EPRI

Pulverizer Maintenance Guide, Volume 1

Raymond Bowl Mills

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Pulverizer Maintenance Guide, Volume 1

Raymond Bowl Mills

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Final Report, August 2004

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REPORT SUMMARY

This guide provides fossil plant personnel with current maintenance information on the Alstom Raymond Bowl mills and will assist a plant in improving the maintenance of the pulverizer mills.

Background

Three groups in EPRI sponsored the *Pulverizer Maintenance Guide*. The Pulverizer Interest Group was formed in 1996 to support plant efforts in optimizing pulverizer performance. The Fossil Maintenance Applications Center (FMAC) concentrates on equipment maintenance issues in the plant. The Maintenance Management and Technology (MM&T) group focuses on improving the maintenance effectiveness of fossil plant equipment.

Objectives

- To identify preventive, predictive, and corrective maintenance practices for the pulverizer mills
- To assist plant maintenance personnel in the identification and resolution of pulverizer equipment problems
- To provide a comprehensive maintenance guide for the Raymond Bowl mills

Approach

A Technical Advisory Group (TAG) was formed, consisting of pulverizer equipment owners from EPRI member utilities of the three organizations described above. Input was solicited concerning the current maintenance issues for the pulverizers. A decision was made to produce the first volume on the Raymond Bowl mill designs. The second volume will cover the Babcock and Wilcox Roll Wheel Pulverizer. The third volume will cover a ball mill. An extensive search of industry and EPRI information was conducted to provide relevant information for this guide.

Results

This guide includes general information on the pulverizer mill function in the power production process, the operation and safety of the mill, performance characteristics, and the calibration and setup of the mills. The failure modes, troubleshooting, predictive, preventive, and component maintenance sections are the main sources of information in the guide. Information on the exhauster and feeder are also included.

EPRI Perspective

The maintenance of the pulverizer mill affects the availability and reliability of the operating unit. The efficiency of the mill in providing the desired coal and air mixture to the furnace has increased cost consequences with the addition of NO_x controls. The repairs and modifications to the mills ensure that the mills operate reliably.

Keywords

Pulverizer mill
Exhauster
Coal feeder
Maintenance
Reliability
Troubleshooting

ABSTRACT

The pulverizer mill is a critical component in the coal-fired power plant. As the age of the mill increases, the maintenance costs required for continued operation also increase. With the addition of NO_x controls, the efficiency of the unit is affected to a greater degree by the air quantity and fineness of the coal going to the furnace.

Monitoring critical dimensions and parameters on the mill ensures that the mill is functioning correctly. Performing routine preventive inspections and anticipating component replacements ensure that the maintenance activities are planned and not forced. In addition, modifications or upgrades to new designed bearings for the vertical shaft and journals ensure longer life for these components.

This guide covers all of the maintenance issues for the Raymond Bowl pulverizer mill designs. It is intended to improve the maintenance practices and reliability of the equipment.

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1 INTRODUCTION

This section describes the background, approach, organization, and key points of this guide.

1.1 Background

The EPRI Pulverizer Interest Group (PIG) was formed in 1996 to support plant efforts to optimize pulverizer performance. The group's mission statement that will guide all research and development activities states that the group will:

- Develop low-cost technologies and operational strategies for pulverizers that improve power plant performance, mitigate plant emissions, and reduce operation and maintenance costs
- Define the influence of pulverizer performance on combustion efficiency, boiler emissions, and downstream equipment
- Develop or improve tools and methods to assess the performance of pulverizers

The results of the annual EPRI Fossil Maintenance Applications Center (FMAC) survey indicated that pulverizers are high-maintenance items in the plants. This is because of the repair and replacement of the grinding rolls, grinding ring, and exhauster blades and liners. In addition, EPRI's Maintenance Management and Technology (MM&T) group has been asked by its members to improve the maintenance effectiveness of the mills. Therefore, these three areas in EPRI are producing a three-volume series of guides on pulverizer maintenance.

A Statement of Work was sent to the EPRI member coal-fired plants, and input was solicited for the guides. A survey was sent to the EPRI member plants to solicit mill information and participation on a Technical Advisory Group (TAG). From the survey results, a decision was made to have the first volume cover Alstom Raymond Bowl mills, the second volume to cover the Babcock & Wilcox Roll Wheel Pulverizer mills, and the third volume to cover the ball mills.

The TAG for the guide consists of seven EPRI employees, representatives of 15 U.S. plants, and 11 representatives from international plants. The TAG reviewed the guide drafts and provided comments. One web cast and one conference call were conducted to discuss the guide contents.

1.2 Approach

An extensive search of existing EPRI guides and industry literature was conducted during the development of this guide.

Because many sources of information were used in the compilation of this guide, it was decided to use a reference system for the appropriate sections. Reference numbers in brackets [#] are used at the beginning of sections and after the titles on tables and figures to denote where the majority of information in that section was obtained. The numbers and corresponding references are listed in the Reference section of the guide.

The following conversion factors in Table 1-1 should be used in this guide to convert from English to Standard International units:

Table 1-1
Conversion Factors

Parameter	English to Standard International
Length	1 in. = 0.0254 m 1 in. = 2.54 cm 1 in. = 25.4 mm 1 in. = 25,400 µm (micron)
	1 ft = 0.3048 m 1 ft = 30.48 cm 1 ft = 304.8 mm 1 ft = 304,800 µm (micron)
Pressure	1 psi = 6.89 kPa
Temperature	ºF = 1.8ºC + 32
Weight	1 oz = 28.35 g 1 lb. = 0.454 kg 1 metric ton = 1000 kg 1 U.S. ton = 2000 lbs = 0.907 metric ton
Volume	1 gal = 3.785 liters
Velocity	1 in./sec = 2.54 cm/sec 1 ft/sec = 0.3048 m/sec

1.3 Organization

This guide is organized into the following sections:

1. **Introduction:** Background, Approach, Organization, Key Points
2. **Glossary**
3. **System Application:** Coal Handling System, Coal Pulverizer System, Coal Characteristics, Environmental Regulations

4. **Technical Description:** Raymond Bowl Design Mills, Gearbox, Feeder, Exhauster, Air Systems, Lubrication System, Pyrite Rejection System

5. **Mill Operation and Safety:** Mill Operating Parameters, Startup and Shutdown, Mill Fires

6. **Performance Testing:** Fineness, Coal Grindability, Mill Capacity, Rejects

7. **Failure Modes Analysis:** Mill Failure Data, Failure Mechanisms, Failure Modes and Effects

8. **Troubleshooting**

9. **Predictive Maintenance:** Vibration Analysis, Oil Analysis, Current Developments

10. **Preventive Maintenance:** Inspection Criteria, Inspection Tasks, Preventive Maintenance Basis

11. **Component Maintenance:** General Philosophy, Mill Converter, Mill Separator, Mill Millside, Exhauster, Feeder Drive, Mill Motor

12. **References**

Appendices: Survey, Maintenance Examples, and Key Points Summary

1.4 Key Points

Key information is summarized in Key Points throughout this guide. Key Points are bold lettered boxes that highlight information covered in the text.

The primary intent of a Key Point is to emphasize information that will allow individuals to act for the benefit of their plant. EPRI personnel who reviewed and prepared this guide selected the information included in these Key Points.

The Key Points are organized in three categories: Human Performance, O&M Costs, and Technical. Each category has an identifying icon to draw attention to it when quickly reviewing the guide. The Key Points are shown in the following way:



Human Performance Key Point

Denotes information that requires personnel action or consideration in order to prevent personal injury, equipment damage, and/or improve the efficiency and effectiveness of the task



O&M Cost Key Point

Emphasizes information that will result in overall reduced costs and/or increase in revenue through additional or restored energy production



Technical Key Point

Targets information that will lead to improved equipment reliability

The Key Points Summary section (Appendix C) of this guide contains a listing of all Key Points in each category. The listing restates each Key Point and provides a reference to its location in the body of the report. By reviewing this listing, users of this guide can determine if they have taken advantage of key information that the writers of this guide believe would benefit their plants.

2
GLOSSARY

AGMA: This is an acronym for the American Gear Manufacturers Association.

Backlash: This is the amount of clearance between the worm threads and the gear tooth flank.

Base capacity: This is the amount of coal the mill will process using coal with a grindability index of 55 and a final product fineness of 70% passing through a 200 mesh screen.

Ball mills: They are low-speed machines that grind the coal with steel balls in a rotating horizontal cylinder. If the diameter of the cylinder is greater than the length of the cylinder, the mill is called a *ball mill*.

Bituminous coal: This is the largest group of coal available. The name bituminous is derived from the fact that when heated, the coal is reduced to a cohesive, binding, sticky mass. The volatile matter is complex and high in heating value. These coals burn easily in pulverized form. Bituminous coals can be further classified as high-volatile, medium-volatile, and low-volatile coals.

Bowl: The bowl contains a grinding ring and rotates with the main vertical shaft.

Classification zone: This zone is the region where the coarse and fine particles separate. The primary classification zone is the bowl perimeter, and the secondary classification zone is the classifier.

Classifier: The classifier is a cone section designed to maintain and control the desired fineness of the coal leaving the mill. The classifier assembly consists of the inner cone, the drum section, the deflector vanes, the deflector ring, and the deflector levers.

Classifier (dynamic): The dynamic classifier is a rotating wheel assembly for separation of coal particles. The classifier is belt driven by a variable speed electric motor.

Converter head: The converter head in the RB, RS, and RPS mills connects the pulverizer outlet to the exhauster inlet piping.

Exhauster fan: The RB, RS, and RPS pulverizers are coupled to an exhauster fan that provides the pressure required to transport the coal and air mixture to the boiler.

Feeder: A coal feeder supplies coal at a metered rate to the pulverizer. Feeders can be gravimetric or volumetric in design.

Fineness: Fineness is the percentage of coal that passes through a set of test sieves. Lower values indicate a more coarse coal. The standard fineness for the RB mills is 70% through a 200 mesh screen.

Fires: Mill fires consist of the active and ongoing combustion of coal and/or debris in the pulverizer.

Gravimetric feeder: The gravimetric feeder weighs material on a length of belt between two fixed rollers located in the feeder body.

Grindability: This is a measure of the ease with which a coal can be pulverized when compared with other coals. The higher grindability index indicates easier-to-grind coal.

Hardgrove grindability: A standard index has been developed based on use of the Hardgrove grindability machine and is called the *Hardgrove Grindability Index*. Grindability is determined by the amount of new material that will pass through a 200 mesh sieve.

Ignition support: Ignition support is the addition of supplemental oil or gas for start-up and low-load stabilization of the fire in the boiler.

Impact mill: This is a high-speed impact machine that uses beater wheels to crush the coal.

Inerting substance: An inerting substance is deficient in active properties. The substance lacks the usual or anticipated chemical or biological action. For fire fighting, the inerting substance can be carbon dioxide, water, or steam.

Inertant: This is a substance that is non-combustible, non-reactive and incapable of supporting burning with the contents of the system being protected.

Journal: The journal assembly is the spring-loaded roll that grinds the coal.

Journal spring: The journal spring assembly provides the force that keeps the journal roller over the grinding ring.

Journal hydraulic cylinder system: This applies hydraulic pressure to the rolls in lieu of springs for the 110-in. RP style mills.

Lignite: Lignite coal is brown with a laminar structure; the remnants of woody fibers may be apparent. They are high in volatile matter and moisture content, but they are low in heating value. Brown coal contains more than 45% moisture.

Loss on ignition (LOI): This is the amount of unburned carbon from the furnace combustion process.

Lubrication system: There are three lubrication systems for the pulverizer mill: journal, gearbox, and exhauster bearing.

Millside: This is the area in the pulverizer that distributes the hot air evenly around the bowl and provides the non-grindable material an exit from the mill.

Moisture: This is the amount of water retained by the coal expressed as a percentage of a coal sample's weight. Moisture reduces the mill capacity because it takes time for the hot air to dry the coal for grinding.

Ni-Hard: Ni-Hard is a nickel-hardened cast iron material. Ni-Hard 1 has a hardness in the range of 550–600 Brinell Hardness Number.

NO_x: NO_x is an abbreviation for all combinations of nitrogen and oxygen. Typically NO_x as a combustion product in a power plant is 90% NO and 10% NO_2.

PRB: Powder River Basin Type Coal

Plowing: Plowing is the effect of a grinding roll not turning. The most common cause of plowing is a failed or seized journal bearing.

Primary air: The primary air required for the drying and transport of the pulverized coal enters the mill below the bowl. In the RB and RS mill, the primary air entering the mill is a combination of air from the air preheater and ambient air. In the RPS and RP mills, the primary air is a combination of air from the boiler windboxes (secondary air supply) and cold air from a forced draft or primary air fan.

Puff: A mill puff is an explosion in the pulverizer caused by operational problems with the coal, air, and temperature.

Pyrite: Pyrite can mean any material that is rejected from the mill. Pyrites are actually a compound of iron and sulfur, FeS_2, found in coal.

Riffle: The riffle distributor is a device that splits a single stream of the coal and air mixture into two separate streams.

Scraper: A scraper is attached to the bowl hub skirt and pushes debris to the reject chute. A rigid guard acts as a shield for the scraper pivot arm.

Separator body: The separator body holds the components that direct the coarse-size coal back to the bowl for additional grinding.

Spillage: Spillage is raw coal passing over the edge of the bowl and into the pyrite chute instead of being picked up by the air to the classifier.

Sub-bituminous coals: Sub-bituminous coals are brownish black or black and have high moisture content (as much as 15 to 30 percent). Powder River Basin (PRB) coal is a sub-bituminous coal.

Tramp iron: Tramp iron is any metal that enters the pulverizer with the coal, such as nuts, bolts, scrap steel, and tools.

Tube mills: The tube mills are low-speed machines that grind the coal with steel balls in a rotating horizontal cylinder. If the length of the cylinder is greater than the diameter of the cylinder, it is called a tube mill.

Vane wheel: The vane wheel allows airflow around the bowl circumference for more uniform distribution of coal and air entering the classifier. Vane wheels replaced separator body liners and the adjacent air inlet vanes on the Alstom mills.

Vertical spindle mill: These are medium-speed machines that include bowl mills, ring roll mills, and ring and ball mills. The bowl mills are further divided into deep bowl or shallow bowl mills.

Volumetric feeders: Feeders that deliver coal at a uniform controlled rate based on volume are called *volumetric feeders*. Some examples of volumetric feeders are drag, table, pocket, apron, and belt.

Worm gear set: The worm gear set consists of the steel worm and the bronze worm gear. The mill motor turns the worm. The worm turns the bronze worm gear that is keyed to the vertical shaft. The vertical shaft turns the bowl, hub, and the grinding ring.

3
SYSTEM APPLICATION

In a coal-fired power plant, the fuel handling system consists of the following functions:

- Delivering the coal
- Unloading the coal
- Weighing the coal
- Initial crushing of the coal
- Conveying the coal to an active pile and/or into the plant
- Unloading the coal into bunkers or silos for each unit
- Metering (feeders) and controlling the coal in the coal pulverizer mills
- Moving the pulverized coal and primary air into the distribution box for entry into the boiler

The fuel handling system can be divided into two groups: the coal handling system and the coal pulverizer system. These systems, along with consideration for using Powder River Basin (PRB) coal and environmental regulations, are described in this section.

3.1 Coal Handling System

In a coal-fired power plant, the coal handling system provides the following functions:

- Unloads the coal from railroad cars, dump trucks, barges, and so on.
- Weighs the coal being received into the plant.
- Crushes the coal so it can be moved by a conveyor system into the plant.
- Transports (typically by conveyor belts) the coal from the unloading site to crushing equipment, to an active coal pile or inside the plant, to bunkers or silos, and then to the coal feeders.
- Separates tramp iron from the incoming coal.
- Stores coal in bunkers or silos to provide an adequate supply of coal to the plant should a malfunction of the coal handling equipment occur. The bunkers are sized to store a 12–24 hour or more supply of coal.

Figures 3-1 and 3-2 show typical one-line diagrams of the coal handling system.

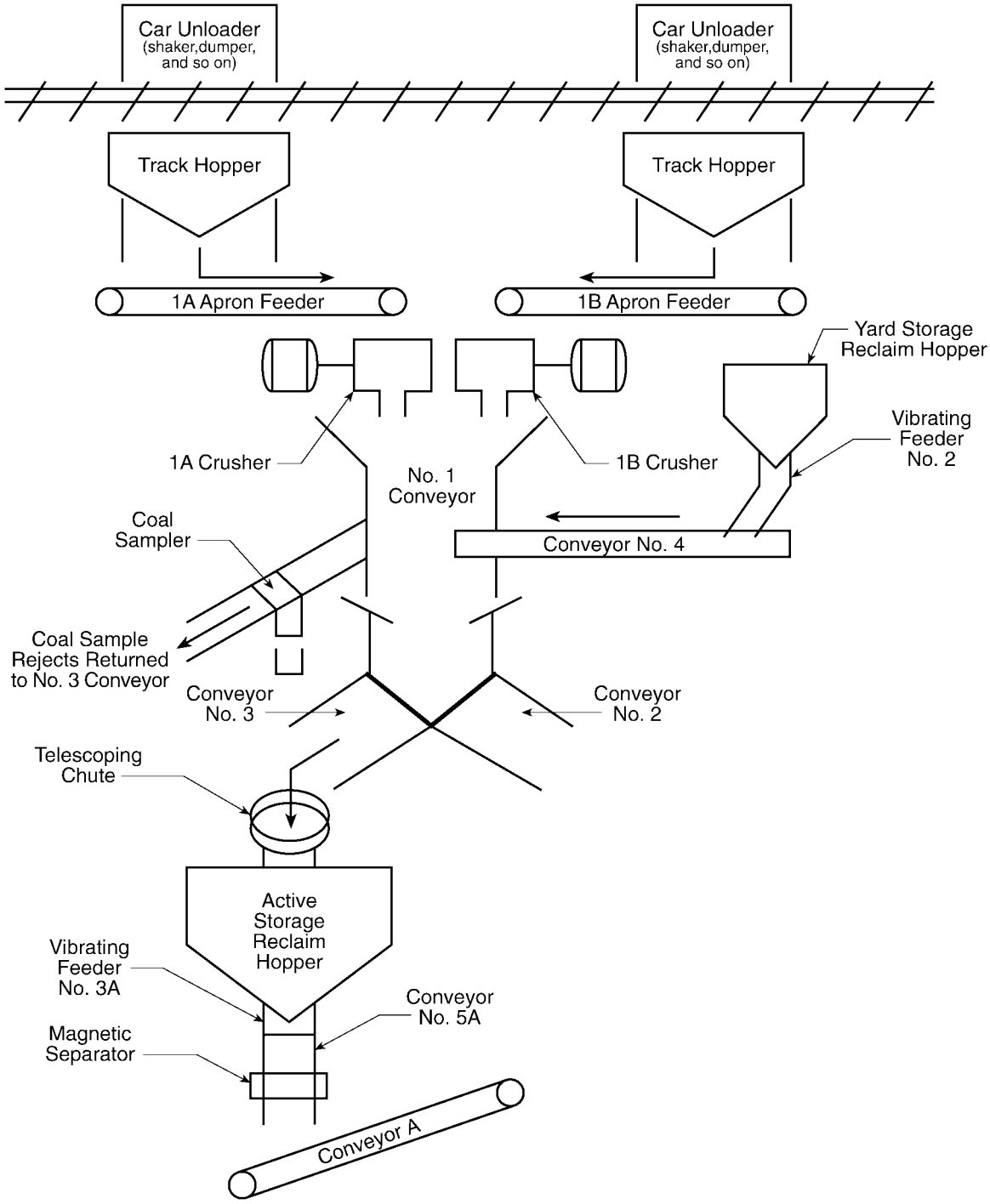


Figure 3-1
A Typical Coal Handling Diagram from Unloading to the Plant
(Courtesy of SCANA McMeekin Station Units 1 and 2)

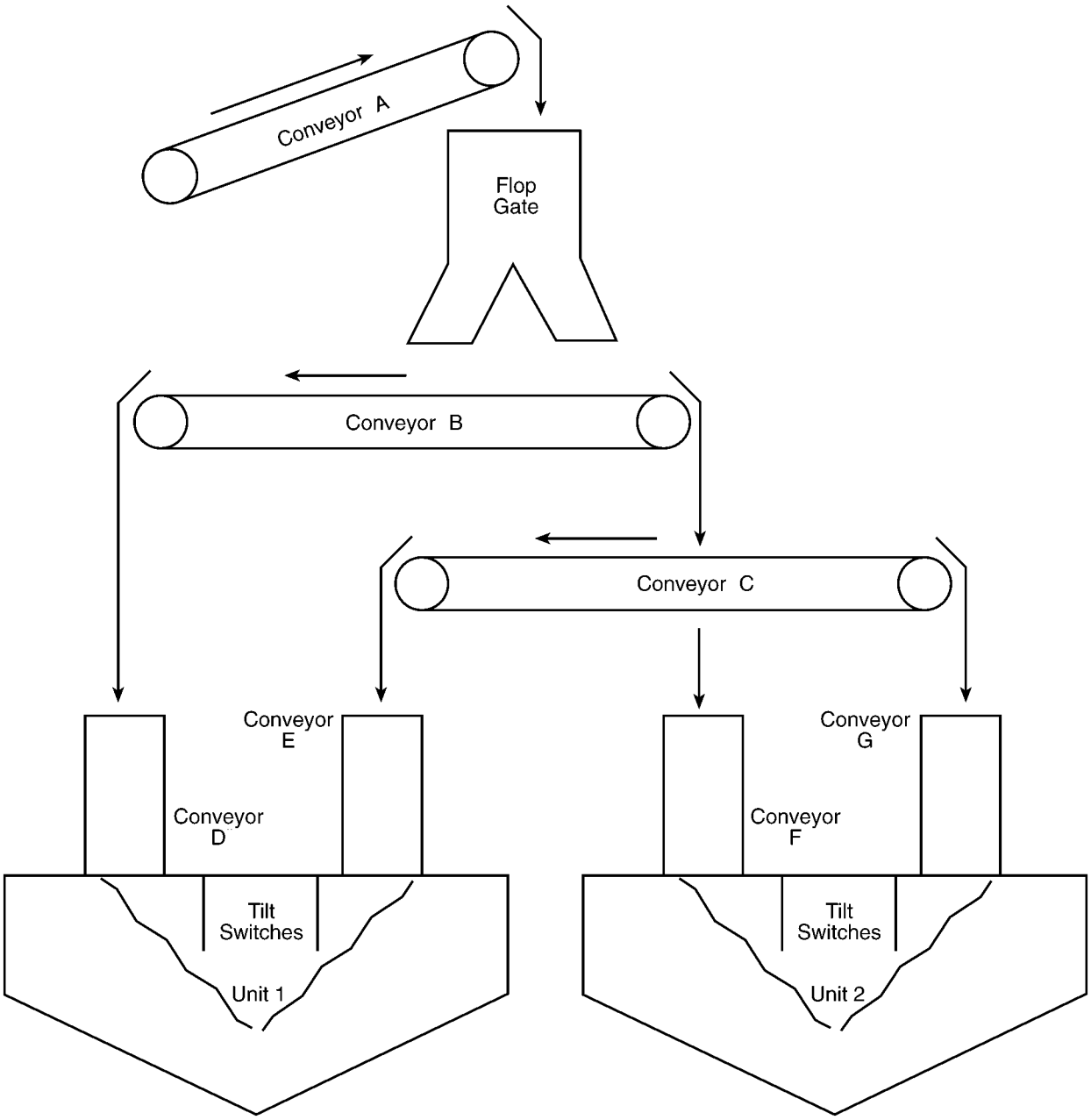


Figure 3-2
A Typical Coal Handling Diagram from Plant to Unit Bunkers (Courtesy of SCANA McMeekin Station Units 1 and 2)

For stations with railroad delivery of coal, the cars are capable of holding between 70–100 tons of coal. It is necessary to weigh the coal in each railroad car. This can be accomplished using electronic scales on the track to weigh the car full and then empty to find the subtracted weight of the unloaded coal. In addition, the coal can be weighed on a scale below the unloading area grating.

