## UNDERSTANDING AIR PREHEATER PERFORMANCE

The air heater is the last heat trap in most utility boiler systems. Once flue gas passes through the air heater it is rejected out of the stack, in most systems. Dry gas losses, which is any remaining heat in the flue gas, is lost energy, which reduces the boiler efficiency/heat rate. Dry gas losses account for the largest losses in PTC 4.0 boiler efficiency testing. Air heater performance is directly impacted by the conditions in which it operates including flow rates, entering temperatures, and pressures.

# Air heater performance is typically evaluated by these factors:

- Air In-Leakage
- Corrected Gas Outlet Temperature
- X-Ratio

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- Gas Side Efficiency
- Pressure Drop

While each of these factors are important in reviewing air heater efficiency all are required to understand the true performance.

In balanced draft systems, there are many locations in which air in-leakage can occur and each has different impacts on the system and efficiency. The air inleakage negatively impacts flow rates and temperatures throughout the system. Air leaking into the gas flow adds to the flow going through the air heater and subsequent downstream equipment. In addition, the diluting air temperature is lower than that of the gas stream and thus reduces the gas temperature. Sometimes poor air heater performance goes unnoticed because the gas outlet temperatures are so low. However, if you were to evaluate the air heater performance on the actual Corrected Gas Outlet Temperature, the temperature of the gas without any diluting air, then the performance would not look quite as impressive.



One of the biggest impacts air heater leakage has is not on the air heater itself, but on the ID fans and back end equipment. As the air in-leakage increases, the fans work harder to maintain the desired drafts and flows into and out of the furnace. Not only do the fans have to move more volume, but even more costly, they must operate at a pressure higher than design. In the summer months when the ambient air has a greater volume, it's possible that the fans can no longer keep up with the increased demands placed on the system. If the unit cannot make full load during the hours when the price of energy is at its greatest, the financial impact of air heater leakage is quite large.

#### Some typical rules of thumb

Parameter	Change	Percent Change in Heat Rate
Corrected Outlet Gas Temp Change (12,000 Btu/Lb Coal)	10 <b>°F</b>	0.25%
Corrected Outlet Gas Temp Change (8,000 Btu/Lb Coal)	10 <b>°F</b>	0.35%
Outlet Has O2	1%	0.29%
Air Heater Leakage	1%	0.05%
Air Heater Effectiveness	1%	0.15%

Air in-leakage after the furnace and prior to the air heater is not typically measured during a typical air heater performance test (ASME PTC 4.3), however air in-leakage here impacts not only combustion but the air heater performance. Infiltrating air at the boiler roof/penthouse penetrations, back pass, economizer hoppers or expansion joints before the O2 probes are seen by the system O2 probes as combustion air which in turn robs air from entering the furnace. Air entering after the temperature quench point does little to nothing for combustion of carbon. This type of air inleakage often results in higher carbon in ash, increased temperatures, and secondary furnace exit gas Infiltrating air impacts combustion. air heater performance because it is air entering the system which did not pass through the air heater. Reducing the airflow and increasing the flue gas flow results in reduced air heater performance. This air heater performance parameter is evaluated with the X-ratio, which is the ratio of the heat capacity of the air passing through the air heater to the heat capacity of flue gas passing through the air heater. Reduced airflow and/or increased flue gas flow will thus reduce the X-ratio.

#### Factors that can Impact X-Ratio

Any air that enters the system and does not pass through the air heater will impact the air heater Xratio.

- Boiler or backpass air in-leakage
- Increase in tempering air
- Increased primary air ratios requiring lower mill inlet temperature and thus more tempering air
- Changes in fuel moisture
- Any changes in cold air bypass
- Hot air recirculation
- While less of an impact, excess air

Air heater air in-leakage is measured and calculated based on flue gas constituents at the air heater inlet and outlet. In the ASME PTC 4.3 test code the percent air in-leakage is calculated on a mass flow rate basis in terms of wet products of combustion per pound of as fired fuel entering and leaving the air heater. This test requires a full analysis of the flue gas, fuel analysis and carbon in ash, however an empirical calculation can be utilized which only requires O2 measurements at the air heater inlet and outlet which is based on a volume basis rather than mass basis. Storm has found this empirical or abbreviated leakage calculation to produce results very close to the full PTC 4.3 test and can be performed at a fraction of the cost and time.



