalizing damper(s) at the ESP passes out let (down-stream straight duct after the outlet funnel of the individual ESP pass). Simple, pitot-tube principle based (zero pressure loss), flow measuring devices can be incorporated at the individual ESP pass outlet and these remote manually operated flow equalizing dampers (with minimum position limit-stop arrangement - to prevent accidental full closure of these dampers by the operator) can be adjusted by the operator (once in a way drift adjustment, as no continuous changes are expected in pass to pass flow rate deviation / variation), based on the individual ESP pass flow rate indication. The action of these dampers can cause an add-on gas side draft loss of 10.0 milli meter(mm) water column and an estimated additional (Induced Draft Fan) power consumption of 60.0 KW – 80.0 Kw on typical 210 MW unit. The scheme of this flow equalizing damper system is shown in figure 2.

2.1.1.6: Hence, Fuel quality variation / deterioration is not the major cause for huge increase in the flue-gas flow rates in most of the ESPs of boilers in the age group 15 years to 30 years. It is the deterioration in unit gross heat rate, ,atmospheric air in-leakage thru' boiler setting & duct work and the Air pre-heater air side(s) to gas side air leak that contributes heavily to the flue-gas flow rate thru' the ESPs.

2.1.1.7: In some of the plants, specific flue-gas flow Rate (per MW output at TG terminal) increase over the original design specific flue-gas flow rate is as high as 50.0 %. Table -03, 04 & 05 gives the design as well as actual duty conditions in two different plants – which are typical of most of the plants in the age group 15 - 30 years and awaiting major Renovation & Modernisation as well as life extension. All the four causes cited above had contributed to the increase in specific gas volumetric flow rate, with unit gross heat rate deterioration being the leading cause for this increase. The boiler proposal indicates the lowest possible design gas flow rate (best TG heat rate, highest boiler efficiency, ideal RAPH seal setting with minimized air to gas side air leakage, zero air in-leak in TAPH, zero or lowest level of air in-leak in boiler setting & boiler roof refractory work, zero leak in boiler duct work & duct work expansion joints) - like automobile performance claims under ideal test-track conditions – for justifying the sizing of the ESP (or the parameters given for sizing the ESP), quoted boiler efficiency and quoted boiler auxiliary power consumption . Table -02 provides flue gas oxygen levels (excess air coefficient) along the flue gas path on a couple of typical old 210 MW boilers. The data clearly shows the air in-leakage at various boiler zones, which is typical of all boilers in the 15 years - 30 years age group.. The ESP design also (rightly so, in a competitive bidding) forgets at times that ESP casing (huge area of ducted Plate work) can also cause significant air in-leakage (typically 2.0 % to 3.0 % of air in-leakage is provided for in the ESP design), leading to deteriorated ESP performance. The operating plant is unable to maintain the unit gross heat rate at or near the original design value. The condition of the boiler setting, the duct work & the Air pre-heaters are generally found to be sub-optimal (due to down time needed and the cost associated with the add-on works / replacements as well the cost associated with the extended down time of the unit). The net result is that the ESP becomes under sized for the actual operating condition seen by it (lower operating SCA as compared to the design SCA) and the Specific Particulate Matter (SPM) emission level gallops up-wards. The irony is that all parties to this issue (boiler supplier, ESP supplier, the plant owner / plant operator as well as the consultant / the EPC contractor) know this deviation in the operating point from the design point (repeatedly seen, with-out failure, unit after unit) and this deficiency ignored (as setting right this wrong means over all ESP and Project cost increase due to increase in the ESP duty condition & its' size and with no corresponding financial gain / plant generation revenue increase). The ESP vendors proves the ESP guaranteed efficiency by applying the correction factors for the parameters deviating from the design inputs given to them (and rightly so – as long as the boiler vendor and the ESP vendor are different). This can be set right only by properly designing the boiler system and by properly sizing the ESP, to account for all the above cited factors, which in-variably occurs on all older units. While the plant consultant takes care of power generation from the generator terminals - by properly over sizing the boiler & boiler auxiliaries (like coal mills & fans), the same treatment is not given to the ESP (the Induced Draft Fans are generally provided with a volume handling margin of 20.0 % to 25.0 %, while no such margins are provided for sizing the ESPs - which just proceed the Induced Draft Fans). This situation cannot be set right as long as SPM emission codes are not strictly enforced (Unit power generation level shall be mandated to be reduced to a level that complies with statutory emission code) in an energy starved country. If specific SPM emission codes are introduced & enforced (i.e dust emission from the ESP per MW of power generation at the generator terminal), then, all parties to this issue are likely to pay more attention to the critical design factors of Boiler as well as ESP and their up-keep.

