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IMPROVEMENTS IN THE PERFORMANCE OF A SUBCOOLING ZONE IN A FEEDWATER HEATER WITH DUAL END PLATE DESIGN WITH WATER SEAL IN BETWEEN

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ABSTRACT

In a horizontal feedwater heater with a partial length subcooling zone the end plate located at the entrance to the subcooling zone is the only non-welded barrier that prevents the condensing zone steam from entering the subcooling zone. The end plate is usually two or three inches thick and the tube holes in the end plate are drilled to tolerances similar to that of the tubesheet. As the steam from condensing zone tries to enter the subcooling zone it condenses in the tight spaces between the active tube and the tube hole in the end plate forming a liquid barrier that prevents further ingress of steam into the subcooling zone. With usage and wear the gap between the active tube and the tube hole in the end plate increases thereby weakening the liquid barrier. The liquid barrier is completely lost when the tubes are plugged. Steam from condensing zone enters the subcooling zone and disrupts the performance of the subcooling zone, the performance of the feedwater heater and the efficiency of the power plant. This problem is faced by all horizontal feedwater heaters with subcooling zones that are in operation in power plants worldwide. .

This loss of performance can be eliminated by employing the patent pending Maarky concept of "dual end plate subcooling zone with a water seal". The "dual end plate subcooling zone with water seal" concept comprises of two end plates separated by a short distance. The gap between the two end plates is filled with condensate thereby forming a triple barrier to ingress of condensing zone steam into the subcooling zone. The performance of the subcooling zone and the longevity of the heater are preserved,

This paper discusses the design of subcooling zone in present day feedwater heaters, degradation of performance of subcooling zone and the improvements brought about by the patent pending Maarky concept of "dual end plate subcooling zone with water seal".

INTRODUCTION

In a steam power plant feedwater heaters are used to gradually increase the temperature of the feedwater in stages up to the boiler operating conditions. Preheating the feedwater improves the thermodynamic efficiency of the cycle, reduces the plant operating costs and minimizes thermal shock to the boiler metal. A steam power plant may be equipped with a number of feedwater heaters.

The energy used to heat the feedwater is usually derived from steam extracted from the steam turbine. Feedwater heaters can be open or closed heat exchangers. In an open feedwater heater such as deaerator the extraction steam is directly allowed to mix with the feedwater heater thereby heating it.

A closed feedwater heater, topic of present discussion, is a shell and tube heat exchanger wherein the feedwater passes through the tubes and is heated by turbine extraction flowing on the outside of the tubes.

In a steam power plant the feedwater heaters located upstream of the boiler feed pump are termed as high pressure feedwater heaters and those located downstream of the boiler feed pump are referred to as low pressure feedwater heaters.

In high pressure heaters the turbine extraction steam has a sizeable amount of superheat. Feedwater in high pressure feedwater heaters is typically heated in three stages in three separate compartments: a desuperheating zone, a condensing zone and a subcooling zone. Initial heating of the feedwater is carried out in the subcooling zone by subcooling the condensed turbine extraction steam. The feedwater is then further heated in the condensing zone by the condensing turbine extraction steam. The final heating of the feedwater occurs in the desuperheating zone by the superheat in the turbine extraction steam.

In low pressure heaters the turbine extraction steam has minimal amount of superheat or no superheat. Therefore feedwater in low pressure feedwater heaters is typically heated in one or two stages in one or two separate compartments: a condensing zone only or a combination of condensing and subcooling zone. In a two zone low pressure feedwater heater the initial heating of the feedwater heater is carried out in the subcooling zone by subcooling the condensed turbine extraction steam. The second and final heating of the feedwater heater occurs in the condensing zone from the condensing turbine extraction steam.

