

AUDITING ENERGY SYSTEM EFFECTIVELY

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In the growing market of energy systems, Industrial boiler companies have been doing a good business of late. I have to say they are busy too. Lots of new engineers have come in to the field. In the companies the old stalwarts have not put systems for design audit & field audit of the boiler & subsystem. This has indirectly resulted in premature failures & shut down of the plant in many cases. It has become order of the day to engage consultancy companies for design audit & inspection companies for quality audit. If you ask me whether this is working – my answer –yes to some extent. The reason for the remark is the absence of a well defined audit system that could not do the needful to industry. In this article, I have brought out some of the failures by the manufacturing companies who have not institutionalized a proper audit system in place. You would also find that Boiler buyers are over confident about their competency in this field energy system.

- *TYPES OF AUDITS*

Like the various performance review system such as six sigma / TPM we need to have some system up to putting up a power plant. There are five types of audits for power plant equipment. They can be categorized under design audit, manufacturing audit, construction audit, operational audit & shut down audit.

- *DESIGN AUDIT*

Design audit is to be carried out even before placement of the order. The consultancy companies do have bunch of specifications to spell out the requirements. There are data sheets to be filled in by the prospective vendors. Consulting companies make a comparison of heat transfer areas, Equipment sizing, and make of components. This stage definitely does ensure the job as there had been a considerable development in the consulting companies to revise their specifications as they gain experience over a period.

There are many boiler user industries, which simply rely on some employees who have put up some projects in the past. A project co-ordination work is different from purchasing the equipment with right specifications. I have encountered undersized equipment being purchased in this way. Items which have not been proven are being purchased. Particularly in smaller capacity segment, boilers are being purchased without a design verification process. It is my advice to these companies to have a design audit done before order placement. Some of the calls which I get are due to lack of knowledge in the design side by the internal project team.

- *MANUFACTURING AUDIT*

Here comes the knowledge & experience. Many of us have got years of experience in this field. Unless there is a detailed design experience one may not fit into this role. Manufacturing audit goes with lots of design & field experience. Manufacturing audit means mostly checking raw material quality, manufacturing process, dimensional inspection etc. Companies that conduct manufacturing audit mostly do a nice job of reviewing identity of raw material, overall dimensional inspection of the product, reviewing the stage inspection reports, reviewing the shop tests, reviewing the Non destructive testing (NDT) reports & Destructive testing (DT) reports. Yet what we miss here is the purposeful inspection. When the inspector fails to possess the operating experience of the end product he can not inspect the necessary parameters that have to meet the ultimate requirement of product

performance. There are persons in the QC auditing companies, who verify the product with respect to the manufacturer's drawing. Lack of knowledge of drawing reading skill leads to failures in inspection. Some of the problems which I had diagnosed are due to this aspect.

- *CONSTRUCTION AUDIT*

Many manufacturing companies have been forced to recruit fresh engineers to do construction job. This is the present status as the demand has gone up for persons in boiler & power market. Almost all manufacturing companies do not have a field audit system for the boiler system. There have been innumerable cases of failures by the manufacturing companies. The consulting companies who have been part of the project also fail to look in to the construction audit. The audit needs to be purposeful to get the product performance in service. We may see there are no log sheets used by the companies that are engaged in field quality. They tend to see mostly on welding quality rather than the ultimate product performance. Even if one agency is hired to do this job, it may be worth to hire a second agency to construct the audit. Once I was called at a plant for auditing a boiler under conversion to FBC. When the two agencies did the job, number of useful points came up that resulted in a perfect commissioning of the plant. (I know I am selling myself at this point !).

- *OPERATIONAL AUDIT*

There is no doubt that the boiler operation / power plant operations have lots of data being generated by the Data acquisition system. These data are summarized and critically reviewed by the plant senior personnel. There could be lots of improvement possible in the boiler operations in the combustion side & water side that would improve the plant availability. Failures to maintain instrumentation system often have led to deterioration of performance & availability. Equipment supplier could be called upon to conduct an audit of the operational parameters.

Operational audit should include review of operational parameters of the boiler and the computation of boiler efficiency & plant efficiency. There are cases of poor water side management that were detected from the feed water, boiler water, saturated steam, superheated steam, TG condensate, plant condensate & make up water analytical reports. A review by a designer / water treatment specialist could be useful in extending the availability of the plant. The recent demand for high pressure boilers a stringent water quality management. The knowledge gap can be reduced often after a review by the experts.

- *SHUT DOWN AUDIT*

Boiler users are giving a new dimension to this nowadays. I have been getting lots of call related to this. I say it is worth it, if we have to keep the equipment fit. The audit may also be conducted by the manufacturing company. Boiler availability deteriorates over a period due to fuels we use & the design defects, construction defects & operational defects. There is also a need to modify the equipment to suit the changing scenario in fuel characteristics. These could be identified only during a proper shut down audit.

- *CASE STUDIES*

I have chosen to include the reports of some of the audits performed by me in the recent past. I have dressed up the report so that I would not pinpoint that some manufacturer is at fault. The point driven in this article is to say that the auditing needs to be done by inviting an external agency. If an audit can bring out one valid point that can improve the plant availability by a day, it is good enough for a decent payback. I have brought out so many photographs that illustrate the vast scope for improving the performance.

Case study 1

A customer had purchased a boiler based on thumb rule of heating surface per ton of steam generation. He had called me for inspecting the boiler that had reached the site. I found that the boiler design was altogether wrong. Instances of this type can be avoided by engaging the consulting company. The report that was handed over to owner is attached herewith.

Case study 2

This case was an inspection of the power plant during commissioning period. The plant was facing a start up problem and I was called upon. The visit led to revealing of innumerable design defects & construction defects & commissioning defects. The readers may get a dose of education from the report that is dressed up little bit. Read the report that is attached herewith. The consultancy company & quality control company that had been hired missed out many details.

Case study 3

This was a case of boiler inspection during a shut down. The shut down revealed need for modifying the water quality parameters. Impact of fuel characteristics was seen on the bed tubes of the boiler. There were several useful points resulted out of the energy audit. What is more is that the boiler operating engineers got an insight of the equipment which they were handling. No doubt that the shut down audit provides a training session in the process.

SUMMARY

I had been doing audits of this kind to many boiler users. There are numerous cases that the power plant engineers get their supplement knowledge out of the audits performed and the discussions that follow after the audits. Readers may avail our auditing services for the benefit of better availability of the energy system.

We have recently introduced a protocol system devised for a new power plant under construction. Samples of protocol check points are shown at the end of the case studies.

AUDIT OF 12 TPH AFBC BOILER UNDER SUPPLY

The boiler parameters are 12 TPH (from & at 100 deg C), 28 kg/cm² (design pressure), saturated steam, rice husk fired overbed FBC boiler, twin furnace, waterwall cum shell type boiler. The dust collection system is a mechanical dust collector. The heat recovery system given is an Airpreheater. The following are the points of inspection.

1. The shell is provided with 63.5 x 4.06 dia flue tubes. The number of tubes are 161 & 110 in 1 & 2 pass respectively. This too less. The average gas velocities in 1 & 2 pass are estimated to be 39 & 35 m/s. The gas inlet velocity in these tubes are working out to be 41.8 m/s & 37.42 m/s. This kind of gas velocities are used in oil / gas fired boilers. The draft loss across the shell alone will be of the order of 180 mmWC. The erosion of the tube will be high if we try to operate at full load. Also the ID fan head selected is only 210 mmWC which will be totally insufficient. It is recommended to go for a new shell of 340 & 200 number of tubes in 1 & 2 pass respectively. In comparison with the present 8 TPH boiler the number of tubes should have been 385 & 158 in 1 pass & 2 pass respectively.
 2. The FD fan selected is just meeting the MCR requirement. There is no margin considered by supplier. The FD fan flow required with 25% flow margin is 9288 m³/h whereas what is supplied is with 7200 m³/h.
 3. The bed cross sectional area provided is adequate for a 12 TPH boiler. However the DP drop will work out to be 500 mmWC. The FD fan head will not be sufficient to take care of fluidization.
 4. The APH inside tube arrangement is not OK. There is big gap of 150 mm on either side of the central baffle. See photo 5. This needs to be corrected.
 5. The fuel feed point seem to be at a very high level over the bed tubes. See photo 6. Please compare the fuel feed point in the available 8 TPH boiler and revise the location suitably. My recommendation would be 300 mm above bed coil so that the husk will get in to the bed.
 6. See photo 6. The fuel feed point is just above the ash collection chamber wall. The fuel will go directly to ash chamber.
 7. The ID fan casing to impeller cut off is too less. This can create noise & vibration problems. This should be usually 10% of impeller ID. See photo 1.
 8. The ID fan impeller to suction cone clearance is about 30 mm. This will affect the performance of ID fan. The gas recirculation within the fan will be more. The draft at furnace will be affected. The gap should be close 3 mm. This has to be corrected. See photo 2.
 9. The ID fan shall not be provided with suction flap damper. See photo 3. Such a damper at ID fan will affect the fan performance. Locate the damper in MDC outlet duct which is 800 x 800 mm cross section.
 10. The ID fan draft required will be 250 mmWC. At present what is selected is 210 mmWC.
 11. A leak proof casing shall be provided for the furnace to prevent the air ingress in to the furnace.
 12. At present the manufacturer has envisaged supporting waterwall at a different base level than the shell. This is not good as there will be differential thermal expansion. Please note the waterwall outlet header is directly connected to from tube sheet. This is an anchor point.
 13. MDC cone to vane assembly is not proper. All the turning vanes should be at same level inside the cone. See photo 4.
 14. The waterwall on thermal expansion will try to push the refractory wall. To take care of thermal expansion ceramic blanket can be inserted for 20 mm thick at the joint between the waterwall & refractory wall.
 15. MDC outlet pipe to vane clearance is too high. This gap shall be filled with a 5 mm rod all around to prevent erosion of outlet tubes.
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ANNEXURE for case study 1



Photo 1: The cut off between impeller diameter & casing is less. This can cause high noise & high frequency vibration of duct / chimney.



