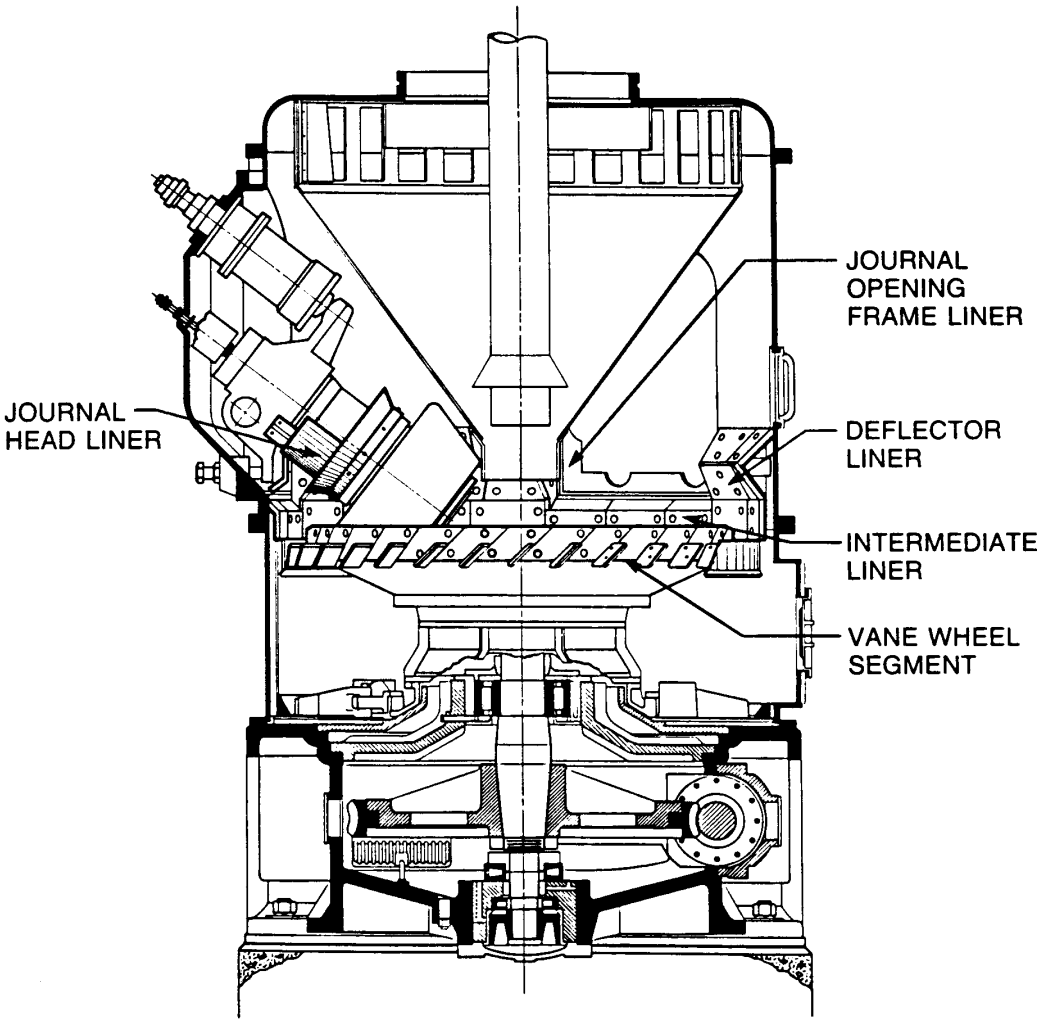
2367 LAKESIDE DRIVE, SUITE A-1 BIRMINGHAM, AL 35244
PHONE (205) 453-0236 FACSIMILE (205) 453-0239
www.innovativecombustion.com

Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

The following is provided as a guideline to inspect a Raymond Shallow Bowl Mill. These guidelines concentrate on performance items and should be conducted in addition to guidelines provided by the original equipment manufacturer.



Inspection

When inspecting the pulverizers, the following items have been found to be critical in achieving optimum pulverizer performance:

- Roll to Bowl Clearances

  Clearance between the journal rolls and the bowl must be a parallel ¼" for the entire length of the roll. If bull segments are the new tapered toe design, we recommend replacing these with the older non-tapered design. The tapered toe design will facilitate longer replacement intervals but will be a significant fineness penalty.

