

## **VISITING BOILER PENTHOUSES & BOILER ROOFS**

Very few operational & maintenance personnel dare to visit this area. This is because there is always a pool of ash and one may end up in inhaling ash to his lungs. This ash leakage is not intended. But many of the boiler users are unaware that the designer's intention is to give a leak proof penthouse. Due to ignorance of construction workers and due to urgency of commissioning the unit, the seal work remains incomplete. Moreover the sealing work is so cumbersome work, the erection staffs tend to compromise the work. If the work is incomplete, it results in ash leakage & air ingress while the boiler is in service. During a replacement / repair work, seals are ignored and it creates air ingress.

*The effects of incomplete seal work are many.*

1. Ash leaks and makes the boiler house dirty.
2. Air ingress leads to increased oxygen percentage in flue gas. Thus excess air setting would be wrong. This results in poor combustion efficiency.
3. ID fan gets overloaded. At times some users go for ID fan change.
4. In some boilers the combustion is drastically affected. The ID fan provides combustion air near the Superheater area. This can lead to high steam temperature in some cases. The design metal temperature may be exceeded at times.
5. Gas leakage to penthouse can corrode the boiler supporting structure.

Almost 50% of the boilers suffer from this man made disease. The case studies are presented for the benefit of readers.

### ***Case study 1***

See photograph 1 & 2. This was an AFBC boiler with unfinned waterwall design. The roof seal work was made of refractory tile followed by castable refractory. The boiler was lignite fired. The complaint in this boiler was the poor combustion efficiency. With air ingress through the cracks in refractory roof, how could any one follow the oxygen? This roof area needed engineering leak proof seal box.

### ***Case study 2***

This was a pulverised coal fired boiler with load carrying oil burners. The visit was made to solve their recurring radiant SH tube failure problem. One of the causes for failure was related to heavy air ingress from roof. This boiler was of loose tangent tube waterwall construction. The side wall casings were in good condition. However the roof design was not OK. Photograph 3 shows the condensation of sulfur dioxide in the roof refractory. The unit was oil supported for many years. Recently due to management decisions, the oil support had been cut. The air ingress to penthouse had been quite high that the gas had condensed and damaged the convection SH hanger tubes. It had been corroding the side waterwall outlet header & roof beams inside the penthouse. See photograph 4 & 5. The penthouse inspection door was not leak tight. The photograph 6 shows the leaky door. Yet more leakage was seen from the roof floor that was not sealing against air ingress.

The customer had been experiencing the shortage in generation capacity of the boiler. The high air ingress has put restriction on supply of FD air. Hence coal mills were unable to deliver the required coal for the full load.

Another serious problem caused by this air ingress was that partial combustion had been taking place in Superheater zone causing high convection SH steam outlet temperature. The weld joints at the convection SH header stubs had been failing frequently. These weld joints were of dissimilar material combination of T11 to carbon steel. Since the design steam temperature was only 390 deg C, boiler supplier had given carbon steel tubes & header at outlet of convection SH. In service the steam

temperature went as high as 490 deg C. See photograph 7.

### ***Case study 3***

This was a bagasse fired boiler. The customer called for improvement of boiler capacity. I found there were several leakage spots downstream the furnace. One major point was that the bagasse particles were found to come out of the furnace roof and burn over the roof. See photograph 8. One can see how difficult it would be to work in the boiler house. Such leakage spots are often created by ignorant maintenance contractors. It remains a fact that we are allergic to engineering drawings. In most cases, sufficient details are given by some manufacturers and documentation is complete.

There are cases, I see that some boiler manufacturers think that it is their trade secret and they do not provide any drawing. A product delivered without technical documentation causes more problems to clients. The customers often rate such companies as incompetent.