Photo 2: The impeller to suction casing clearance is around 30 mm all around. This can cause recirculation of flue gas. Thus the draft will be less at furnace.



Photo 3: There shall be no flap dampers in front of ID fan. This affects the fan performance.



Photo 4: The gas turning vanes at MDC shall be at a uniform height inside the MDC cone. The gap between the outlet pipe & turning vanes shall be closed by a round rod. Otherwise the outlet pipe erodes.

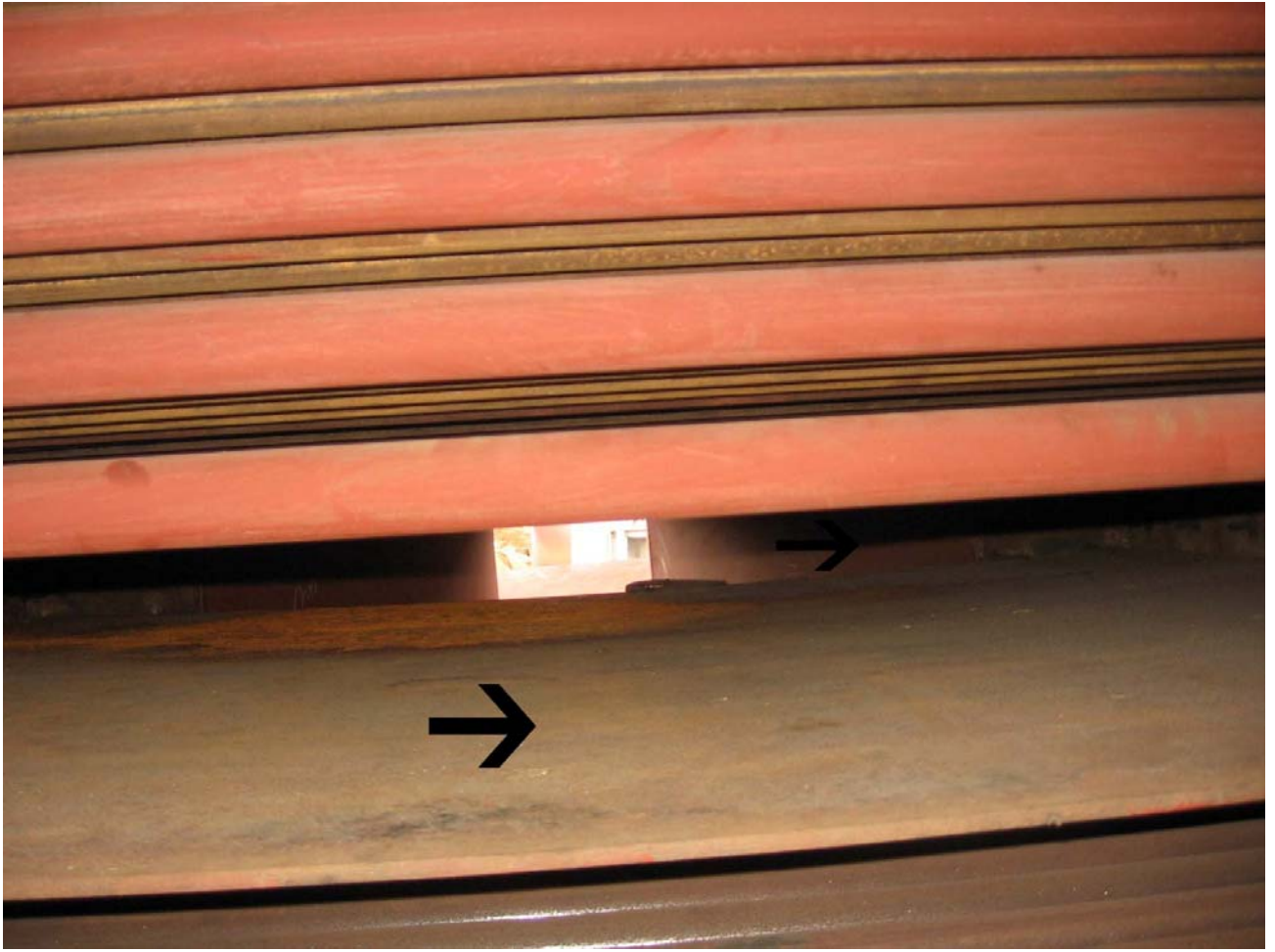


Photo 5: The APH tube to middle baffle gap is too high. This can bypass the gas affecting the APH performance.

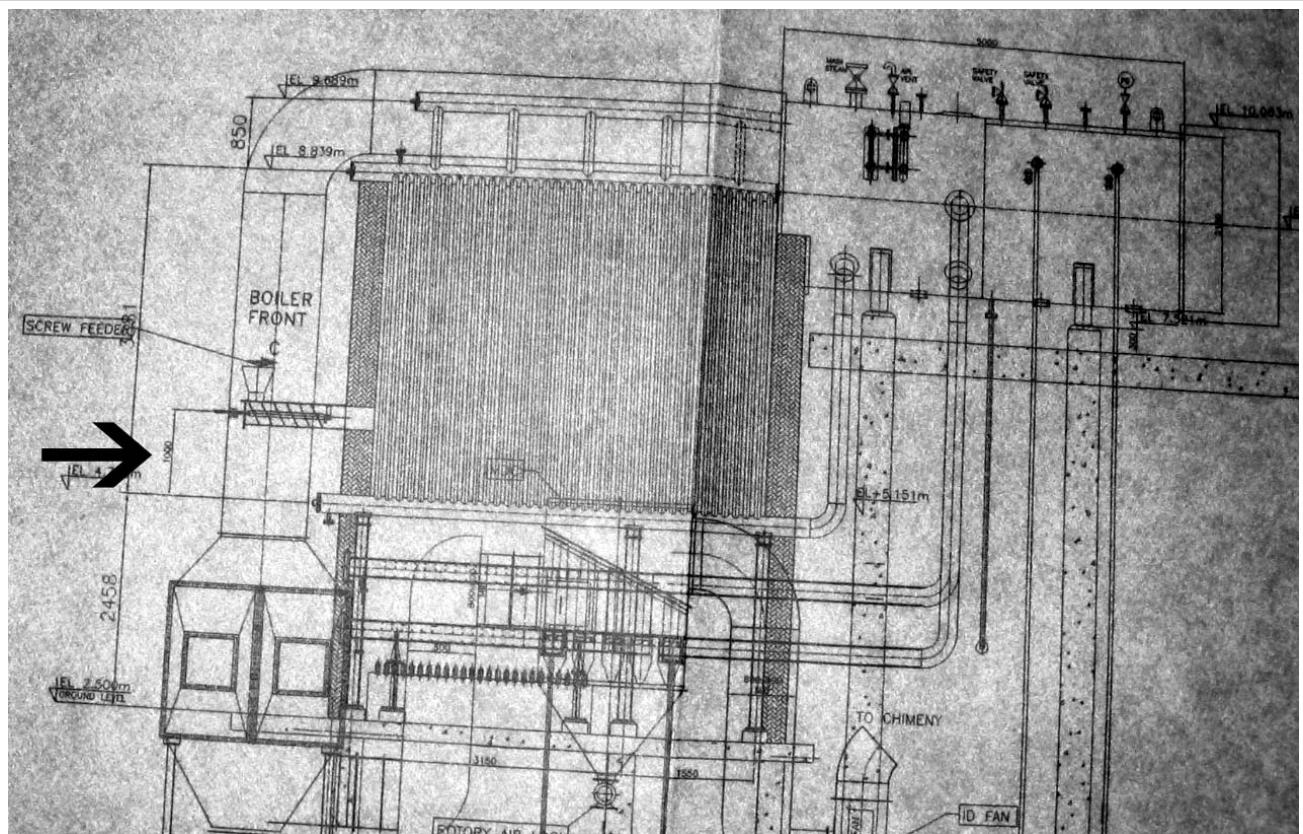


Photo 6. The elevation of screw feeder is too high to bed coil level. Check what is in the present boiler and provide the same. Recommended distance is 300 mm above bed coil.

