THE IMPACT OF PRIMARY AIRFLOW MEASUREMENT AND CONTROL ON SAFETY, RELIABILITY AND OPTIMIZATION

Airflow measurement plays a major role in the operation and control of all types of combustion systems. Storm has tested, calibrated, designed, and tuned nearly every type of airflow measurement device available. This summary provides an overview of the importance of accurate primary airflow measurement and control along with issues that arise when not tuned properly. Primary airflow serves multiple purposes in direct-fired pulverized coal systems.

In This Issue:

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Drying of coal

The first is to dry the coal for safe and effective transport. Wet coal tends to plate out or stick to objects within the firing system such as within the pulverizer, fuel lines, or burners. Coal layout is a safety issue as this can lead to a concentration resulting in smoldering or ignition. Drying is achieved through adequate mixing/contact between the primary air and the finely pulverized coal. Drying is also important as it improves combustion at the burner tip/ignition point. To achieve a safe level of drying while not causing premature ignition, the temperature and air-to-fuel ratios are critical to accurately control. The temperature of the primary air and coal mixture at the mill outlet is the variable utilized to control the mill inlet's primary air temperature. This outlet temperature ranges for various fuels and is determined based on the volatility of the coal. Coals with volatile content of less than 30 percent can utilize higher mill outlet temperatures up to 175°F, while coal with higher volatiles, greater than 30 percent requires mill outlet temperatures of 150°F or lower. Some fuels such as Powder River Basin utilize mill outlet temperatures in the 135-150°F range. To achieve higher mill outlet temperatures, the mill inlet temperature must also be higher and is dependent upon the coal moisture level and air-to-fuel ratio. If the air-to-fuel ratio is allowed to drop too low, then higher inlet temperatures are required to meet the outlet setpoint. Therefore, to have safe control of mill temperatures, both temperature and airflow must be accurately measured and controlled.

Transporting of coal

The other purpose of primary airflow is to transport the pulverized coal from the pulverizer to the burners. As noted with the risks of wet coal plating out in the fuel lines, it is also critical that adequate velocities are maintained to prevent coal from laying out in the fuel lines. This minimum velocity is 3,000 fpm with adequate fineness. This velocity should be utilized to set the minimum primary airflow to the mill. Since each mill has multiple fuel lines, Storm utilized 3,300 fpm to allow for airflow deviations from pipe to pipe (+/-5% Dirty Air Balance). With the minimum airflow set, there must also be a balance in sizing of open area within the fuel lines and pulverizer throat.

The throat is the annular area around the pulverizer table/bowl, which is the first point of contact between the primary air and coal. This velocity must be higher as larger coal particles are encountered and thus have a higher terminal velocity to keep them in suspension and from falling to the under bowl. If coal is allowed to spill into the under bowl, it then sits in contact with high-temperature primary air in a high air-to-fuel ratio zone which can lead to mill excursions or fires. Therefore, if the minimum airflow is not accurately measured and controlled, coal layout and spillage may occur. The charts shown are examples of a typical primary air ramp with a minimum airflow that then ramps at a constant air-to-fuel ratio. The second chart shows the velocities in the fuel lines and at the pulverizer throat showing how the minimum velocities are maintained.

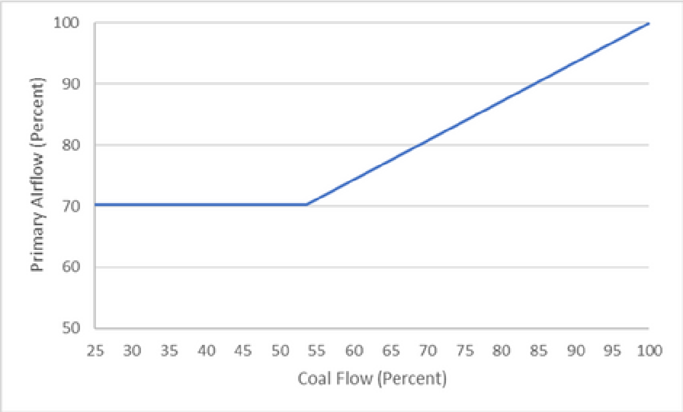


Figure 1: Typical Primary Air Curve with Minimum Airflow and Ramp at constant A/F Ratio when above Minimum