2.1.2 Flue Gas Temperature

Flue gas temperature variation from the design value affects the ESP performance in two ways. First, it causes the particle resistivity to change and thereby alters the charging of the particle as well as its retention on the collecting plate and re-entrainment possibilities. Secondly, it alters the gas volumetric flow rate thru' the ESP, even though this effect is very small ($\pm$ 2.5% for a temperature variation of $\pm$ 10.0 Degree Celsius (De.gC)). Certain conditions of the boiler and its APH (like excessive furnace, roof & boiler 2nd pass setting leakage, choked APH elements / blocked APH tubes, eroded/corroded APH tubes, damaged / in correctly setup by pass seals of RAPH) can cause the flue gas temperature to shoot-up by 20.0Deg. – 30.0 Deg.c or even higher and there-by significantly affecting the ESP collection efficiency performance. In both the cases cited in Table-04&05, the actual flue gas temperature is lower than the design figure (with increased APH leakages) but if the corrections are made in line with the predicted air in-leakages, then the flue-gas temperature leaving the APH would have gone up by 20.0 Deg.C over the indicated values.

2.1.3: Dust Resistivity

This parameter is a measure of how easy or difficult it is for a given particle to conduct electricity. The higher the measured resistivity (the value being expressed in ohm-cm), the harder it is for the particle to transfer the charge. Resistivity is influenced by the chemical composition of the gas stream and particulate, the moisture content of the gas stream, and the temperature.

2.2: Summary of the Boiler side care for the up - keep of ESP performance

2.2.1 Boiler setting, furnace roof & boiler 2nd pass roof integrity (against air in-leakage) must be maintained / re-established during every boiler over haul. This shall be verified by boiler parameters, immediately before & immediately after the boiler over-haul.

2.2..2 APH air – gas side air leakage as well as hot gas to warm / cold gas side gas-bye-pass kept at the lowest possible levels - with latest design of sealing system and thru' proper maintenance during annual over-haul. This shall be verified by boiler parameters, immediately before & immediately after the boiler over-haul.

2.2.3 Choked / Eroded / corroded APH components (baskets, seals, TAPH tubes) shall be replaced promptly during annual boiler over-haul or any other opportunity. Inspection report & replacement logs shall be made & preserved. The effectiveness of APH over-haul activity shall be verified by review of APH air & gas side parameters, immediately before & immediately after the boiler over-haul.

2.2.4 Neglected flue-gas ducting and expansion joints (between economizer outlet to APH inlet & APH outlet to ESP inlet – including APH ash hoppers) to be attended during every boiler over-haul - to eliminate air-in-leakage possibilities thru' these components. The effectiveness of this activity shall be verified by reviewing the flue-gas oxygen traverse data (from Economizer inlet / outlet & APH inlet as well as APH Outlet & ESP inlet).

2.2.5 Incorporating flow measuring system & flow equalizing system at ESP outlet will go a long way in minimizing pass to pass gas flow im-balance - for achieving optimum ESP performance.

2.2.6 Operation of the boiler at the lowest possible excess air level – while keeping the un-burnt carbon loss in fly-ash at a low level (to achieve this, the coal mills must be maintained in trim condition – with proper pulverized coal fineness and air cum pulv. coal distribution between the multiple outlets of each coal mill) to facilitate lower gas flow rates to the ESP. Verification may be carried out periodically on the PC Fineness of each mill & the fuel or clean air distribution between the multiple fuel pipes of each mill, by making measurements after each boiler over-haul / major mill re-build.