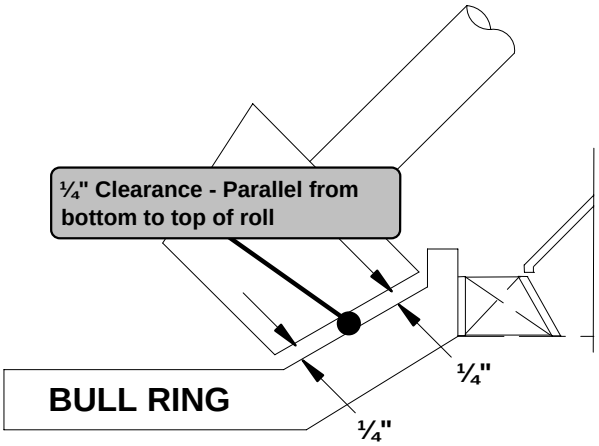
Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

- Roll to Bowl Clearances –*Continued*–

  CE's theory reinforcing the tapered toe design is that past experiences has shown that the center of the rolls and the ring segments wear at an accelerated rate as compared to the top and bottom of the roll and bowl segments. With the tapered toe design coal is forced to the bottom and top of the roll with the intent of inducing uniform wear allowing longer in-service time. Tapered toe bull ring segments usually have an angle that is 8° to 10° steeper in the first 40% of segment length than the angle of the remaining length of the segment. This makes it almost impossible to maintain a parallel ¼" clearance between the roll and bowl. A ¼" clearance will be attainable at the center of the roll with clearances of ½" or greater at the top and bottom of the rolls. If bowl and roll surfaces are not parallel and at desired clearance, the result will be a significant fineness penalty.

  If grinding elements are renewed to design tolerances through hard surfacing rather than replacement, deposited weld metal should be >28% Chrome and >4.5% Carbon composition. To maintain parallel surfaces and desired Roll–Bowl clearances, the deposited metal should be carefully placed with extreme attention to meeting design tolerances. Bowl and Roll wear jigs can be utilized to verify tolerances and geometry of hard surfacing.

  Shallow bowl mills will require two adjustments to achieve desired Roll–Bowl clearances. The eccentric *(trunion)* setting and jack bolt adjustments will be required. Both adjustments will change the axis angle of the roll. Achieving desired ¼" clearance between roll and bowl should first be attempted by lowering or raising the roll with the jack bolts. If this is not successful, adjust the eccentric in one position *(number)* intervals. On a refurbished pulverizer eccentric adjustment should be on position "1". After desired clearance is achieved ensure that jack bolt jam nuts are tightened to prevent changes in setting.



Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

- Pulverizer Throat Free Jet Area

During all mill inspections, measurements should be documented to calculate the free jet area of the pulverizer throat. To calculate this velocity, the outside and inside diameters of mill throat or vane wheel are recorded. The difference in cross sectional area of the outside and inside diameters will yield the free jet area. An example calculation is provided below.

Given

Inside Radius (Diameter ÷ 2) of Throat Annulus = 48.75"
Outside Radius of Throat Annulus = 52.625"
Primary Air Flow (Wpa) = 140,000 lbs./hr.
Density (δ) of Air @ Mill Inlet (425°F and 17"w.c.) = 0.04679 lbs./ft³

Area of Annulus Inside Radius = $\{(48.75")^2 \times \pi\} \div 144$ in²/ft² = 51.85 ft²
Area of Annulus Outside Radius = $\{(52.625")^2 \times \pi\} \div 144$ in²/ft² = 60.42 ft²

