TROUBLE SHOOTING WATER CARRY OVER IN BOILERS

INTRODUCTION

Carry over is any solid, liquid or vaporous contaminant that leaves a boiler steam drum along with steam. Entrained boiler water contains dissolved or suspended solids, which affects the steam purity. Carryover results from incomplete separation of water from steam-water mixture.

EFFECTS OF CARRYOVER

- Water carry over from steam drum leads to loss of treated water through the steam traps in case of saturated steam boilers. Thus it costs additional fuel.
- However in case of boilers with superheater, the carryover will be indicated by the drop in main steam temperature.
- The carryover leads to deposition of solids in SH coils and turbine blades. It affects equipment availability.
- Carryover affects product quality in food & pharmaceutical industries.

CASE STUDIES

It may be appropriate to deal first some cases wherein the carryover had been a concern and the way they were solved.

CASE STUDY 1

The customer has a chemical factory situated at Tamilnadu. He reported that the water carryover is enormous and there has been a large quantity of water flowing from the steam traps in the main steam line. The boiler is a 10 TPH B&W inclined bank tube boiler shifted from a different location and converted to FBC firing. The customer has experienced carry over ever since the boiler was restarted. He complained to the boiler manufacturer who got a reply that they had not done any modification inside the drum. The service engineer who had visited could not resolve the problem.
When I visited the plant the customer had given a brief shut down of the boiler. The steam drum was opened and inspected. The cause for carry over was too simple a reason. The feed distributor pipe was not erected. The feed water inlet pipe bend was facing upwards towards the steam separator pipe.
The cause for carryover here is faulty erection of steam drum internals.

CASE STUDY 2

The customer has a rice mill industry at Andhrapradesh. The customer had complained that he had been replacing SH tubes in the boiler every year. The failed tubes were seen with heavy deposits. The reason for this was clearly carryover. Now I went on to check the reasons.

- DM plant was located in a dusty area, where there were high chances for fouling of resin beds and carryover of suspended solids.
- The Feedwater storage tank manhole door was open giving the possibility of forwarding dust from mill into the boiler.
- There was no suction filter for the boiler feed pumps. Thus impurities would enter the boiler unnoticed.

- There was no deaerator provided for this boiler. There were chances for iron oxides transportation from feed water tank itself.
- There was no pH booster arrangement to improve the feed water pH. There were chances of metal loss from the pipes and contaminating the feedwater.
- There were frequent boiler stoppages during which time no preservation procedures were followed.
- The feedwater flow was not regulated. The feed pump was being operated on /off.

There were enough number of reasons for carry over and thus deposition inside SH tubes was the net result.

CASE STUDY 3

This boiler user from Tamilnadu is a well-known tyre manufacturer. The customer called for an annual inspection visit. During the visit the boiler operators explained about the drum water level fluctuation in the steam drum. They experienced erratic variation in drum level, though the plant runs fairly at a constant load. The boiler is of bi drum configuration producing saturated steam. The steam traps in the plant were all connected in closed circuit. All the traps exhaust are connected to the blow down tank from where the water is pumped back to boiler through the Ogden pump. There was no way one could suspect the carry over.
On inspection of DM water storage tank, I found severe corrosion inside tank. The tank was unlined and made of carbon steel. The pH of water stored in this tank was 6.5 to 7. Clearly there was high possibility of corroded metal being transported to boiler.
There had been a huge loss of heat energy when the water from drum is transported to Blow down tank without consuming the energy in the plant. The gain in DM water and fuel has been remarkable.
Cases like this are really found to be many. Boiler sellers do not seem to offer such services to ensure the water quality would be assured after the plant is put into operation. It is true consultants like me get our bread from such boilermakers.

CASE STUDY 4

This Boiler user from Andhrapradesh is a big chemical Industry. Recently a second hand John Thomson boiler was bought and converted to higher capacity by a boiler repairer. The repairer had ignored the importance off the steam drum internals. When the steam generation rate is increased it is necessary to ensure the right type Steam driers are put. The client was interested in an audit of the boiler after erection by me. I recommended for changing of driers for ensuring steam quality. Customer had postponed the decision until the unit was stabilized. After stabilizing the unit the steam temperature remained lower to rated temperature by 20 deg C.
AS per my recommendations, the customer had now procured the driers and installed. To his surprise the SH outlet temperature now went up. There was an improvement of 40 deg C just after changing the driers. This implies there had been carry over of water from the boiler. There was a huge pay back of the expenses incurred in attending the drum internals. As the steam temperature turbine specific steam consumption came down and thus the savings.

CASE STUDY 5

This Boiler user at Orissa is a Chemical plant making sulfuric acid. The Boiler system has a waste heat boiler, two Superheater stages and an economiser, which form part of sulfuric acid plant. The various heating surfaces are designed to maintain the process temperatures for the necessary chemical reactions to take place. The customer reported that the gas temperatures after SH stage was too low. The plant supplier who visited the plant advised to

check water carryover from the steam drum. The boiler vendor deputed me to solve the problem. The water chemistry data for last one month was checked. It was clear there had been a serious deviation in water chemistry. The boiler water pH had been at 6.5 to 7 for a period of 10 days prior to this incident. The boiler TDS was double that of recommended value. The phosphate concentration in boiler water had exceeded the recommended value. I suspected that the boiler water is contaminated with corrosion product that was generated within the boiler itself. I recommended the boiler water is replaced completely. The boiler was blown down from the lowest points and the next day the SH temperature got restored. The process temperatures reached the requirement.

