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Clean Air Balancing of Fuel Lines

Balancing system resistance of fuel lines on ***clean air*** is the first phase of a comprehensive fuel and air balancing program. It is important to remember that clean air balancing is an important factor in optimizing pulverizer fuel and air balance, however, it is only one of many critical parameters which must be addressed. Optimum fuel balance is achieved through a combined effort aimed at improving pulverizer grinding efficiency (improved fineness), riffle distributor condition, and classifier timing and condition.

Clean air balancing is performed to:

- Establish similar system resistance for each coal line on a balanced air flow basis.
- Provide a correlation between fuel line “dirty air” and clean air velocities.
- Clean air balancing is an integral part of fuel line air to fuel ratio balancing which incorporates air, as well as fuel balancing.
- To ensure the minimum fuel line velocity is maintained after optimization of primary air flow to improve flame stability at lower loads and reduce fuel line stoppages.

The clean air velocity traverse is very similar to a dirty air traverse. The difference between these two tests is the absence of coal flow during a “clean air” test. This permits the use of an industry accepted standard 90° Pitot instead of a dirty air probe.

A clean air test should consist of two crews working simultaneously on the same pulverizer, starting at opposite sides or corners of the boiler and each crew performing a complete clean air test. This will facilitate collection of two independent sets of data.

Collected test data should be reduced immediately following completion of the test. Reduction of clean air data will consist of calculation of velocity, mass flow and deviation from the mean velocity for each individual fuel line. The reduced data from each separate team will be compared. Percent deviation between the results of the two separate sets of data should be no more than ±1%. If ±1% repeatability is not obtained, the test is considered invalid and should be repeated. This is required to ensure repeatability, accuracy and validity of the test conditions. If repeatability is not achieved, one or more of the following factors may be the cause:

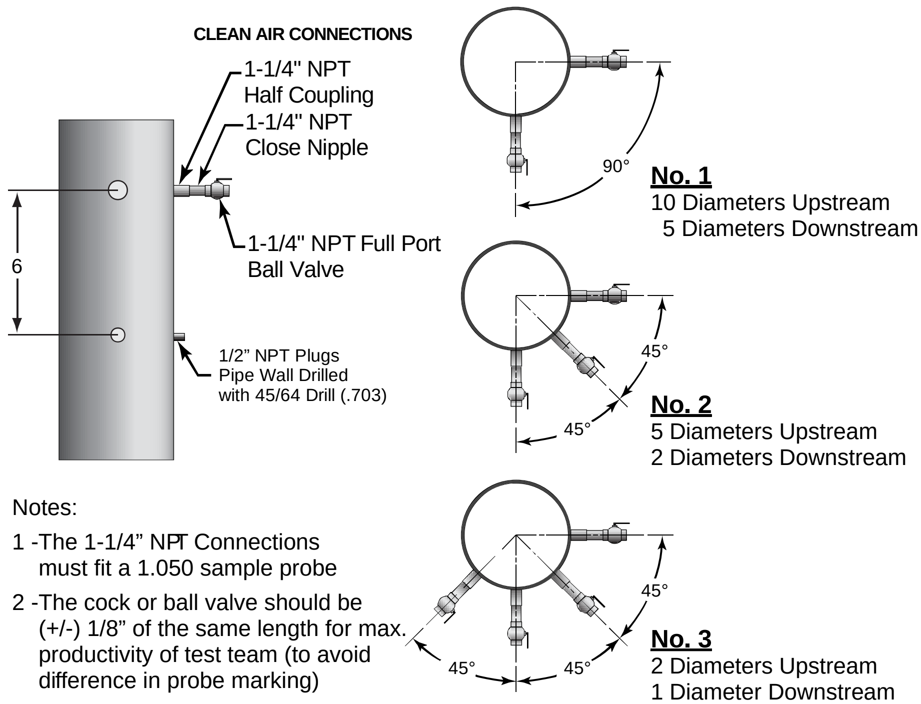
- Human error.
- Leaking and/or plugged Pitot tube, sensing lines, tubing or manometer.
- Fluctuations in pulverizer air flow or temperature.

Performing a Clean Air Test

1. Install coal line test taps to facilitate insertion of Pitot tubes. Ideally, coal line test taps should be located between five and ten diameters downstream or upstream of the nearest elbow. Two test ports 90° apart per pipe are required. Clean air test ports are installed by drilling and tapping ½" N.P.T. holes through the pipe wall and inserting a threaded pipe plug.