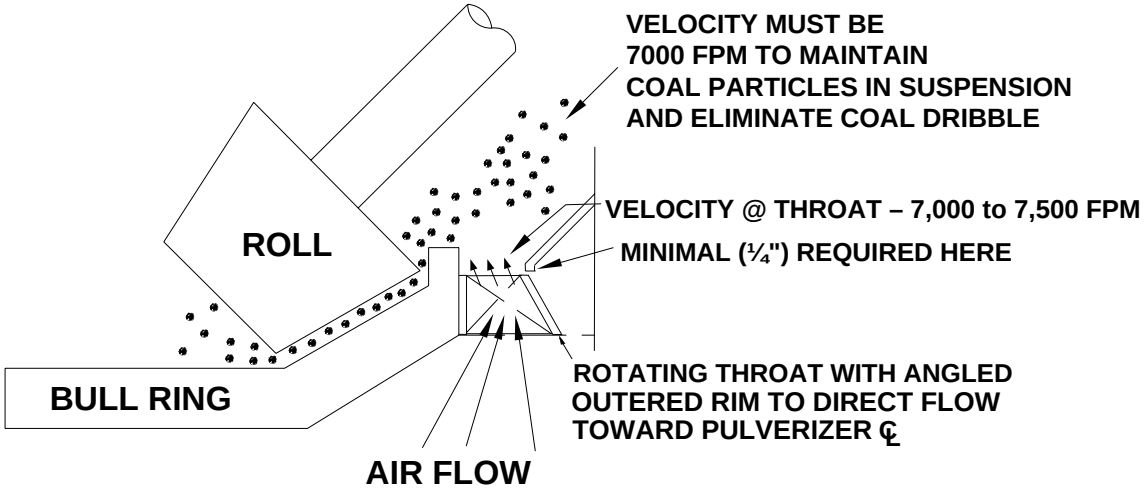
Free Jet Area of Annulus = (60.42 ft² - 51.85 ft²) = 8.57 ft²

$$\text{Current Mill Throat Velocity} = \frac{\text{Wpa}}{(\delta) \times 60 \text{ Min/hr.} \times \text{Free Jet Area (ft}^3\text{)}}$$

$$= \frac{140{,}000 \text{ lbs./hr}}{0.04679 \text{ lbs./ft}^3 \times 60 \text{ min/hr.} \times 8.57 \text{ ft}^2}$$

$$= 5{,}818.92 \text{ Fpm}$$

In this case the pulverizer throat opening is too large to yield desired throat velocity, calculations for determining optimum throat opening are provided on the following page.



Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

- Pulverizer Throat Free Jet Area *–Continued–*

As previously mentioned, throat velocity must be in the range of 7,000 to 7,500 Fpm to prevent excessive coal spillage. The below calculation illustrates the equations required to determine throat opening to yield 7,500 Fpm.

Given

Inside Radius (Diameter ÷ 2) of Throat Annulus	=	48.75"
Outside Radius of Throat Annulus	=	52.625"
Primary Air Flow (Wpa)	=	140,000 lbs./hr.
Density (δ) of Air @ Mill Inlet (425°F and 17"w.c.)	=	0.04679 lbs./ft³
Current Free Jet Area of Annulus	=	8.57 ft²

$$\text{7500 Fpm Mill Throat Velocity} = \frac{\text{Wpa}}{(\delta) \times 60 \text{ Min/hr.} \times \text{Free Jet Area (ft}^3\text{)}}$$

$$\text{7500 Fpm} = \frac{\text{140,000 lbs./hr.}}{0.04679 \times 60 \times \text{Free Jet Area}}$$

$$\text{Free Jet Pulverizer Throat Area } \textit{(to yield 7,500 Fpm Velocity)} = \frac{\text{140,000 lbs./hr.}}{0.04679 \text{ lbs./ft}^3 \times 60 \text{ min/hr} \times 7500 \text{ Fpm}}$$

$$= 5.12930 \text{ ft}^2$$

$$\text{Free Jet Area of Annulus} = (\pi r^2_{\text{ out}} - 51.85 \text{ ft}^2) = 5.12930 \text{ ft}^2$$

$$\pi r^2_{\text{ out}} = 56.979 \text{ ft}^2$$

$$r^2 = 56.979 \text{ ft}^2 \div \pi$$

$$r = 4.25976 \text{ ft}$$

$$r = 51.105 \text{ in (1½" reduction in outside radius)}$$

Installation of a rotating throat is the preferred method to optimize throat velocity, however, inserting steel throat reduction blocks will eliminate coal spillage caused by insufficient throat velocity. When inspecting mill throats or vane wheels, inspect the seal between the outside diameter of the throat or vane wheel and the outer mill housing. A tight seal in required to prevent air from bypassing the throat. Absence of this seal will reduce air flow through the throat annulus which will subsequently reduce free jet area velocity. The 7,000 to 7,500 velocity has been derived from extensive testing. This velocity will prevent coal spillage into the pyrite hopper while allowing rocks and tramp iron to be discharged from the mill through the pyrite hopper.

Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

- General Condition of the Pulverizer

  While inspecting the pulverizer, visually locate any holes, erosion, wear or missing ceramics. Missing ceramics will focus erosion and will eventually become a hole as time passes.

  Holes or cracks in the mill housing will allow tramp air to enter the mill, reducing mill outlet temperature or capability to make mill outlet temperature.

  Gaps in mating surfaces, cracks or holes in the inner classifier cone will allow coarse coal particles to bypass the classifier and enter the fuel lines.

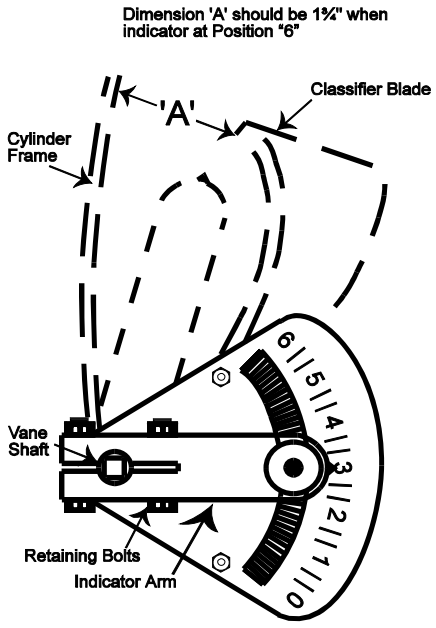
  Gaps in mating surfaces of the mill throat will allow air to bypass the critical areas of the throat and may worsen or exacerbate coal spillage.

  Excessive or non-uniform wear of grinding elements will reduce the effectiveness or capacity of the pulverizer. It is important to remember that mill capacity is not measured in the raw quantity of coal a pulverizer can discharge. True mill capacity is the amount of coal which can be discharged at satisfactory fineness *(>75% passing 200 Mesh and <0.3% remaining on 50 Mesh).*

- Classifier Blade Synchronization and Condition

  Optimum timing and satisfactory condition of the classifier blades is mandatory for attainment of desired coal fineness levels. Classifier blades should be synchronized with the opening between all blades within a ±¼" tolerance. At position "6" *(closed)* on the external indicator, classifier blades should be set at an opening of 1¾". This is easily accomplished by inserting a 2" × 4" between the classifier blades and classifier cylinder frame, rotate blade until it is in contact with 2" × 4" and set external indicator to position "6". The end of the classifier blade shaft that penetrates beyond the indicator plate should be "tack" welded to ensure the blades stay in time.

  When setting classifier blades, measure and document the width and vertical height of classifier blades.



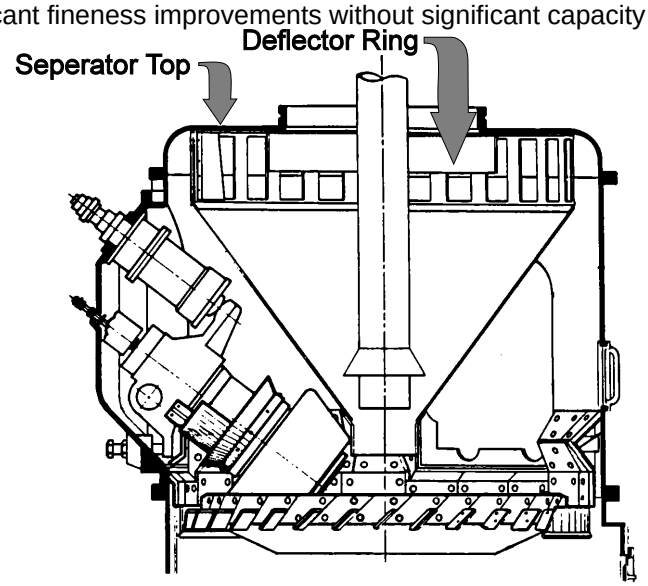
Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