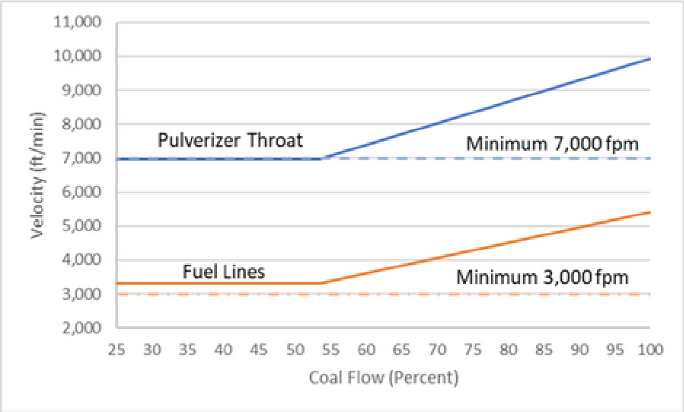


Figure 2: Resulting Velocities from an Ideal Primary Air Ramp

The burner nozzles are a set area and thus the rate of primary airflow sets the velocities at the burner tip. As mentioned above, low primary airflow can result in coal layout; however, at the burner nozzle, it can result in burner damage and burner fires in some cases. Low velocities due to imbalance or low airflow can allow the flame to be pulled back into the burner nozzle. When accompanied with layout within the burner nozzle, this can lead to burner damage as shown in the two figures.

Figure 3: Burner damage from two sites with low airflow on damaged burner

Having a high primary airflow can result in the primary airflow outpacing the secondary airflow; resulting in poor burner mixing. This can often be seen visually as a detached flame. High primary airflow at the pulverizer results in larger particles being sent out of the mill. The larger particles (50 mesh) do not have time to burn within the available residence time in the boiler. Storm has also found that high primary airflow and poor fineness result in poor distribution to the burners. Also, erosion is proportional to velocity. Therefore even a minor increase in velocity can accelerate the wear rate of the mill, fuel lines, and burner components.

The combination of poor mixing at the burner, bad distribution, and poor fineness results in high unburned carbon, secondary combustion, slagging, high superheat and reheat temperatures, and higher emission levels.

High primary airflow can also result in unsafe air-to-fuel ratios within the mill and fuel lines. This is most common at lower loads or transient operation of the mill when higher air-to-fuel ratios occur. High air-to-fuel ratios can lead to mill and fuel line excursions.

Typical Reasons Primary Airflow is increased or is high:

- Mill Load Response Time
- Pulverizer Spillage
- Inaccurate airflow measurement and control
- Poor fuel line dirty air balance requiring higher airflow to maintain velocities in all fuel lines
- Biased up to lower mill inlet temperature

Impacts

- Wear/Abrasion
- Pulverizer performance
  - Fineness
  - Distribution
- Combustion performance
  - Flame Stability/Detached Flames
  - Carbon in Ash
  - Slagging/Fouling
  - Secondary Combustion
  - Increased Spray Flows
  - Increased NOx Emissions
  - Reliability

How does Storm Recommend Accessing Primary Airflow Measurement Accuracy?

Airflow measurement devices should always be field-calibrated across the operating ranges of the device and in close proximity to the device. That is testing at the mill inlet rather than downstream in the fuel lines. All primary airflow measurement devices should be temperature compensated since it is desired to control the mass flow of primary air. Bernoulli's equation for fluid flow is an energy conservation equation that includes kinetic, potential, and pressure energy components. One of the variables in Bernoulli's equation is the density of the fluid. With that being said, temperature compensation is a critical piece in the plant's ability to accurately measure and control airflow within the plant. This is easily seen when comparing volumetric and mass flow with varying densities as illustrated in Table 1.

Volumeric Flow	ft^3/min	45,000	45,000
Primary Air Temperature	deg. F	80	450
Barometric Pressure	"Hg	29.92	29.92
Primary Air Static Pressure	"w.c.	30	30
Air Density	lbm/ft^3	0.0790	0.0469
Mass Flow	lb/hr	213,403	126,635