A locomotive is used to position the cars directly over the unloading hoppers. The cars can be unloaded from the bottom doors with car shakers to loosen the coal from the cars. The cars can also be turned upside down in a rotary dumper. From the unloading hoppers, the coal is transported to the crushers, where it is broken into smaller, finer particles. Coal sampling equipment is positioned near the conveyor belt to take uncrushed coal for testing.

Typically, crushers are motor-driven equipment that use rolling rings or ring hammers to reduce the chunks of coal to less than 1 in. in size. The crushed coal is then placed on a series of conveyor belts, which can be of varying widths. They are propelled by a drum that is belt driven from a speed reducer gearbox and a motor. The belt rests on idlers that are evenly spaced under the belt.

These belts transport the coal to the active storage pile, where it is stored before being transported into the plant. Coal from the active storage pile then gravitates into the active storage reclaim hopper. A vibrator feeder is located at the discharge of the hopper. The coal falls onto the conveyor and is transported into the plant.

In the plant, the coal travels beneath a magnetic separator. This device pulls out any metal material, such as iron and steel, that can be attracted by a magnet. The transfer conveyor then unloads the coal onto a conveyor with a movable tripper device. The tripper device is positioned over each silo or bunker until it is filled. The coal then flows to a coal silo (which has a circular shape with conical outlet) or a coal bunker (rectangular shape with a pyramidal outlet).

The outlet from the silo or bunker is usually equipped with a fully enclosed slide gate. The slide gate can be manually operated or motor operated. There is usually one silo or bunker for each feeder and one feeder for each pulverizer mill. The coal moves through the silo or bunker, through the feeder, and enters the pulverizer.

Because of the strict regulations concerning fugitive dust emissions, dust control is required on the coal handling system. The dust control systems may inject a water and/or chemical mixture at different points along the coal path or may use water to cover the surface of the coal on the belt.

3.2 Coal Pulverizer System

The coal pulverizer system starts when the coal is fed through the bunkers to a raw coal feeder. Figure 3-3 shows a diagram of the coal pulverizer system.

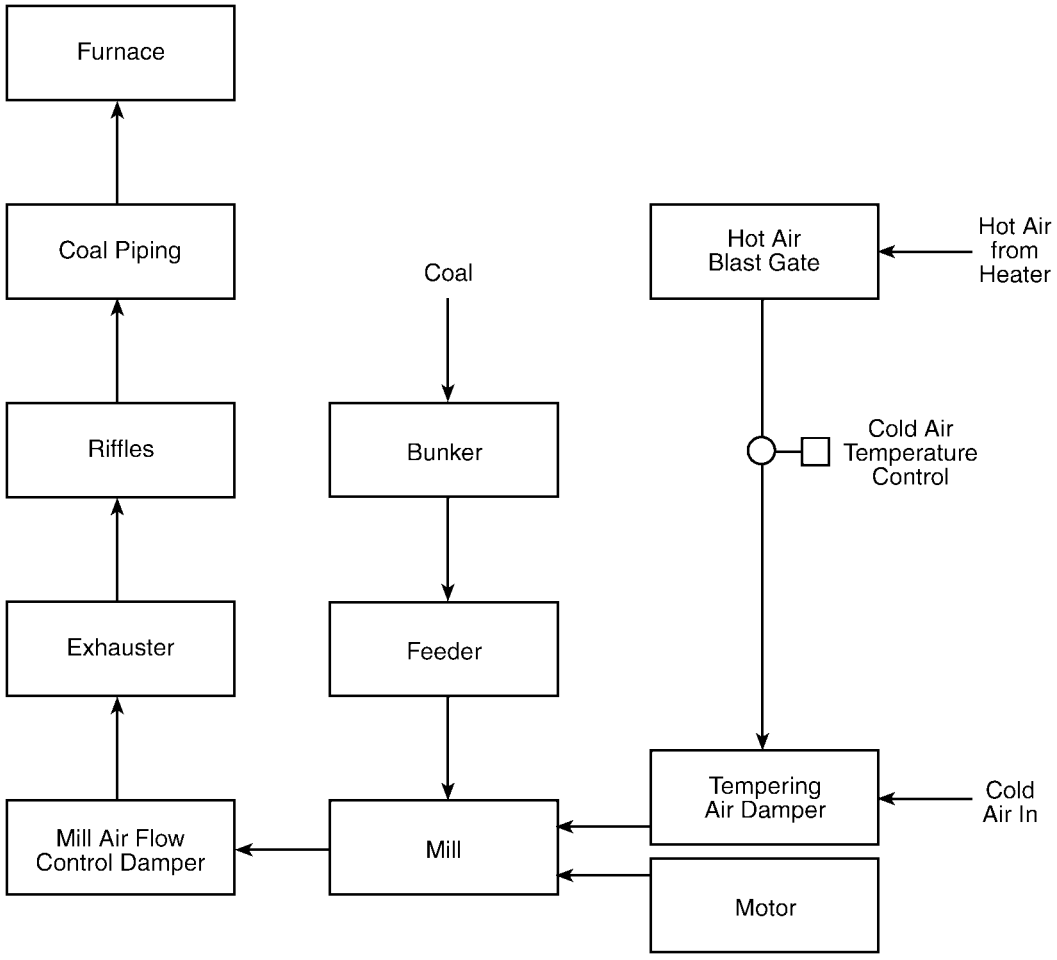


Figure 3-3
Coal Pulverizer System

The coal flow is controlled by the feeder, allowing coal to flow into the pulverizer mill. The pulverized coal and air mixture is then transported from the mill outlet to the exhauster. From the exit of the exhauster, the coal and air mixture flows to the distributor box or riffle. From the riffle, the coal and air flow to the boiler burner panels. This guide covers the coal pulverizer system from the feeder to the exhauster outlet.

One or more feeders are provided for each pulverizer. A feeder supplies and meters the coal going to the pulverizer mill. The feeders can be volumetric or gravimetric designed. The feeders are typically driven by induction motors.

3.2.1 Coal Pulverizer Mills

The purpose of the pulverizer mill is to:

- Reduce the coal to small particles by grinding for better combustion
- Dry the coal
- Classify the particle size of the coal leaving the mill
- Transport the coal from the classifier to the exhauster

Three styles of pulverizer mills are:

- **Tube or ball mills:** These are low-speed machines that grind the coal with steel balls in a rotating horizontal cylinder. If the diameter of the cylinder is greater than the length of the cylinder, the mill is called a *ball mill*. If the length of the cylinder is greater than the diameter of the cylinder, it is called a *tube mill*.
- **Vertical spindle mill:** These are medium-speed machines that include bowl mills, ring roll mills, and ring and ball mills. The bowl mills are further divided into deep bowl or shallow bowl mills.
- **Impact mill:** These are high-speed impact machines that use beater wheels to crush the coal.

The mills covered in this guide are the vertical spindle mill design, deep and shallow Raymond Bowl mills produced by Alstom (previously Asea Brown Boveri [ABB] Combustion Engineering [CE]). These mills will be referred to as Alstom Raymond Bowl (RB) mills in this report. Figure 3-4 shows a picture of the Alstom RB deep bowl mill.

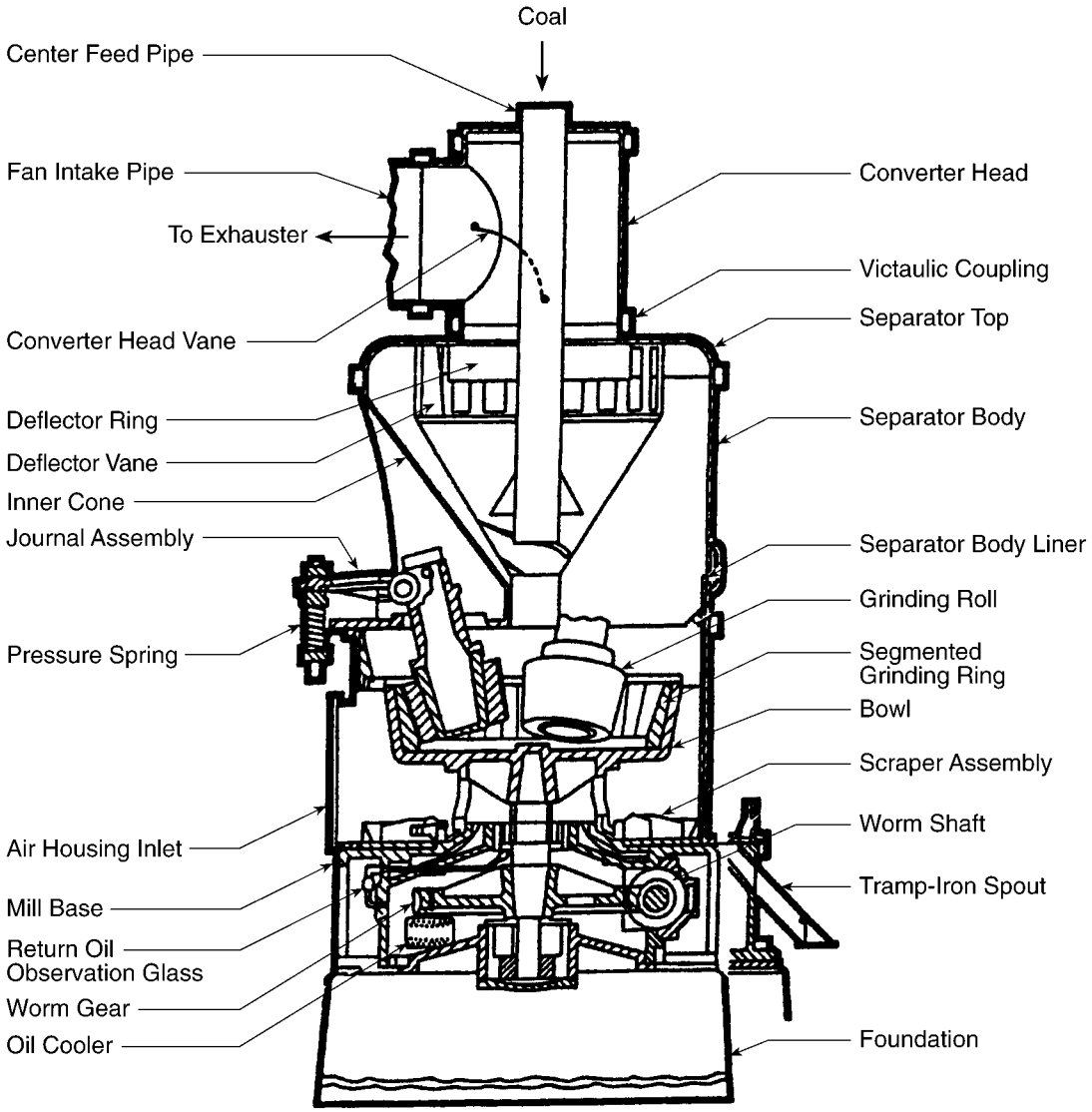


Figure 3-4
Alstom Deep Bowl Mill [1]

Coal enters the mill in the center through a feed pipe and falls onto the grinding bowl. It mixes with partly dried, partly crushed coal that is ground between the bowl and the grinding rolls. The grinding bowl is rotated beneath the grinding rollers. The grinding bowl is driven through a worm gear from an induction motor. The rolls are in a fixed position and rotate as the grinding bowl slowly rotates below the rolls. A mechanical spring compresses the journal roll down towards the bowl, and the journal stop prevents the roll from making direct contact with the bowl. The grinding bowl or table consists of the lower ring, seat ring, and yoke.

After the roll crushes the coal, the coal spills over the ring seat and into the throat area. Any large particles of pyrite or foreign material pass over the edge of the bowl and fall against the air stream. Scraper blades, rotating with the grinding bowl, push the rejects into the reject chute and outside the mill into a bin or pyrite removal system. As the coal passes over the edge of the bowl, it becomes entrained in the rising flow of hot air. The primary air is taken from the secondary air

duct downstream of the air preheaters and combined with cold or tempering ambient air. Air enters the mill from both ends through a centrally located air tube. The desired air temperature is achieved by blending the hot primary air with cold tempering air through an adjustable damper arrangement upstream of the pulverizer.

The air exchanges heat with the coal and dries the coal. In this process, the temperature of the air reduces from the inlet temperature of 500ºF to an exit temperature of 160ºF. From the throat area, the coal is carried up toward the top of the mill into the classifier section of the mill. The classifier section allows suitably sized particles to exit to the exhausters. Rejected coal particles flow back to the grinding section for further pulverizing.

In the suction design mills, the primary air and fuel, after passing through the classifier, are drawn through the exhauster inlet elbow and into the exhauster. The exhauster is essentially a bladed paddle wheel that receives the fuel mixture at the center of the wheel and discharges the fuel mixture at the periphery of the blades. The exhauster pulls air through the mill to pick up coal and discharges the fuel mixture to the distributor box or riffles. The airflow is regulated by the position of the exhauster output damper. In a pressurized mill design, the primary air and fuel exit the pulverizer through a discharge valve, and no exhauster is used.

The exhauster and mill are both driven by an induction motor. The motor is protected by a low-voltage relay and an instantaneous relay trip device. The earlier designed mills used a 2300-V motor. Later designs used a 4160-V motor, and the latest designs use a 7-kV voltage motor.

The riffles distribute the fuel uniformly to the burners in the boiler. Each riffle segment has openings that are about 1-in. wide for primary riffles and 2-in. wide for secondary riffles. A coarse-cut riffle has openings that are about 5-in. wide. The coarse type of riffle can be a major contributor to coal flow imbalance because the coal entering the rifle housing is concentrated in a stream or rope.

After the riffle, the coal is distributed into several coal pipes that transport the coal to the burners and burner nozzles. Usually the mills and riffles are located in the basement of the power plant, and the burners are located several levels above the basement. This results in significant lengths of coal piping with horizontal runs, vertical runs, and many turns.

In order to have equal coal and air flow from the riffles to the burner, the pressure drop through each coal pipe and burner must be equal. This is accomplished in two ways: each of the pipe runs from the riffles to the individual burners is equal in pressure drop (which includes the number and angle of bends), or an orifice in the coal pipe is installed to create a higher pressure drop in the coal piping with a shorter run.

The burner shutoff valves allow the operator to take the burners out of service without affecting the operation of the other burners.

Figure 3-5 shows an Alstom shallow bowl mill.



Figure 3-5
Alstom Shallow Bowl Mill
(Courtesy of Great River Energy)

3.3 Coal Characteristics

The four major types of coal are anthracite, bituminous, sub-bituminous, and lignite [2].

Anthracite coals are hard coals with a high percentage of fixed carbon and lower percentage of volatile matter. Anthracite coals are used primarily for heating homes and in gas production.

Bituminous coals make up the largest group of coal available. The name *bituminous* is derived from the fact that when heated, the coal is reduced to a cohesive, binding, sticky mass. The volatile matter is complex and high in heating value. These coals burn easily in pulverized form. Bituminous coals can be further classified as high-volatile, medium-volatile, and low-volatile coals.

Sub-bituminous coals are brownish black or black. Most are homogeneous with smooth surfaces and with no indication of layers. They have a high moisture content, as much as 15–30 percent, although appearing dry.

Lignites are brown and of a laminar structure; the remnants of woody fibers may be apparent. They are high in volatile matter, moisture content, and low in heating value. Brown coal contains more than 45% moisture.

The following are seven coal producing areas in the United States:

- **Eastern:** Pennsylvania, Rhode Island, Virginia, North Carolina, Ohio, Kentucky, West Virginia, Tennessee, and Alabama. This area contains the largest deposits of high-grade bituminous and semi-bituminous coals.
- **Interior:** Mississippi Valley region, Texas, and Michigan. Bituminous coals (lignites) found here are of a lower value and higher sulfur content than the eastern area.
- **Gulf:** Alabama, Mississippi, Louisiana, Arkansas, and Texas. The lowest value coals are found in this area. Lignites have a moisture content as high as 55% and heating values below 4000 Btu/lb.
- **Northern Great Plains:** North Dakota, South Dakota, Wyoming, and Montana. The Dakotas have lignite deposits. Wyoming and Montana have bituminous and sub-bituminous coals.
- **Rocky Mountain:** Montana, Wyoming, Utah, Colorado, and New Mexico. The coals range from lignite to sub-bituminous and high-grade bituminous to anthracite.
- **Pacific Coast:** Washington, Oregon, California. The coals in this area range from sub-bituminous to bituminous to anthracite.
- **Alaska:** The coal reserves here are estimated to be 15% bituminous and 85% sub-bituminous and lignite.

Powder River Basin (PRB) coal is a sub-bituminous coal. The PRB is a 12,000–14,000-ft deep depression filled with sediments eroded from land uplifted during the formation of the Rocky Mountains. The PRB is located in Montana and Wyoming between the Bighorn Mountains and the Black Hills. PRB coal has an average heating value around 8,500 Btu/lb. The most attractive quality characteristic of the PRB coal is its low sulfur content. With an average of approximately

0.3% sulfur, most of the coal meets the environmental compliance requirements for utility boilers without scrubbers.

Coal from the eastern part of the country is a high-sulfur bituminous coal. Typical coal costs for PRB coal is $1.00/M BTU versus $1.30/M BTU for eastern bituminous coals. It takes approximately 113 lb of PRB coal to equal the same BTU content of 80 lb of eastern coal. This means that it takes 30% more PRB coal to equal the BTU content of eastern coal.

The 1990 Clean Air Act Amendments (Title IV - Acid Rain) have required utilities to reduce their sulfur emissions. Methods of compliance include flue gas desulfurization, fuel switching, fuel blending, and emission allowance trading. For the fuel blending, some utilities are blending the PRB coals with the eastern coals to meet air quality requirements.

With fuel blending, a common area of significant concern is the pulverizer grinding capacity with PRB coal or coal blends. PRB coals typically have a reduced heating value and higher moisture content compared to eastern coals. Because of the higher moisture content, a higher level of mill coal drying is required.

Mill grinding capacity requirements depend on the PRB blend ratio, the maximum boiler load required, and the amount of reserve mill capacity desired. For example, a plant may relax its normal requirement of attaining full load with five of six mills in service, as long as full load can be attained using PRB coals with six mills. However, if maintaining full-load capacity with five mills in service is required, then mill capacity upgrades may be necessary.

Inadequate mill drying capacity will result in lower than normal mill outlet temperatures because of higher coal mass flow rates, higher coal moisture content, and capacity limitations of the hot primary air supply system. Lower acceptable mill outlet temperature requirements for PRB coals may offset the hot primary air drying requirements to some extent. However, in general practice, an increase in primary airflow has been associated with the use of PRB coals. If the forced draft fans are limited in their capacity to deliver more primary air, adding a primary air fan for additional airflow may be necessary. If the primary airflow requirements are sufficiently high, the velocities in the coal piping may increase significantly, and erosion problems may occur.