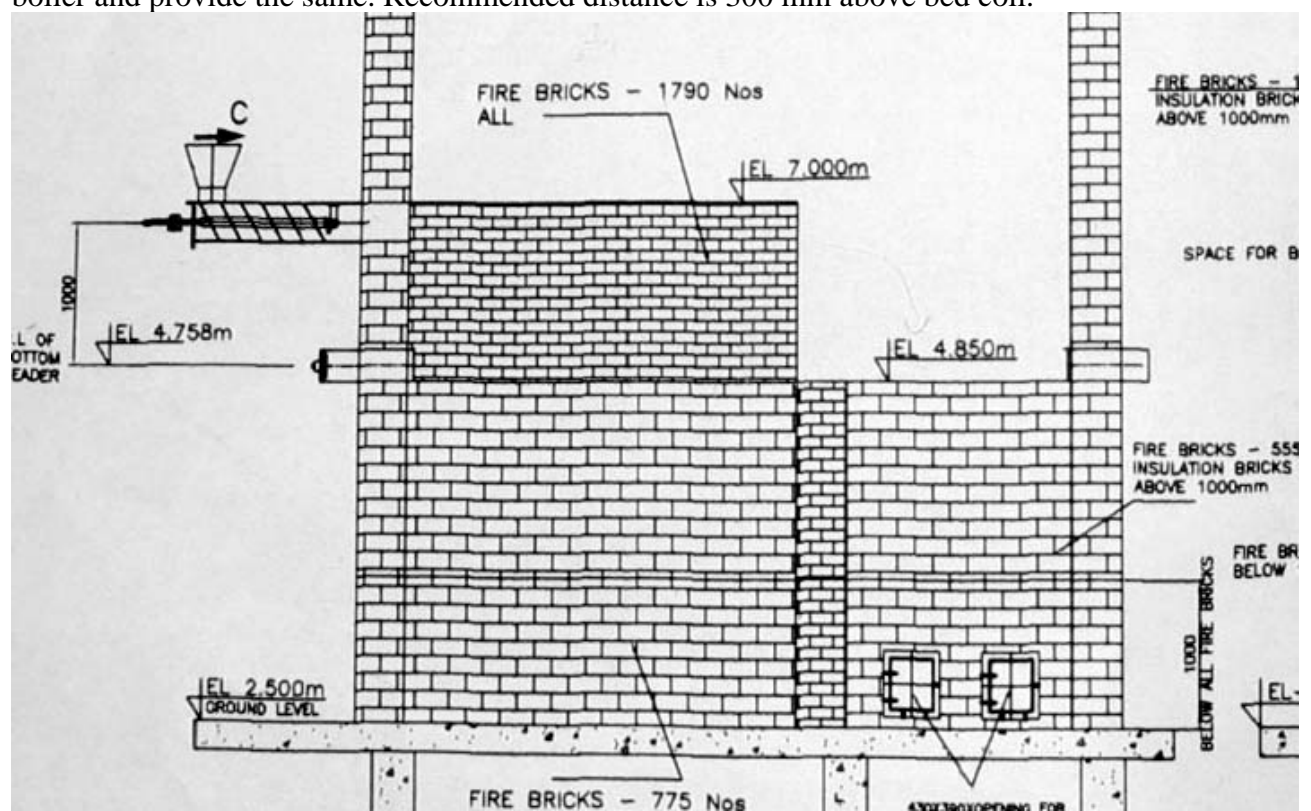


Photo 7. The husk may directly go to ash settling chamber, as the partition wall height is less.

REPORT ON AUDIT OF 18 MW POWER PLANT

The Petcoke / coal based thermal power plant is commissioned recently. The boiler parameters are of 85 TPH, 88 kg/cm², 520 deg C. The design fuels are Coal, petcoke and partly lignite. The boiler is of single drum design with convection SH, Radiant SH and bed SH. The boiler was under shut at the time of visit. It was informed that the bed frequently clinkered during start up & during operation. The reason for such repeating problem is analyzed and reported in this report. Further the boiler & power plant steam piping installation were inspected. There are many points, which call for immediate attention. The report on such installation defects are covered in annexure illustratively.

BED CLINKERING PROBLEM

1. The design bed height as per O&M manual is 425 -485 mmWC. Actual operating data of the past one month indicates that the Airbox pressure is only 450 mmWC. This means the operating bed height is 300 mmWC. This is not a stable bed height for start up compartment after start up or for a compartmental operation. Low operating bed height means that the bed HTA is more. It is necessary to camouflage portion of bed coils so that the operating height increases. Phoscast may be applied above coal nozzle but with care. It may unnecessarily invite sites for erosion. If done above coal nozzles, both outer & inner coils are to be covered.
2. When a compartment is slumped its air bleed off valve must be kept open.
3. At present there is no instrumentation for knowing the operating bed height. The airflow measured will be too low with one compartment during start up. Only DP drop can be made use of as a measure for air flow. With this one can see how much bed height is available after mixing. At times the bed material from start up compartment spills to adjoining compartment. With less bed material ignition / bed temperature stabilization is difficult.
4. With less bed height the combustion is incomplete in the operating bed. The particles just leave after ignition. A minimum start up bed height of 250 mmWC is required. The bed spilling to adjacent compartment is reduced when we make a tall border along the edge of 2nd compartment during start up.
5. The bed coil area required for 950 deg C combustion temperature @ 30% Excess air is 113m². The studded coil length required is 707 m. For a 900 mm expanded bed height, the immersed coil length available is 797 m. We can go for refractory cover of 550 mm in the 158 number outer coils only. This will provide a coverage of 87 meter.

IMPORTANCE OF WATER CHEMISTRY

1. For this boiler the pH-PO₄ regime has to be in congruent mode. Excess of both will lead to caustic gouging. Bed coil in idle bed is more susceptible for caustic gouging.
2. The pH control for condensate has to be with morpholine. We should not attempt to maintain pH with Ammonia. It may not offer the indented protection to Air cooled condenser tubes as the ammonia has higher steam distribution ratio.

VANISHING OF WATER LEVEL DURING START UP

1. At present the water after pressurizing may be going in to the economiser due to the long piping. It is recommended to maintain a minimum leakage flow in economiser while the bed temperature rises during a start up. If drum level goes up keep CBD crack open.

OTHER OBSERVATIONS

The other observations are as per enclosed annexure.

FINAL RECOMMENDATIONS

Bed height instrumentation & refractory lining together is expected to avoid clinker operation during start up. Compartmental operation if unavoidable, rotate compartments every 3 hrs. Boiler water chemistry shall be managed with a 70:30 mix of tri-sodium phosphate & di-sodium phosphate. All piping spring supports shall be attended immediately.

ANNEXURE for case study 2



Photo 1: The flowmeter & APH bypass air duct are placed very close to FD fan. There is no expansion joint as well. The aerodynamic disturbance placed in the immediate vicinity of FD discharge is likely to be cause for vibration & noise. The flowmeter reading will not be proper as there is a damper at outlet.



Photo 2: The buckstays link erection is wrong. The present arrangement does not permit the expansion of waterwall. At some boilers this has resulted in waterwall corner tube fin tearing off & boiler waterwall caving in. This needs to be corrected as per drawing.



Photo 3: The Spring support base is distorted / erected improperly. A bracket could have been provided.



Photo 4: The Main steam line spring hanger is not carrying any load. The hanger rod from spring support is bent.



Photo 5: The rigid base support at main steam piping is likely to lift off after thermal expansion. It will be then wrong to have assumed that the pipe is supported at this point.



Photo 6: Already the feeder is of under capacity for petcoke. To this feeder, the limestone chute is connected. Moreover the petcoke regulation is not possible when limestone mixing is done like this. This is a very fundamental mistake.



Photo 7: Limestone feed chute is of rectangular. This would give problem as the limestone is hygroscopic. The Limestone has to be connected to drag chain feeder directly.



Photo 8,9 &10: Roof panel to CSH / RSH sealing is not OK. Ash is seen in the insulation cladding. Oxygen can not be taken as a guide for setting the air flow, since the air ingress will mislead.