FACTORS THAT AFFECT THE CARRYOVER

- Operating pressure
- Water level in steam drum
- Load characteristics
- Drum size
- Drum internal geometry
- Condition of drum internals
- Feed water chemistry
- Boiler water chemistry
- High drum level operation
- Improper water treatment
- Blow down practice
- Offline preservation

Influence of each factor is elaborated below.

OPERATING PRESSURE

Operating the boiler at significantly below the design pressure is a cause for carryover. Lower the steam pressure more the steam specific volume. Hence the steam velocity in drum internals would now be more. The separation of water droplets from the driers would not be good.

LOAD CHARACTERISTICS

Fluctuating loads lead to sudden withdrawal of steam. Hence the velocity in the drier zone will be more and hence the water droplets get carried over to the steam before they fall out from the steam. In addition when the load demand is larger, the drum pressure will be lowered and this causes a momentary raise in water level, called priming. At this time, the carryover of water will be more.

DRUM SIZE

This factor is by design. Three-element drum level control had made it possible to design smaller diameter drums. The drum internals include baffle plates, cyclone type separators, Chevron separators or screen driers, perforated boxes. The drum diameter should be selected so that the distance from water-steam interface to driers is quite adequate. Failure to address this would result in carryover.

DRUM INTERNAL GEOMETRY

There is no single standard method to arrange the drum internals. The boiler configuration calls for extensive variation of drum internal arrangement between boilermakers and even within the product range of single manufacturer. Figures show several internals arrangement followed / encountered by me.
Improper internals arrangement is a major cause for carryover. There is always good scope for improving the steam quality by critically reviewing the present arrangements. Drum internal design should aim at fulfilling the following criteria.

- Reducing the turbulence created by the risers & downcomers by adopting baffles.
- Creating a tortuous path for steam before it enters drier section.
- Provide adequate drier section to trap water droplets and drain off without allowing re-entrainment into the steam.
- Maximize the distance between the water-steam interface and the driers.
- Distribute the chemicals over the entire drum length
- Extract the blow down water across the entire drum length
- Distribute the feed water without creating turbulence

Low-pressure boilers, generally, the fire tube boilers are provided with dry pipes at steam pipe inlet. High-pressure boilers are to be provided with multi stage separators such as cyclones, chevron separators. Some boilermakers use demisters with higher drum sizes.

CONDITION OF DRUM INTERNALS

Whatever be the proper engineering & supply made by the boiler vendor, it is possible that things go wrong in erection at site. Even in operating boilers, the drum internals get disturbed during maintenance. The drum internals fail due to corrosion in service due to poor water chemistry or improper boiler storage at idle times. Regular check by the manufacturer or competent boiler consultant would be worth.

FEEDWATER CHEMISTRY

The chemistry of feedwater should meet certain minimum requirements laid out by the boilermakers. The feedwater if contains oil or organic matter, the same leads to foaming. The carryover of solids is very high.
If the feedwater has dissolved iron, which may be either from condensate or from the make up water or generated within the boiler will again lead to foaming.
If the feedwater contains suspended impurities then also carry over will be high. Dissolved oxygen in feedwater leads to corrosion of economiser and this leads to generation of iron oxide, which again leads to increased suspended iron in the boiler water.

BOILER WATER CHEMISTRY

The chemistry of Boiler water should meet certain minimum requirements laid out by the boilermakers. The boiler water if contains high TDS the carryover of solids will be more. Since the efficiency of separator which is fixed, the only way to bring carryover is to bring down the Boiler water TDS. In boiler water, the presence of free NaOH must be eliminated by practicing coordinated phosphate control. High alkalinity and presence of suspended impurities increase carryover.
When the suspended impurities are more, there is a blanket formation over the water-steam interface and this prevents the easy passage of steam bubbles from the boiler water. The

steam bubbles out of the skin formed by the impurities throwing the suspended impurities to the steam driers.
The silica in boiler water is to be controlled more stringently based on pressures. Silica carryover is more at pressures above 28kg/cm2.

HIGH DRUM LEVEL OPERATION

The operating level, alarm levels & trip levels such as NWL, Low water level, very low water level, High water levels are decided by the boilermaker. At site conditions the levels are to be clearly marked and set by competent persons. While the low levels affect the circulation, the high level affects steam purity. The carryover is more with high water level. Lowering the NWL settings should be examined ensuring that roof tubes are within the water level. In many cases, Boiler users have reduced the carryover in the boiler simply by altering the NWL settings and by tuning the control valve action.
On off operation of boiler feed pumps a cause for carryover in flue tube boiler. It can be practiced only when the drum size is big as in an oil-fired boiler with internal furnace. In external furnace cases, the steam space is less, thus feed water regulation would give purer steam.