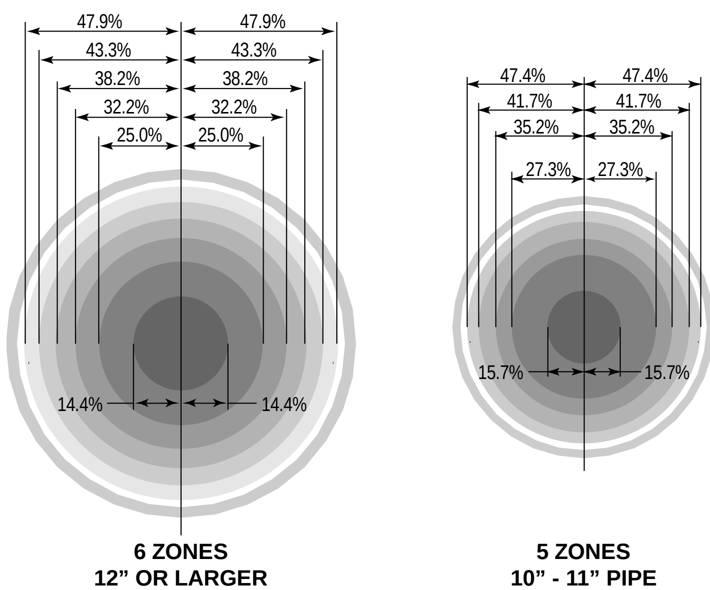
Figure 1 below illustrates the correct orientation for clean and dirty air test taps.

Figure 1 - Clean and Dirty Air Test Tap Locations



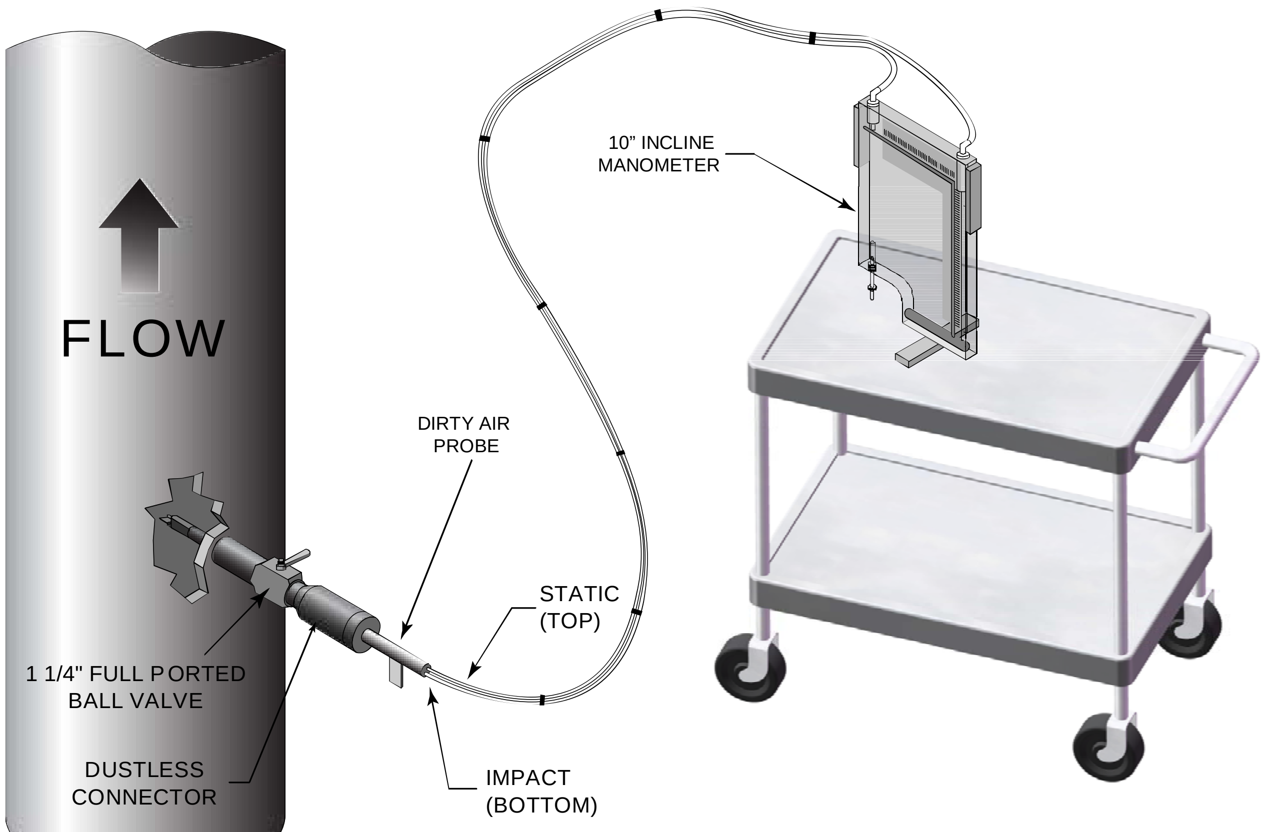
2. Traverse points on the Pitot tube are marked on an equal area grid in accordance to ASME Performance Test Code for traversing circular ducts. This ASME standard, for pipes with 10" or larger diameters, is illustrated by Figure 2.