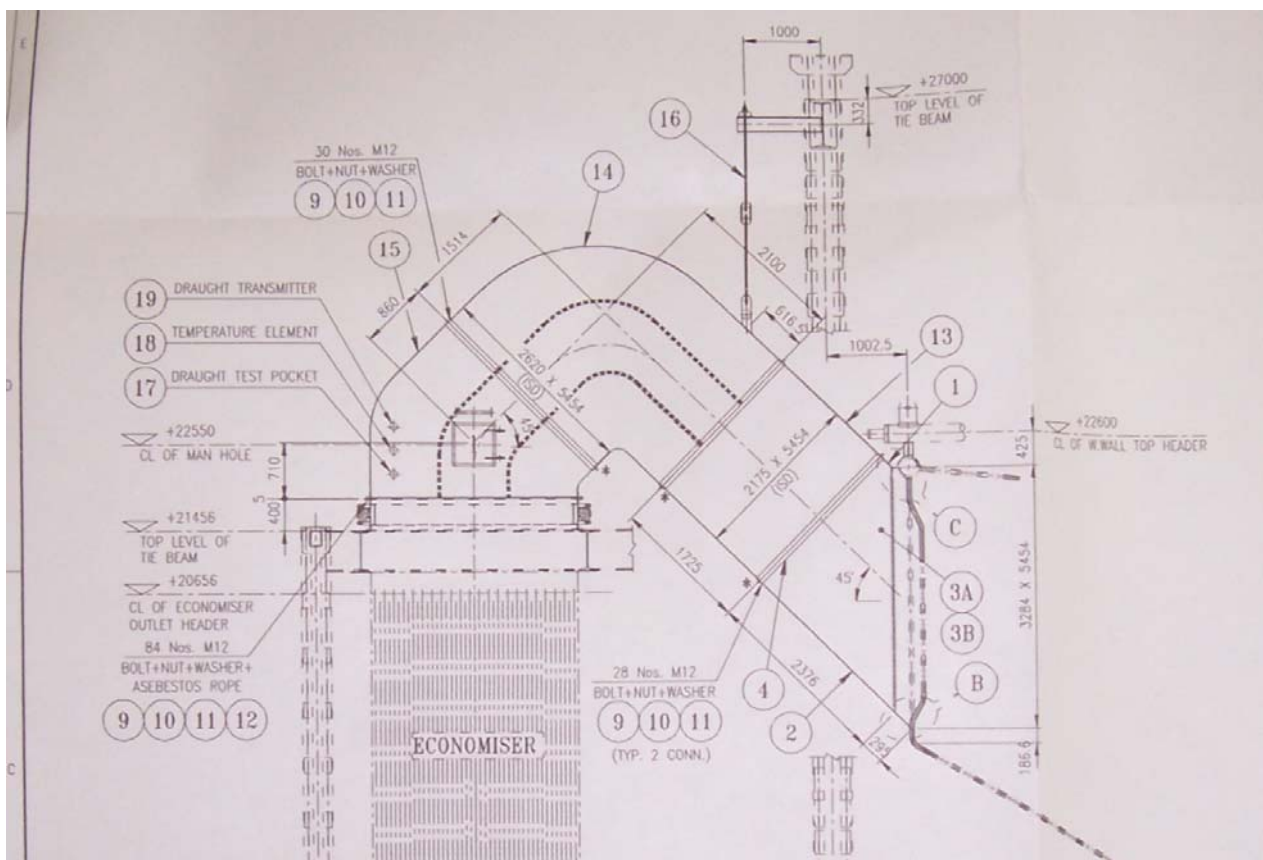


Photo 11: The hanger supports provided for economizer gas outlet duct are not loaded evenly. The link plates are not vertical proving the uneven loading.



Photo 12 & 13: Waterwall top header hangers are unevenly loaded. The link plate is not vertical. The sound of hanger rods when hammered is found to be different from each other.



Photo 13: Drum anchoring has to be in both in X & Y axes. Then only the expansion of drum will be identical on either side.



Photo 14. The hanger rod needs some clearance around it at the seat to permit deflection on expansion.



Photo 15: The boiler to economiser inlet fabric needs a rain guard. Any asbestos based expansion joint will fail on rain water damage.



Photo16. All the APH base supports are directly welded to insert plates on the RCC. This restricts the thermal expansion and this RCC may damage.



Photo 17,18 & 19: The air box thermal expansion pushes the insert plate. The airbox is also bottom supported. The RCC cracks due to this.



Photo 20. The ash hopper wall plate slopes are inadequate for complete discharge of ash from inside. There must have been a compromise on providing the required number of ash transmitters.



Photo 21. Today CFD has become a thrust area of energy conservation in terms of reducing unnecessary draft loss. But here, the PA duct bend is a right angle duct without a smooth bend.



Photo 22 & 23: The economiser support beams are directly welded to support columns in this design. Other reputed manufacturers allow free thermal expansion of Economiser / APH as shown on the photo on right. The manufacturer needs to update their design.

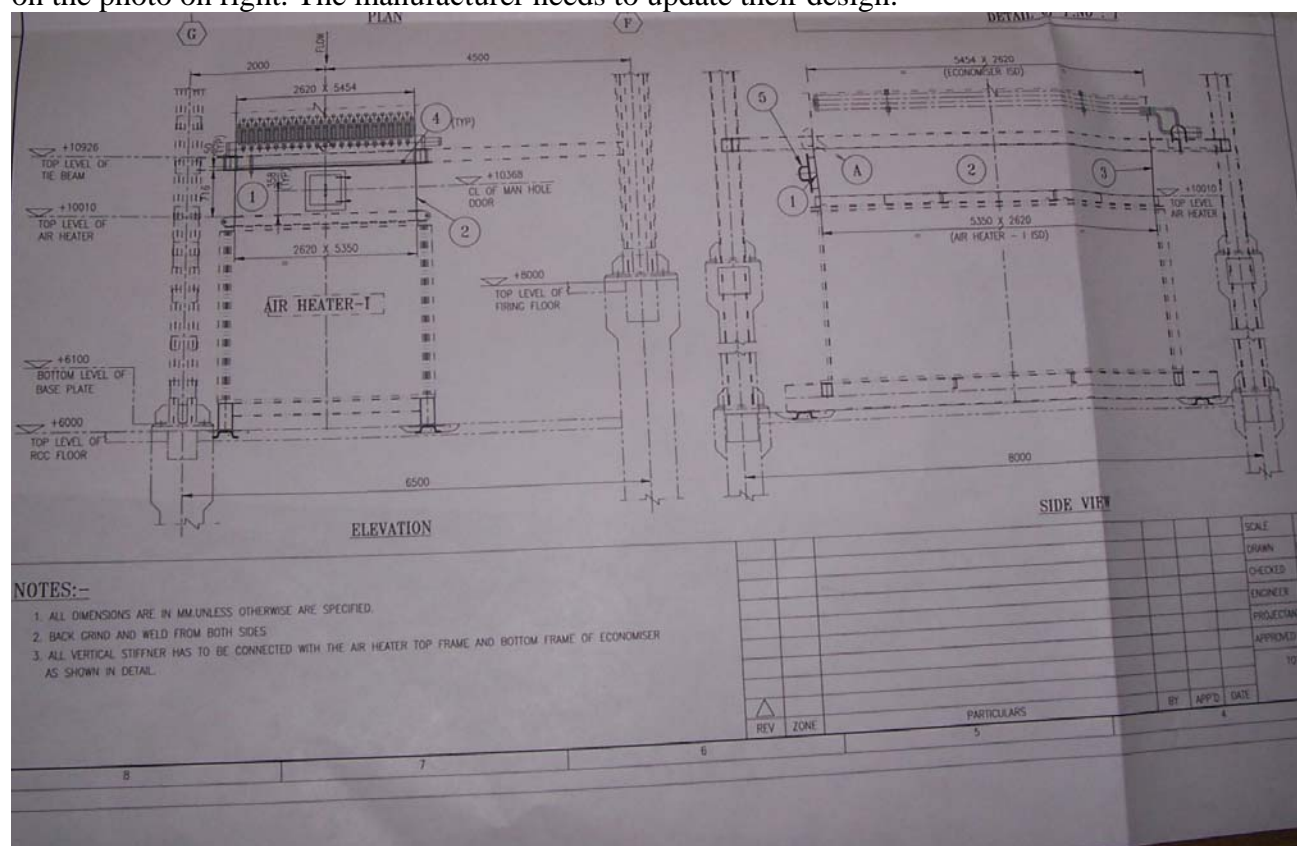


Photo 24: In between APH & economiser there is no expansion joint. As the APH expands upwards, the Economiser casing will be put under strain.