Specific pulverizer-related issues that should be evaluated when burning PRB coals include:

- Mill grinding capacity and fineness requirements
- Coal drying capacity requirements (primary air and fuel ratio)
- Primary Air (PA) fan capacity, fan discharge pressure, and gas temperature
- Feeder discharge pluggage and cleaning practices for PRB coal
- Mill fire protection, CO_2 inerting, water wash systems, water fogging nozzle installation at the classifier (coal dust dampening and removal for explosion prevention to work in conjunction with CO_2 inerting system)
- Mill fire detection system (CO_2 detection)

- Coal pipe line velocities and potential long-term erosion
- Mill outlet temperatures (possible reduction from ~150ºF to ~130–135ºF for PRB coals to offset some of the increased PA requirements)

For additional information on coals in the United States, reference the following EPRI reports:

- *Effects of Coal Quality on Power Plant Performance and Costs, Volumes 1–4.* EPRI, Palo Alto, CA: 1988. CS-4283.
- *Coal Quality Information Book, Volumes 1–2.* EPRI, Palo Alto, CA: 1991. GS-7194.

3.4 Environmental Regulations

The Clean Air Act of 1990 established lower NO_x emission rates for utility boilers. Because NO_x formation is largely dependent on how the fuel is combusted, the efforts to reduce NO_x emissions have focused on modifying the combustion process.

NO_x includes NO, NO_2, and N_2O formation during combustion. The following are the three primary sources for the formation of NO_x:

- **Thermal NO:** Thermal NO is the oxidation of molecular nitrogen (N_2) to form NO. The triple-bonded N_2 requires significant energy for oxidative attack and occurs only at high temperatures. Thermal NO accounts for approximately 20–30% of the final NO_x emissions.
- **Prompt NO:** Prompt NO describes the hydrocarbon radical attack of N_2 to form fixed nitrogen compounds (such as NH_x, XCN) that can subsequently react to form NO. Prompt NO accounts for approximately 5–10% of the final NO_x emissions.
- **Fuel NO:** Fuel NO is the oxidation of fuel-bound nitrogen in the coal to NO_x compounds. Typically, fuel-bound nitrogen evolves as an amine or cyano compound and is oxidized to NO or reduced to N_2. Fuel NO accounts for approximately 60–70% of the final NO_x emissions.

Figure 3-6 shows how the fuel-bound nitrogen evolves to form either NO_x pollutants or nitrogen gas. Char is the combustible residue remaining after the destructive distillation of coal.

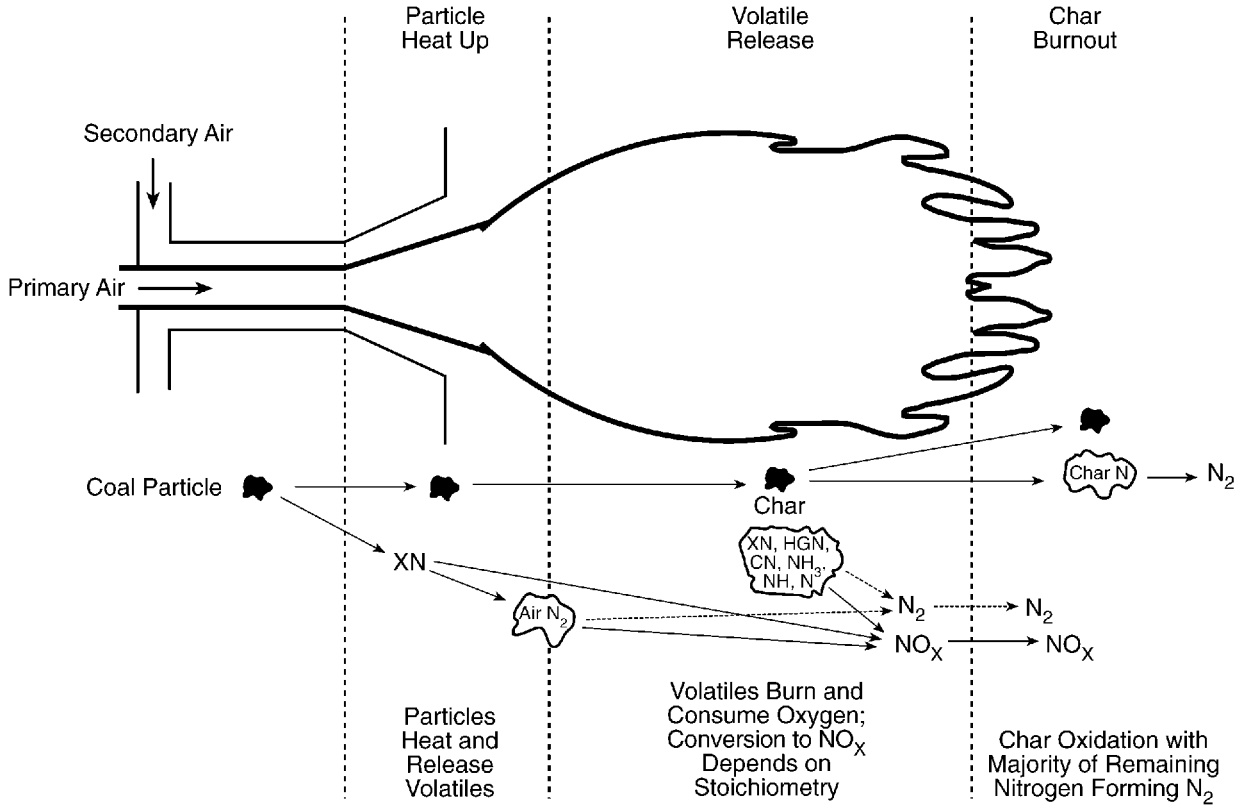


Figure 3-6
Fuel-Bound Nitrogen Evolution to NO_x [1]

The amount of NO_x formed when coal burns is a function of the nitrogen content of the coal, the flame temperature, the amount and distribution of air during combustion, and the flame structure. Three technologies used for reducing the NO_x formed are low NO_x burners, overfire air, and selective catalytic reduction (SCR). The addition of SCRs involves adding a catalyst bed in the boiler flue gas that captures the NO_x leaving the boiler.

Low NO_x burners control fuel and air mixing to create larger and more branched flames, reduce peak flame temperatures, and lower the amount of NO_x formed. The improved flame structure also improves burner efficiency by reducing the amount of oxygen available in the hottest part of the flame.

In principle, there are three activities in a conventional low NO_x burner: combustion, reduction, and burnout. In the first stage, the combustion occurs in a fuel-rich, oxygen-deficient zone where the NO_x is formed. In the reduction stage, hydrocarbons are formed and react with the already formed NO_x. In the burnout stage, internal air staging completes the combustion. Additional NO_x is formed in the burnout stage. However, the additional NO_x can be minimized by an air-lean environment.

Low NO_x burners can be combined with overfire air technologies that create two stages for combustion. This requires a primary and a secondary source of combustion air. The secondary

air nozzles are located above the burners. This system results in more complete burnout of the fuel and formation of N_2, rather than NO_x.

The operation of low NO_x burners tends to increase the unburned carbon in the ash. Unburned carbon can occur in both the bottom ash and fly ash. Unburned carbon in the fly ash is termed *loss on ignition* (LOI). With NO_x control, the LOI for tangentially fired furnaces increases an average of 2% and for a wall-fired furnace, the LOI increases 3–5%.



O&M Cost Key Point

The increases in loss on LOI from NO_x combustion controls increase heat rate. The average industry loss is 12 BTU/kWh per 1% change in unburned carbon. This increase in LOI creates a need for greater fineness to compensate for the increased LOI. Some units have increased fineness from 70% passing a 200 mesh screen to 75–80% passing a 200 mesh screen and 99–99.5% passing a 50 mesh screen. The increase in fineness settings requires more work from the pulverizer.

In other words, the increase of LOI in the boiler increases the heat rate for the unit. In order to offset the heat rate increase, the mill is required to perform more work. Performing more work for the given amount and type of coal can increase the maintenance costs for the mill.

4
TECHNICAL DESCRIPTIONS

This section covers technical descriptions for the following equipment and systems [3]:

- Raymond bowl design mills
- Gearbox
- Feeder
- Exhauster
- Air system
- Lubrication system
- Pyrite rejection system

4.1 Raymond Bowl Design Mills

Combustion Engineering (CE) is the original manufacturer of the Raymond Bowl (RB) mills. Asea Brown Boveri (ABB) joined with CE and for a time the mills were called ABB-CE mills. The current manufacturer of these mills is a company called Alstom. In this guide, the Raymond Bowl mills will be referred to as Alstom RB mills.

The Alstom RB mills are designed for grinding bituminous, sub-bituminous, and lignite fuels with Hardgrove Grindability Indices of 25–100 and the moisture content of lignite up to 45%. (The Hardgrove Grindability Index is a standard index based on use of the Hardgrove Grindability Machine and is determined by the amount of new material that will pass through a 200 mesh sieve.)

Figure 4-1 shows an Alstom deep bowl RB mill.

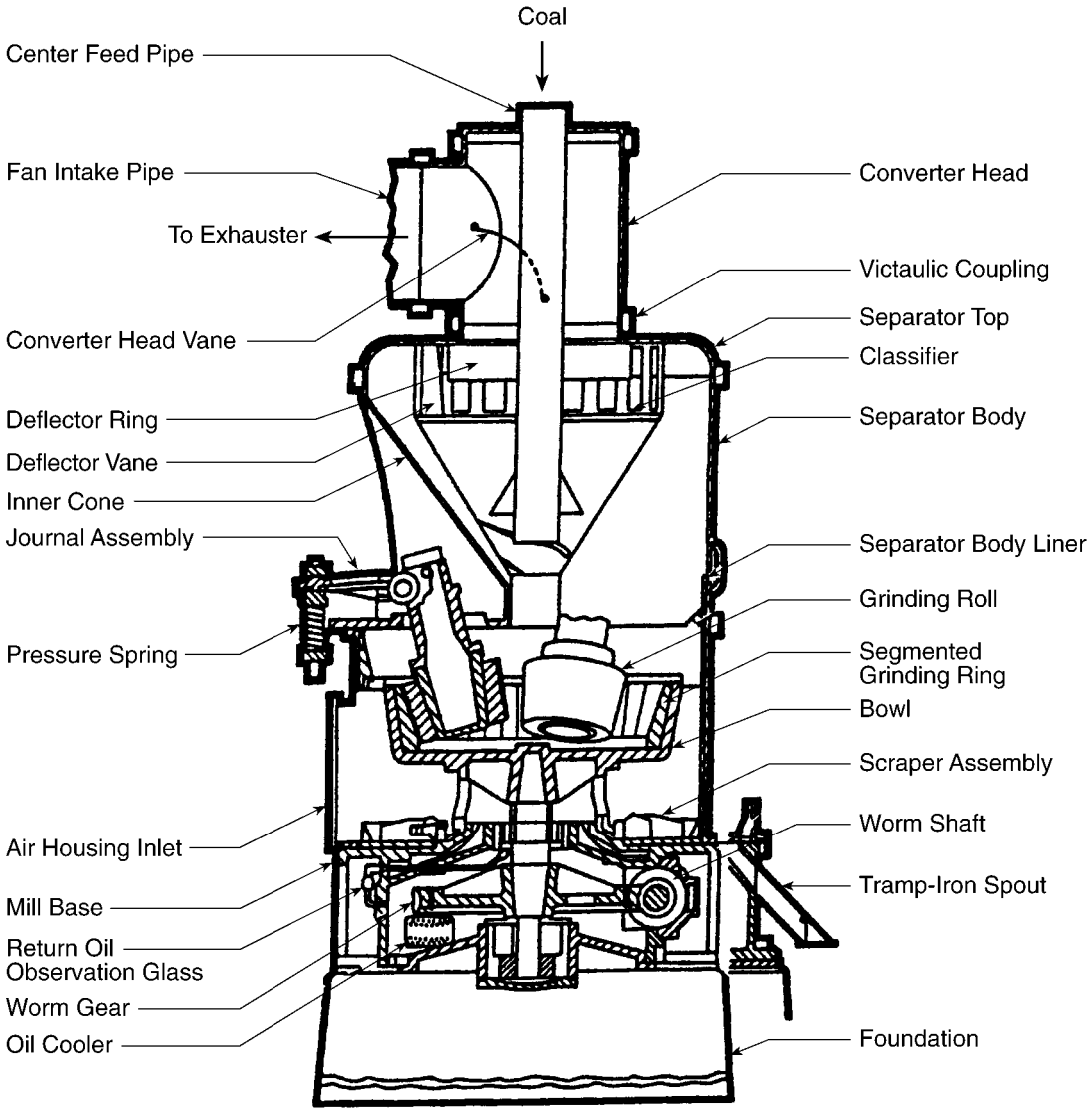


Figure 4-1
Alstom RB Mill [1]

The raw coal drops into the grinding bowl and is moved onto the rotating grinding ring by centrifugal force. As it passes under the spring-loaded rollers, it is partially pulverized by a combination of rolling, crushing, and attrition action. The partially ground material passes over the edge of the rotating bowl and is entrained in the rising hot air stream, flash dried, and carried up to the classifier. The larger coal particles drop out of the air stream and fall back into the bowl for more grinding.

The smaller particles and fine material enter the classifier tangentially through a number of circumferentially located openings. Externally adjustable vanes located within the periphery of the classifier impart a spinning action to the coal and air mixture. The more spin that is imparted, the finer the product that leaves the pulverizer. Larger size material is rejected by the classifier and returns to the bowl for further grinding. The fine material is carried out of the pulverizer by

the air stream and into the rotating exhauster fan or through a discharge valve for movement to the distribution riffles.

Approximately 75–80% of the classifier input is returned to the grinding chamber where it mixes with the incoming raw coal. In the recirculation of the coal, some predrying of the raw coal occurs, and the average particle surface moisture in the flash drying zone is reduced. This feature enables the bowl mill to handle high-moisture coals without reduction of pulverizer capacity or classification efficiency. Foreign material in the coal falls through the annulus around the rotating bowl and is rejected from the lower housing of the pulverizer.

The earliest version of the Alstom mill is the deep bowl type mill. The deep bowl mill is operated under suction using an exhauster to induce airflow through the pulverizer. The deep bowl mill was built with a maximum capacity of 60,000 lb/hr and furnished with an exhauster.

In 1949, with the advent of pressurized furnaces, CE began the development of a bowl mill for operation under pressure or suction. This mill became the shallow bowl mill.

The shallow bowl mill was built with a maximum capacity of 200,000 lb/hr. The shallow bowl mill is supplied with an exhauster for capacities up to 100,000 lb/hr. As the exhausters increased in size, the pounds of coal per unit of wearing area increased and caused an increase in exhauster maintenance. All pulverizers with capacities over 100,000 lb/hr are operated under pressure and do not have exhausters.

The shallow bowl mill uses about 10% less power and produces a greater output for the same grinding ring diameter of the deep bowl mill. The grinding elements and the linings of the housings for both type mills are made of abrasion-resistant castings, such as Ni-Hard or chrome-molybdenum irons. The grinding rings are made of segments for easy removal. The rollers are replaced by removing the journal assemblies from the pulverizers.

Figure 4-2 shows a chart of the Alstom RB design mills.

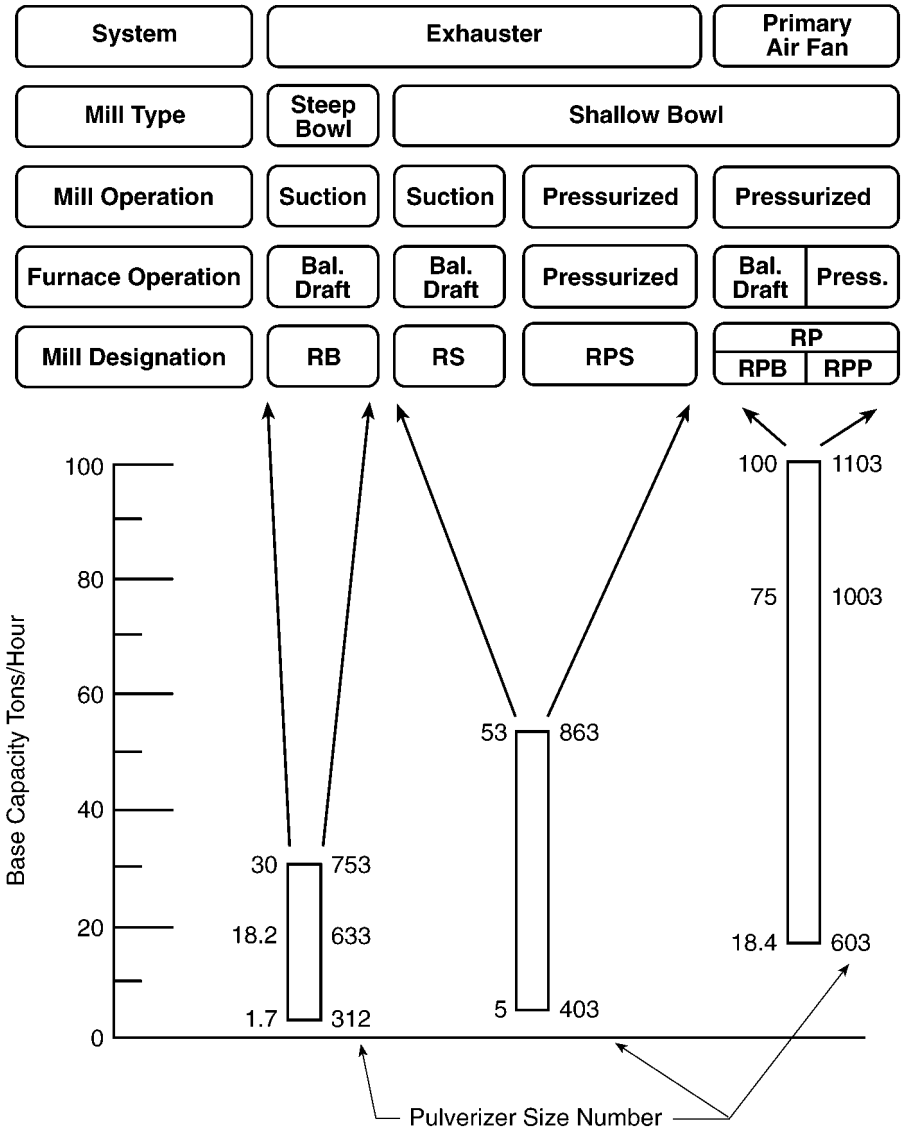


Figure 4-2
Alstom Bowl Mill Designs [4]

Table 4-1 shows the Alstom deep bowl mill types. The designation of the mill provides the size and configuration of the mill. For example, a 633 RB mill is a Raymond Bowl steep mill design; the first two numbers indicate the nominal bowl diameter in inches (63 in.), and the last number indicates the number of journal assemblies per mill (3). Table 4-2 shows the Raymond Bowl shallow bowl pulverizer designations and sizes.