PROBLEMS WITH SUBCOOLING ZONE IN EXISTING FEEDWATER HEATERS

In low as well as high pressure feedwater heaters the subcooling zone is surrounded by turbine extraction steam. Leakage of extraction steam into the subcooling zone leads to condensate reheating, flashing and subsequent degradation in heater performance. In the present day heater design the extraction steam is prevented from entering the subcooling zone by (a) proper welding of the subcooling zone components (b) of the maintaining the water level above the entrance to the subcooling zone and (c) employing an end plate to separate the subcooling zone from the condensing zone. The end plate is usually 2”-3” thick and the tube holes in the end plate are drilled to a tolerance similar to that of the tubesheet. When the extraction steam enters the tight spaces between the active tube outer diameter and the end plate tube hole it condenses and forms water seal that prevents further ingress of steam into the subcooling zone.

Improper tube hole drilling tolerances, inactive tube because of tube plugging, extended usage or a combination thereof leads to widening of the gap between the outer diameter of the tube and the tube hole in the end plate. In such a scenario, extraction steam enters the subcooling zone and heats the condensate thereby compromising the performance of the subcooling zone and the entire heater. With each passing year the problem escalates with substantial decrease in the heater efficiency. When the degradation in performance is unsustainable the heater is replaced.

Steam ingress into subcooling zone through the end plate holes is a major problem affecting the performance and reliability of present day feedwater heaters operating in power plants worldwide.

REMEDY FOR THE PROBLEMS AFFLICTING SUBCOOLING ZONE

The ingress of steam into the subcooling zone can be eliminated by using two end plates with a water seal in between. The dual end plate with water seal eliminate the problems associated with leakage of condensing zone steam into the subcooling zone. If required multiple end plates can be used. The patent pending Maarky innovation includes the following design features:

- Employ two end plates instead of one.
- Close the gap between the end plates at the bottom and side so as to create a water compartment. Leave the top open so that condensate can enter the water compartment.
- Install a small drain hole in the bottom of the compartment so as to prevent water stagnation and facilitate marginal flow of condensate.

The dual end plate with a water seal offers the following advantages:

- There is a triple layer of separation between the condensing and the subcooling zone. The present day technology offers a single layer of separation.
- Condensate collected in the enclosure between the end plates will fill the space between the tube outer diameter and the end plate tube hole on the inner and outer end plate.
- As the condensate in the annular space is close to the shellside saturation temperature condensing zone steam cannot condense on the condensate. The absence of a heat sink voids the incentive for the condensing zone steam to enter the annular space.
- The outer end plate constitutes the first barrier, the condensate in the annular space forms the second barrier and the inner end plate forms the third barrier.
- Widening of the gap between the tube outer diameter and the tube hole in the outer end plate and subsequent ingress of steam into the gap between the end plate will not impact the performance of the subcooling zone.

The dual end plate with an in-between water seal offers a triple seal that prevents leakage of steam into the subcooling zone. The performance of subcooling zone is secured and the life of the feedwater heater is prolonged.

CONCLUSION

Degradation in the performance of the subcooling zone is impacting the longevity of the horizontal feedwater heaters and efficiency of power plants worldwide. The loss of performance and subsequent failure of subcooling zone is attributed to ingress of condensing zone steam into the subcooling zone due to widening of the annular space between the active tube and the tube hole in the end plate due to wear and tear during normal usage and in the event the tubes are plugged. The patent pending Maarky concept of dual end plate design with water seal in between provides a triple barrier against the ingress of condensing zone steam into the subcooling zone. Steam leakage into the subcooling zone is eliminated. The performance of the subcooling zone, the reliability and the longevity of the feedwater heater and the efficiency of the power plant is preserved.

REFERENCES

[1] Heat Exchange Institute Standards for Feedwater Heaters, 9th Edition.