### ***Case study 4***

A rice husk fired boiler with leaking boiler roof. The water wall roof is finned. But during replacement of SH tubes, the sealing has been ignored. This has led to combustion of rice husk near the convection superheater. The Steam temperature crossed the design values. Photographs 9 & 10 show the air ingress locations. Many times the metallurgy of tubes / pipes adopted may not allow such temperature excursions. Often the superheater suffers localised overheating failures at the locations where small dirt or deposit is present inside the coil.

### ***Case study 5***

Photograph 11 is the roof view of a boiler audited by me for availability & efficiency improvement. I often see maintenance team tries to apply castable work on the roof. Castable refractory cracks once the heating takes place. I recommend that the final insulation layer is plastered with cement – magnesia mortar mix or Plaster of Paris. This is to be covered by Hessian cloth & painted with shalikote paint finish. This alternative has been able to arrest the leakage with least effort.

### ***Case study 6***

This is a recently commissioned 90 TPH AFBC boiler. Customer called me for diagnosis of high LOI in ash. The boiler was shut & offered for my inspection. We can see the incomplete erection work by the manufacturer at the roof. Photo 12 shows the inside view of the convection SH penetrations in roof panel. The fresh air ingress mark is clearly seen. Look at the outside header view in photo 13. The ash marks around the hanger support proves the air ingress. Customer had been trying to maintain the O<sub>2</sub> at 3.5% in order to keep the excess air at 20%. With air ingress the oxygen indicated would be wrong. In such a situation, seeing the optimum LOI in fly ash of ESP 1 ash hopper, the air flow has to be adjusted.

### ***Case study 7***

This is a 76 TPH boiler AFBC boiler. In this case the shut down audit was performed after three years of operation. Photographs 14,15 & 16 prove the severe leakage of flue gas from penthouse. The boiler being a pet coke fired boiler the SO<sub>x</sub> is condensed inside the penthouse and to the structure which is close by.

### ***What needs to be done to prevent the disease?***

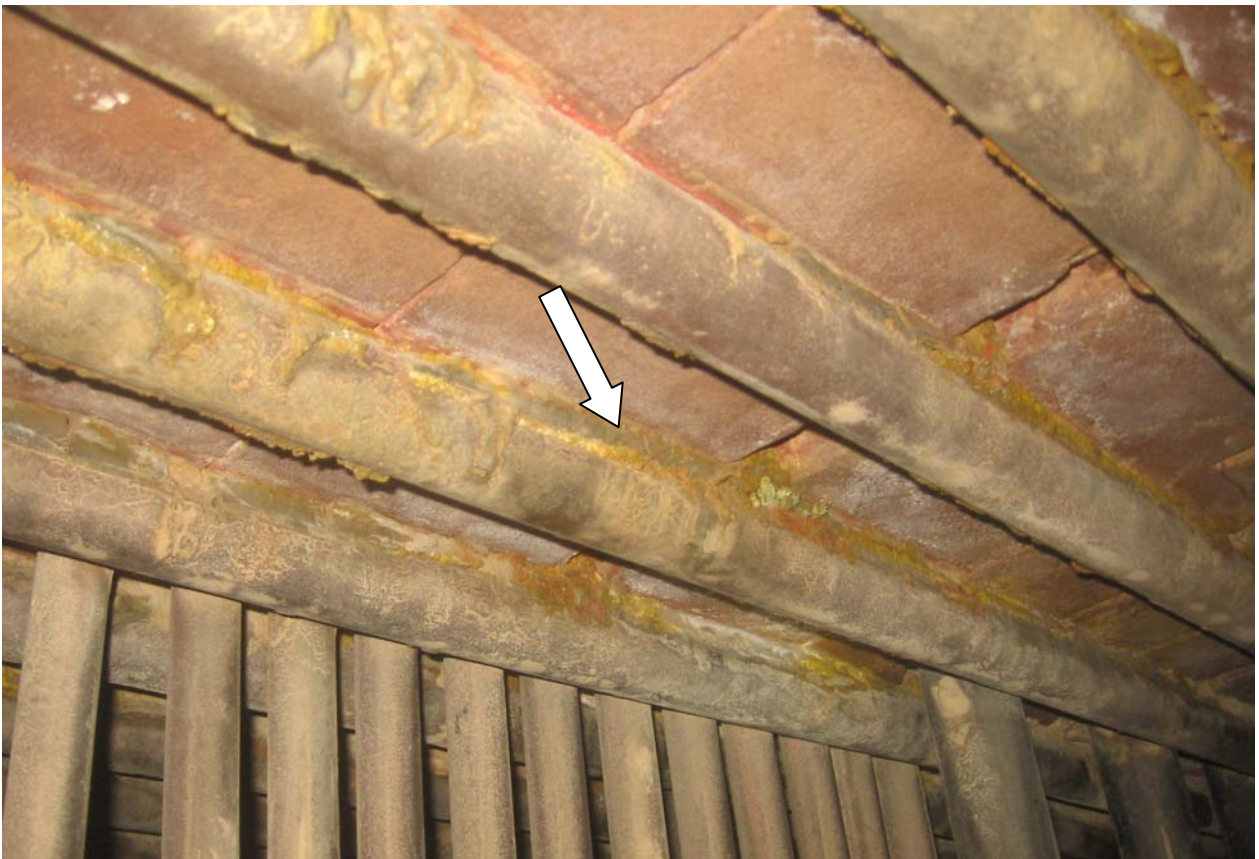
The boiler makers however organized they may be at their production shop, there is inconsistent