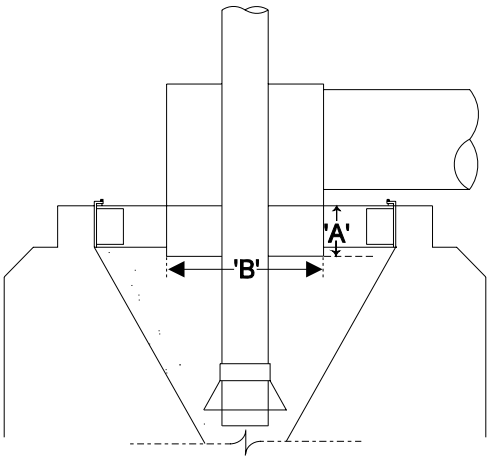
- Deflector Ring

  Inspect the deflector ring for erosion of holes. Ensure that the deflector ring is tightly sealed with the separator top. A gap between the mating surfaces of the deflector ring and the separator top will reduce the classification of coal and will result in accelerated erosion.

  The vertical length of the deflector ring should be measured. *(distance between separator top & bottom of deflector ring).* Any reduction in length of the deflector ring will result in decreased coal fineness. The circumference and material thickness of the deflector ring should also be measured during inspection.

  Extension of the deflector ring is a common modification that will improve coal fineness and fuel balance. If the deflector ring does not extend below the bottom of the classifier blades. Lengthening of the deflector ring to extend 1" below the bottom of the classifier blades has resulted in significant fineness improvements without significant capacity reduction.



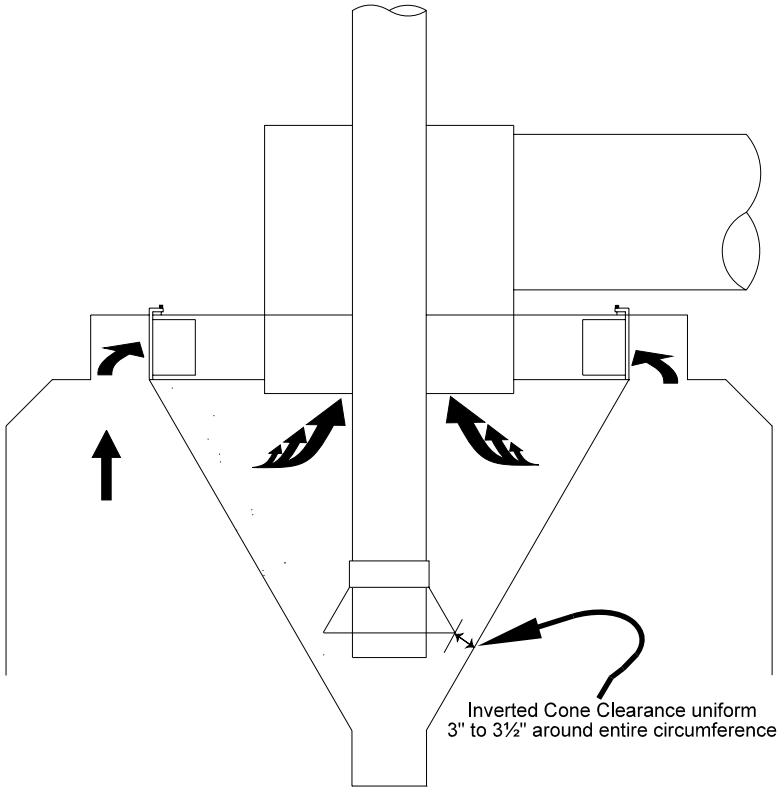


Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

- Inverted Cone Clearance

  Inverted cone clearance is the perpendicular distance between the inverted cone and the classifier cone. Inverted cone clearance must be 3" to 3½". In some special cases, such as firing coal with very low Hardgrove Grindability Indexes it is necessary to increase the inverted cone clearance to prevent surging of the pulverizer. This clearance must be uniform around the entire circumference of the cone. Maintaining proper inverted cone clearance is required to achieve optimum coal fineness levels.