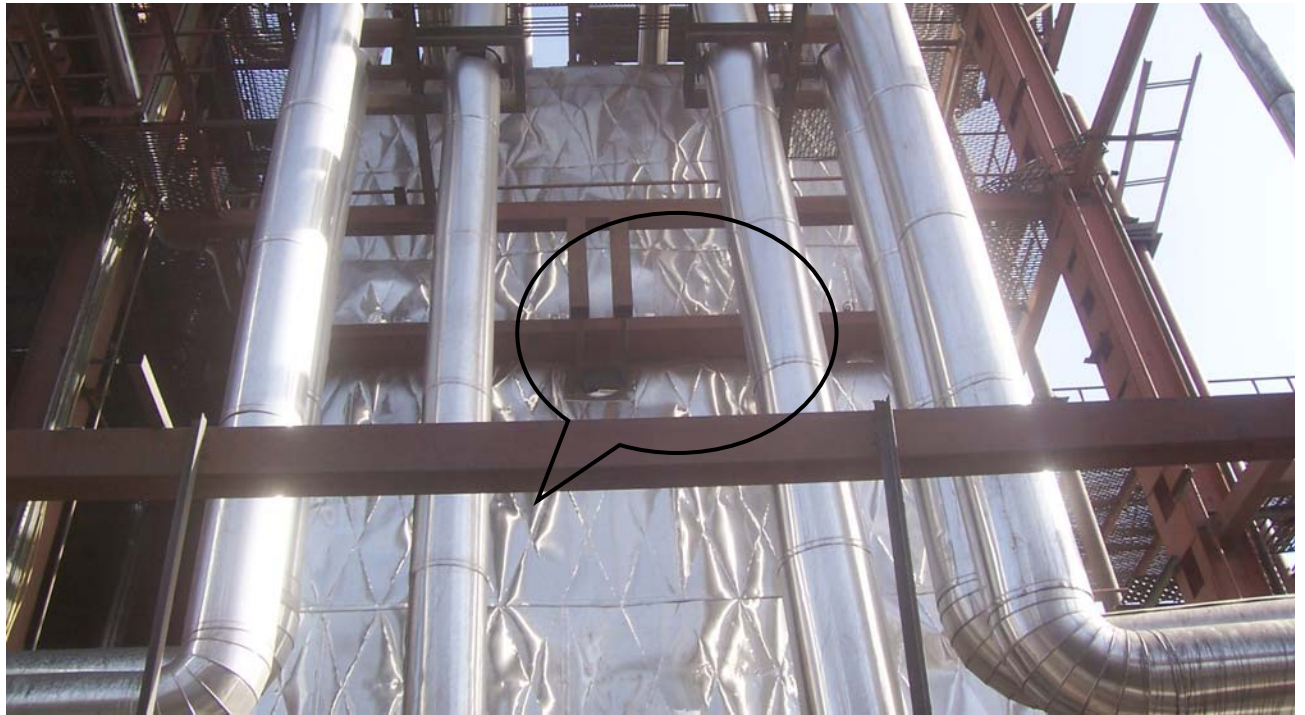


Photo 25: Boiler thermal expansion guide is not strong enough. This needs redesign.



Photo 26: Main steam header roller support is off the base. There is no jack arrangement to load in the support. Commissioning engineers are not trained enough to look into this aspects.



Photo 27 & 28: Piping supports are engineered to ensure piping deflects due to thermal expansion with minimum stress. Spring supports are supposed to be on a rigid base. But if the spring supports are on awkward supports, we can not ensure that the spring would offer the flexible support. Critical high temperature main steam piping is on flexible supporting system. There will be failures of piping at later date.



Photo 29: The constant load hanger support remained locked even after a month of boiler operation. There are many spring supports which are not unlocked / not preset before. There seems no protocol signed by commissioning engineer.



Photo 30: There is no insert plate on RCC to enable thermal expansion of deaerator on RCC pedestals. The coefficient of friction will be high between steel & RCC.



Photo 31: In cold condition itself some spring supports have crossed the load limits. The guide rod is bent. The lock is yet to be released. Many spring supports are like this. Commissioning engineer should submit a spring support commissioning protocol.



Photo 32: The CEP suction reducer is wrongly erected. Pump manufacturers recommend that the top of the pipe should be flat without a chance of air lock / cavity.

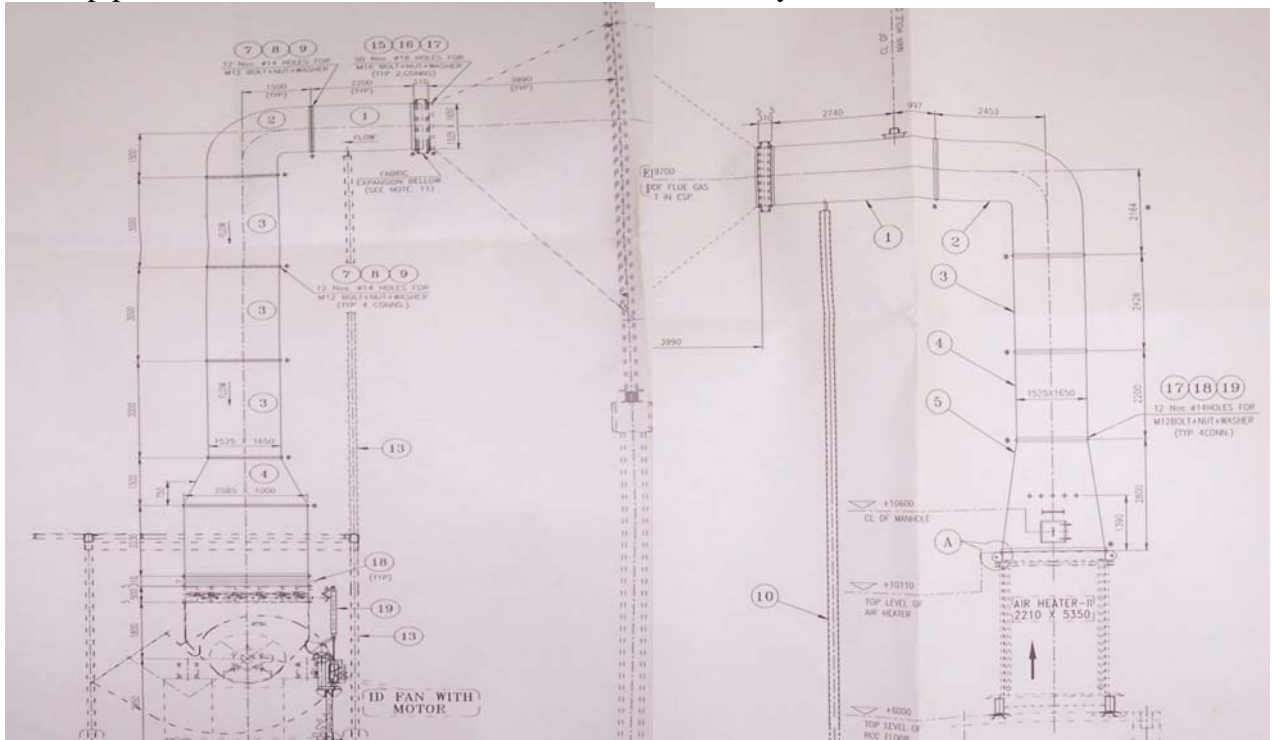


Photo 32 & 33: The ID inlet duct is provided with expansion joint to take care of downward expansion movement of inlet duct. The APH out let duct expansion is not taken care of this way.