quality workmanship at field. This is due to fact that the field quality audits are not performed. Customer engineers concentrate on project schedule expediting delivery and thus the focus to field quality audit is lost. External inspection companies do not have the product knowledge and thus they miss the intricate points. Consulting companies have the problem of shortage of knowledgeable persons who can go in to the drawing details.

Insisting on design engineer's visit, specifically the person who made / approved the drawing, can help to prevent these mistakes. Auditing the erection by boiler operating engineers can be of help.

During maintenance, things are getting worse for various reasons. The continuity is lost when the people are changing jobs faster. Documentation is not at all available, even if a dedicated engineer gets in to the subject. With short shut down time available, ensuring a good quality would be impossible. But this can be overcome by meticulous planning. During shut down experts can be hired from boiler makers just to look after the quality job. Engineers may be specifically assigned the jobs relieving from regular report making, etc. At many plants, maintenance engineers are content once the job is assigned to a contractor.





Case study 2- Photo 3- cracks in roof refractory work leading to condensation of sulfur di oxide.



Case study 2: Photo 4: Corroded waterwall header due to condensation of flue gas.



Case study 2: Photo 5- Roof beams under corrosion.



Case study 2: Photo 6: leaky penthouse door.



Case study 2- Photo 7-Failures of weld joint of dissimilar materials caused by high steam temperature.



Case study 3- Photo 8: Fuel & ash leakage in the roof.



Case study 4: Photo 9- Waterwall roof with leakage



Case study 4- Photo 10: leakages around the headers.





Case study 5 -Photo 11- marks of flue gas leakage.



Case study 6-Photo 12: Inside view of SH coil penetrations in the roof shows the air ingress.



Case study 6- Photo 13- Ash leakage marks at SH header area above the roof in a new boiler.



Case study 7 -Photo 14: dust leakage seen around the side cladding sheet below the penthouse.



Case study 7- Photo 15- corrosion seen at roof beams – indication of gas leakage. With high sulfur fuel the corrosion damage will be more.



Case study 7- Photo 16: Flue gas condensation as droplets over the ash is seen. A proof air ingress & ash leak.