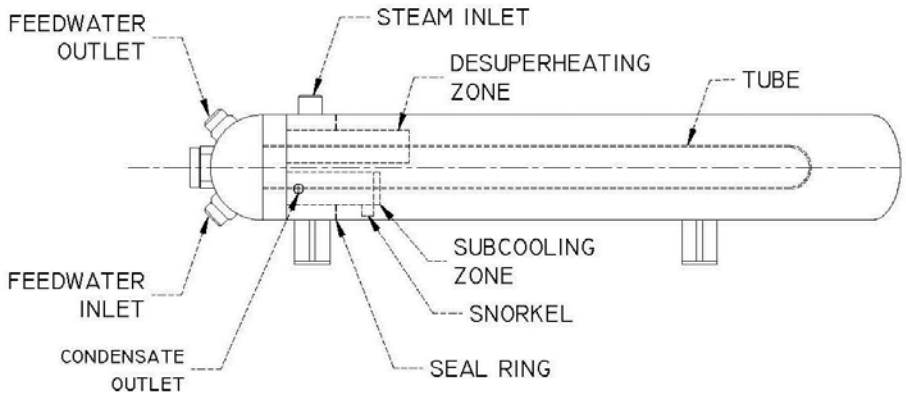


FIGURE I: HIGH PRESSURE FEED WATER HEATER

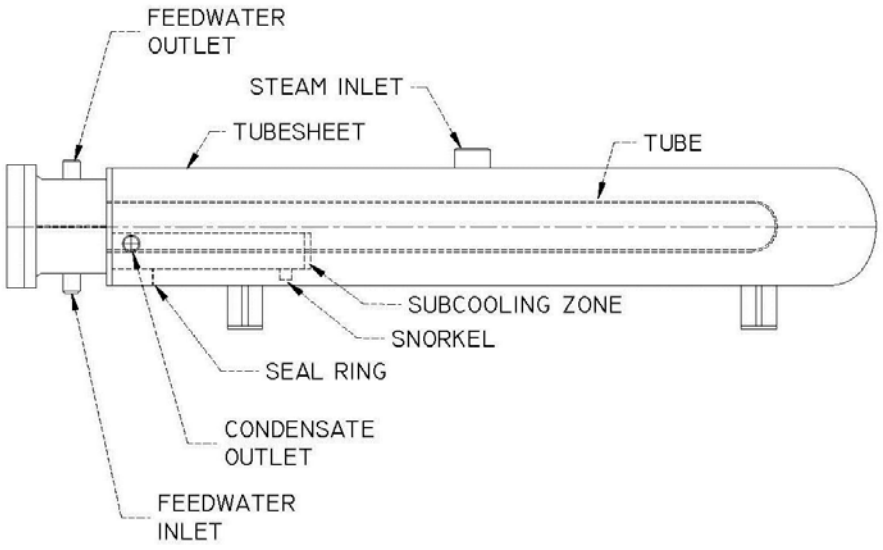
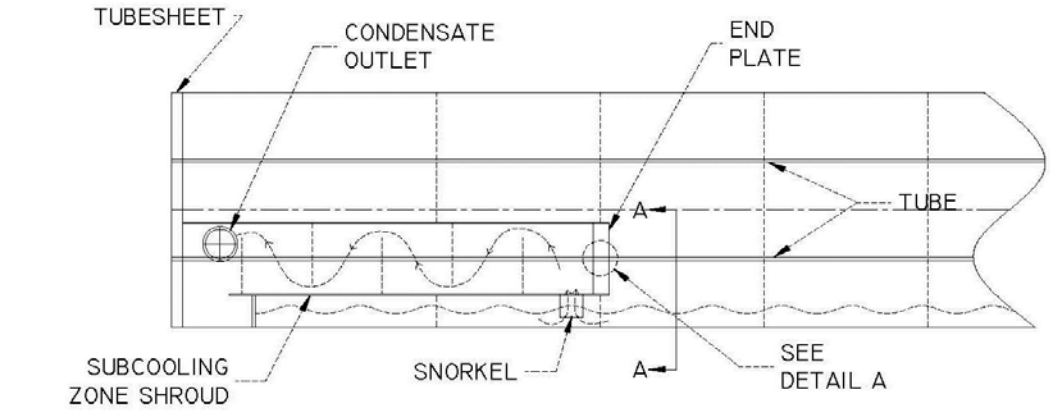
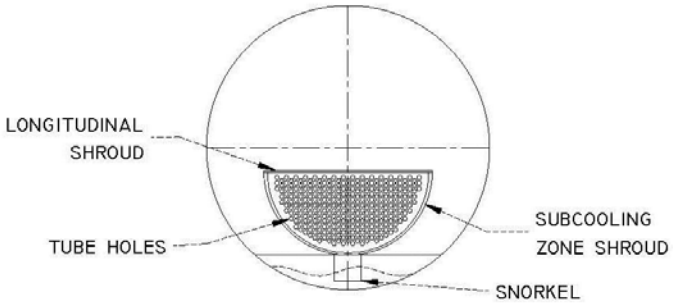