  If inverted cone clearance is excessive, coal will bypass the classifier via the reject chute and leave pulverizer as coarse product. If this clearance is too tight *(<2½")* coal will bridge between the inverted cone and classifier cone. This bridging will overload the classifier, this will result is coarse rejected coal being swept into the outlet pipe(s). Bridging will also result in "surging" of the pulverizer as each bridge becomes large and releases. Pulverizer "surging" is a cyclic process which the pulverizer continually loads up and unloads. This process usually results in continual boiler Oxygen and pressure swings. In some cases, pulverizer "surging" can be severe enough to cause mill run-back or trip due to high mill motor current when the classifier cone is evacuated.



Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

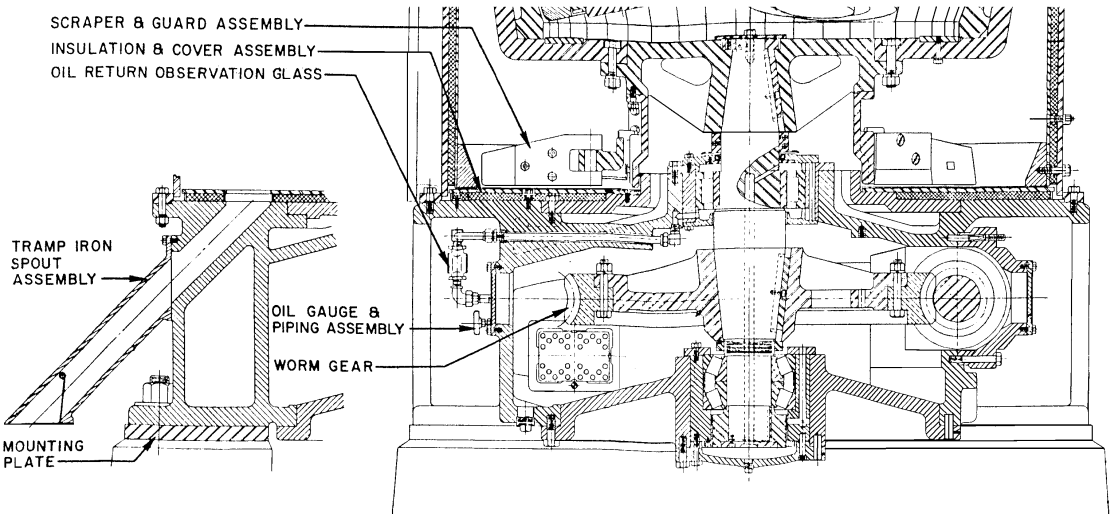
- Pyrite Plow Clearance and Condition

  Well maintained condition and optimum clearance of pyrite plows is mandatory for optimum operation of the pulverizer. Bowl mills are designed with two pyrite plows at 180° from each other. The plows are present to force the pyrites from the lower housing to the pyrite discharge chute or hopper. Damaged, missing pyrite plows or excessive pyrite plow clearance will allow coal or pyrites to accumulate in the lower housing. These accumulations can result in the following:

  - Mill Fire or explosion. The lower housing *(pyrite section)* of the pulverizer is heated to 300°F to 500°F *(same temperature as primary air entering pulverizer)*. This temperature is sufficient to facilitate spontaneous combustion of any coal accumulations.