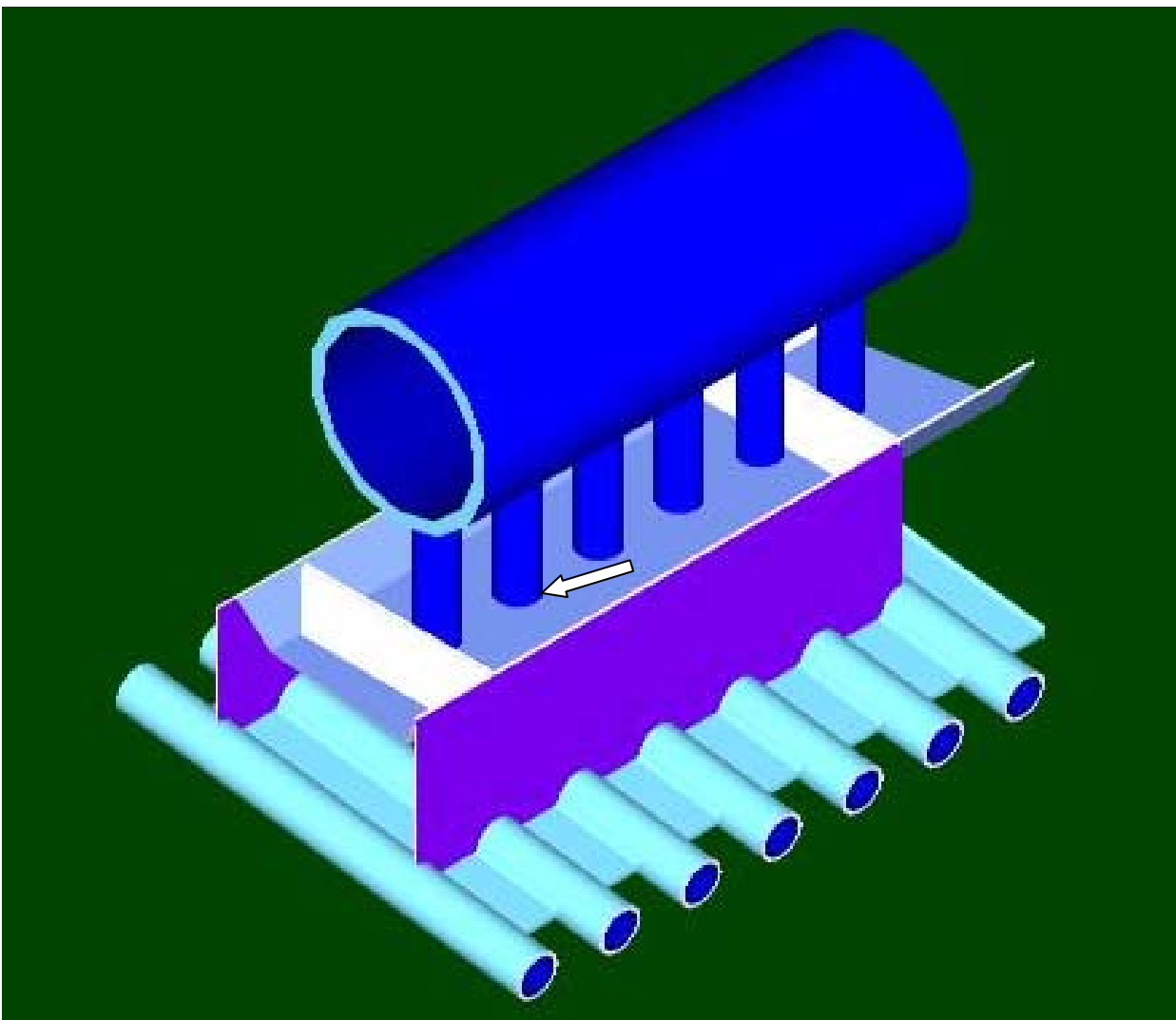


Figure 1: A cross sectional view of roof seal box design followed by boiler manufacturer. What was intended in Computer screen is this. This is a leak proof design taking care of differential thermal expansion between roof panel, SH tubes & the seal box. The arrow shows the location of seal weld which is missed out at site most of the time.