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Calculation of Pulverizer Minimum Primary Airflow and Proper Air to Fuel Relationship

To achieve the best possible combustion and NO_x, primary air should typically be 15% to 20% of total airflow. Primary air is intended to provide adequate heat to dry the fuel and provide stable pneumatic transport to the burners; it should not be a significant portion of the airflow required for combustion. High primary airflows are quite often the cause of many of the problems we encounter such as:

- Poor fineness
- Non-optimum dirty air and fuel balance
- Furnace slagging
- High NO_x generation
- High flyash L.O.I
- Flame impingement on heat transfer surfaces

Coal line velocities cannot be allowed to fall below 3,000 feet per minute (Fpm) otherwise coal will begin to "lay out" in horizontal runs of piping. Coal lay out on burner lines can result in "slugs of fuel being delivered to the burner and burner line stoppages or even fires. Ideally, pulverizer minimum airflow would be calculated to maintain 3,250 Fpm to 3,300 Fpm to allow some forgiveness to imbalances between burner lines.

To calculate the minimum primary airflow through a pulverizer that will maintain 3,000 feet per minute in the burner lines we will use (4) 13.25" I.D. burner lines as an example.

Volumetric Flow (Q)= V (velocity) x A (area). (A) is the cross sectional area of the pipe (πr^2)

$A=\left(\frac{13.25}{2}\right)^2 \pi = 137.886465 \text{ in}^2$ To convert inches^2 to feet^2 divide by 144 in^2 per square foot.

$$\frac{137.886465}{144} = 0.09575449 \text{ ft}^2$$

If there are (4) burner lines, then total flow area is 0.09575449 ft^2 x 4 = 3.8302 ft^2

Assuming 3,000 Fpm minimum air velocity and the area of the (4) pipes, apply Q=VxA and minimum volumetric flow is Q=3,000 Fpm x 3.80302 ft^2 = **11,490.53876 ft^3 per minute.**

Assuming a pulverizer outlet temperature of ~165°, 1" w.c. burner line static pressure and a barometric pressure of 29.92" H.g. air density is calculated as follows:

$$\rho = \left(\frac{460°+70°}{460°+165°}\right) \bullet \left(\frac{29.92\text{" H.g.} + \frac{1\text{" w.c.}}{13.6\text{"} \frac{\text{w.c}}{\text{H.g.}}}}{29.92\text{" H.g.}}\right) \bullet 0.075 \text{ Lbs/ft}^3$$

Air density = 0.063713786 Lbs/ft^3

To calculate weighted or mass flow from volumetric flow, multiply volumetric flow by density and 60 to convert minutes to hour.

$\dot{M}$ = 11,490.539 Ft^3/min x 60 min/hour x 0.063714 Lbs/Ft^3 = **43,926.3 Lbs/Hr** required to maintain a minimum burner line velocity of 3,000 Fpm in all (4) burner lines.

After determining proper minimum primary airflow, an adequate air to fuel relationship must be established as well. Low NO_x burner designs work best with a 1.8:1 air/fuel ratio and a 1:1 velocity ratio between the secondary air and the primary air. The higher end of burner line velocities is ~5,000 Fpm or less. A typical primary air ramp for a B&W front wall fired unit is shown below.

Pulv. Outlet Temp.:	170	°F
Burner Line Static:	4	"w.c.
B. Line Air Density:	0.0637	Lbs./ft³
Burner Line ID:	13 1/4	inches
B. Line CS Area:	0.9575	ft²
No. Burner Lines:	4	–

Desired Minimum Velocity:	3,000	Fpm
Calculated Minimum Airflow:	43,928	Lbs./Hour
Barometric Pressure:	29.92	"Hg
Ramp break point (coal flow):	24,404	Lbs./Hour
Ramp break point (coal flow):	12.20	Tons/Hour

Coal Flow (Lbs./Hr.)	Coal Flow (Tons/Hr.)	Recommended Primary Airflow Ramp (Lbs./Hr.)	Air Fuel Ratio for Rec. Airflow Ramp	Burner Line Velocity (Fpm)
0	0.0	43,928	-	3,001
2,000	1.0	43,928	21.96	3,001
4,000	2.0	43,928	10.98	3,001
6,000	3.0	43,928	7.32	3,001
8,000	4.0	43,928	5.49	3,001
10,000	5.0	43,928	4.39	3,001
12,000	6.0	43,928	3.66	3,001
14,000	7.0	43,928	3.14	3,001
16,000	8.0	43,928	2.75	3,001
18,000	9.0	43,928	2.44	3,001
20,000	10.0	43,928	2.20	3,001
22,000	11.0	43,928	2.00	3,001
23,800	11.9	43,928	1.85	3,001
24,000	12.0	43,928	1.83	3,001
24,200	12.1	43,928	1.82	3,001
24,404	12.2	43,928	1.80	3,001
25,000	12.5	45,000	1.80	3,074
25,800	12.9	46,440	1.80	3,173
26,000	13.0	46,800	1.80	3,197
26,200	13.1	47,160	1.80	3,222
26,400	13.2	47,520	1.80	3,246
26,402	13.2	47,524	1.80	3,247
28,000	14.0	50,400	1.80	3,443
30,000	15.0	54,000	1.80	3,689

Calculating proper air to fuel relationship begins with calculating proper minimum airflow. After this has been determined, it is relatively simple to establish the optimum primary air ramp. Air to fuel ratio is determined by dividing the total dirty airflow (Lbs/hr) by the total fuel flow (Lbs/hr). Minimum airflow (43,928 Lbs/hr in the example shown) is maintained while coal flow is increased until a 1.8:1 air/fuel ratio is achieved. When this "break point" is reached, primary airflow is "ramped" up along with fuel flow in order to maintain the desired air/fuel ratio. Some adverse effects of improper air/fuel ratio are as follows:

- Higher than desired NO_x generation
- Higher than desired flyash L.O.I.
- Increased propensity for furnace slagging
- Higher than desired furnace exit gas temps
- Increased attemperator spray flows
- Increased pulverizer and coal pipe erosion