Table 4-1
Alstom Deep Bowl Mill Types [4]

Pulv. Size	Base Capacity (lb/hr)	Maxi-mum Air/Pulv. (lb/min)	Static Pressure @ Fan Discharge (in. W.G.)[1]	Power Input (kw)			Rated Motor Power (hp)			Motor Service Factor	Motor Speed (rpm)
				Total	Pulv.	Fan	Total	Pulv.	Fan		
312	3,550	150	8	31	18	13	40	25	20	1.15	1800
312A	4,000	160	8	35	21	14	50	30	20	1.00	1800
352	4,450	170	8	39	24	15	50	30	20	1.15	1800
352A	5,300	180	8	45	29	16	60	40	20	1.00	1800
372	6,200	200	8	52	33	19	75	40	25	1.0	1800
372A	7,100	225	8	59	38	21	75	50	30	1.15	1800
412	8,000	250	8	65	42	23	100	60	30	1.0	1200
			12	71	42	30	100	60	40	1.0	1200
452	9,700	310	8	76	49	27	125	60	40	1.0	1200
			12	84	49	35	125	60	50	1.0	1200
453	11,500	350	8	87	56	31	125	75	40	1.0	1200
			12	96	56	40	125	75	50	1.15	1200
473	13,300	400	8	98	63	35	125	100	50	1.15	1200
			12	108	63	45	150	100	60	1.0	1200
473A	15,500	425	8	110	71	39	150	100	50	1.0	1200
			12	121	71	50	150	100	75	1.15	1200
493	16,800	450	8	118	77	41	150	100	50	1.15	1200
			12	130	77	53	200	100	75	1.0	1200

Table 4-1 (cont.)
Alstom Deep Bowl Mill Types [4]

Pulv. Size	Base Capacity (lb/hr)	Max-mum Air/Pulv. (lb/min)	Static Pressure @ Fan Discharge (in. W.G.)[1]	Power Input (kw)			Rated Motor Power (hp)			Motor Service Factor	Motor Speed (rpm)
				Total	Pulv.	Fan	Total	Pulv.	Fan		
533	20,300	550	8	138	90	48	200	125	60	1.0	1200
			12	152	90	62	200	125	75	1.15	1200
			15	163	90	73	200	125	100	1.15	1200
533A	23,800	600	8	158	105	53	200	150	75	1.15	1200
			12	174	105	69	250	150	100	1.0	1200
			15	188	105	83	250	150	125	1.15	1200
573	26,500	660	8	173	115	58	250	150	75	1.0	900
			12	190	115	75	250	150	100	1.15	900
			15	207	115	92	250	150	125	1.15	900
593	28,200	750	8	185	122	63	250	150	100	1.0	900
			12	204	122	82	250	150	100	1.15	900
			15	216	122	94	300	150	125	1.0	900
613	32,700	850	8	210	139	71	300	200	100	1.0	900
			12	232	139	93	300	200	125	1.15	900
			15	250	139	111	350	200	150	1.0	900
633	36,500	950	8	232	154	78	300	200	100	1.15	900
			12	256	154	102	350	200	125	1.0	900
			15	278	154	124	350	200	150	1.15	900

Table 4-1 (cont.)
Alstom Deep Bowl Mill Types [4]

Pulv. Size	Base Capacity (lb/hr)	Maxi-mum Air/Pulv. (lb/min)	Static Pressure @ Fan Discharge (in. W.G.)[1]	Power Input (kw)			Rated Motor Power (hp)			Motor Service Factor	Motor Speed (rpm)
				Total	Pulv.	Fan	Total	Pulv.	Fan		
673	41,500	1070	8	260	180	80	350	250	100	1.0	900
			12	290	180	110	400	250	150	1.0	900
			15	310	180	130	400	250	200	1.15	900
713	50,100	1250	8	320	220	100	400	300	125	1.15	900
			12	355	220	135	450	300	200	1.15	900
			15	380	220	160	500	300	200	1.15	900
733	54,500	1340	8	335	230	105	450	300	150	1.0	900
			12	374	230	144	500	300	200	1.0	900
			15	397	230	167	500	300	250	1.15	900
753	59,100	1500	8	368	248	120	450	300	150	1.15	900
			12	406	248	158	500	300	200	1.15	900
			15	435	248	187	600	300	250	1.0	900

[1] Inches of water gauge

Table 4-2
Raymond Shallow Bowl Mill Capacities and Motor Sizes [4]

Pulv. Size	Base[1] Capacity (lb/hr) Grind-ability 55	Max-mum Air/Pulv. (lb/min)	Exhaust Discharge Pressure (in. W.G.)[2]	Mill Motor Power Input[3] (kw)			Rated Motor Power (hp)			Motor Service Factor	Motor Speed (rpm)
				Total[3]	Pulv.	Fan[3]	Total	Pulv.	Fan		
443	14,000	390	6	93	62	31	125	75	40	1.0	1200
			8	97	62	35	125	75	50	1.15	1200
			12	105	62	43	125	75	60	1.15	1200
463	16,200	440	6	105	69	36	125	100	50	1.15	1200
			8	111	69	42	150	100	50	1.0	1200
			12	118	69	49	150	100	60	1.15	1200
483	18,700	485	6	118	78	40	150	100	50	1.15	1200
			8	123	78	45	150	100	60	1.15	1200
			12	133	78	55	200	100	75	1.0	1200
503	21,200	550	6	132	87	45	200	125	60	1.0	1200
			8	137	87	50	200	125	60	1.0	1200
			12	149	87	62	200	125	75	1.0	1200
523	24,000	600	8	152	97	55	200	125	75	1.0	1200
			12	165	97	68	200	125	100	1.15	1200
			15	174	97	77	250	125	100	1.0	1200
543	27,000	675	8	169	108	61	250	150	75	1.0	900
			12	183	108	75	250	150	100	1.0	900
			15	193	108	85	250	150	125	1.15	900

Table 4-2 (cont.)
Raymond Shallow Bowl Mill Capacities and Motor Sizes [4]

Pulv. Size	Base[1] Capacity (lb/hr) Grind-ability 55	Maximum ,Air/Pulv. (lb/min)	Exhaust Dis-charge Pressure (in. W.G.)[2]	Mill Motor Power Input[3] (kw)			Rated Motor Power (hp)			Motor Service Factor	Motor Speed (rpm)
				Total[3]	Pulv.	Fan[3]	Total	Pulv.	Fan		
583	33,200	835	8	208	132	76	300	200	100	1.0	900
			12	225	132	93	300	200	125	1.0	900
			15	238	132	106	300	200	150	1.15	900
603	36,800	950	8	230	145	84	300	200	125	1.15	900
			12	249	146	103	300	200	125	1.15	900
			15	263	148	117	350	200	150	1.0	900
623	40,500	1060	8	253	160	93	350	200	125	1.0	900
			12	274	160	114	350	200	150	1.15	900
			15	288	160	128	350	200	200	1.15	900
643	44,500	1160	8	278	175	103	350	250	125	1.15	900
			12	300	175	125	400	250	150	1.0	900
			15	317	175	142	400	250	200	1.15	900
663	48,500	1250	8	304	191	113	400	250	150	1.0	900
			12	330	191	139	400	250	200	1.15	900
			15	349	191	158	450	250	200	1.15	900
683	53,000	1325	8	329	209	120	400	300	150	1.15	900
			12	356	209	147	450	300	200	1.15	900
			15	376	209	167	500	300	250	1.0	900

Table 4-2 (cont.)
Raymond Shallow Bowl Mill Capacities and Motor Sizes [4]

Pulv. Size	Base[1] Capacity (lb/hr) Grind-ability 55	Maximum Air/Pulv. (lb/min)	Exhaust Discharge Pressure (in. W.G.)[2]	Mill Motor Power Input[3] (kw)			Rated Motor Power (hp)			Motor Service Factor	Motor Speed (rpm)
				Total[3]	Pulv.	Fan[3]	Total	Pulv.	Fan		
703	58,000	1450	8	356	229	127	450	300	200	1.15	900
			12	385	229	156	500	300	200	1.15	900
			15	406	229	177	500	300	250	1.15	900
723	63,000	1570	8	388	248	140	500	300	200	1.15	900
			12	419	248	171	500	300	250	1.15	900
			15	442	248	194	600	300	250	1.0	900
743	68,500	1710	8	404	254	150	500	350	200	1.15	900
			12	437	254	183	600	350	250	1.0	900
			15	463	254	209	600	350	300	1.15	900
763	74,500	1925	8	429	260	169	600	350	250	1.0	900
			12	465	260	205	600	350	250	1.15	900
			15	493	260	233	600	350	300	1.15	900
783	80,500	2000	8	454	273	181	600	350	250	1.15	900
			12	494	273	221	600	350	300	1.15	900
			15	524	273	251	700	350	350	1.0	900
803	87,500	2180	8	492	295	197	600	400	250	1.15	900
			12	535	295	240	700	400	300	1.15	900
			15	570	295	275	700	400	350	1.15	900

Table 4-2 (cont.)
Raymond Shallow Bowl Mill Capacities and Motor Sizes [4]

Pulv. Size	Base[1] Capacity (lb/hr) Grind-ability 55	Maximum Air/Pulv. (lb/min)	Exhaust Discharge Pressure (in. W.G.)[2]	Mill Motor Power Input[3] (kw)			Rated Motor Power (hp)			Motor Service Factor	Motor Speed (rpm)
				Total[3]	Pulv.	Fan[3]	Total	Pulv.	Fan		
823	93,500	2400	8	523	313	210	700	400	300	1.0	900
			12	570	313	257	700	400	350	1.15	900
			15	605	313	292	800	400	400	1.15	900
843	100,000	2500	8	569	335	234	700	450	300	1.15	900
			12	621	335	286	800	450	350	1.15	900
			15	659	335	324	800	450	400	1.15	900
863	106,500	2650	8	603	355	248	800	450	300	1.15	900
			12	657	355	302	800	450	400	1.15	900
			15	689	355	334	900	450	450	1.15	900

[1] For 90% assumed motor efficiency

[2] Inches of water gauge

[3] For RS mills only. This kW input for RPS mills may be obtained from the motor input curve for the applicable pulverizer size.

The 943, 963, 983, 1003, 1023, 1043, 1063, and 1103 RP and RS type mills' base capacities, maximum air per mill, mill motor inputs, rated motor powers, motor service factors, and motor speeds are given by Alstom.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a figure that shows an RS pulverizer mill.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a figure that shows the RPS pulverizer mill.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service.power.alstom.com.

Figure 4-3 shows an RP-1043 pulverizer mill.



Figure 4-3
Alstom RP-1043 Mill
(Courtesy of Great River Energy)

There is a figure showing a typical RP pulverizer mill.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service.power.alstom.com.

There are figures that show the 100-in. RP series pulverizer mill.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There are figures that show the 110-in. RP series pulverizer mill.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

4.2 Gearbox

The gearbox [1] contains the millside liner, scraper assembly, mill base, vertical shaft, worm gear, and worm. The earlier designed model gearboxes contain the oil cooler and oil pump.

A separate gearbox is used on the RB pulverizer mills built during the 1950s. Since the 1950s, the integral gearbox has been used. For the separate gearbox, the body and millside are supported by the mill base plate. The base plate rests on two concrete foundation piers. The gearbox is bolted to the mill base hub and held by four support rods threaded into the mill base plate and attached to the gear housing bolt flange. The millside is insulated on the vertical walls and air inlet only. Insulation cover plates are not used. The bowl hub does not have removable skirts, and it forms a simple labyrinth seal with the mill base hub. Two pivoting scraper assemblies are bolted to the bowl hub and rotate with it.

There is a figure that shows an Alstom RB pulverizer mill with the pod-type gearbox.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service.power.alstom.com.

The gearbox is a two-piece design using antifriction bearings and worm gear drive. It is removable from the pulverizer with the vertical shaft. The vertical shaft has a tapered fit to the bowl hub and also uses a key. This is the same arrangement that is used on the integral gearboxes. The gear hub has a loose straight fit to the shaft and is secured to it by a key and a locknut.

There is a figure that shows an RB pulverizer with an integral gearbox.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service.power.alstom.com.

There is a figure that shows an RB pulverizer with a bushing gearbox.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service.power.alstom.com.



Technical Key Point

A replaceable oil seal and a labyrinth-type dust guard seal the gearbox top above the upper radial bearing and prevent dust contamination. Seal air drawn by the millside suction through the labyrinth seal formed by the bowl hub skirt and the mill bottom casting prevents dust from accumulating on top of the oil seal. The labyrinth seal is not greased.

For information on lubrication systems, refer to Section 4.6 in this guide.

A chart exists that lists the center distance, minimum shift, nominal shift, maximum shift, and minimum backlash for the different mill types.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

4.3 Feeder

The uniform or consistent feed of coal is important to the mill performance and ultimately to the unit performance. Although there are several types of feeders [5], the two types covered in this guide are the volumetric and gravimetric feeders.

Feeders that deliver coal at a uniformly controlled rate based on volume are called volumetric feeders. Some examples of volumetric feeders are drag, table, pocket, apron, and belt. Figure 4-4 shows a picture of a volumetric feeder.

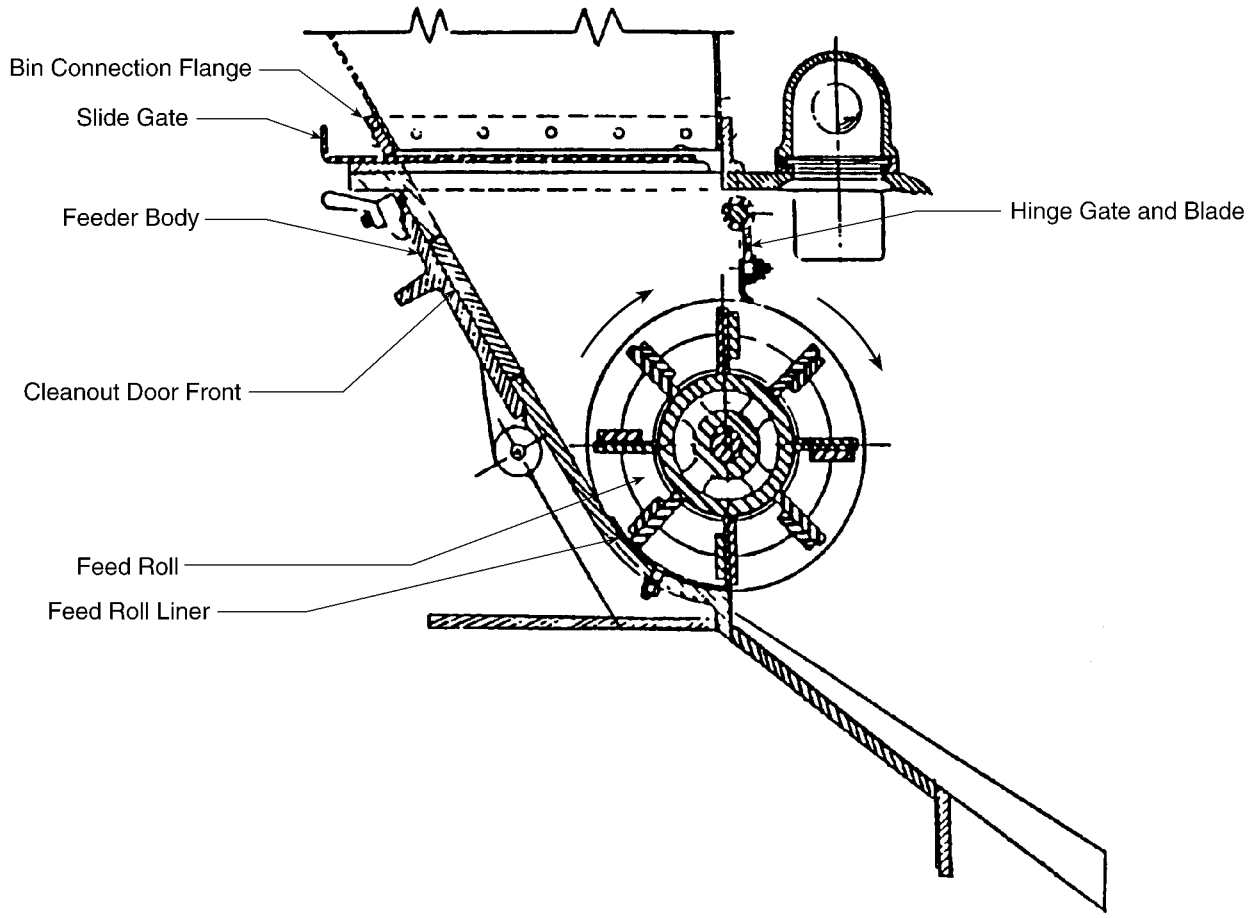


Figure 4-4
Volumetric Pocket Feeder [1]

A pocket feeder is a volumetric feeder designed to deliver approximately 50 lb of coal per revolution. The feeder has eight pockets. Each pocket should contain approximately 6 1/4 lb of coal after passing the hinged gate blade. Each feed roll blade should be set uniformly from the feed roll liner plate with clearance of 1/8–1/4 in. to prevent dribble under the feed roll. End clearance of the feed roll blades should be maintained at 3/32–5/32 in. The hinged gate and blade to feed roll blade clearance should be adjusted uniformly to 1/8–1/4 in. to provide uniform feed.

The minimum feeder setting for the volumetric feeders should be 25% of the pulverizer capacity. The mills should never be operated at this feedrate without ignition support, which is the addition of supplemental oil or gas for start-up and low-load stabilization of the fire in the boiler. Any momentary interruption of coal feed would allow the mill to empty, causing loss of fire and a potential boiler explosion. The minimum feed rate for the Alstom mills without ignitions support is approximately 40% of rated capacity.

Because of the abrasive wear in the inlet and outlet sections to the feeder, liner plates made of carbon or stainless steel can be welded onto the hoppers. As these plates wear through, the liners are removed and replaced with new plate material. The liners protect the outer walls of the hoppers from wearing too thin.

Figure 4-5 shows a clutch-driven feeder, and Figure 4-6 shows a chain-driven feeder.

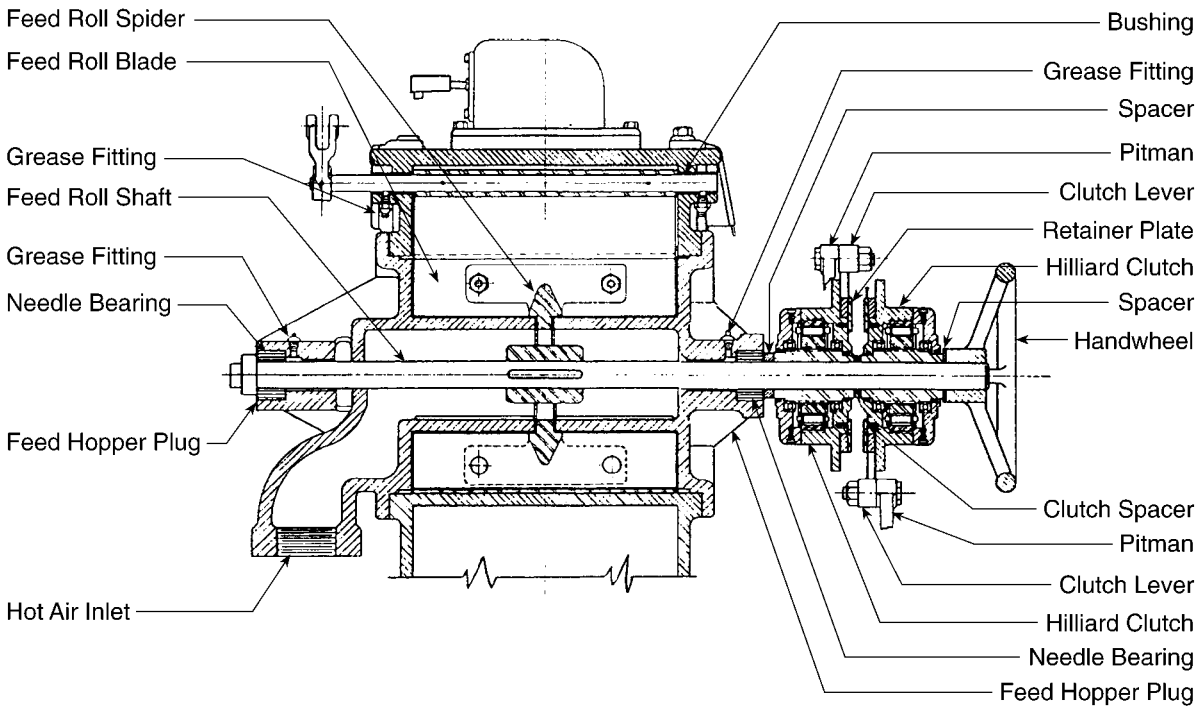


Figure 4-5
Clutch-Driven Feeder [5]

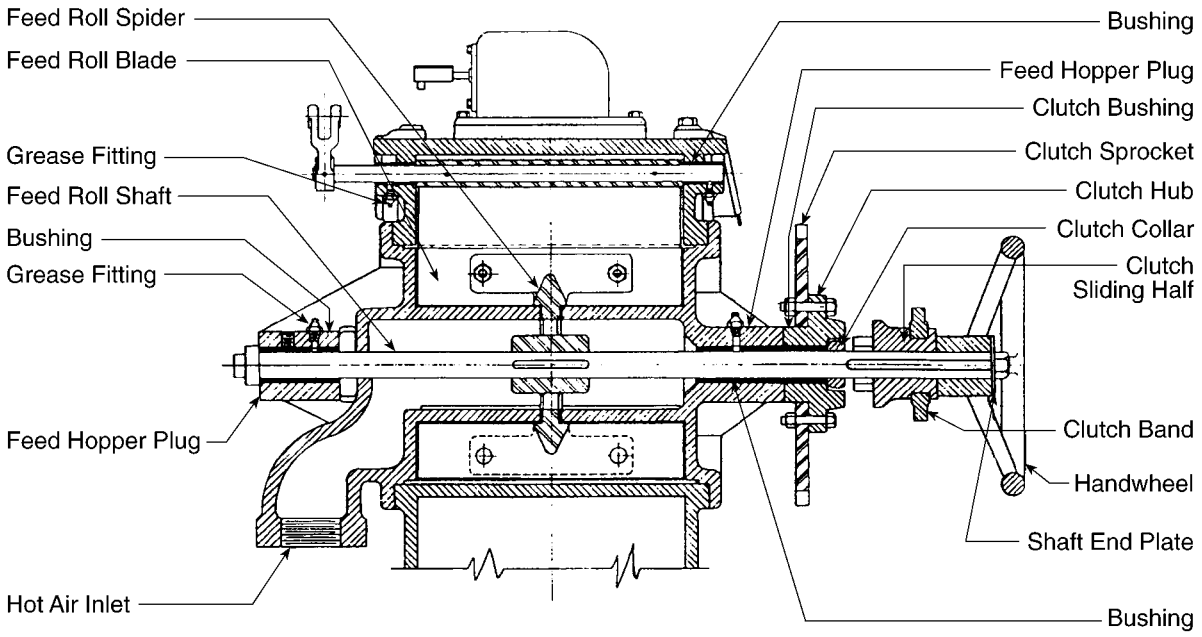


Figure 4-6
Chain-Driven Feeder [5]

Another type of feeder is the gravimetric feeder. Figure 4-7 shows a schematic of a belt-type gravimetric feeder.