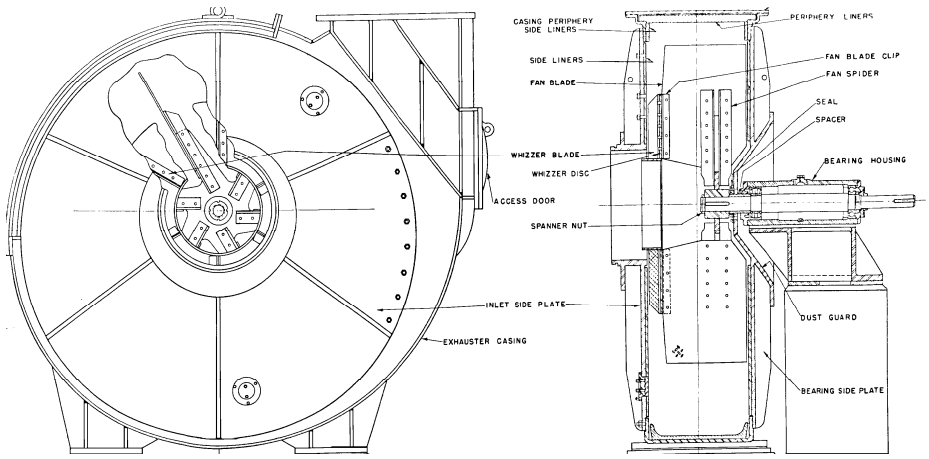
  - Excessive accumulation in the pyrite section will restrict primary air flow through the pulverizer. This restriction will reduce the velocity across the mill throat, allow more accumulation of coal and exacerbate the problem.

  Clearance between the bottom of the pyrite plow *(scraper)* and the lower housing table should be 1/8". The discharge chute and flapper door should be closely inspected for holes. Holes in the chute or flapper door allow mill suction to pull pyrites back in to the mill. Holes will also allow air in-leakage, temper hot primary air and will reduce attainable mill outlet temperature. Flapper door should be checked to insure proper function. Flapper door is intended to periodically release rejects when enough pyrites fall on the door to overcome counterweight of the door.



Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

- Exhauster



The following areas should be inspected to ensure optimum exhauster performance:

♦ Fan Blades

Inspect the condition of each fan blade and the bolts securing blades to the exhauster. Fan blade lengths and diameter should be measured. Ensure that all fan blades are of similar lengths *(±1/8").* Clearance between the fan blades and the back plate should be 9/16" ±3/16" *(3/8" to 3/4").*

♦ Whizzer Blades

Inspect the condition of and clearance of whizzer blades. Worn blades must be pad welded or replaced.

♦ Fan Spider

Inspect the fan spider for erosion. Any erosion must be repaired to prevent catastrophic failure of exhauster. In most cases, moderate erosion may be repaired by pad welding. The manufacturers welding procedure must be strictly adhered to. Pad welds should be applied conservatively and symmetrical, exhauster must be balanced after repair. Dye-Penetrant or "Mag-Particle" checks for cracking of the spider is recommended.

♦ Ceramics and Periphery Liners

Inspect the ceramic and internal liners for erosion and integrity. Any worn liners or missing ceramics must be replaced. Absence of ceramic tiles or excessive localized erosion will result in further focused erosion and should be repaired upon discovery.

♦ Fan "Cut-Off" Sheet

The fan "Cut-Off" sheet, commonly called the "Nosepiece" should be closely inspected for erosion. The horizontal length of the cut-off sheet must be parallel with the fan blade tips. Measure the perpendicular distance between the cut-off and the fan blade tip to ensure this dimension is within design tolerances. If severe erosion of the cut-off sheet is observed, the surface of cut-off should be pad-welds or armored with a half-section of a pipe.

Raymond Bowl Mill – Inspection Guidelines (Shallow Bowl)

- Exhauster –*continued*–

  - ♦ Inlet and Outlet Piping

    Inlet and outlet piping should be inspected for areas of excessive erosion or holes. Inspect and stroke the inlet damper. Internal position and alignment with external indication of the exhauster inlet damper should be verified and corrected as required.

- Spring Compression

  Optimum spring compression is mandatory for satisfactory pulverizer fineness and capacity. During operation, spring compression can be checked by observing spring deflection. Spring deflection should be ½" at full pulverizer loading and should be uniform between journals.

  During inspection, ensure spring button is touching the journal assembly pressure plate. If spring button is not touching the journal, the effectiveness of setting Roll–Bowl clearances to ¼" will be reduced.

- Classifier Setting After Pulverizer Overhaul

  All Classifier blades for each pulverizer will be set to position “3” after a pulverizer overhaul. After start-up, coal fineness testing will be conducted at full pulverizer load to determine coal fineness. After coal fineness results are obtained, classifiers will be adjusted to achieve >75% passing 200 Mesh and less than 0.3% remaining on 50 Mesh.