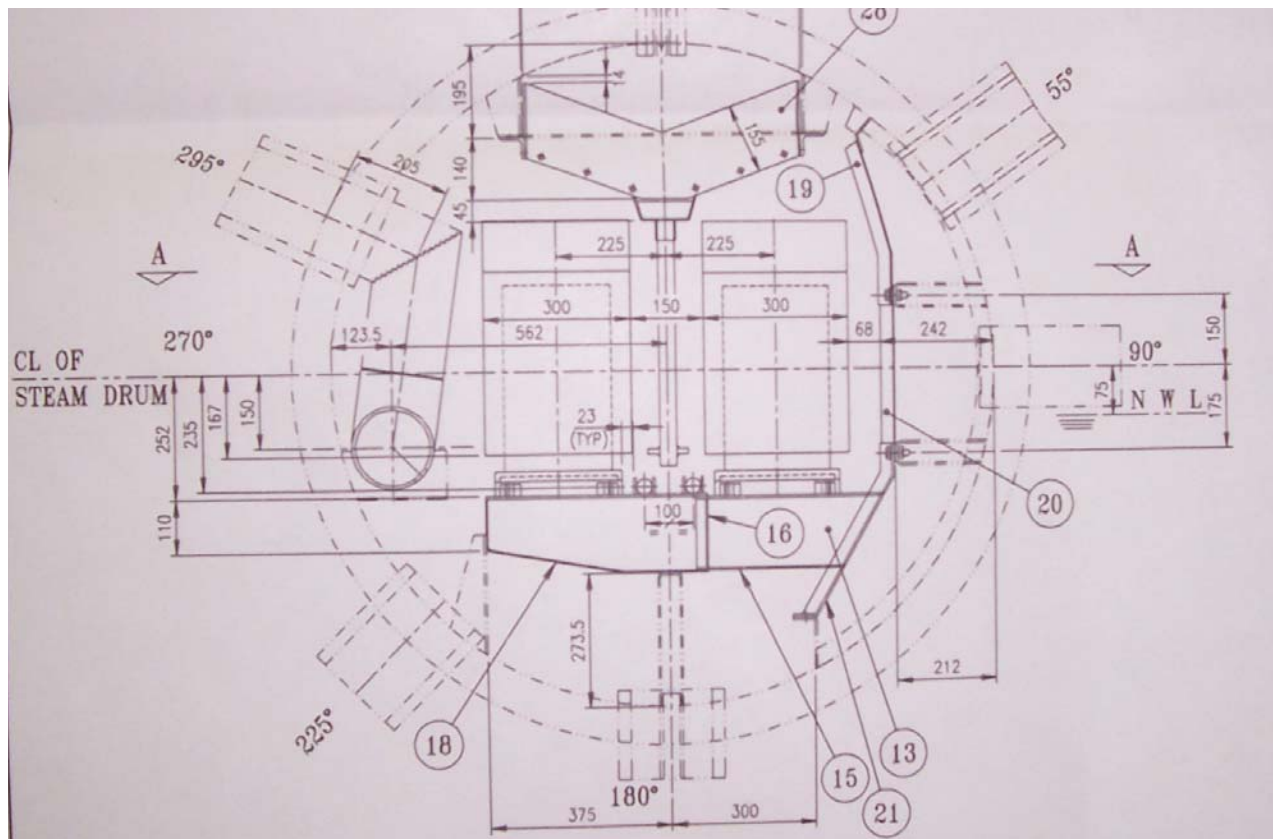


Photo 34: The CBD piping & HP chemical dosing piping are laid at 100 mm distance to each other. This leads to high pH / PO₄ in water sample than what is in the bulk water. The HP dosing has to be shifted below the Feed distributor.

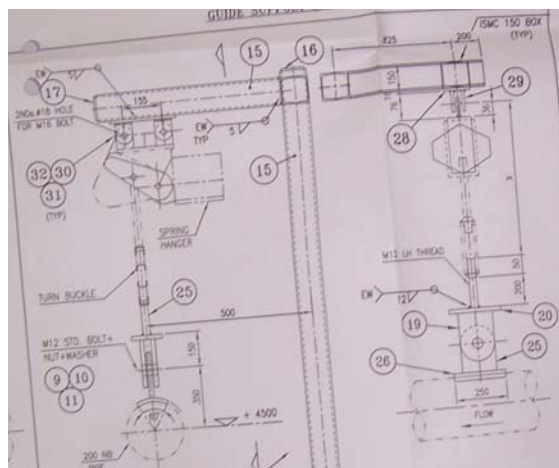


Photo 35: Supports in multi plane is seen in several places. Drawing itself envisages such supports. This supports can not offer a rigid base for the spring support.

REPORT ON SHUT DOWN AUDIT OF 90 TPH AFBC BOILER

The 90 TPH AFBC boiler was under shut down at the time of visit. The various systems of the boiler were inspected. The following are the observations & recommendations.

1. The fluidised bed was clean at the time of inspection. The bed coils were externally inspected for any sign of erosion. There were no marks of erosion, though there was no protection system such as shields or phoscast refractory. However there were marks of ash deposition / fouling above all fuel points. See the photographs 1, 2 & 3. At all fuel points the fouling of ash was seen to a radius of 250 mm. The fuel used has a low ash fusion temperature.
2. The bed material which was drained from the bed was available for inspection. It did not contain any clinker. The bed temperature readings were found to be just 875 – 900 deg C. The load on the boiler was also confirmed to be less than MCR load. Hence there is a need to analyze the coal on a regular basis for ash fusion temperatures such as initial deformation, softening and fusion temperatures. It is advised to check for every lot of coal consignment received at site. It is recommended to check the ash chemical composition so that any abnormal iron ingress can be monitored.
3. The bed coil thickness was measured at 12⁰ clock position at the lower part of the coils, where caustic gouging phenomenon was experienced earlier. The readings did not indicate any such phenomenon. As the measurement was found to be difficult, sampling was done only at 3 locations above fuel feed points.
4. It was informed that the boiler water pH & phosphate were maintained properly after the first failure. The drum was opened and inspected. The photographs taken (see enclosed photo 4 to 7) revealed that the boiler is yet subject to corrosion. The color of the drum in the water zone is still reddish. The drum internal design needs to be changed to correct this. Right now the chemical dosed can easily go to CBD line as the two lines are close to each other. By this, the sample drawn from CBD will always indicate higher PO₄ & pH as compared to circulating water. The chemical dosing line can be brought under the feed water distributor. See photograph no 8 for a good drum of another manufacturer with right type internal.
5. The internal of deaerator was inspected. The feed water box support was in adequate. The two tubular supports, additional venting done at manhole seemed to have helped to tide over the Oxygen related corrosion. Looking at the design it is found there is no water removal arrangement from the perforated air vent chamber. At least a 'U' loop can be provided to drain off the water from air vent chamber. A better design of this air vent chamber is to extend up to top of dished end so that the feed water box bottom plate gets an inner support. Also it is possible to accommodate a vent condensing arrangement as illustrated in figure 1.
6. It was confirmed that the feed water temperature could be maintained at 105 deg C after the additional vent was incorporated at the deaerator tower manhole. The steam drum did not seem to contain oxidation product in the water. The drum level mark was fairly normal indicating there was not much of suspended matter which was created by iron oxides from feed water system. As the economizer failures did not occur again we can presume that the deaerator temperature was maintained and the chemical oxygen scavenging was satisfactory.
7. The APH erosion was seen in the lower block. The cause for the failure was the excessive tube to casing plate clearance. See photograph 14. As the flue gas tends to go through the excessive gap, the erosion is also more. The tube had thinned down at 3⁰ clock position that is facing the casing. The idea of plugging the tube increases the pressure drop to some extent. But yet it may not affect the boiler steam generation, In future if the tubes are replaced at this place, the failure can not be prevented. It is better to leave the tubes as sacrificial tubes. When the tubes loose their shape, they must be replaced. Gas baffles can be provided at the entry and at exit as it is done at economizer inlet and as shown in figure 2.

8. It was seen the many birds have come through the FD fan and plugged the I pass of the APH tubes. See photograph 15. The dead birds must be removed as otherwise the draft loss across APH will be more.
 9. It was observed that the APH outlet duct to APH tube sheet welding was partly complete. This leads to leakage of hot air to outside. See photograph 21. Hence the welding must be completed.
 10. The economizer is found to be eroding. The reason for the erosion could be the high gas velocity adopted. The top baffles provided by manufacturer to prevent bypassing of gas through the end gaps are not fully welded to casing. The width of the baffles shall be 100 mm only. Presently it is more than 200 mm reducing the gas flow area. The baffles are not to be too close the tubes. As the ash stocks and falls off from the baffle, the flue gas tends to cut the tube. It is necessary to leave a gap of 100 mm above the tubes. Also the tubes need shields for erosion protection as shown in the figure 2.
 11. The tubes are arranged in staggered manner at economizer. Only the top rows of tubes are provided with impingement erosion shields. With staggered pitch, the second rows of the tubes are to be protected with shields too. See photograph 17.
 12. The tube bends of economizer were found to be eroding in between the banks. The tubes can be provided with cassette baffles as shown in the figure 2.
 13. It is seen that the bed ash is being screened manually. It is recommended to use mechanized system so that the bed material specification can be easily adhered to.
 14. The fabric expansion joint at water wall to wind box was found to be taut indicating the filling of the bed material. Wherever it is taut, the bed material shall be removed to avoid distortion / failure of windbox supports as the boiler expands down. Thermal expansion loads are of very high order when they are prevented. See photograph 12.
 15. There were ash accumulations in convection superheater area over the nose panel. This shall be cleaned. See photograph 13. The present design of the ducting system needs to be addressed by manufacturer.
 16. The waterwall outlet duct to economizer duct is found to be distorted as the fabric expansion joint filled with ash. The fabric expansion joint needs to be cleared of ash to permit the thermal expansion of the boiler. See photograph 16.
 17. There was no manhole at the APH outlet gas duct. A manhole shall be introduced to facilitate inspection. See photograph 20.
 18. At many places manholes are buried inside the insulation. See photograph 20.
 19. The economizer casing is leaking in many places. When the economizer was repaired for the joint leakage, the welding is not completed. The outside air goes in to the system loading ID fan. See photograph 18 & 19 for samples.
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ANNEXURE for case study 3



Photo 1-3: Photos above illustrate the ash fouling above coal nozzles. Blunting of outer studs is seen.