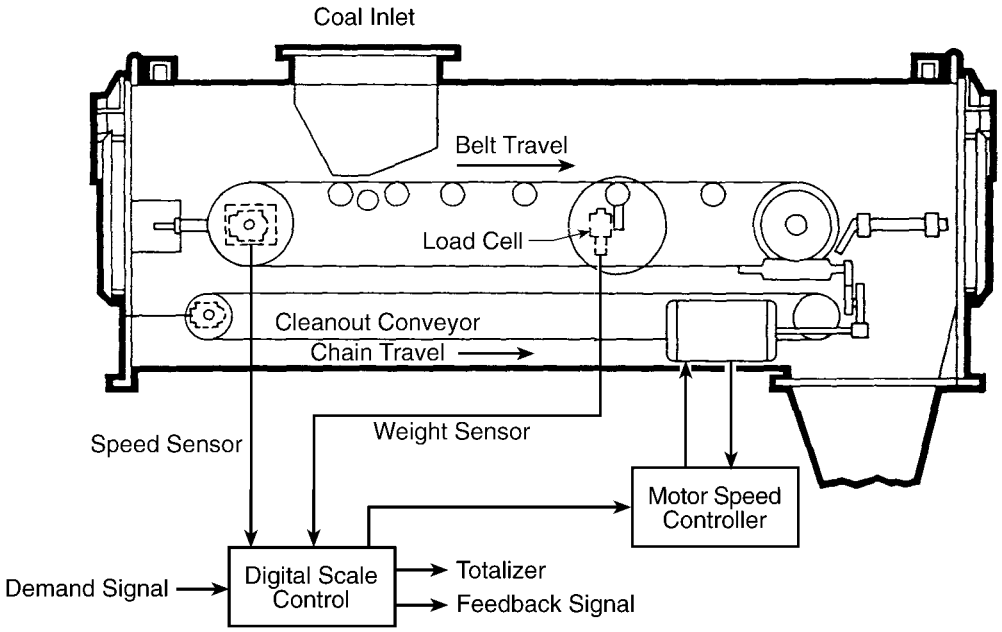


Figure 4-7
Schematic Diagram of a Belt-Type Gravimetric Feeder

Human Performance Key Point

The belts, skirts, leveling plates, and so on require some attention to maintain the integrity and reliability of the feeder and feed rate. Section 10 of this guide lists some areas for preventive maintenance checks. Consistency is required from feeder to feeder. The electronic calibration checks of the weighting elements need to be made on a regular basis to maintain the required accuracy. Verification tests must be developed and performed to maintain the correct interface signals between the weighting elements and the control system.

The gravimetric feeder weighs material on a length of belt between two fixed rollers located in the feeder body. A third roller is located in the middle of the length of belt used for weighing the coal. The center roller is supported at each end by load cells and supports half the weight on the span. As the material passes over the center roller, the load cell generates an electrical signal directly proportional to the weight supported by the center roller. A microprocessor takes samples of the data from each load cell. The data from each load cell are compared and converted into a signal equivalent to the weight per unit of belt length.

The belt speed is measured by an AC tachometer attached to the motor shaft. The microprocessor multiplies the belt weight and speed to find the feeder output. The microprocessor matches the feeder output to the demand output by adjusting the feeder motor speed. In this manner, it corrects for changes in demand or material density due to moisture.

For calibration of the feeder, a weight is used to apply a force on the load cells and calibrate the output. Two plug-in probes measure the belt travel and calibrate the output of the AC tachometer.

4.4 Exhauster

The exhauster [1] operates in a very harsh environment. The high velocities and abrasiveness of the coal cause significant wear of the exhauster internals. For this reason many exhauster wheels and housing liners have been retrofitted with ceramic tiles. The tiles are attached with epoxy and hand-fitted to the metal wheel or housing. The ceramic material is more tolerant of the wear caused by the coal.

The speed of the exhauster or fan wheel is the same speed as the mill motor and the mill input shaft. The vibration levels of the exhauster shaft are important to the overall operation of the mill, motor, and exhauster. Section 11.5.2 in this guide covers balancing of the fan wheel.

Figure 4-8 shows the side view of a typical exhauster.

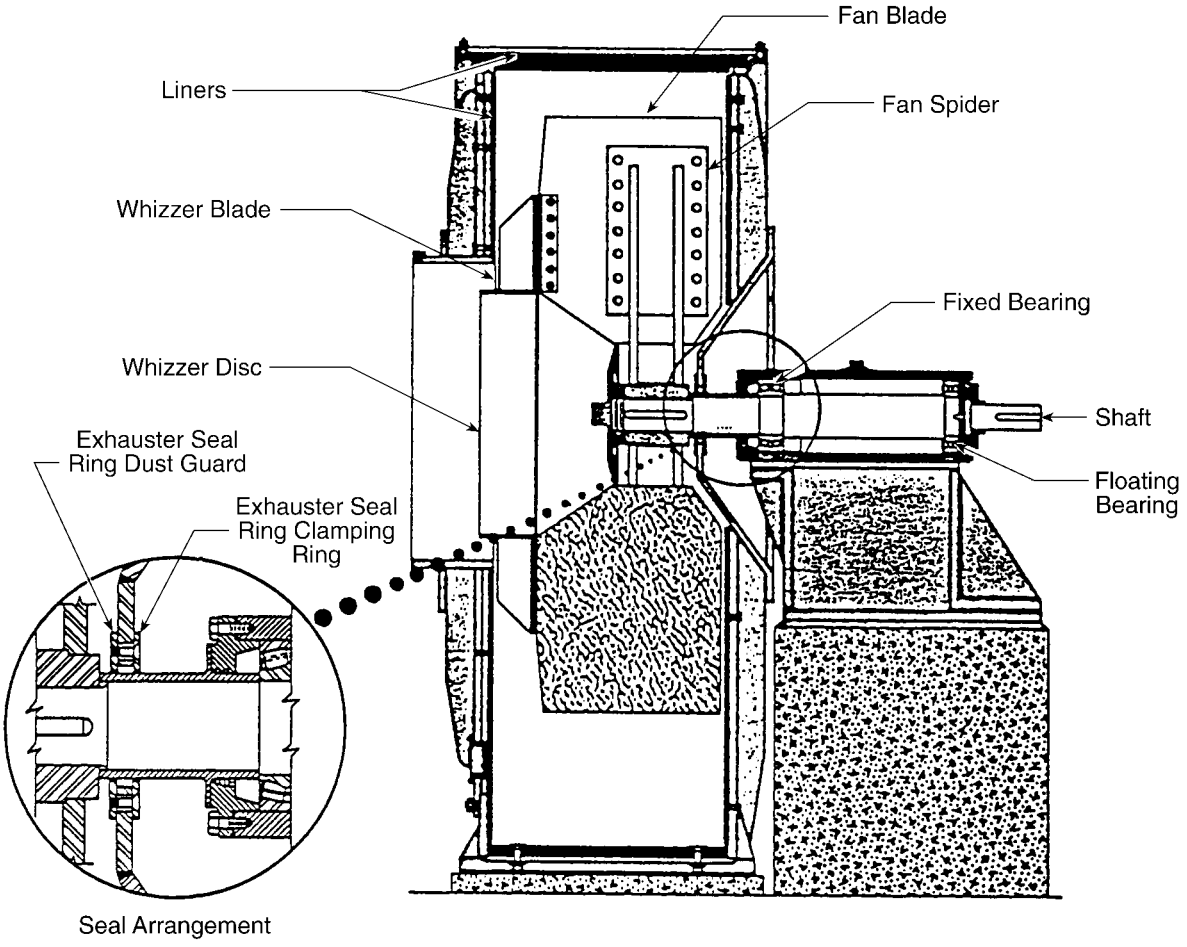


Figure 4-8
Typical Exhauster [1]

There is a figure that shows the front view of an RB style exhauster.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service.power.alstom.com.

The exhauster inlet damper should be properly timed and set up with minimum stops to prevent fuel-line velocity from falling below the minimum pick-up velocity of 3300 ft/min. The setup instructions for the exhauster inlet damper are given in Section 5.1.

The primary riffle distributor is located immediately after the exhauster discharge. The secondary riffles are located after the primary riffle. Eight corner furnaces will have a second stage of riffles typically located between the exhauster and the burner wind boxes.

4.4.1 Exhauster Discharge Valves

For the RB/RS/RPS style mills a discharge valve is located in the exhauster outlet. This valve prevents furnace gas and heat from flowing into the exhauster and mill when mills are first started for a boiler elevation.

There is a figure that shows the seal air valve, discharge valve disc, and pneumatic drive cylinder for the exhauster discharge valve.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

Typically, there is one discharge valve per exhauster. On older RB mills there are four manually operated isolation valves. For the RPS style mills, the discharge valves are located after the pulverizer and before the exhauster. There are four discharge valves per mill that are located directly above the mill.

The discharge valve is the slide-gate type valve. It is composed of a steel plate that slides across the flow area to cut off flow, and it is designed to provide a positive seal between the boiler and the exhauster.

4.5 Air Systems



Technical Key Point

The pulverizer design airflow is 1.5 lb of air per lb of coal at full load. This number can be higher at lower loads.

There are three air systems offered with the Alstom RB mills: suction system, pressurized exhauster system, and cold primary air system.

- **Suction System** – The suction system is shown in Figure 4-9.

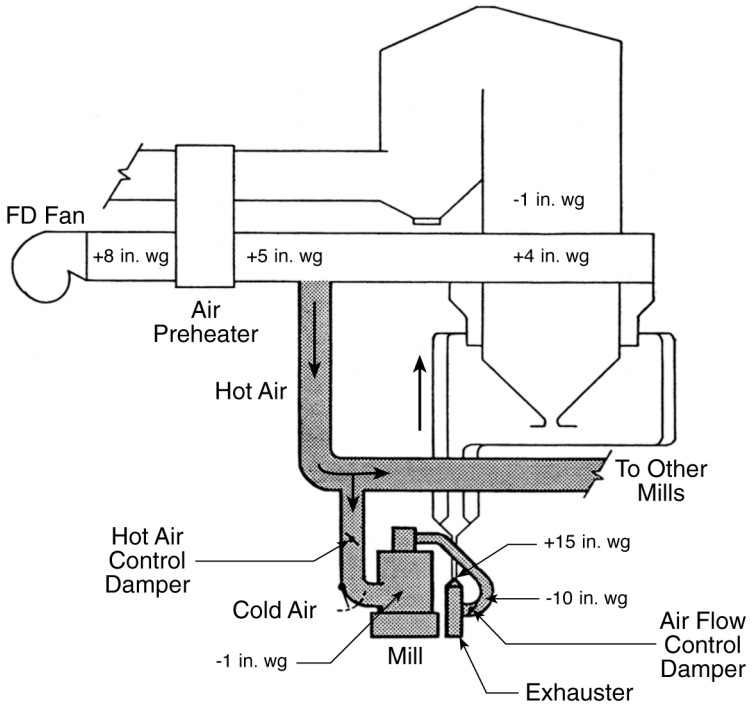


Figure 4-9
Suction System [3]

In this system, the exhauster induces airflow through the mill and discharges the coal and air mixture under pressure to the boiler.

The suction system has several advantages. The area around the mill is relatively clean, and the system is relatively simple. The control of the airflow through the pulverizer occurs with a hot air damper and a barometric damper. The control of ambient air is induced by the suction in the mill. The exhauster fan is designed for a constant, low temperature mixture and has low power consumption. However, the fans have a low efficiency of 55–60%. The main disadvantage of the suction air system is the high maintenance required on the exhauster.

- **Pressurized Exhauster** – The pressurized exhauster system is shown in Figure 4-10.

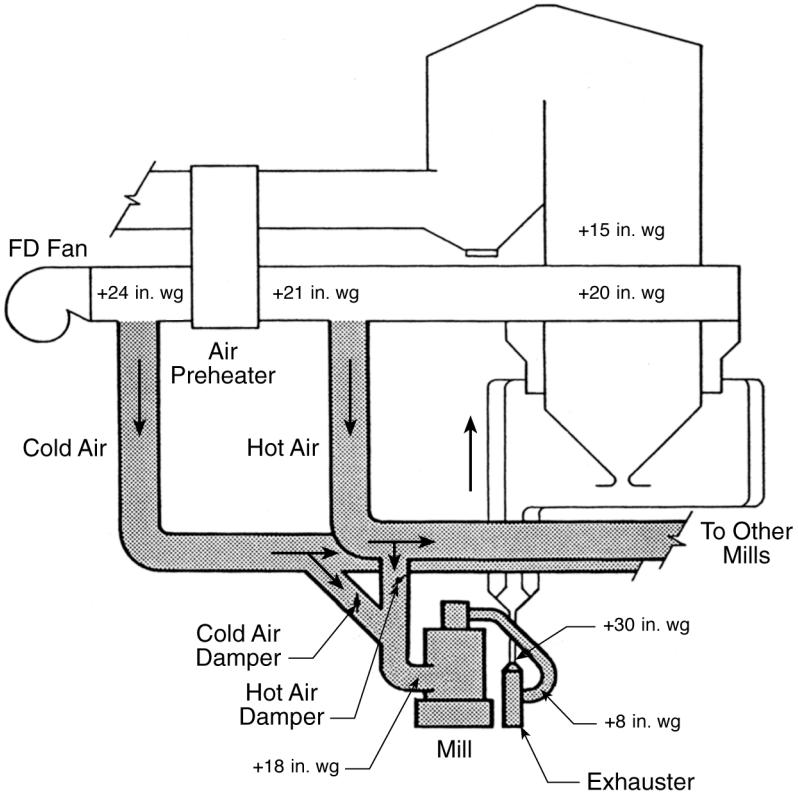


Figure 4-10
Pressurized Exhauster System [3]

The pressurized exhauster system is used with pressurized boilers only. The pulverizer is pressurized by the forced draft fan with both hot and ambient air. The coal air mixture is discharged from the pulverizer through an exhauster that acts as a booster fan.

Two dampers, one in the hot air duct to the mill and the other one in the cold air duct to the mill, control the amount of mill airflow. This flow varies with the amount of fuel being fed to the mill. The airflow is measured by an orifice or other flow measurement device located between the hot and cold air mixing box and the mill. The temperature of the mixture leaving the pulverizer is controlled by biasing the amount of opening between the hot and cold air dampers.

An advantage of the pressurized exhauster system is that the forced draft fan pressure can be used for sealing the pulverizer. Another advantage is that the low pressures in the mill do not interfere with sealing the head of coal over the feeders. The disadvantages of this system are the high maintenance on the exhauster and the presence of coal dust around the mill from leaks.

- **Cold Primary Air System** – The cold primary air (PA) system is shown in Figure 4-11.

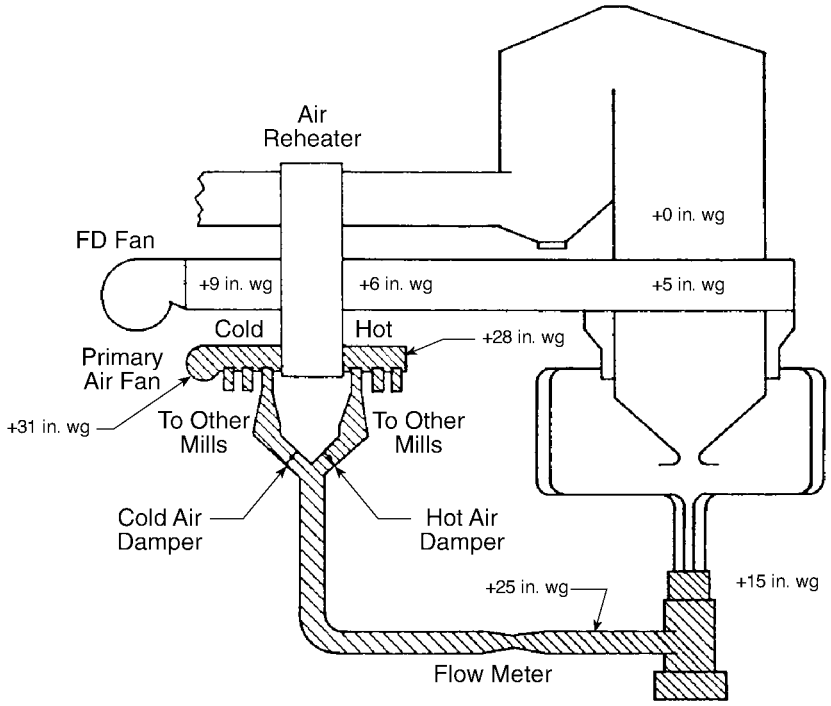


Figure 4-11
Cold Primary Air System [3]

In this system, a primary air (PA) fan forces air through the air preheater, into the mill, and then to the boiler. The primary air fan handles clean, cold air and is located upstream of the air preheater. The primary fans are smaller fans, operating at high speeds with efficient airfoil blade shapes. Inlet vanes are used to control airflow and add to the efficiency gains of the fan.

A main advantage of the cold primary air system is the elimination of the exhauster fans.

With the efficiency of the cold air fans, only one fan is needed for the PA system. The airflow requirement for a mill is met by operating a hot PA damper and a cold PA damper to control temperature in the mill.

4.5.1 Seal Air System

Seal air is provided to prevent contamination of the journal bearings, the gearbox internals, and the exhauster bearings. The journal seal air system prevents coal dust from contaminating the journal lubrication system.

For the RB mills there is an air seal clamp assembly that surrounds the journal head skirt. The portion of the assembly that contacts the journal is made of a soft neoprene material. The slight vacuum in the mill forces air to move in and around the top of the journal, keeping dust purged from around the housing oil seal. If the neoprene is damaged or hardens, the air bypasses the

collar, and dust can fill the space above the oil seal. A labyrinth seal for the RB journal assemblies is available from Alstom. See Section 11.3.2.5 of this guide for more information on this seal.

There is a figure that shows the seal air slots, filler cap, seal air entry point, air seal clamp assembly, air seal assembly, and point of seal air exit for the RB journal air seal clamp assembly.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

For the smaller RS mills, seal air for the journal assembly is supplied through the ends of the trunnion shaft, through holes bored through the shaft and into the journal head. The mill area above the bowl is usually under suction, and air is pulled into this area. The air flows from the journal head through the small annular clearance between the upper journal housing and the journal head skirt. The journal housing rotates, and the journal skirt is stationary. The flow of seal air prevents the coal dust from going up to the area around the oil and possibly contaminating the oil supply.

For the larger RS and RPS/RP mills, the seal air flows around the journal head and between the upper and lower air seal rings. The air then exists around the journal dust cover.

There is a figure that shows the grinding roll, journal housing, oil seal, seal air passage, journal head skirt, and bearings for the RS/PRS/RP journal seal air system.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

The seal pressurizes this area and prevents coal dust from entering. Seal air is ambient air taken from the cold PA duct. The air passes through an air filter and booster fan. The self-cleaning mechanical air filter is designed for large volumes of air at high velocities with a minimum pressure drop. There are usually two seal air booster fans; one operates and the other is used as a spare fan. The booster fans raise the air pressure of the seal air above the operating pressure of the mill.

The RPS/RP gearbox is fitted with a system that prevents hot air and dust from contaminating the bearings.

There is a figure that shows the seal air supply for the standard and alternate assembly for the RPS/RP gearbox air seal.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

Above the upper radial bearings, a dust guard and an oil seal prevent outward leakage of oil and inward leakage of hot air and dust.

The RB/RS mill exhauster uses a mechanical-type dust slinger around the exhauster fan shaft entrance to the exhauster bearing housing.

There is a figure that shows the RB/RS exhauster shaft seal assembly.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

The mechanical seal consists of two inner seal plates and two outer seal plates joined together with hex head cap screws. A 1/32 in. clearance exists above and below the shaft and seal plates for expansion. This seal primarily keeps coal dust from leaking from the exhauster while maintaining a negative pressure within the exhauster.

For the RPS mills, a pressurized air housing is positioned where the shaft penetrates the fan casing. This arrangement compensates for the slight positive pressure in the exhauster near the shaft.

There is a figure that shows the RPS exhauster fan shaft seals.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

4.6 Lubrication System

For the pulverizer mills, bearings and gears require lubrication to reduce friction and wear, remove heat, and prevent rust and corrosion. Grease is composed of oil (mineral or synthetic), thickener (soap or non-soap), and additives. The lubrication systems [5] for the Alstom mills include:

- Journal
- Gearbox: worm and worm gear, vertical shaft
- Exhauster (if present)

Oil can be supplied to the gearbox, rolls, and the exhauster bearings from the outside of the Alstom RBMs while they are in operation. Figure 4-12 shows the RB pulverizer and areas for lubrication. Table 4-3 lists the specifics for the RB style mill lubrication systems.