2.3: SIZING the ESP: While sizing the ESP, the following margins on the ESP inlet flue-gas side parameters are suggested (based on boiler design worst coal / ESP design coal data furnished – whichever is more demanding on ESP sizing):

a) to calculate the flue gas mass flow rate at APH outlet, with no credits from coal oxygen. after duely accounting for predicted APH air in-leakage.

b) Addition of 15.0% to the calculated flue gas mass flow rate at ESP inlet (as per point 2.3a) – to account for leakages in the boiler and APH system located ahead of the ESP.

c) Addition of 10.0 Deg.C to the flue gas temperature at APH outlet over the calculated APH outlet flue gas temperature – as all APH lose their effectiveness over time. Specification to account for roughly 2.50 % further increase in volumetric flow rate with mass flow rate remaining the same as that derived in step 2.3 b cited above - to account for the volumetric flow rate increase due to the cited temperature rise of 10.0 Deg.C.

d) Consider 90.0% of the total coal ash for the ESP inlet dust burden calculation. This concept will partly offset the effect of pass to pass dust burden variation, which is very difficult to control & rein-in.

e) Specification may be made such that the required SPM emission norm shall be met with one field in each pass out of service. Specification may include space provision for minimum one field to two fields addition, to meet future SPM emission norm mandates and to off-set the effect of possible coal quality deterioration. currently, almost all old plants are suffering due to coal quality deterioration and due to space restrictions for adding additional ESP fields.

3.0 ESP AUGMENTAION

While doing Renovation & Modernisation study for old units (110 MW, 210 M W) measurements on flow, temperature and inlet dust concentration (IDC) taken and also arrived based on coal analysis. These are design input for augmenting existing ESP to meet present outlet emission requirements. These are tabulated in Table No. 04 & 05. From the data it is seen that collecting area requirement goes between 1.5 to 2 times for 110 MW, 210 MW respectively for ensuring desired performance level.

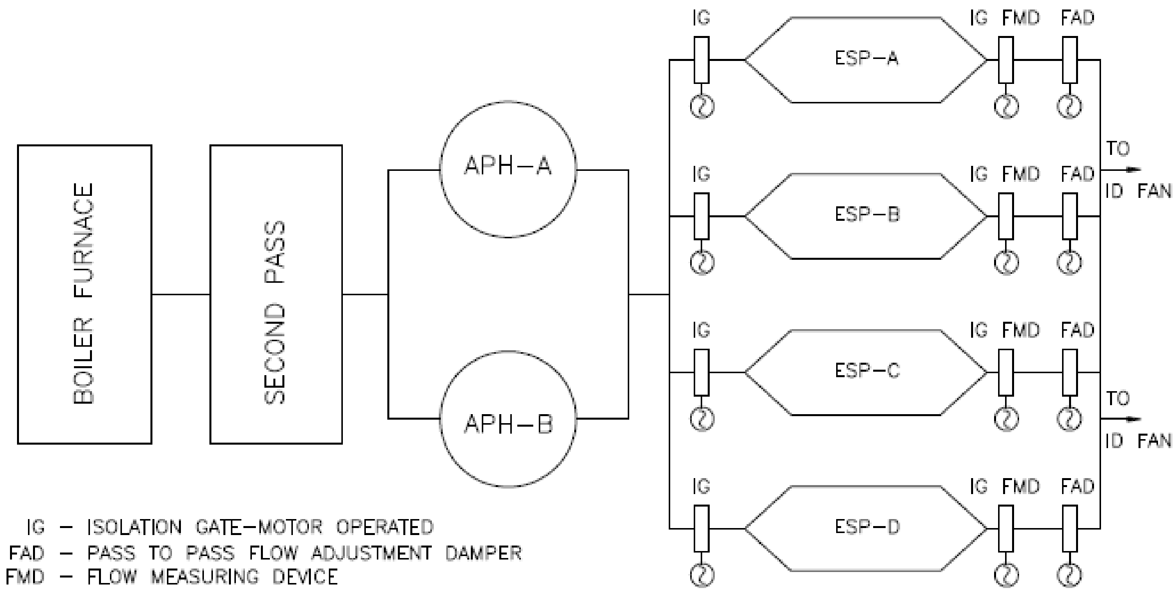

FIG 2

CONCEPTUAL DIAGRAM OF

FLOW ADJUSTMENT/FLOW EQUALITY DAMPER AT ESP OUTLET

TABLE - 01

LIST SHOWING ELECTROSTATIC PRECIPITATOR STRUCTURAL FAILURES DUE TO ASH ACCUMULATION IN INDIAN POWER PLANTS

PLANT	CAPACITY
Farakka Super Thermal Power Station	500 Mega Watts
Kothagudam Thermal Power Station	250 Mega Watts – Unit No.10
Raichur Thermal Power Station	210 Mega Watts – Unit NO.8
Patratu Thermal Power Station	110 Mega Watts
Ramagundam B Staion	62.5 Mega Watts
Indra Prasatha Power Station	62.5 Mega Watts