IMPROPER CHEMICAL DOSAGE

A good water treatment is important for water controlling carryover. Excess chemical dosage leads to upset in boiler water chemistry. Antifoam agents are used to control the carryover. Use of sludge conditioners also help in preventing carryover besides preventing deposits.

BLOW DOWN PRACTICE

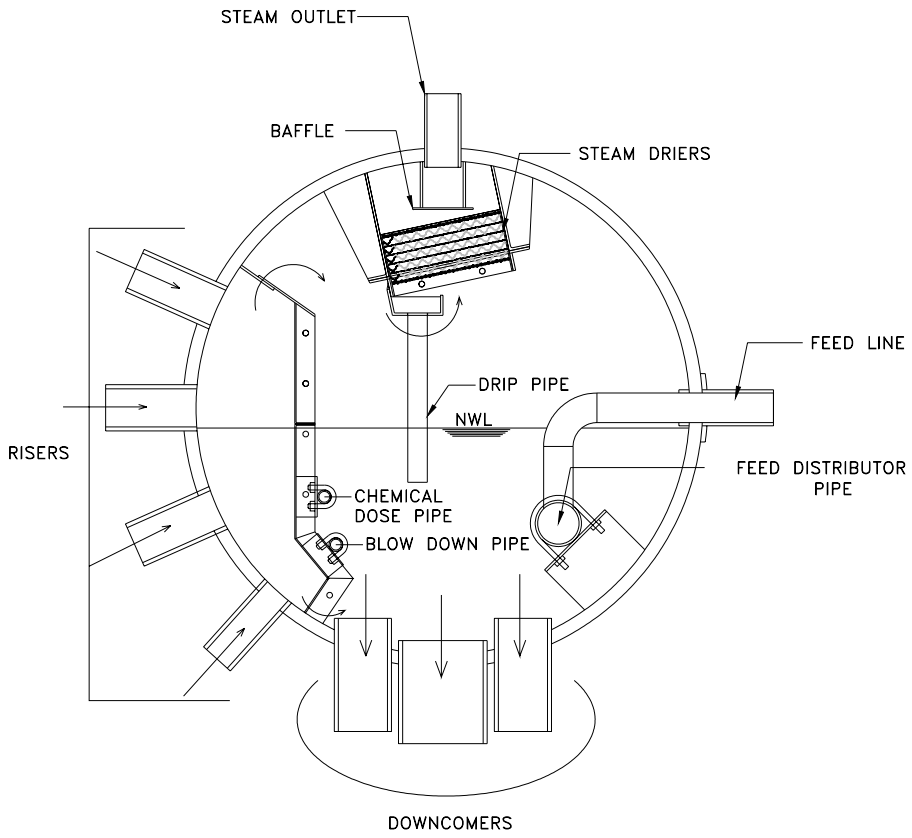
Continuous blow down is the best way to maintain a constant boiler water quality. Blow down at lowest points of the boiler must be done at every opportunity without affecting the circulation in boiler.

OFFLINE PRESERVATION

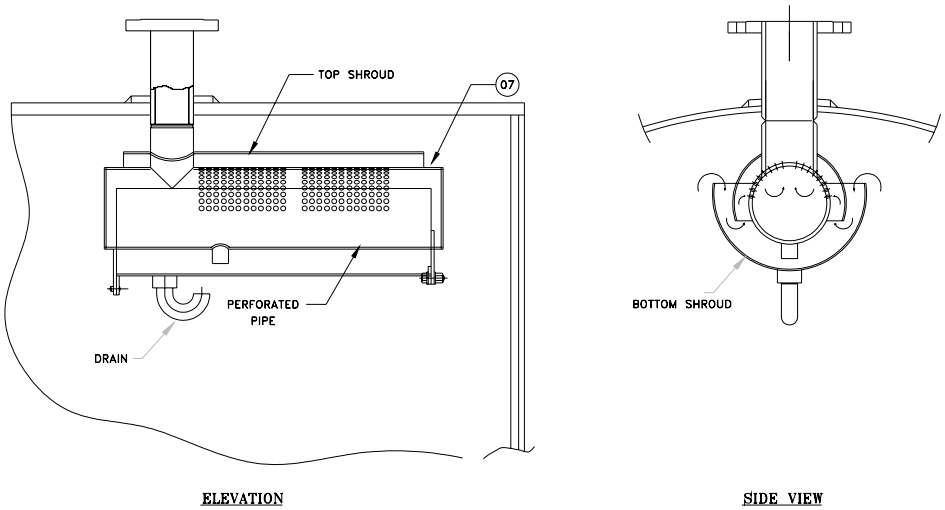
Improper offline preservation leads to iron oxide generation in boiler water and this leads to carryover during boiler restarting.

CONCLUSION

Equipment availability is greatly affected by the carryover, though it appears to be a simple matter. It is hoped that the readers are benefited out of this article. Take care to inspect the drum internals in the next shut. There are many users who do not open the steam drum manhole even during annual maintenance. Please be benefited by a thorough shut down inspection of drum internals.



STEAM DRUM INTERNAL ARRANGEMENT



STEAM DRIER ARRANGEMENT IN SHELL TYPE BOILER