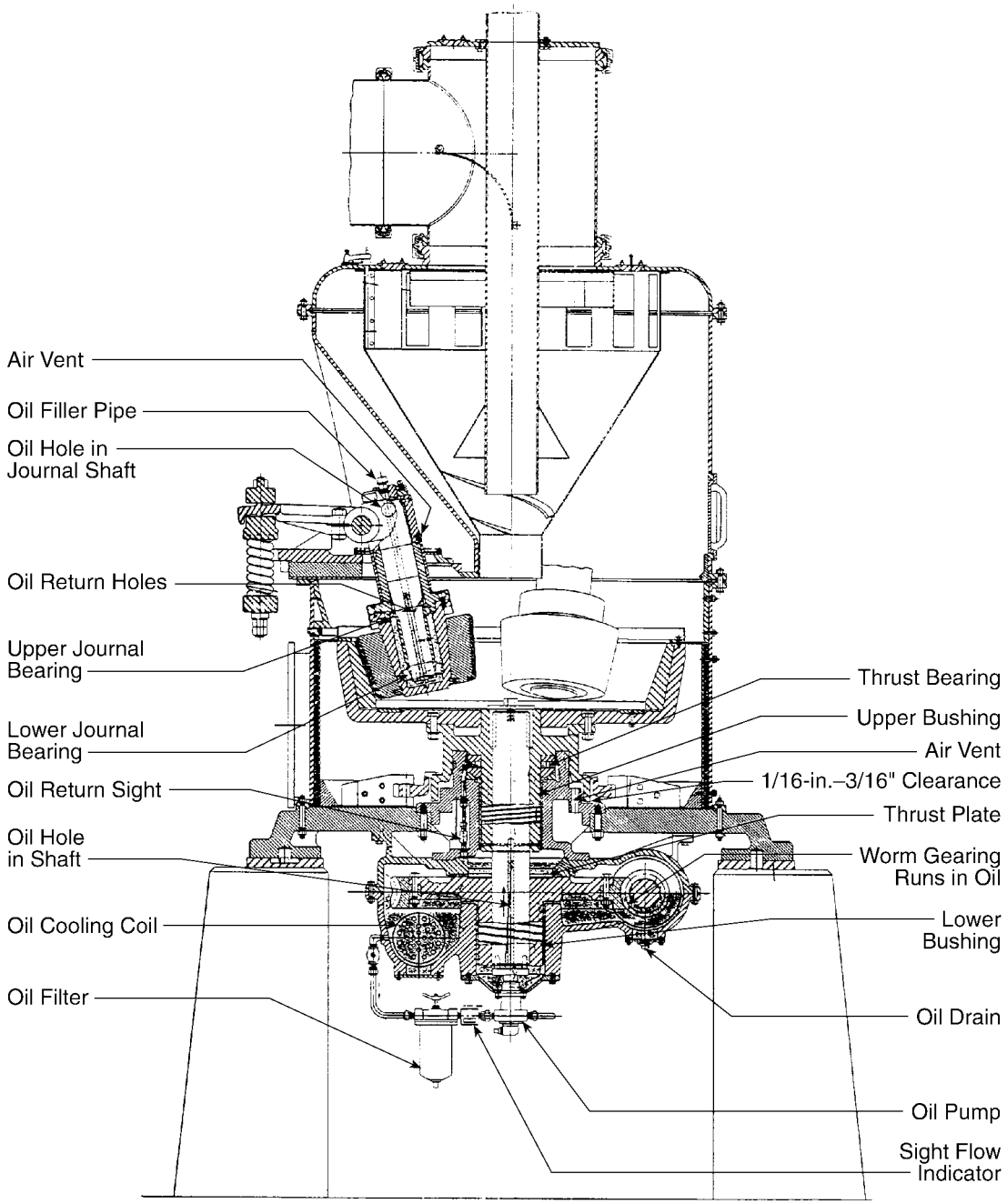


Figure 4-12
RB Style Mill Lubrication Areas [5]

Table 4-3
Pulverizer Mill Lubrication Parameters [5]

Component	Observation Frequency	Change Interval	Oil Level	Fitting	AGMA Number	ISO Viscosity Grade	Viscosity	Pour Point	EP Type Additive	Quantity (gal)
Gearbox – worm drive (RB/RS/RPS mills)	Daily	6 months sample analysis	Sight glass	Fill pipe in sump or oil tank	6EP	320	288 to 352 CST @ 40ºC (1505 to 1840 SSU @ 100ºF) 21.8 to 26.4 CST @ 100ºC (108 to 129 SSU @ 212ºF)	+10ºF maxi-mum	Sulfur phosphorus	Consult Alstom
Gearbox – double reduction	Daily	6 months Sample analysis	Sight glass	Fill pipe in sump or oil tank	6EP	320	288 to 352 CST @ 40ºC (1505 to 1840 SSU @ 100ºF) 21.8 to 26.4 CST @ 100ºC (108 to 129 SSU @ 212ºF)	+10ºF max.	Sulfur phosphorus	350
Gearbox – triple reduction	Daily	6 months Sample analysis	Sight glass	Fill pipe in sump or oil tank	7EP	460	414 to 506 CST @40ºC (2185 to 2671 SSU @ 100ºF) 26.4 to 32.1 CST @ 100ºC (129 to 155 SSU @ 212ºF)	+20ºF max.	Sulfur phosphorus	100 upper, 225 lower, 325 total

Table 4-3 (cont.)
Pulverizer Mill Lubrication Parameters

Component	Observation Frequency	Change Interval	Oil Level	Fitting	AGMA No.	ISO Viscosity Grade	Viscosity	Pour Point	EP Type Additive	Quantity (gal)
Journals – Sleeve bearings	3 months max.	6 months– 1 year	Dip-stick	Reservoir cap	6EP	320	288 to 352 CST @ 40ºC (1505 to 1840 SSU @ 100ºF) 21.8 to 26.4 CST @ 100ºC (108 to 129 SSU @212ºF)	+10ºF maxi-mum	Sulfur Phosphorus	Consult Alstom
Journals – Rolling element bearings	3 months max.	6 months– 1 year	Dip-stick	Reservoir cap	8EP	680	612 – 748 CST @40ºC (3261 to 3986 SSU @ 100ºF) 32.1 – 41.1 CST @100ºC (155 to 197 SSU @ 212ºF)	+20ºF max-imum	Sulfur Phosphorus	Consult Alstom
Journal hydraulic	Daily	6 months– 1 year	Sight glass	Reservoir cap	Turbine -grade	68	61.2 – 74.8 CST @40ºC (314 to 383 SSU @ 100ºC (51 – 59 SSU @ 212ºF)	0ºF maxi-mum	Anti-wear	60

Table 4-3 (cont.)
Pulverizer Mill Lubrication Parameters

Component	Observation Frequency	Change Interval	Oil Level	Fitting	AGMA Number	ISO Viscosity Grade	Viscosity	Pour Point	EP Type Additive	Quantity (gal)
Exhauster bearings	Daily	Yearly	Sight glass	Reservoir plug	7EP	460	414 to 506 CST @40ºC (2185 to 2671 SSU @ 100ºF) 26.4 to 32.1 CST @ 100ºC (129 to 155 SSU @ 212ºF)	+20ºF max.	Sulfur Phosphorus	Consult Alstom
Vari-stroke feeder drive	Daily	Yearly	Sight glass	Reservoir fill pipe	6EP	320	288 to 352 CST @ 40ºC (1505 to 1840 SSU @ 100ºF) 21.8 to 26.4 CST @ 100ºC (108 to 129 SSU @ 212ºF)	+10ºF max.	Sulfur Phosphorus	11 qt
Feeder reduction gear	Daily	Yearly	Sight glass	Reservoir fill pipe	6EP	320	288 to 352 CST @ 40ºC (1505 to 1840 SSU @ 100ºF) 21.8 to 26.4 CST @ 100ºC (108 to 129 SSU @ 212ºF)	+10ºF max.	Sulfur Phosphorus	1 qt

There is a table that lists the gearbox oil quantity for the different style mills.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a table that lists the journal sleeve bearing oil quantity for the different style mills.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a table that lists the journal rolling element bearings oil quantity for the different style mills.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a table that lists the exhauster bearings oil quantity for the different style mills.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

4.6.1 Journal

There is a figure showing the RB journal lubrication arrangement of oil filler cap, air vent, oil return hole, upper journal bearing, and lower journal bearing.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a figure showing the RS/RPS/RP journal lubrication arrangement of the oil return hole, journal seal air, upper journal bearing, and lower journal bearing.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a figure showing the 110-in. RP journal lubrication arrangement of journal head, air seal rings, O-rings, lower journal bearing, grinding roll, trunnion shaft, journal seal air, journal shaft, and journal oil fill.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

4.6.2 Gearbox

Figure 4-13 shows the oil system in the RB style mill gearbox.

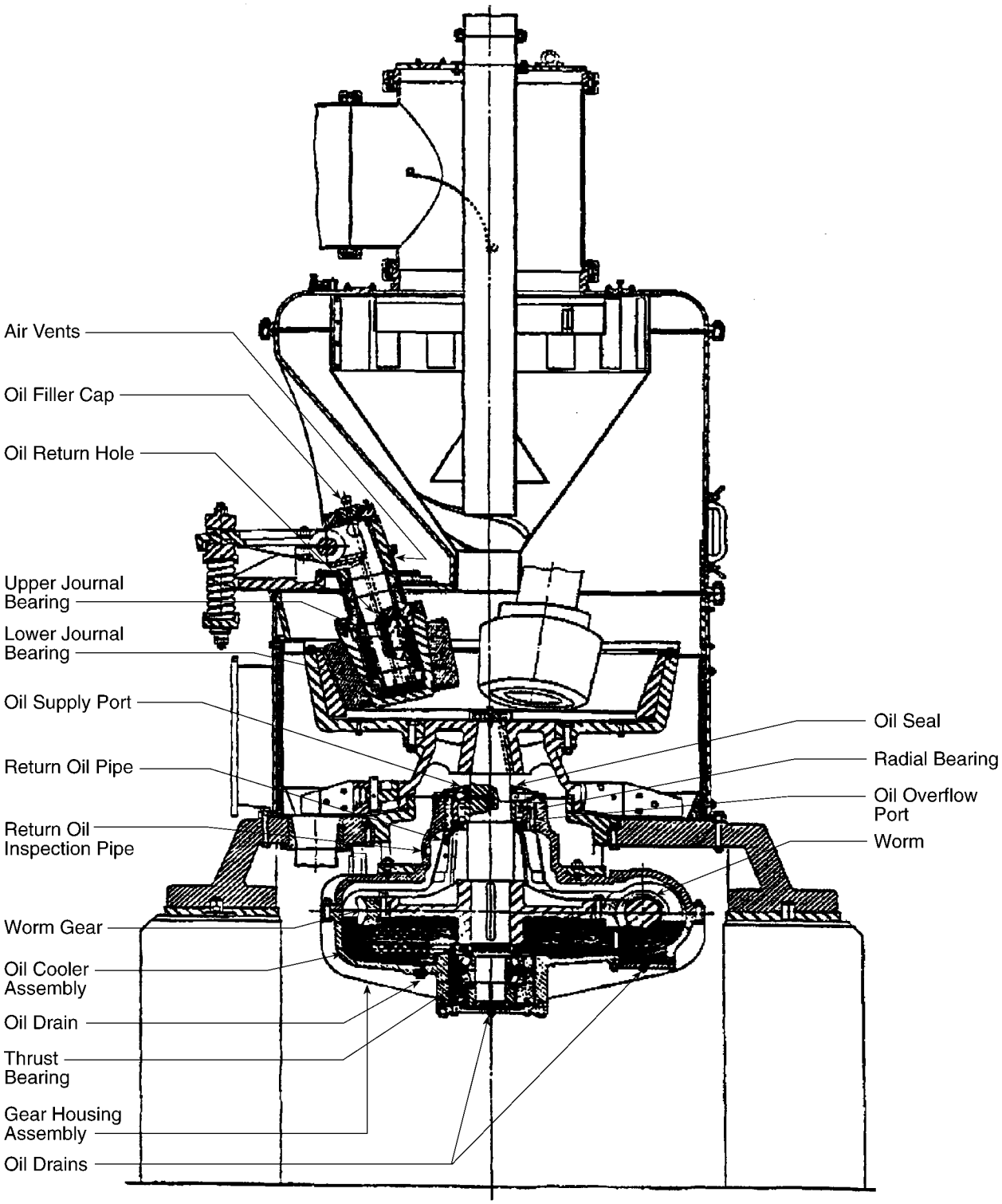


Figure 4-13
Gearbox Oil System [1]

The gearbox can be filled with oil through the filler cap. The oil level should be maintained to the center of the worm gear when the mill is idle. An oil change should be made when an oil sample analysis indicates deteriorating oil conditions. See Section 9.2 for more details on oil analysis.

A thermocouple is installed in the sidewall of the lower gearbox casing to measure the oil temperature, which should not exceed 160ºF. If the oil temperature is above 160ºF, the following may be occurring:

- The oil level is too low.
- The lubricant properties have deteriorated.
- The oil cooler has scale in it.
- The water supply to the oil cooler is too low.
- The inlet water supply temperature is too high.

The bearings in the gearbox are lubricated in several ways. The vertical shaft thrust bearings are immersed in oil and are flood lubricated. The pumping action of the thrust bearing assembly circulates oil through the gearbox.

The worm gear bearings are flood lubricated from the oil bath in the gear case. The pumping action of the worm gear thrust bearing circulates oil through the gearbox. The radial bearing oil circulation is provided by the pumping action of the worm gear.

Oil is supplied by an external oil pump or an internal oil pump hub to the vertical shaft upper radial bearing through a hole drilled in the vertical shaft. The oil discharges above the bearing, flooding the bearing as it passes through it. The oil then returns to the gearbox through the oil collector overflow with some of the oil flow going through the oil sight glass return line on the upper gear housing.

Early gearbox designs have an external lubrication system using a motor-driven oil pump and filter assembly and an external oil cooler. The pump discharges oil to separate oil lines going to the worm gear bearing housings and the gearbox thrust bearing housing. At the thrust bearing housing, the oil is forced up the vertical shaft oil hole to the upper radial bearing. Each oil line has an oil flow meter and flow control valve on it to regulate the oil flow.

Later designed gearboxes use an internal lubrication system with a tube-type oil cooler set in the lower gearbox housing. A spiral-grooved oil pump hub is connected to the vertical shaft. The pump rotates against a replaceable bushing on the thrust bearing housing. Oil from the gearbox housing enters an annular chamber in the oil pump bushing at the top of the oil pump through drilled holes. As the shaft rotates, the spiral grooves in the pump hub force the oil into a cavity in the thrust bearing housing below the vertical shaft. From the cavity, the oil rises through the vertical shaft oil hole to the upper radial bearing.

The flow of oil from the vertical shaft upper radial bearing should be checked periodically by observation through the sight glass window attached to the upper gear housing. Normal flow is approximately a 1/4-in. diameter stream. A narrower stream indicates a worn oil pump bushing, worn oil pump hub, or obstruction forming in the vertical shaft oil hole or sight glass return line. If no flow is present during operation, stop the pulverizer. During start-up, the oil flow takes a few minutes to appear, especially if the oil is cold. However, the pulverizer should be stopped if oil flow does not appear within 10 minutes of start-up.

The lubrication system in the gearbox includes the vertical shaft oil pump and the worm gearing.

A lubrication skid for an RP mill is shown in Figure 4-14.



Figure 4-14
External Lubrication Skid
(Courtesy of Great River Energy)

There are figures that show a typical gearbox for an RP mill, a double reduction gearbox, and a reduction gearbox.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service.power.alstom.com.

4.6.3 Exhauster

There is a figure that shows the typical exhauster bearing lubrication arrangement and oil level.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

4.7 Pyrite Rejection System

The pyrite rejection system removes material (typically, tramp iron and foreign objects) from the mill bowl that cannot be easily ground and burned in the boiler. Tramp iron is defined as any metal that enters the pulverizer with the coal, for example, nuts, bolts, scrap steel, and tools. The removal process occurs when the heavier material falls out of the bowl to the millside area below.

The pivoted scraper assembly that is attached to the bowl sweeps the foreign material around to the reject chute, which directs the material outside the mill. Figure 4-15 shows a pivoted scraper assembly.

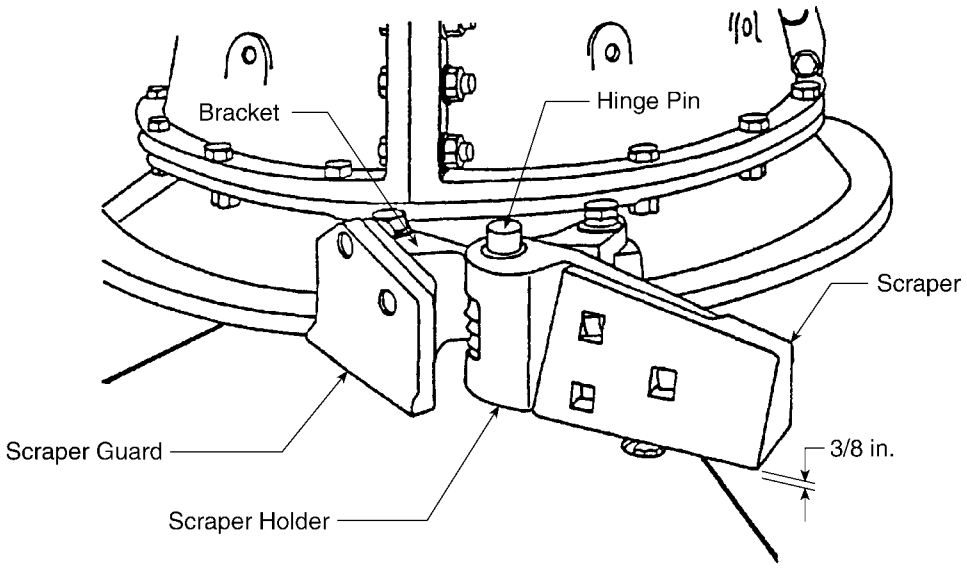


Figure 4-15
Pivoted Scraper Assembly [1]

Figure 4-16 shows a scraper assembly for an RP-1043 mill.



Figure 4-16
Scraper Assembly for an RP-1043 Mill
(Courtesy of Great River Energy)

In the RB/RS mill, the material falls onto a counterweighted plate in the reject chute. During normal operation, the plate remains closed. When material accumulates against the plate, the plate opens and the material falls into a hopper.

There is a figure that shows the weighted pyrite rejection chute consisting of a plate, tramp iron spout, and counterweight.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

In the RPS/RP mill, the material falls through a seal door into a pyrite hopper where it is stored for slurry transfer. A sizing grid is located inside the reject hopper. Small pieces pass through the grid and are stored in the bottom of the hopper until the jet pump transfers the materials to a waste storage area. Figure 4-17 shows a mixing chamber for a reject slurry mixture.



Figure 4-17
Mixing Chamber for a Reject Slurry Mixture
(Courtesy of Great River Energy)

A floodlight is installed inside the hopper to enable the operator to observe through the handhold observation port the accumulation of oversized pyrite on the sizing grid. The operator can remove the oversized material through the observation port handhold.



Human Performance Key Point

For the RPS/RP mills, the observation port handhold should never be opened when the hopper isolation valve is open. This will expose personnel to hot pulverizer air that can cause serious injury.

5
MILL OPERATION/SAFETY

This section [1] [4] [5] covers mill operating parameters, startup/shutdown, and mill fires.

5.1 Mill Operating Parameters



Technical Key Point

Safely operating an Alstom mill means meeting the following criteria:

- Minimum pipe velocity is 3300 ft/min.
- Exit temperature of the mill is 150–180ºF.
- Air/fuel ratio is between 1.6 and 2.4.

To meet the safe operating criteria, the following operating parameters must be established:

- Feeder rate of coal into the mill
- Temperature and flow of the primary air
- Pressure between the rolls and the grinding bowl
- Setting of the classifier
- Exhauster inlet damper setup (if applicable)

- **Feeder rate of coal into the mill**



Human Performance Key Point

The manufacturer's recommendation is not to operate the mills below 40% of the design capacity without ignition support in the boiler. Below 40% design capacity, the air and fuel mixture can cause coal flame stability problems and boiler explosions. With ignition support the minimum feeder rate is 25% of the pulverizer capacity. At feed rates below 25% capacity, any momentary interruption of coal feed will allow the pulverizer to empty. This will cause a loss of boiler fire and possible boiler explosion.

As more emphasis is placed on low-load operation, the use of boiler ignition support below a 40% load may require new perspectives from Alstom.

For the Alstom RB bowl mills, Tables 5-1 and 5-2 show the design capacity, minimum feeder rate without ignition support (40% capacity), and minimum feeder rate with ignition support (25% capacity).

Table 5-1
Mill Capacities for RB Mills [4]

Bowl Mill Designation RB	Design Capacity (lb/hr)	Minimum Feeder Rate Without Ignition Support (lb/hr)	Minimum Feeder Rate with Ignition Support (lb/hr)
312	3,550	1,420	887
312A	4,000	1,600	1,000
351	4,450	1,780	1,112
352A	5,300	2,120	1,325
372	6,200	2,480	1,550
372A	7,100	2,840	1,775
412	8,000	3,200	2,000
452	9,700	3,880	2,425
453	11,500	4,600	2,875
473	13,300	5,320	3,325
473A	15,500	6,200	3,875
493	16,800	6,720	4,200
533	20,300	8,120	5,075
533A	23,800	9,520	5,950
573	26,500	10,600	6,625
593	28,200	11,280	7,050
613	32,700	13,080	8,175
633	36,500	14,600	9,125
673	41,500	16,600	10,375
713	50,100	20,040	12,525
733	54,500	21,800	13,625
753	59,100	23,640	14,775

Table 5-2
Mill Capacities for RS, RPS, and RP Mills [4]

Bowl Mill Designation	Design Capacity (lb/hr)[1]	Minimum Feeder Rate Without Ignition Support (lb/hr)	Minimum Feeder Rate with Ignition Support (lb/hr)
443 RS,RPS	14,000	5,600	3,500
463 RS,RPS	16,200	6,480	4,050
483 RS,RPS	18,700	7,480	4,675
503 RS,RPS	21,200	8,480	5,300
523 RS,RPS	24,000	9,600	6,000
543 RS,RPS	27,000	10,800	6,750
583 RS,RPS	33,200	13,280	8,300
603 RS/RPS	36,800	14,720	9,200
623 RS,RPS	40,500	16,200	10,125
643 RS/RPS	44,500	17,800	11,125
663 RS,RPS	48,500	19,400	12,125
683 RS,RPS	53,000	21,200	13,250
703 RS,RPS	58,000	23,200	14,500
723 RS/RPS	63,000	25,200	15,750
743 RS/RPS	68,500	27,400	17,125
763 RS/RPS/RP	74,500	29,800	18,625
783 RS/RPS/RP	80,500	32,200	20,125
803 RS/RPS/RP	87,500	35,000	21,875
823 RS/RPS/RP	93,500	37,400	23,375
843 RS/RPS/RP	100,000	40,000	25,000
863 RS/RPS/RP	106,000	42,400	26,500
The values for the 943, 963, 983, 1003, 1023, 1043, 1063, 1103 RP mills were considered proprietary by Alstom.			
[1]Note: The values in this table for shallow bowl design assume a 55 grindability coal and 90% motor efficiency.			