Table 1: Volumetric Flow vs. Mass Flow

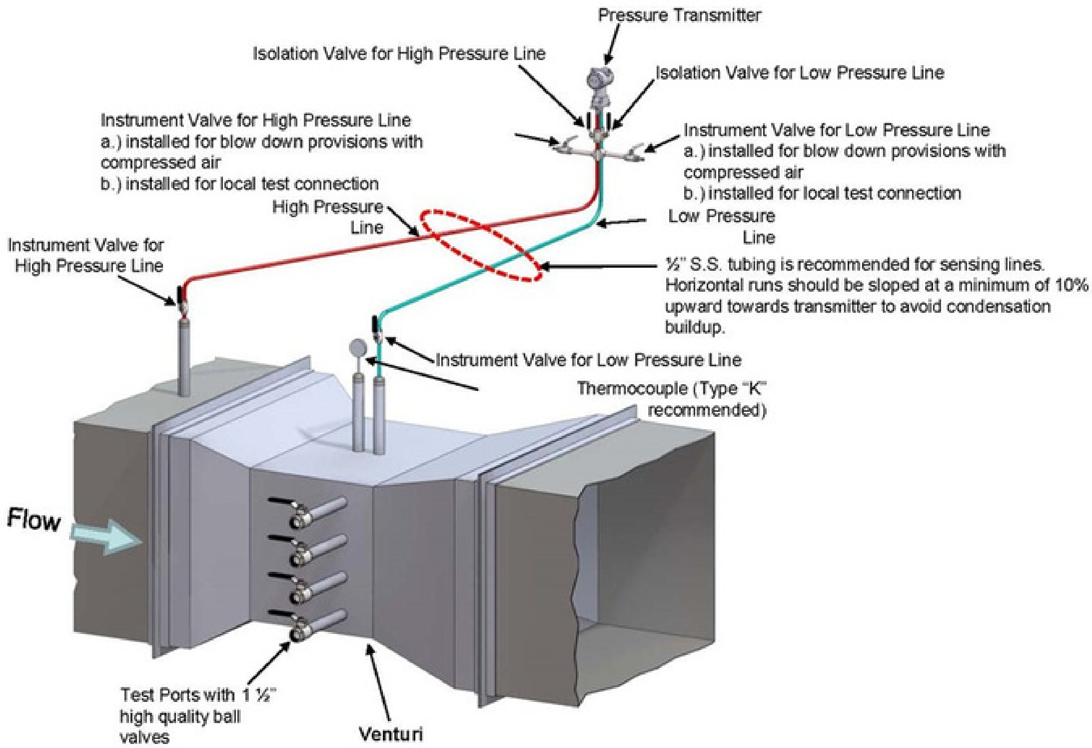
Regardless of the device, the system conditions will impact the calibration. So all devices should be field-calibrated. When testing multiple identical ducts, it is rare that they all have the same gain or K-factor following calibration, to reach the goal of +/-3% measurement accuracy. It is also important to test at normal operating conditions. Airflow density changes a good deal from cold to normal operating mill inlet temperatures. This density change impacts the accuracy of the flow measurement device, regardless if it is temperature-compensated.

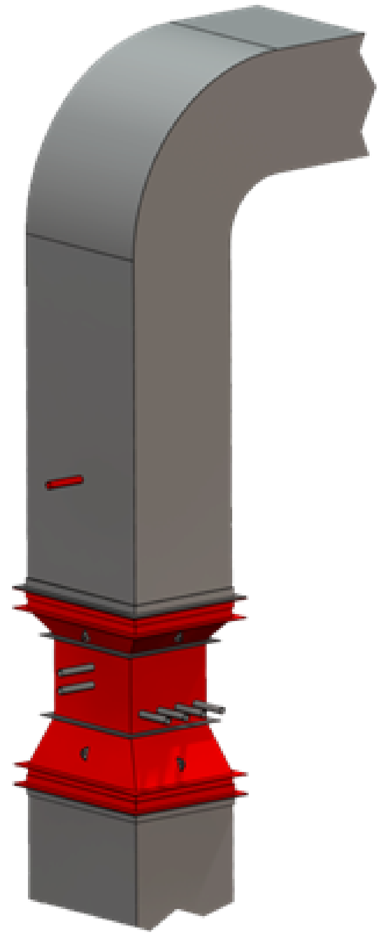
Once testing has been completed at a minimum of three load points across the operating range, the measured versus indicated flow can be reviewed to determine airflow measurement accuracy. Often plugs due to ash or leaks in sensing lines can impact measurement accuracy.

So leak checks and blowing back of the lines should be completed before testing. If the device seems to shift in accuracy across the flow range further review is needed to determine the root cause.

Storm's Preferred Airflow Measurement Device

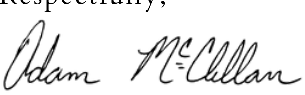
After testing many different devices over large periods of time, Storm has found that venturis have provided the most accurate, lowest maintenance, and least prone to shifting/error flow measurement devices available. Storm airflow measurement venturis are custom designed for each application and have low non-recoverable pressure drop. The test ports and thermowell taps are located in the venturi throat for the best laminar flow location and best mixing. Storm venturis utilize large skin taps for low and high-pressure measurements which are much less prone to plugging and are out of the flow stream, therefore erosion and wear do not impact indication over time.





If Storm can assist with reviewing your primary air measurement and control system, please do not hesitate to contact us.

Respectfully,



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Disclaimer: These suggestions are offered in the spirit of sharing our favorable experiences over many years. Storm Technologies, Inc. does not accept responsibility for the actions of others who may attempt to apply our suggestions without Storm Technologies' involvement.