(Does not require measured mass flow rate)

The largest limitation to increasing air heater performance is the requirement to stay above the gas outlet acid dew point temperature. If the average cold end temperature or gas exit temperatures drop too low, they can impart a great deal of damage over a short period of time to the airheater and any downstream equipment.

#### Other Factors Impacting Air Heater Performance

Entering air temperature change will cause air heater exit gas temperatures to trend in the same direction. This is due to changes in temperature head difference. For quick calculation:

Exit Gas Temp Change = Entering Air Temp Change\*Gas Side Efficiency

For example, with a gas side efficiency of 65%, if the entering air temperature increases  $10^{\circ}$ F then the air heater gas outlet temperature will likely increase approximately  $6.5^{\circ}$ F.

 $10^{\circ}F \ge 0.65 = 6.5^{\circ}F$ 

Entering gas temperature change will cause the exist	t
gas temperature to change in the same direction. For	r
quick calculation:	

Exit Gas Temp Change=Entering Gas Temp Change\*(1-Gas Side Efficiency)

For example, with a gas side efficiency of 65%, if the entering gas temperature increases 10°F then the gas outlet temperature will likely increase approximately 3.5°F.

$$10^{\circ}F x (1 - 0.65) = 3.5^{\circ}F$$

Storm Technologies, Inc. has always strived to provide each plant we are involved at with a path towards improved efficiency and heat rate. Often, as shown in the following example, we find through standard air heater testing that the performance of the air heater has degraded to a point where there could be 2% or more of efficiency and heat rate improvements available on the table.

APH Performance Summary						
Parameter	Units	"A" APH	"В" АРН	Design		
APH Inlet O2	%	3.80	3.37	N/A		
APH Outlet O2	%	8.74	8.04	N/A		
Avg. Measured Gas Inlet	۴F	660.2	658.4	723.0		
Avg. Measured Gas Outlet	۴F	262.4	262.4	266.0		
Indicated Air Inlet Temp.	۴F	120.2	104.0	107.2		
Indicated Air Outlet Temp.	۴F	612.5	617.0	679.4		
Leakage	%	36.6	32.7	8.1		
Corrected Gas Outlet Temp	۴F	314.6	314.3	278.9		
X-Ratio		0.70	0.67	0.78		
Gas Side Effectiveness	%	64.01	62.06	72.17		
Gas Side DP	"w.c.	4.84	4.01	4.05		

Design Leakage 8%

> Measured Leakage 32% - 35%

36°F Above design corrected gas outlet temperature

## **Expanded Air Heater Services**



In the past Storm would have conducted the performance testing and possible a condition inspection of the radial and circumferential seals and left the other details to the facility. However, in the fourth quarter of 2020, Storm expanded our air heater service capabilities with the addition of industry expert Kent Ritter. Kent Ritter has over 40 years of experience in the air heater industry with regenerative-style air heaters. With Kent onboard at Storm Technologies, Inc. we can now provide a fully comprehensive list of services.

- Performance testing (Abbreviated and Complete ASME PTC 4.3)
- Detailed air heater inspection services
- Air heater project management
- Onsite training

2021

- Air heater inventory and spare part assessments
- Engineering review of air heater
- Technical support and 3rd party review of APH work/performance

- Life extension and planning of air heater components
- Review of APH proposals, develop specifications and work scope for construction
- Review cost benefits and ROI
- Outage planning and management services
- "Turn-Key" construction management of APH components

With our expanded list of air heater services, we can now offer a complete package to measure the performance of your air heaters, inspect, repair, and ensure your air heaters are not elevating the heat rate of your facility. Please give us a call today to find out how we can better support you and your air heater needs in 2021.

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## STORM TECHNOLOGIES HAS THE ABILITY TO SUPPORT ALMOST ANY APH SERVICE REQUIREMENT... 77

### PROJECT MANAGEMENT

- APH Components Supplier
- Vendor Review and Pricing
- Shop Review and Quality Audit of APH Components at Manufacturing Facility
- Guarantee Review/Verification
- Technical Support, Progress Review, and Condition Assessment
- Proven Synergetic Team Management for Multiple Vendors and Sub-Contracts



### PERFORMANCE TESTING

- Airheater Performance Testing
- ASME PTC 4.3
- Boiler Efficiency
- Flue Gas Velocity
- Comprehensive Boiler Testing

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