- **Temperature and flow of the primary air** – Primary air provides the means to dry, classify, and transport the coal from the grinding zone of the mill through the classifier, exhauster, and into the distributor box. For the RB and RS pulverizer system used with a balanced draft furnace, the primary air consists of hot air from the air preheater outlet at a temperature of approximately 500ºF combined with ambient air at about 100ºF. Figure 5-1 shows the RB/RS air supply system.

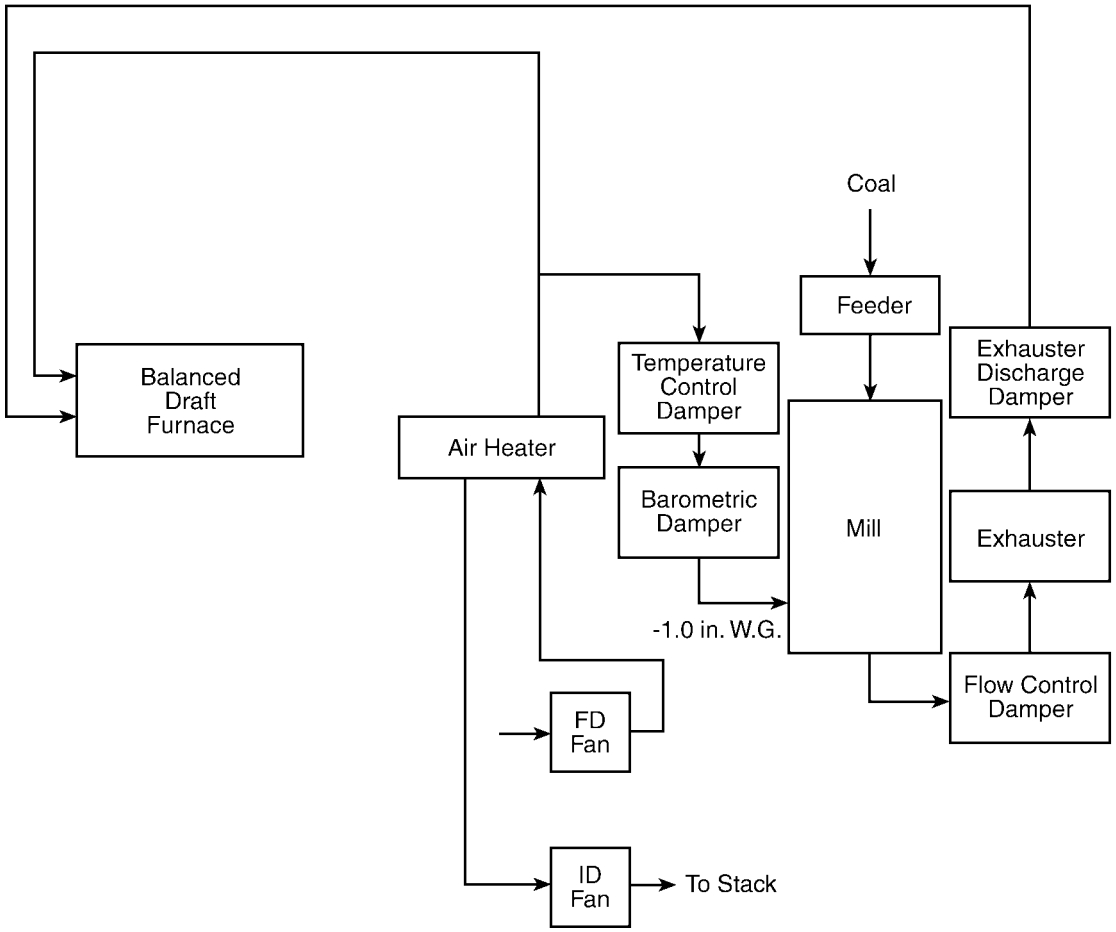


Figure 5-1
RB/RS Air Supply System

The hot PA flow is controlled by the pulverizer outlet temperature. The cold air for the mill is controlled by a barometric damper, sometimes called a tempering damper. The actual inlet PA temperature will vary significantly with the mill loading and total moisture of the coal. The mill outlet temperature of 160ºF ± 10ºF remains relatively constant. It is not uncommon for the mill inlet temperature to be near the air preheater outlet or boiler inlet temperature of 480–500ºF.

The RPS pulverizer system is used for a pressurized furnace application. The cold air is supplied before the air preheater, and the hot air is supplied after the air preheater. Two dampers for each mill regulate the mill outlet temperature PA flow entering the mill. Figure 5-2 shows the RPS air supply system.

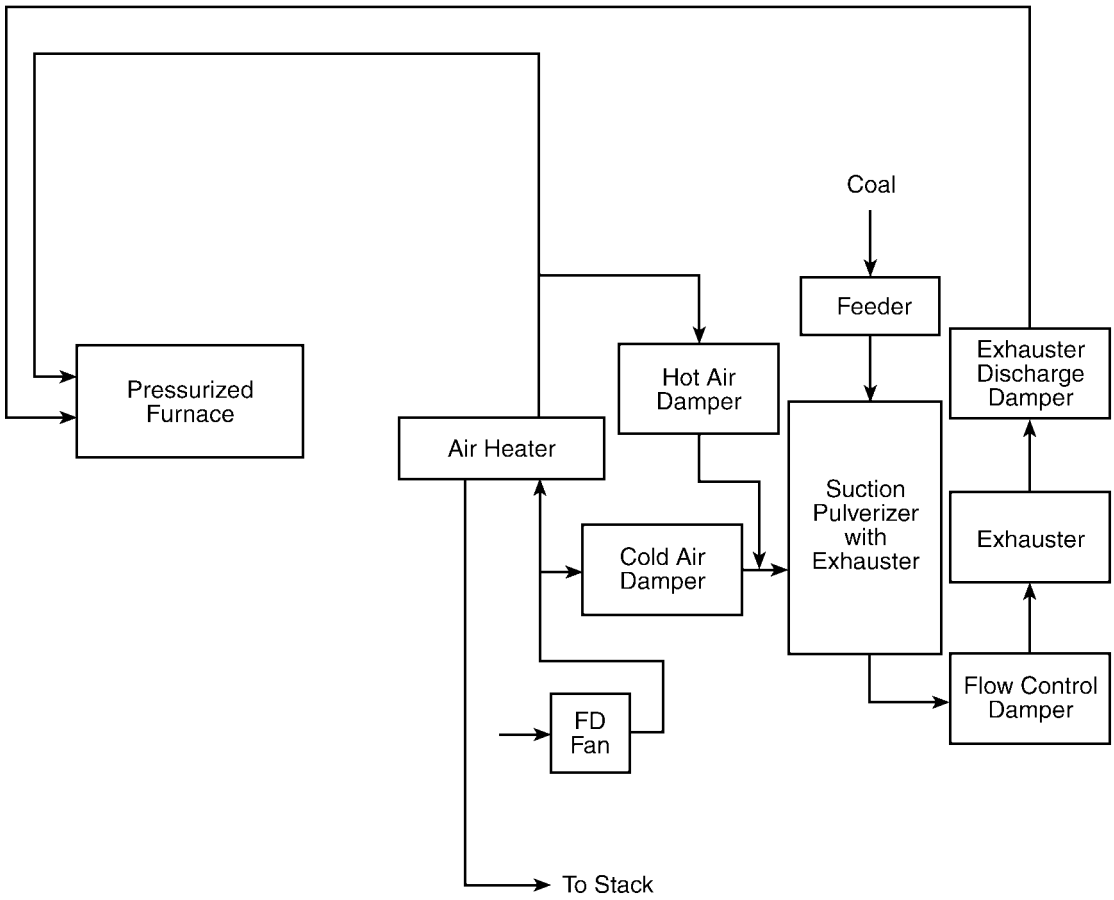


Figure 5-2
RPS Air System

The RP pulverizer system is used with a balanced draft furnace or pressurized furnace. The air enters the mill from the PA fans. These fans supply cold air taken before the air preheaters and hot air taken after the air preheaters. Two dampers for each mill regulate the mill outlet temperature and primary airflow entering the mill. Figure 5-3 shows the RP air supply system.

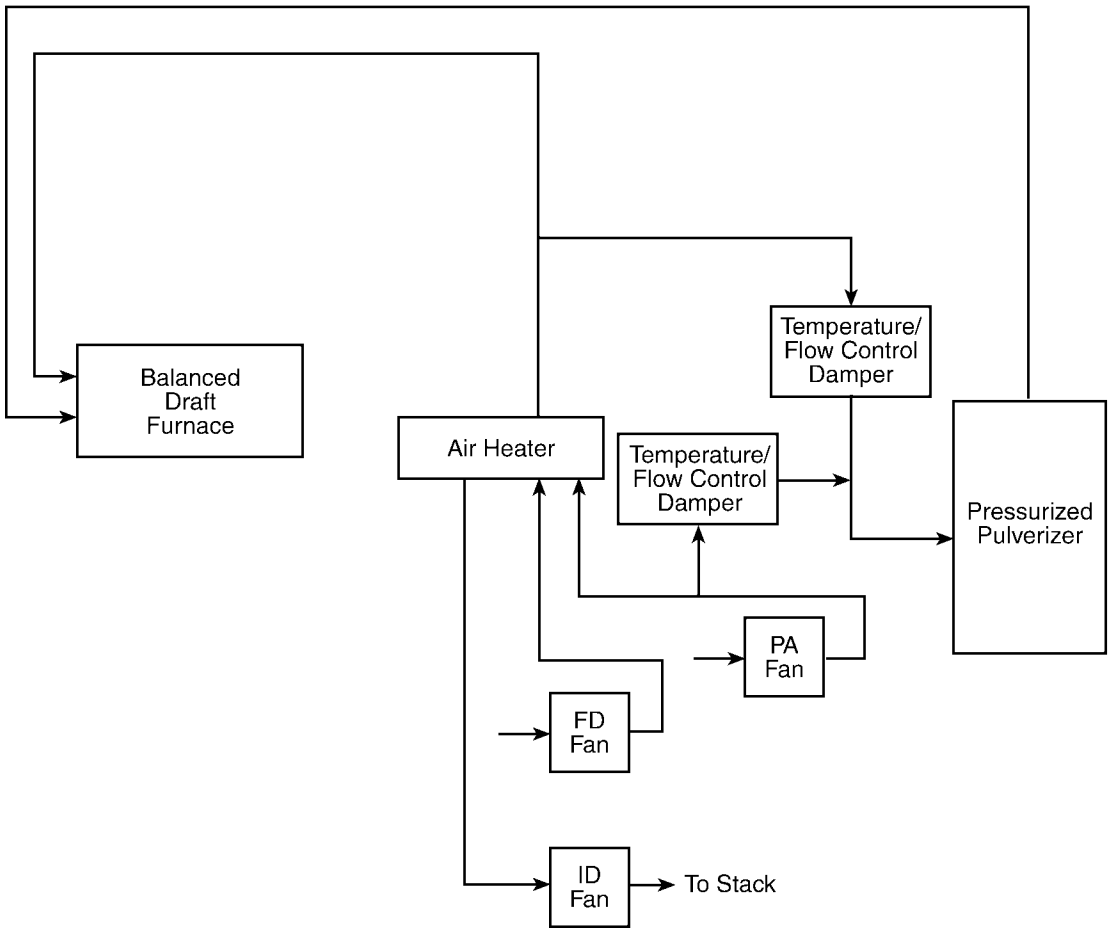


Figure 5-3
RP Air System

Two constraints for the PA flow are:

- Ability to maintain the minimum air velocity (3000–3300 ft/min) to transport the coal
- Capacity of the exhauster fan to move the air and fuel mixture

The correct air and fuel ratio for a RB mill is normally 1.8 to 2.2. It is acceptable to go as low as 1.5 lb air/lb fuel at nearly full-load conditions. This ratio is not possible at lower loads in order to maintain the minimum air velocity to transport the coal. The advantages for a lower air and fuel ratio are:

- Reduced exhauster fan power requirements with more motor power are available for mill grinding.
- Lower velocities reduce mill and transport piping erosion.
- Classification improves because reduced velocities do not carry the heavy particles out of the mill. The heavy particles then drop down and are ground again to finer particles
- More open classifier blade settings exist.
- Fires and explosions are reduced because there is less air for combustion.
- Balance in the rifflers and pipe distribution is improved. Higher air and fuel ratios cause biasing from the primary riffler outlet to the secondary riffler inlet.

The deep bowl mills do not typically have air and fuel ratio control. However, this function is accomplished through the settings of the exhauster inlet damper and the feeder speed. The initial and final damper setting procedure can be found in Section 5.1 on exhausters.

- **Pressure between the rolls and the grinding bowl –** The pressure between the rolls and the grinding bowl is controlled by the spring settings for each roller. See Section 11.3.2.3 for details on this setting.
- **Setting of the classifier –** With increasing fineness, there is a decrease in the capacity of the mill and an increase in the auxiliary costs (motor) to produce the desired fineness.

Classifiers are either the stationary vane or rotary design. For the stationary vane design, the fineness is adjusted by moving the deflector pointers on the top of the separator. See Figure 5-4 for the point and vane alignment.

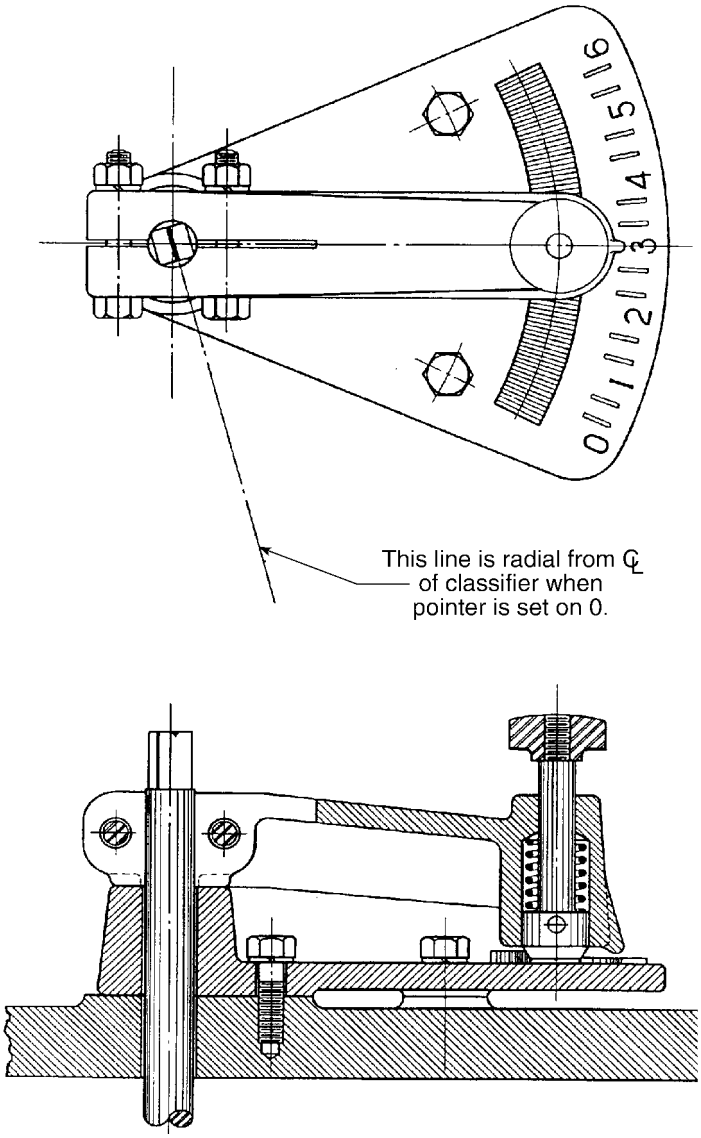


Figure 5-4
Classifier Pointer and Vane Alignment [5]

Coal samples should be taken after the mill is returned to service following a classifier calibration. Adjustments can be made based on the fineness results. Moving the blade toward 0 increases coarseness. Moving the blade toward 6 (individual deflectors) or 10 (ganged deflectors) increases the fineness. The pointers should be set the same and periodic checks should be made to ensure proper settings.

Plotting the fineness test results for the 50 mesh and 200 mesh test results versus the deflector regulator setting gives an indication of the dead-band problems in the classifier settings.

Technical Key Point

For optimum mill operation, the classifier pointers should be set between 0 and 3. If the coal is too fine when the setting is on point 1, the spring pressure on the rolls may be too great. If the coal is too coarse when the setting is on 3, the spring pressure on the rolls may not be enough.

The adjustable cone at the bottom of the classifier inner cone should be set so that the clearance to the inner cone is approximately 3.0 in. up to a maximum of 5.0 in. If the clearance is too small, bridging of coal between the inverted cone and classifier cone will occur. If the opening is too large, the large coal particles can be carried out of the mill due to high-velocity air, and poor fineness results. The clearance between the adjustable cone (inverted cone) and the inner cone should not be less than 2 in. Figure 5-5 shows the inverted cone clearance.

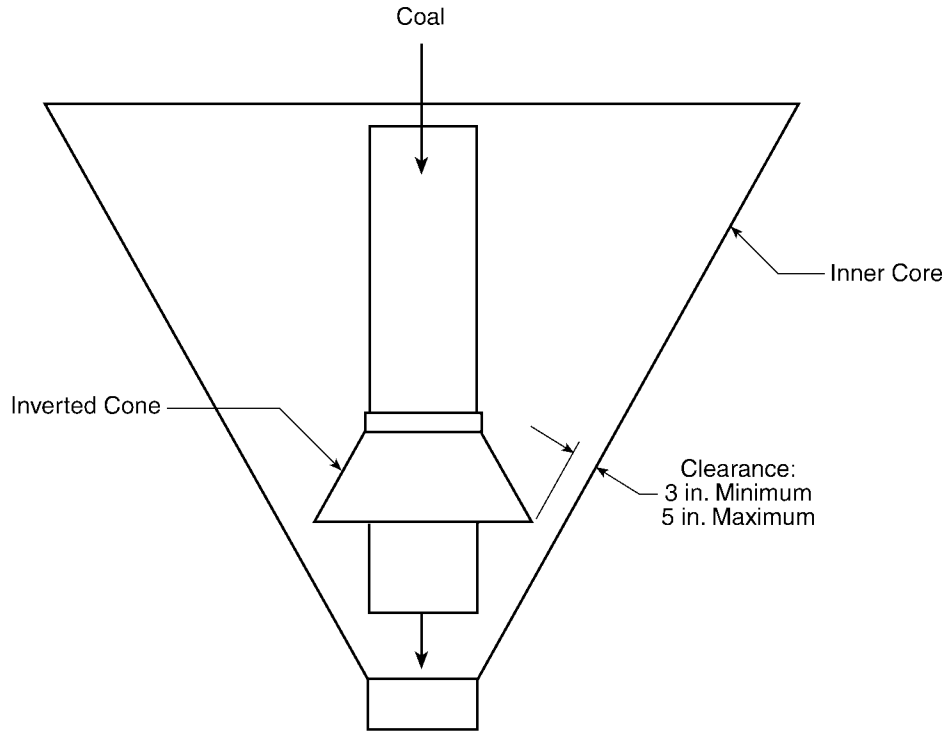


Figure 5-5
Inverted Cone Clearance

Technical Key Point

If the inverted cone is raised to a point that the clearance between the inverted cone and inner cone is greater than 4 in., coarse coal will be carried out of the mill and not returned to the bowl for grinding.

- **Exhauster inlet damper setup [5]:** For units with exhausters, it may be necessary to adjust the airflow through the mill to maintain the correct fuel-to-air ratio (for reduced mill capacity). A reduction in airflow is accomplished by adjusting the inlet damper to the exhauster. See Figure 5-6 for a picture of the exhauster inlet pipe.

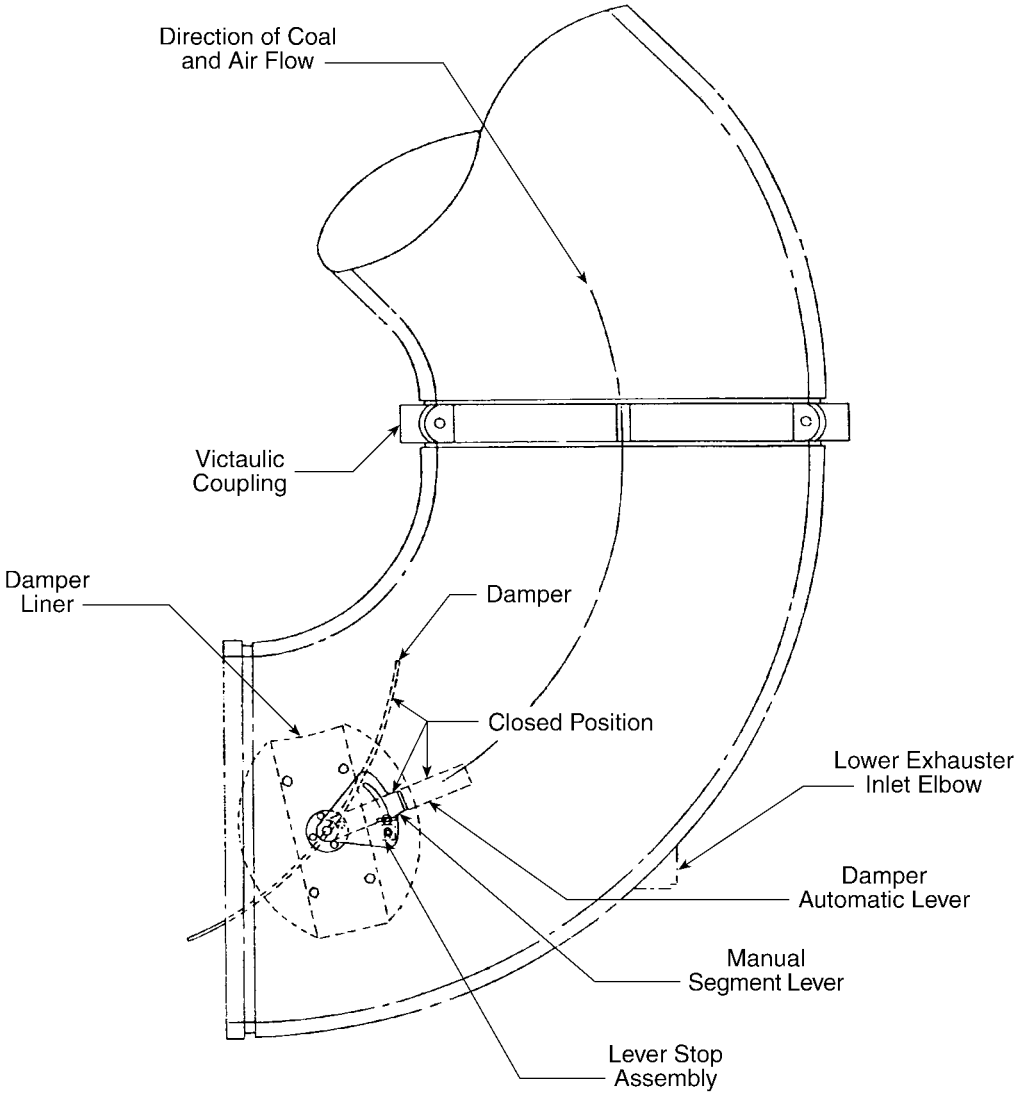


Figure 5-6
Exhauster Inlet Pipe [5]

The inlet damper is approximately the same size as the inside of the pipe. A mechanical stop is provided for minimum inlet flow for the mill.