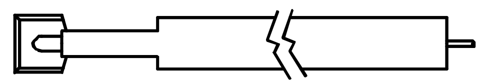
Figure 2 - Equal Area Traverse Points



EQUAL AREA TRAVERSE GRID FOR CIRCULAR DUCTS AND PIPE
DIMENSIONS ARE "PERCENT OF PIPE DIAMETERS"

3. Two equal sections of tubing are cut to desired length. The tubing is then taped or bound together and one tube is marked on both ends to identify it as the “high–pressure” or “total” line. The remaining tube, which is unmarked, is identified as the “low–pressure” or “static” line.
4. A 10" vertically inclined manometer is set up on a level and stable location. tubing is attached to the correct taps on the Pitot tube and the manometer. The figure below illustrates a Pitot tube properly connected to an incline manometer.





DETAIL OF DIRTY AIR PROBE
BOTTOM VIEW

5. The following data should be recorded for each test:

- Coal pipe designation
- Individual velocity heads for each traverse point (typically (24) points - (12) per port)
- Temperature and Static pressure for each pipe

6. Prior to inserting the Pitot tube, ensure the incline manometer is level and “zeroed”.
7. Insert the Pitot tube to the first mark with the pointer directed in the flow, and observe. Allow the incline manometer indication to stabilize, then record and move to the next point. Repeat this process for all (12) traverse points on both ports. A standard data sheet is provided on the following page for recording the velocity head measurements.
8. After traversing both ports, a static pressure is measured by inserting a ¼" Ø stainless steel tube into the fuel line. Static pressure will be measured using a “U-tube” manometer connected to the stainless tube by a single piece of tubing. Record Static Pressure on data sheet.
9. Following static pressure, temperature will be measured by inserting a thermocouple into the fuel line. Record temperatures on data sheet.

An example data sheet for recording clean air traverse data is illustrated below.

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Coal Pipe I.D. (inches) : ____________

Coal Pipe Area (Ft²) : ____________

Test Personnel: ________________________

Barometric Pressure (" Hg) :

Pulverizer : ____________

Date: ____________

Test No. : ____________

Burner No. :	PIPE 1	
Point	Port 1	Port 2
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
K Factor		
Sqrt Vh		"w.c.
Temperature		°F
Static		"w.c.
Density		Lbs./Ft³
Velocity		Fpm
Airflow		Lbs./Hr.

Burner No. :	PIPE 2	
Point	Port 1	Port 2
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
K Factor		
Sqrt Vh		"w.c.
Temperature		°F
Static		"w.c.
Density		Lbs./Ft³
Velocity		Fpm
Airflow		Lbs./Hr.

Burner No. :	PIPE 3	
Point	Port 1	Port 2
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
K Factor		
Sqrt Vh		"w.c.
Temperature		°F
Static		"w.c.
Density		Lbs./Ft³
Velocity		Fpm
Airflow		Lbs./Hr.

Burner No. :	PIPE 4	
Point	Port 1	Port 2
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
K Factor		
Sqrt Vh		"w.c.
Temperature		°F
Static		"w.c.
Density		Lbs./Ft³
Velocity		Fpm
Airflow		Lbs./Hr.

Total Dirty Airflow		Lbs./Hr.
Average Pipe Temperature		°F
Average Pipe Velocity		Fpm

Clean Air Balance (% Velocity Deviation)			
PIPE 1	PIPE 2	PIPE 3	PIPE 4

10. Calculate velocity in each fuel line and ascertain balance. Balance should be expressed as deviation from the mean velocity of all pipes. The following equations are utilized to reduce clean air traverse data:

$$\text{Density } (\delta) = \frac{460 + 70^{\circ}\text{F}}{460 + {}^{\circ}\text{F}} \times \frac{\text{Bp} + \dfrac{\text{Sp}}{13.6}}{29.92''\text{ Hg}} \times 0.075 \text{ Lbs./ft}^3$$

$$\text{Velocity} = 1096 \frac{\text{Avg}\sqrt{\text{vh}}}{\sqrt{\delta}} \qquad \text{Avg}\sqrt{\text{vh}} = \frac{\sum_{vh=1}^{n} \sqrt{\text{vh}}}{\text{n}}$$

$$\%\text{ Deviation} = \frac{\text{Velocity - Average Velocity}}{\text{Average Velocity}} \times 100$$

$$\text{Bp} = \text{Barometric Pressure ("Hg)}$$

$$\text{Sp} = \text{Static Pressure (" w.c.)}$$

11. After determination of fuel line clean air balance, the installation of orifices is evaluated. One of the primary reasons for the dual-team approach is to facilitate a high confidence level in the data. Highly accurate, repeatable data is of utmost importance to make informed decisions on changing orifices. Desired clean air balance of ±2% requires data between the two separate crews to be within ±1% before making any orifice changes.

12. Fuel lines are orificed by an iterative process utilizing trial orifices fabricated from 10 gauge Carbon Steel. After optimum orifice configuration is determined, permanent 304 Stainless steel orifices are installed.