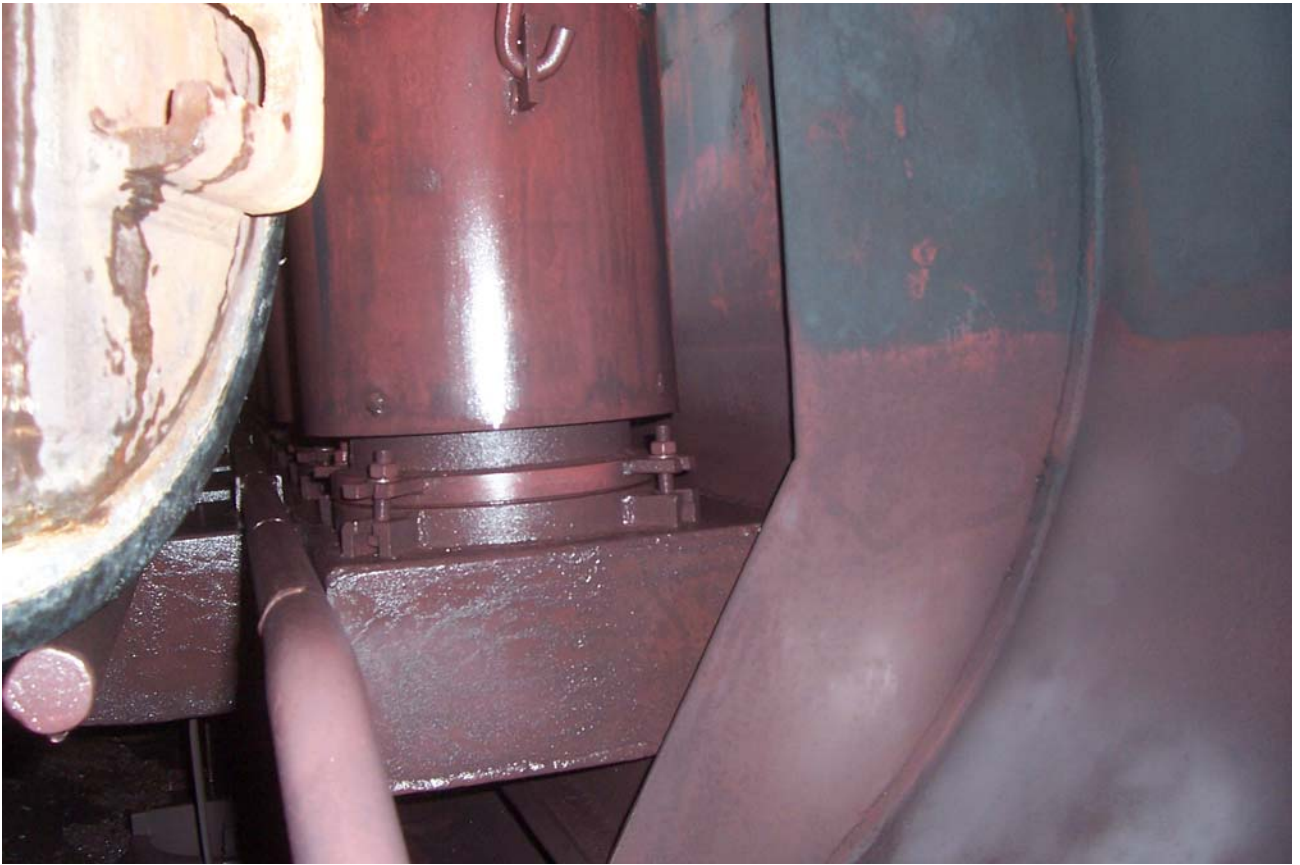


Photo 4 & 5: Photos above illustrate the boiler is corroding. The distinguished red color in water space proves the boiler water chemistry regime is not OK.

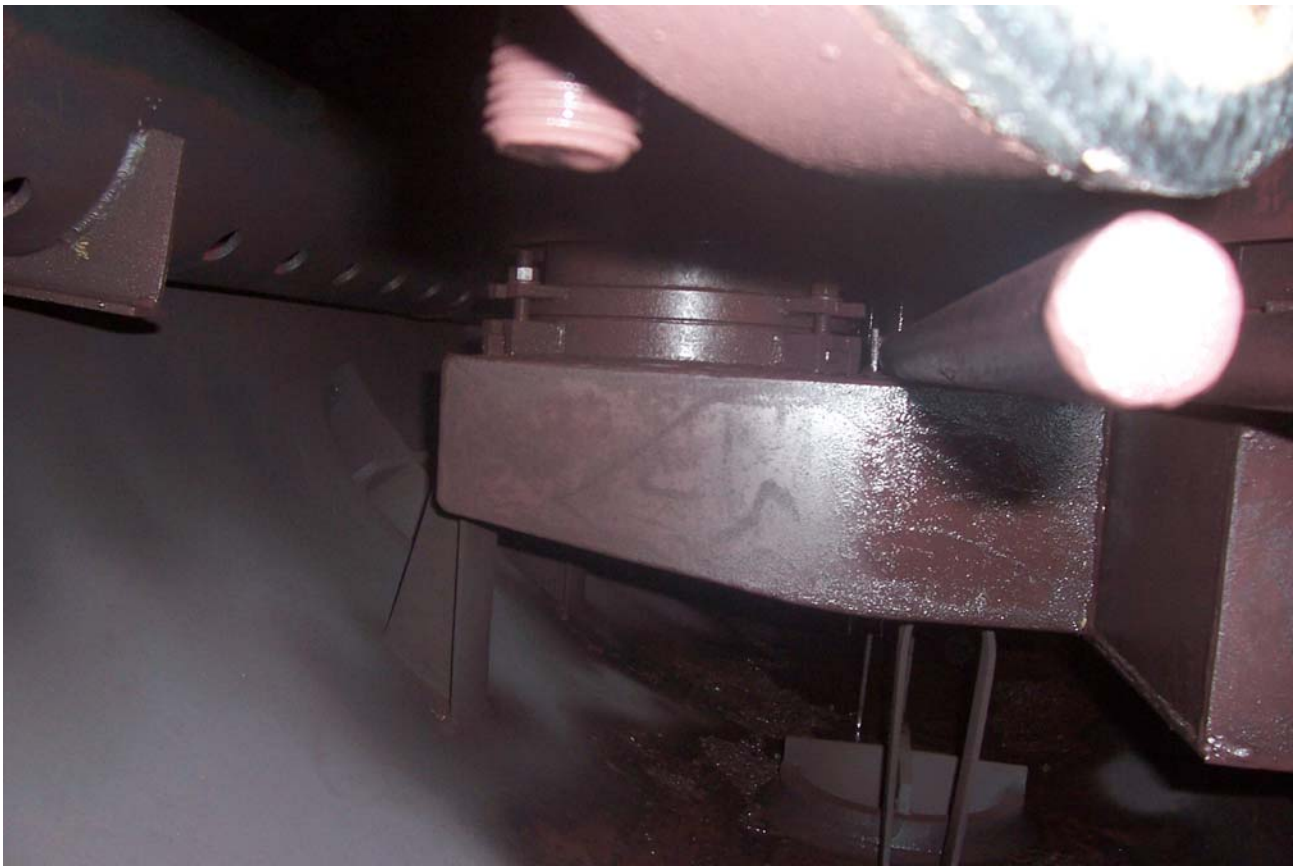


Photo 6-7: Loose corrosion products are seen inside. This must be from previous regime of operation in which pH & O₂ were not controlled. O₂ could not be controlled as the deaerator water chamber failed. The uniform corrosion due to low pH water is seen by a rub off.



Photo 8 & 9: The top photo is a drum with proper internal arrangement showing the dark grey magnetite layer of steel. The bottom photo is what was observed earlier when the pH was not under control. The drum surface is comparatively better this time.



Photo 10 & 11: The two photos indicate that the feed water pH was OK. The utter reddish surface is not seen. Also the clear tray indicates there is no transportation of corroded steel to boiler.

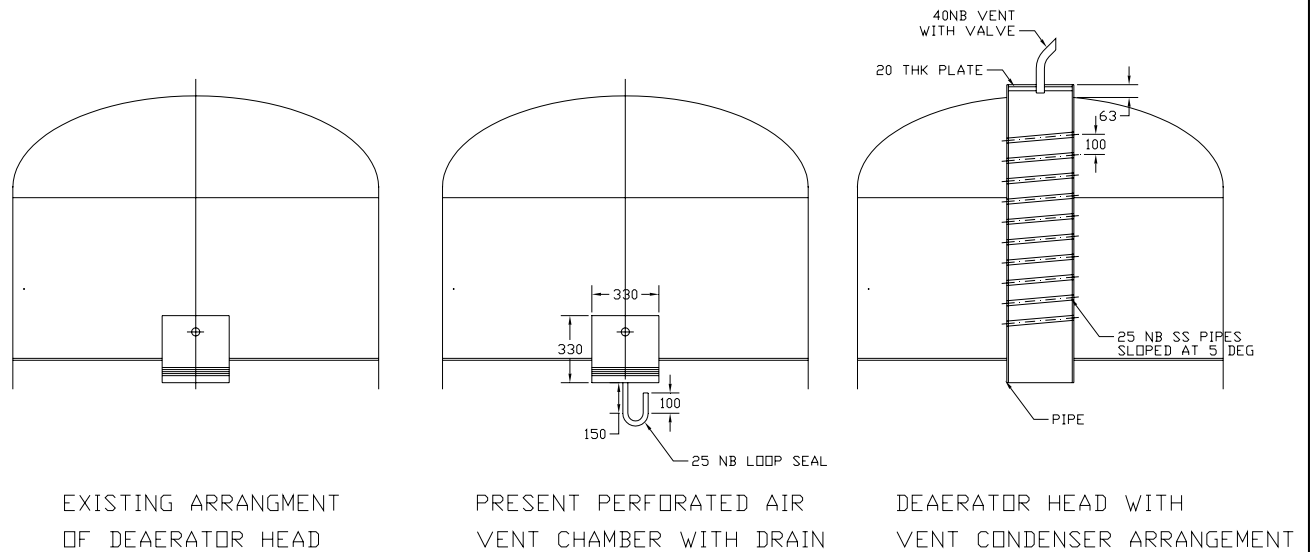


Figure 1: The deaerator air vent chamber needs a drain pipe system to remove the water that will form inside the chamber as the vent steam passes. A 'U' loop seal shall be provided with a 25 nb pipe as shown above. A vent condenser is recommended as shown from steam saving point of view.

