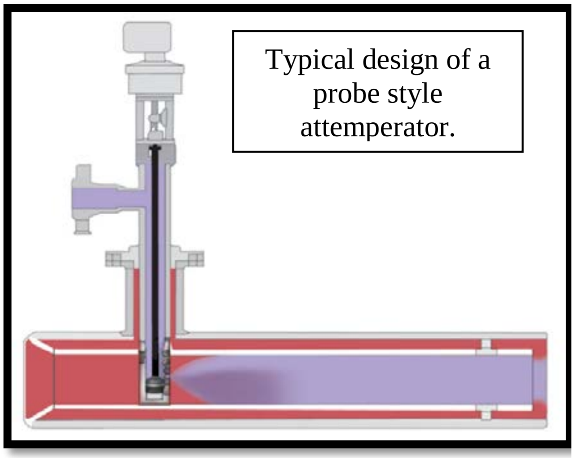
The Vulnerability of Attemperators

THIELSCH ENGINEERING

Because of the severe thermal and differential-pressure environments desuperheaters (also called attemperators) of combined cycle units operate in, routine inspection is a necessity to avoiding costly damage. Even well-designed hardware requires routine inspection to identify and replace worn or broken components before they damage steam pipes, headers, tubes, or worse yet, make their way to the steam turbine.

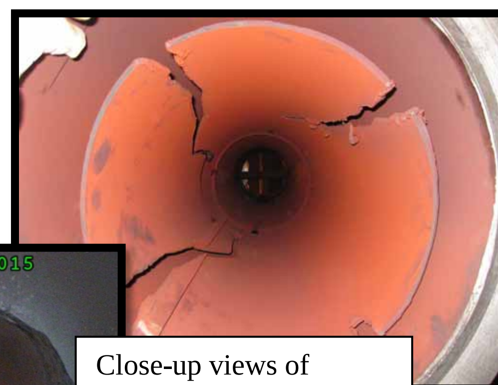


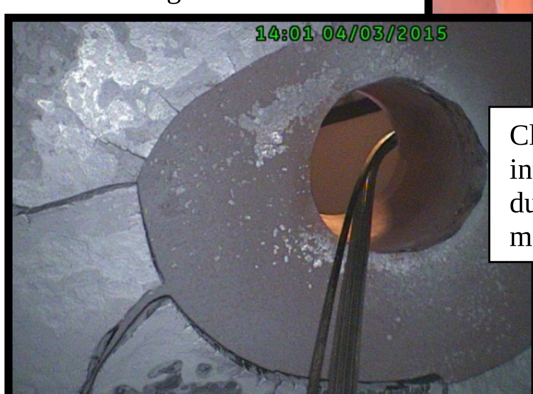
Typical design of a probe style attemperator.

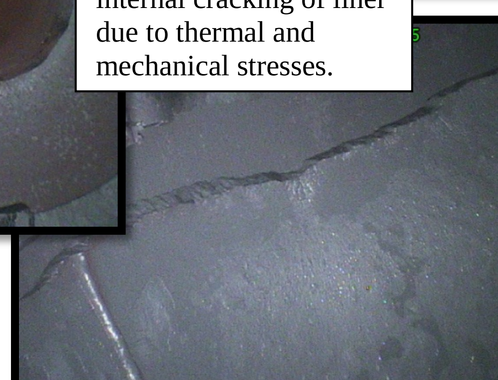
Attemperators prevent thermal damage to superheater and reheater tubes, and to outlet steam piping and downstream equipment. The attemperators in combined cycle power plants operate in a manner similar to that of standard desuperheaters used in conventional coal fired power plants for the past 40 years. High-pressure feedwater is extracted from the feedwater discharge line and directed to a valve control station, which regulates feedwater sprayed directly into path of the high-temperature steam. This process reduces the temperature and pressure of the primary steam systems so that it can be recaptured without doing harm to the downstream components.

The desuperheater components in combined cycle units were originally designed to operate for short periods of time during start-up to reduce the temperature of steam entering the condenser or to maintain low-temperature steam flow through the HRSG until adequate steam flow and temperature are achieved for steam turbine operation. However, several conditions exist within the combined cycle design and operation that lend to a more vulnerable environment for the attemperators.

The initial wave of combined cycle power plant construction that began in the 1990's, projected low generating costs through baseload operation. Instead, volatile natural gas prices and variations in electricity demand forced most of these plants to begin cycling operations. Similarly, their associated heat recovery steam generators (HRSGs) have been used to meet market demand. The HRSG is the boiler placed after the gas turbine to absorb remaining hot exhaust gasses and produce steam to power an additional turbine/generator set. Basically, the HRSG enables the added power generation and efficiency of the combined cycle power plant.







Close-up views of internal cracking of liner due to thermal and mechanical stresses.

In addition to the stresses induced by cycling operations, in the 1990's the design and operating temperature requirements for desuperheaters used in HRSGs increased from below 900F to over 1,050F. In most cases, the commonly used probe style attemperators were not designed to deal with these elevated steam temperatures, much less the added thermodynamic stresses that came with cycling service.

With these probe style attemperators used in many combined cycle plants, the in-line piping associated with the desuperheaters does not include an internal liner commonly found in conventional power plants. This results in spray water coming in direct contact with the pressure boundary piping and quenching the material. It is the quenching that has produced very high thermal and mechanical stresses that have resulted in through-wall failures and has resulted in numerous failures over a very short period of time.

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The spray assembly itself can also experience thermal cycling damage depending on the operating charactiersitics of the particular boiler and the extent of load swings it is subjected to. Some of the conditions that contribute to thermal cycling of the attemperator assembly include the temperature differentials between the steam and water, intermittent attemperator operation, and low load operation. Additionally, rapid changes in gas-turbine exhaust temperature during start-up, and high exhaust temperature which is characteristic of low load operation, can make it challenging for the attemperator to maintain steam temperatures within the design limits and avoid overspray conditons.

View of internal and external cracking at spray nozzle penetrations.

Inspection recommendations
All attemperators with liners should be visually inspected after ten years of operation. Those without a liner, however, should be inspected after five years of service. Future inspections for all attemperators should be on five-year intervals unless damage is found. The visual inspection should thoroughly examine the following areas for damage:

- Spray nozzle assembly including the diaphragm, welds on the nozzle extensions, backplate, and the inside and outside of the spray head.
- Attemperator liner including the liner welds (circumferential and longitudinal) and the liner retainer block welds.
- Attemperator body including cracks and erosion, especially when there is not a liner.

All areas should be inspected for cracked or broken welds and cracked or broken nozzles, liners and piping. A typical inspection involves removing the spray nozzle and inspecting the venturi and thermal liner using a fiber optic borescopescope. However, if the attemporator cannot be removed, the inspection can be performed through a radiograph plug or thermowell opening.

The reliability of attemperators can be maximized by understanding the conditions giving rise to potential damage mechanisms. Proactive inspections of these failure vulnerable components is critical to identifying existing damage conditions, determining necessary repair action and preventing unexpected outages.

For more information on failures associated with attemperators or would like Thielsch Engineering to develop a scope of work for an engineering inspection and evaluation, please call 401-467-6454 or you can e-mail Peter Kennefick at Pkennefick@thielsch.com.