TABLE - 02

Flue gas Oxygen content, Excess air level & Flue gas quantity ratio at various boiler locations as measured on typical 210 MEGA WATTS units with more than 25 years of service

S.No	Boiler Location	Plant A			Plant B		
		FG O_2,%	EA Level,%	FG Qty Ratio	FG O_2,%	EA Level,%	FG Qty Ratio
01	Economiser Inlet	5.28	33.50	1.00	4.00	23.50	1.00
	% Air leakage			10.50			3.40
02	APH Inlet	6.85	48.40	1.105	4.60	28.00	1.034
	% Air leakage			16.60 (expected 0%)			23.00 (expected 12%)
03	APH Outlet	8.95	74.30	1.288	7.82	59.30	1.272
	% Air leakage			4.74			9.36
04	ESP Inlet	9.52	82.9	1.349	9.00	75.0	1.391
	% Air leakage			1.56			3.74
05	ESP Outlet	9.70	85.8	1.370	9.45	81.80	1.443
	% Air leakage			3.07			4.00
06	Induced Draft Fan Outlet	10.05	91.80	1.412	9.90	89.20	1.50

Legends:

FG O_2 - Flue gas oxygen content by volume; FG EA Level - Flue gas Excess Air level;

FG Qty Ratio - Flue gas weight at any given location as a ratio of the flue gas weight at Economizer Inlet;

APH - Air Pre-heater;

ESP - Electrostatic Precipitator

% Air leakage - Weight %-age of air in-leakage between the related sections

TABLE - 03

Sl.No.	Description	Design / Rated Parameters	Actual Operating Parameters
Plant A	Unit Rating, MW	210	160
	ESP gas flow rate, M^3//Sec	320	400
	Inlet Dust Burden, TPH	36	37
	Inlet Dust Burden, Gms. / N.Cu.M	47.96	39.29
	Gas Temperature at WSP inlet, Deg.C	146	144.5
	ESP outlet emission mg./ N.Cu.M.	740	1045
	Gross Unit rate, Kcal / Kw.Hr.	2393	2925
	Specific gas flow rate M^3 / Sec./MW	1.5238	2.5
	Specific solid particulate emission, Kg /Hr./ MW	2.643	6.15 (2.33 times the design value)
	Absolute solid particulate emission, Kg / Hr.	555	984 (1.77 times the design value)
Plant B	Unit Rating, MW	210	170
	ESP gas flow rate, M^3//Sec	346	432
	Inlet Dust Burden, TPH	36.7	27
	Inlet Dust Burden, Gms. / N.Cu.M	44.79	25.88
	Gas Temperature at WSP inlet, Deg.C	142	134
	ESP outlet emission mg./ N.Cu.M.	300	560
	Gross Unit rate, Kcal / Kw.Hr.	2383	2976
	Specific gas flow rate M^3 / Sec./MW	1.6476	2.5412
	Specific solid particulate emission, Kg /Hr./ MW	1.171	3.435 (2.93 times the design value)
	Absolute solid particulate emission, Kg / Hr..	246	584 (2.37 times the design value)

Table - 04

RECENT ELECTROSTATIC PRECIPITATOR CONDITIONAL ASSESSMENT AT 110 MW PLANT

Description	As per Original Design (1985)	Present Condition (2012)
Flow Rate Cu.Velocity in meters per second	192	240
Temperature Deg,C	143	170
Inlet Dust Concentration gm/ N.Cu.M	37.5	62
Outlet Dust Concentration mg/N.Cu.M	150	100
ESP with collecting area in m^2	Seven fields with 2 passes with 32256	Proposal is as follows No. of ESP– 2 8 fields / ESP, total collecting area 46656 m^2 with one field out of service in each ESP shall guarantee outlet emission.

TABLE - 5

RECENT ELECTROSTATIC PRECIPITATOR CONDITIONAL ASSESSMENT AT 210 MW PLANT IN 2012

Description	As per Original Design (1982)	Present Condition (2012)
Flow Rate Cu.Velocity in meters per second	366	407
Temperature Deg,C	147	150
Inlet Dust Concentration mg/ N.Cu.M	31.6	53.752
Outlet Dust Concentration mg/N.Cu.M	300	50
ESP with collecting area in m^2	Five fields with 4 passes with 42624	Proposal is as follows No. of ESP– 2 8 fields / ESP, total collecting area 93120 m^2 with one field out of service in each ESP shall guarantee outlet emission..