FIGURE 2: LOW PRESSURE FEEDWATER HEATER



SECTION A-A



DETAIL A

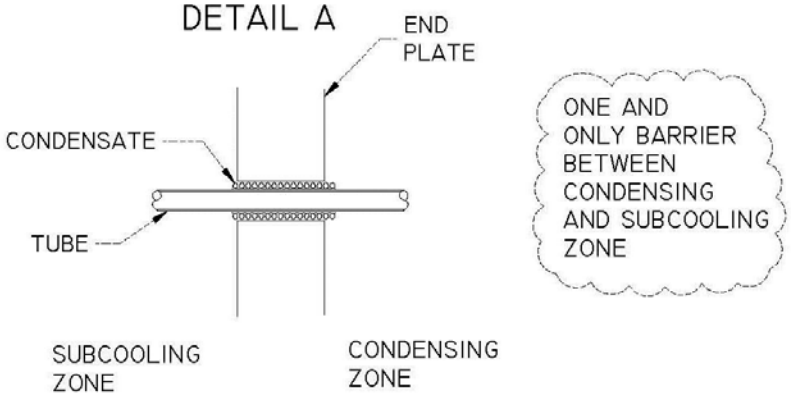


FIGURE 3: SUBCOOLING ZONE DETAIL

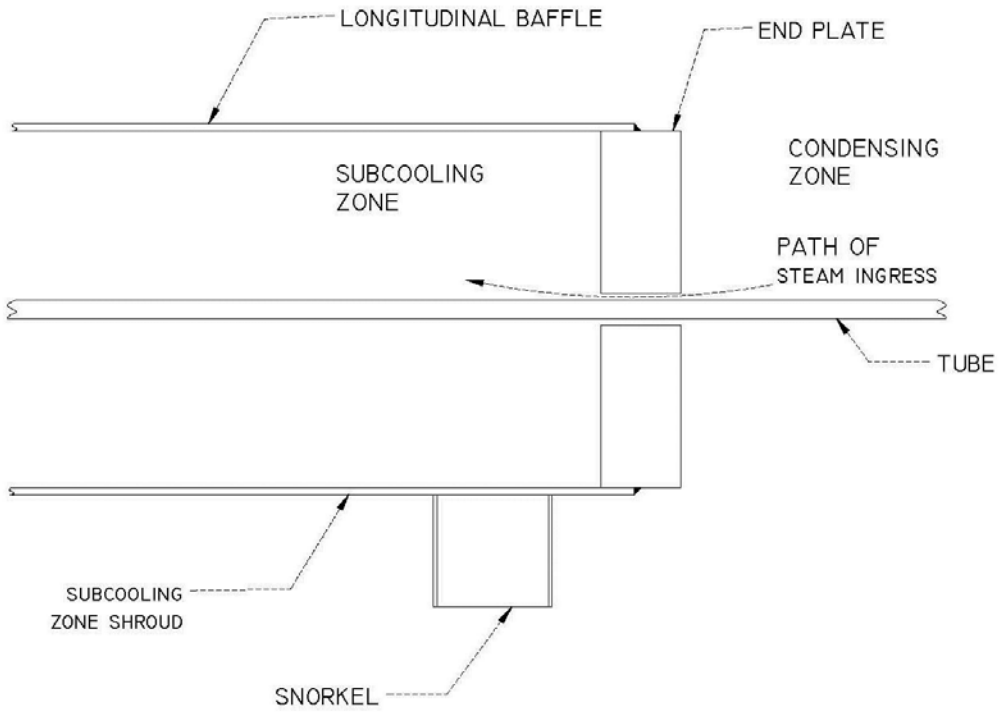


FIGURE 4: SINGLE END PLATE DETAIL

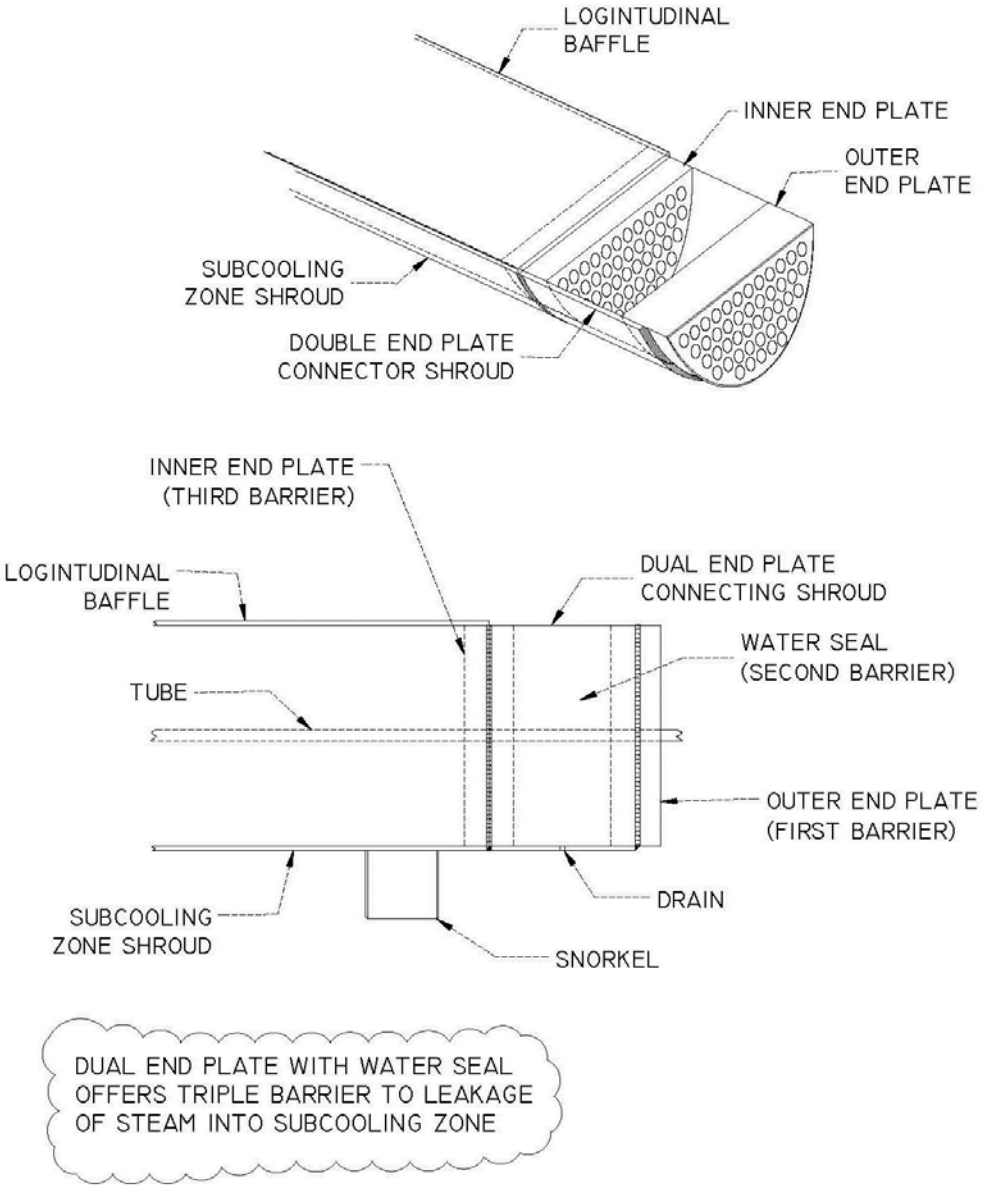


FIGURE 5: DUEL END PLATE DETAIL WITH WATERSEAL