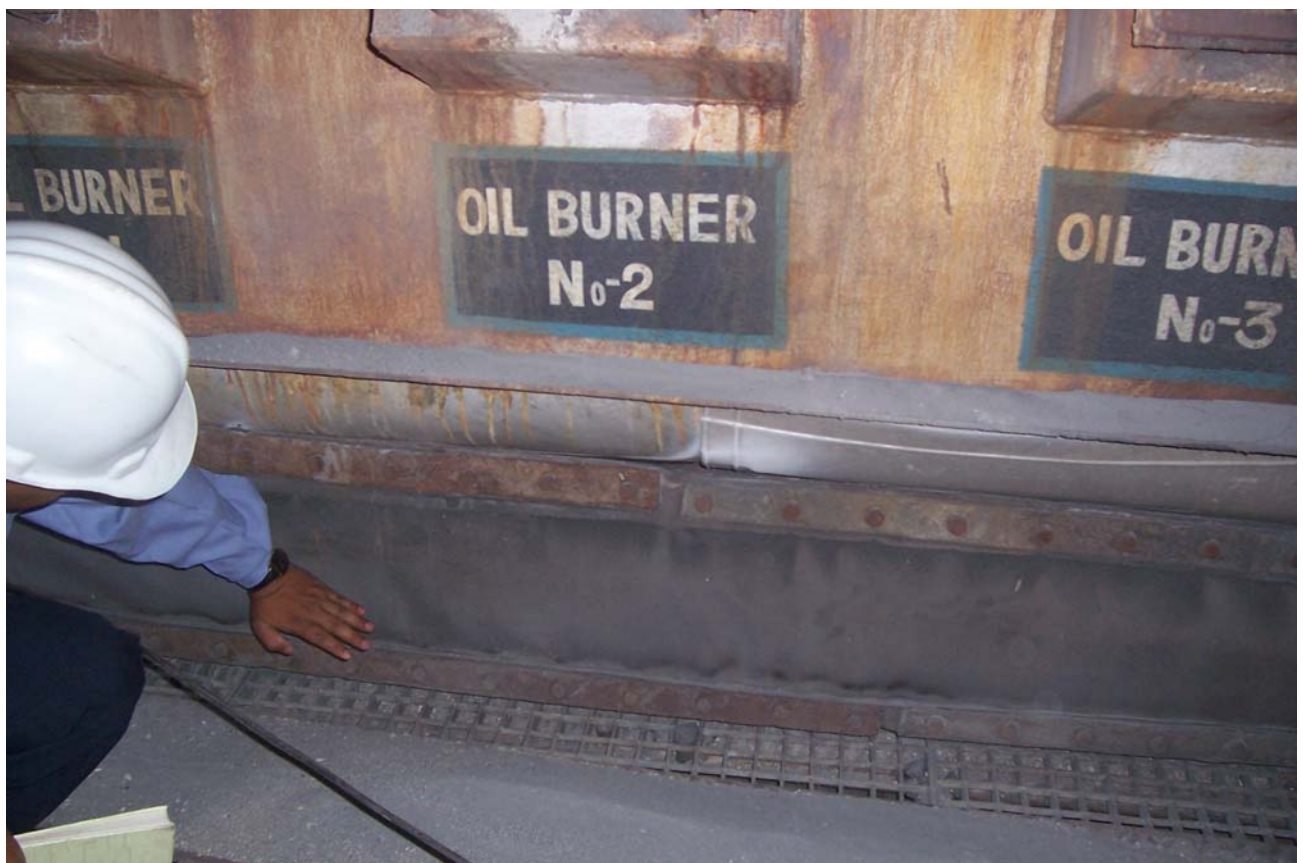


Photo12. The waterwall to windbox expansion joint was taut at some places. The accumulated bed material must be cleared.



Photo 13: There is quite a good amount of ash accumulations seen in superheater area



Photo14. The APH end tube to casing clearance is about 100 mm. Due to excessive gap the gas had bypassed and eroded the tube surface that is facing the casing.



Photo 15: The APH air side tubes are blocked by the dead birds. This has to be cleared to permit the free air passage.



Photo 16. The water wall to economizer duct is distorted as the thermal expansion is prevented due to ash filling at fabric expansion joint. This can be avoided by addressing at design change. This may be referred to manufacturer.



Photo 17: The top row of economizer tubes are provided with impingement shields. The second row is not provided with such an arrangement. The polishing of tubes are seen in the second row.



Photo18. Lot of welding work is found to be left out while the economizer was repaired. All the leakages shall be arrested.



Photo 19. The welding of economizer casing is pending leading to outside air ingress in to the economizer.



Photo 20. It is found that the manufacturer had not provided handles in the manhole doors to facilitate easy access inside. Also the frame is inside the insulation itself. The frame has to be out of insulation



Photo 21: APH outlet duct is only stitch welded at erection stage itself. The field quality inspection system is missing. The hot air is leaking to outside.

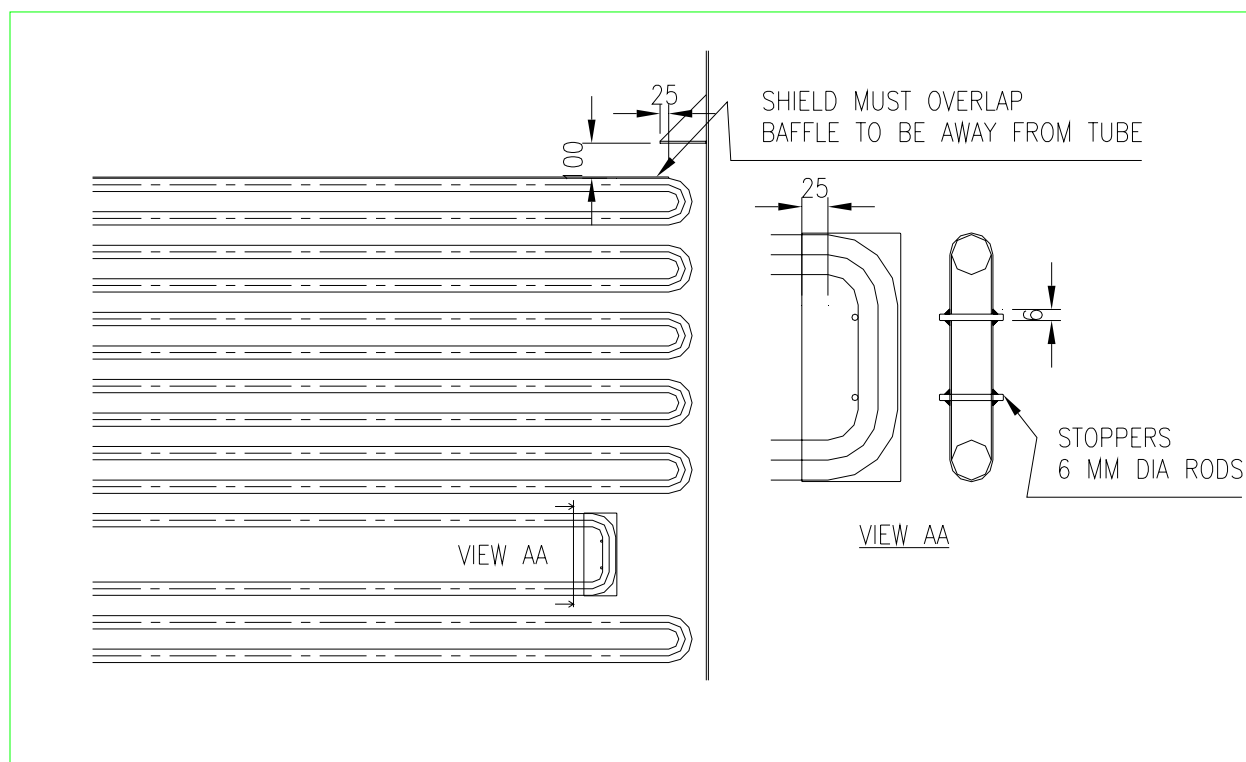


Figure 2: Economizer to be given baffles as shown in future.