Table 5-3 shows the initial and final inlet damper procedure.

Table 5-3
Initial and Final Inlet Damper Procedure [4]

Initial Inlet Damper Setting Procedure
1. Install a manometer at the exhauster fan discharge.
2. With the mill operating and no coal flow, open the exhauster fan inlet damper until the discharge pressure as measured by the manometer is no longer increasing. Record this pressure.
3. Establish this position as the full open position of the exhauster inlet damper. Any further degree of opening will delay the response time. Note: Once the exhauster inlet damper is open to about 75–80%, any further degree of opening will have no effect on the exhauster discharge pressure.
4. Calculate the discharge pressure that corresponds to 70% of the value recorded in Step 2.
5. Close the damper to provide a fan discharge pressure equal to 70% of the wide-open discharge pressure. This will become the damper's temporary minimum position, and a stop should be temporarily placed to prevent the damper from closing beyond this point.
Note: This initial procedure ensures an adequate amount of PA for the final setting procedure.
Final Inlet Damper Setting Procedure
1. Open the exhauster fan inlet damper to the full open position as established in the initial setting procedure. Establish coal flow to the pulverizer at maximum design capacity.
2. When the coal firing has been established at the maximum design coal flow and all conditions appear to be stable, record the exhauster fan discharge pressure.
3. Calculate the discharge pressure that corresponds to 60% of this value.
4. Reduce the feeder speed to its minimum feedrate (25%).
5. With the feeder operating at minimum feedrate, close the exhauster fan inlet damper to obtain the value of exhauster fan discharge pressure calculated in Step 2.
6. This is the final minimum setting for the damper. Place a permanent mechanical stop in place to prevent the damper from closing beyond this point.
Note: The combustion control system should regulate the coal feeder and the exhauster inlet damper with the minimum exhauster inlet damper position corresponding to the 25% feeder speed.

5.2 Startup/Shutdown

The following discussion for a startup and shutdown was taken from *Instructions for the Installation, Operation, and Maintenance of CE- Raymond Bowl Mills No.633* [5]. During a startup, it is advisable to have a high setting on the feeder. The mill should be at operating speed before the coal goes into the mill. After ignition occurs in the boiler, the feeder speed can be reduced to the required amount. The mill outlet temperature is usually 175–185ºF for eastern U.S. or low-volatile coals and 165–175ºF for the western, mid-western or higher volatile coals. It may be desirable for the mill outlet temperature to be as high as 200ºF. Excessive temperature may cause fires in the mill. In addition, the mill outlet temperature may go as low as 150ºF. Too low a temperature will prevent complete drying, increase the load on the mill, and contribute to excessive spillage.

In extremely cold weather it might be necessary to warm the gear housing oil by running the mill empty for 10 to 15 minutes with the oil cooler water supply shut off. An acetylene torch should never be used to warm the mill because carbonization of the oil may result and expansion strains put on the gear housing

For the suction designed mills, the mill should be operated in suction at all times, and a gauge can be installed below the bowl in a pipe tap opening. The suction maintained should be between -0.5 in. and -1.5 in. water.

The gate in the pyrite chute should not be held open. Excessive spillage indicates that the mill is not functioning properly. Holding the gate open by artificial means may prevent the discharge of considerable material to the floor. However, the retention of the material in the bowl increases the wear on the scrapers, scraper guards, and holders.

Shutdown: Normal

For a 633-RB mill, the feeder is stopped first for a normal shutdown [5]. The feeder hot air and the hot air regulating damper or the mill hot air blast gate should be closed before or immediately after shutting down the feeder. The mill should be operated for several minutes until it is completely empty. Just before the mill is shut down, the exhauster inlet damper should be opened to empty the pipe between the mill and the exhauster. If the hot air regulating damper, rather than the hot air blast gate, was closed when stopping the feeder, the blast gate must be closed as soon as the mill is stopped. These steps will greatly reduce the fire hazard when the pulverizer is shut down.

When the mill is shut down in cold weather for any length of time, it is necessary to drain the water in the oil cooler (cooling coil) in the gear housing. The water inlet valve should be closed and plugs removed to drain the water from the coil. See Figure 5-7 for a diagram and instructions for draining the water.

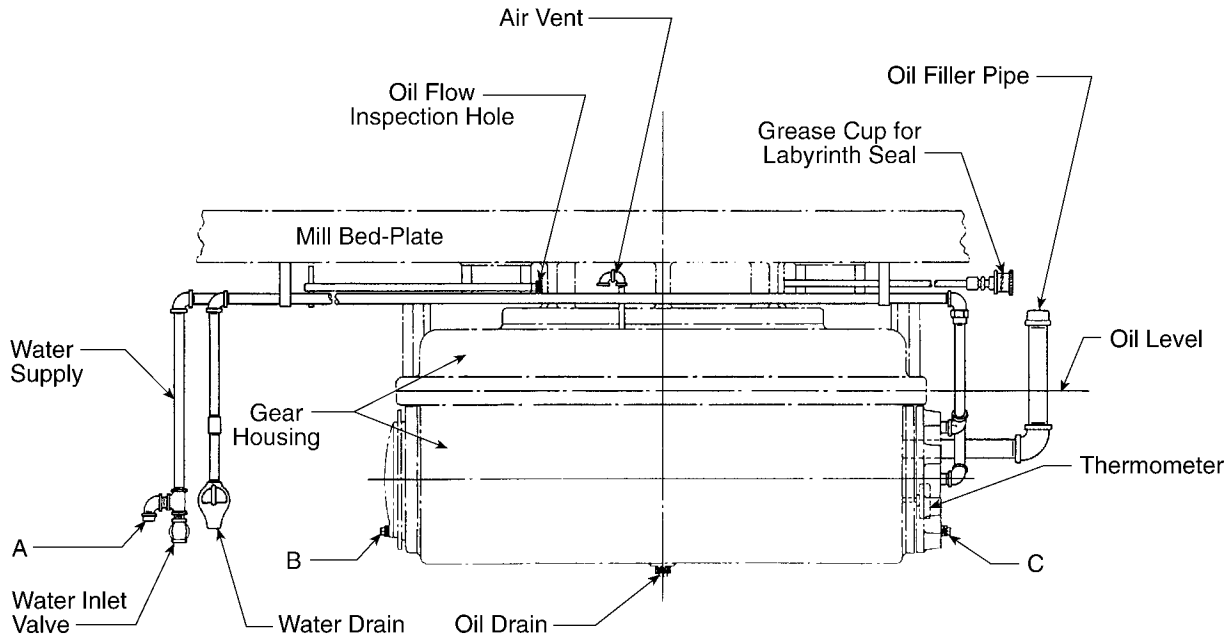


Figure 5-7
Draining the Cooling Coil [5]

If, for any reason, ice has formed in the coil, a careful examination should be made before starting up to make sure that the coil has not ruptured. A ruptured coil would allow the cooling water to contaminate the gear lubricant. On outdoor installations, where there is a chance of freezing, a slight flow of cooling water should be maintained.

Shutdown: Emergency

If the fire is lost or the water level is lost or some other condition arises [5] necessitating a manual emergency fuel trip, the mill motors should be stopped immediately. The feeders will automatically trip out. The hot air blast gate and feeder hot air on each mill should be closed as quickly as possible after the mill has been stopped.

If the pulverizer is out of service for periods longer than one month, the mill should be operated without fuel for a 10-minute period once or twice a week. This operation will help in preventing corrosion of bearings and other normally oil-coated materials.

5.3 Mill Fires

Pulverizer fires [5] can occur in five areas of the pulverizer system, as follows:

- Feeders
- Above the grinding bowl
- Under the grinding bowl
- Exhauster
- Coal piping

The usual causes of pulverizer fires are:

- **Excessive mill temperatures:** The mill outlet temperature should not be greater than 20ºF above the normal operating outlet temperature and not exceed 200°F for the RB, RS, and RPS pulverizer systems. The maximum recommended outlet temperature for eastern bituminous coals is 180°F, for midwestern bituminous coals is 170°F, and sub-bituminous coals, 150°F. See the shutdown discussion in Section 5.2.
- **Foreign material collecting in the inner cone and other places in the mill:** Foreign material, such as paper, rags, straw, and wood, cannot be pulverized and should be kept out of the coal supply because these items collect in the system and can catch fire.
- **Blockage of the pyrite chute:** Incorrect or excessive application of trowel-applied, wear-resistant material can break off and block the pyrite rejection chute. The pyrite chute should be kept operating freely. The pulverizer rejection chute should be periodically inspected and any broken or loose trowel-applied wear-resistant material should be removed.

  If there is a large amount of pyrites present near the mill, the coal in the pyrites can catch fire. The pyrite bin should be emptied when it is full and not allowed to flow over and back onto the mill bed plate.

  Also, the pyrite bin should not be near the hot air inlet because spilled coal and excessive amounts of pyrites in the hot air inlet can ignite.
- **Introduction of burning material from the bunker:** Burning material can be introduced from the bunker, through the feeder, and into the mill. Coal should not be allowed to remain in the bunkers for extended periods.
- **Abnormal operation:** If the pulverizer operates with low airflow, the coal can drop out of the air stream and accumulate in the coal piping. Sufficient air velocity should be maintained at all loads to prevent the settling of coal from the air stream.
- **Worn parts:** Worn grinding rolls and bull rings cause coal spillage. Coal lodging in the worn liners above or under the bowl can cause the coal to ignite. The worn parts should be replaced as necessary.
- **Hot air shutoff gate:** The hot air shutoff gate must be closed before the pulverizer is removed from service. The hot air regulating damper is not designed to form an absolutely tight seal. A mill fire and explosion can occur from a small amount of hot air leakage into a stopped mill.
- **Feeder hot air supply:** The hot air supply to the feeder must be shut off when the feeder is stopped for more than three minutes. The hot air supply normally comes from the hot air duct downstream from the hot air blast gate. If the coal feeder air is not closed, the hot air will flow through the coal feeder and cause the coal to ignite. Shutting the hot air blast gate will not stop the flow of air to the feeder.
- **Pulverizer discharge valves:** The exhauster discharge valves protect the exhauster and pulverizer from the hot gases and burning coal particles that can flow back from the boiler. On a fuel trip with the pulverizers full of coal, the exhauster discharge valves should remain open to allow the flow of cooling air to carry away any combustible gases generated in the

pulverizer and exhauster. Before starting the first pulverizer, the discharge valves should be closed on the other pulverizers. This will prevent the furnace pressure surge developed by the initial ignition of coal from forcing hot boiler gases back to the other pulverizers.

Figure 5-8 shows cutoff valves for an RP-1043 mill.



Figure 5-8
Pulverizer Discharge Cut-Off Valves
(Courtesy of Great River Energy)

- **Tramp iron:** Sparks can be created by contact between the rotating and non-rotating parts. The correct clearances between rotating and non-rotating parts should be maintained. Also, sparks can be created from metal mixed in with the coal. Remove tramp iron from the coal feed.

In the event of a mill fire, the following are strongly recommended:

- Do not direct a steam jet on burning or smoldering coal or pyrites.
- Never use compressed air to blow out the fire.
- Do not stir a burning or smoldering coal fire.
- Do not hammer on fuel lines unless the exhauster is operating.

Several factors influence how a mill fire is extinguished. The type of coal, moisture content, coal heating value, and others determine the methods used. In general, the following are recommendations of what should be done in the event of a mill or exhauster fire:

- Evacuate all personnel from the area around the mill, air inlet ducts, feeder, and coal piping.
- Do not shut down the mill.
- Close the hot air blast gate and hot air inlet damper.
- Open the exhauster inlet damper or cold air damper to 100% position.
- Maintain the fuel feed as heavy as possible without causing coal spillage.
- After the evidence of fire is gone, stop the feeder. The mill outlet temperature will indicate when the fire is out.
- Operate the mill for several minutes to empty it and purge the system.
- Shut down and isolate the mill.
- Open all inspection doors and hand hole covers of the mill, exhauster, and feeder. Never open any mill inspection doors until all evidence of the fire has disappeared.
- Clean out all coal from the mill, exhauster, and feeder.
- Inspect the mill, exhauster, and feeder for damage and repair before placing the mill back in service.

In the event of a fire under the bowl, above the bowl, or in the exhauster, it is necessary to extinguish the fire by admitting water through the feeder discharge. In the case of a feeder fire, the feeder hot air valve should be closed, and water flow introduced in the discharge of the feeder

Alstom supplies a water spray fire extinguishing system that wets the coal and mill internals, puts out the fire, and lowers the mill temperature. The system is manually activated by the operator. The water spray nozzles are located in the separator top, separator body, millside housing, inlet air duct of the mill, and exhauster casing.

Alstom also provides a steam inerting system. The system uses steam as the inerting fluid. The system can be activated automatically or manually by the operator.

For more information on pulverizer fires on the Alstom mills, see the Service Information Letter (SIL) 2003-03 *Inerting and Fire Fighting Procedures for Direct Fired RB, RS, and RPS Pulverizers* or SIL 2003-02 *Inerting and Fire Fighting Procedures for Direct Fired RP Pulverizers.*

For some of the RP-style mills, the addition of coal is not the prescribed course of action. When the control system detects a temperature of 100°C, the feeder and primary air fan trip automatically. The air dampers and bunker outlet gate close. The operator shuts down the seal air, leaving the fire to suffocate.

In addition, the following are EPRI publications that address mill fires in more detail:

- *Prevention, Detection, and Control of Coal Pulverizer Fires and Explosions.* EPRI, Palo Alto, CA: 1986. CS-5069.
- *Proceedings: Symposium on Coal Pulverizers.* EPRI: Palo Alto, CA: 1992. TR-101692.

5.3.1 Mill Puffs

Mill puffs [5] are the result of pressurization of the mills from incorrect operation. Three causes of mill puffs are:

- **Insufficient airflow:** Low airflow through the mill and coal piping will cause settling of coal in the system. To prevent low air flow, a velocity of approximately 85 ft/sec for minimum load operation is recommended for tangentially fired systems. In addition, a stop should be placed on the exhauster damper outlet to prevent closing the damper below the required airflow velocity.
- **Hot air blast gate:** The hot air blast gate should be closed immediately before or after the mill is removed from service. The hot air regulating damper is not designed to form a tight seal. The damper may not restrict the hot air supply enough to keep the temperatures down. A small amount of hot air leakage can cause a mill puff. Before the mill is shut down, the exhauster damper should be opened to purge the coal from the mill. The mill should continue in operation until the exit temperature is 110ºF.
- **Feeder hot air:** The hot air to the feeder should be off immediately before or after the feeder is taken out of service.

5.3.2 Inerting and Fire Fighting Systems

The purpose of an inerting and fire fighting system is to:

- Reduce the oxygen level in the mill
- Transport the coal to the boiler when the air is removed
- Extinguish fires in the fuel lines

The inerting medium can be steam or carbon dioxide. Steam is readily available and in sufficient quantity to allow a flow through the system for continuous purging of volatile gases. Steam is less damaging to the equipment and allows a safer restart of the mill. Carbon dioxide is also commonly used to extinguish fires by reducing the amount of air in the mill available for combustion. However, carbon dioxide can be hazardous to personnel as it leaves the mill equipment.

Fire fighting systems often use water to extinguish a fire. Water should be introduced into the mill in quantities and at locations that will not cause pluggage or interruption of raw fuel feed or stir up any deposits of combustible material.

There is a figure showing a pulverizer inerting system.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service.power.alstom.com.



Technical Key Point

After a mill fire has been extinguished, the grinding rolls, grinding ring, and liners should be inspected for cracks. In addition, the journal and gearbox lubricants should be tested for carbonization.

6
PERFORMANCE TESTING

This section covers fineness, coal grindability, capacity, and rejects.

6.1 Fineness

Fineness [1] [4] is an indicator of the quality of the pulverizer action. Specifically, fineness is a measurement of the percentage of a coal sample that passes through a set of test sieves usually designated at 50, 100, and 200 mesh. Table 6-1 shows the standard sieve dimensions.

Table 6-1
Standard Sieve Dimensions [4]

Mesh	Inches	Microns
20	0.0331	840
30	0.0234	595
40	0.0165	420
50	0.0117	297
60	0.0098	250
100	0.0059	149
140	0.0041	105
200	0.0029	74
325	0.0017	44
400	0.0015	37



O&M Cost Key Point

A 70% coal sample passing through a 200 mesh screen indicates optimum mill performance. Values greater than 70% require the mill to perform more work. The mill wear and the power consumption are increased if the 70% value is exceeded. Values lower than 70% mean higher carbon loss and increased fuel consumption.

In addition, coal retained on the 50 mesh screen should be in the 1–2% range. Higher values indicate worn internals or improper settings. Also, the higher percentages can cause boiler slagging and high unburned carbon. Figure 6-1 shows the fineness testing screens.

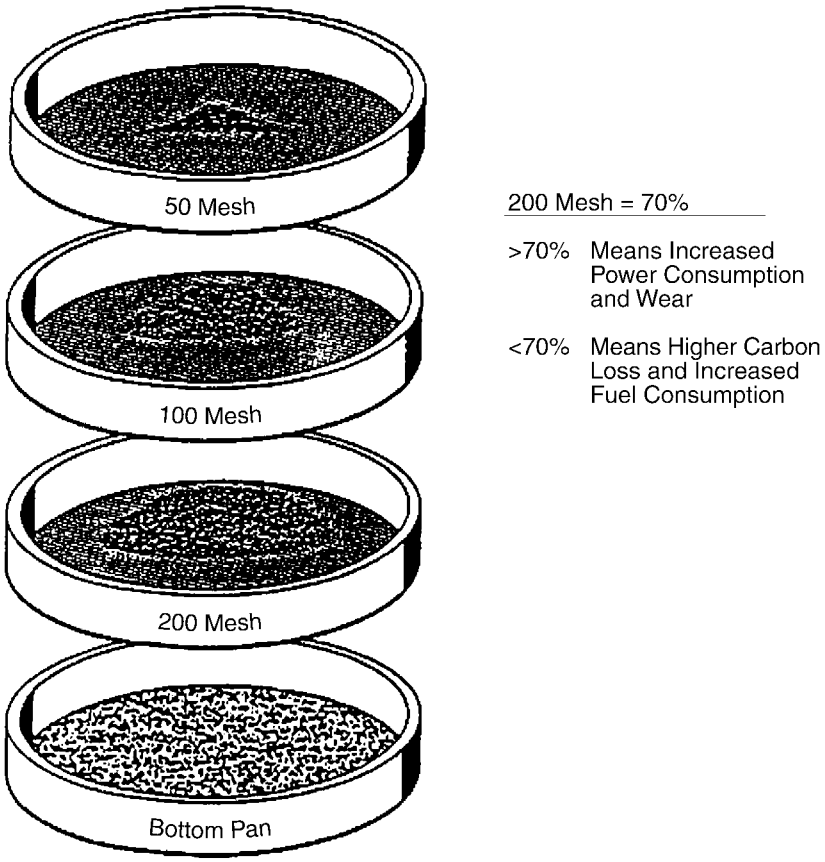


Figure 6-1
Fineness Testing Screens [1]

An optional top screen of 30 mesh is available to detect coarseness problems. The 50 mesh screen is an indication of relative coarseness. The 100 mesh screen indicates an unsuccessful test, and the 200 mesh screen indicates relative fineness.

Conducting a fineness test before and after a mill rebuild is a measurement of the effectiveness of the rebuild. There are two standards that are used in fineness testing. One is the American Society of Mechanical Engineers (ASME) Performance Test Code (PTC) 3.2-1054, Solid Fuels. Another test is the American Society of Testing Materials (ASTM) D 197 (1980) Sampling and Fineness Test of Pulverized Coal.

6.2 Coal Grindability

Grindability is defined as the ease with which the coal can be pulverized. This should not be confused with hardness. Coal of the same hardness may have a range of different grindability indices because of other constituents, such as moisture.

A standard index has been developed based on use of the Hardgrove Grindability machine and is called the Hardgrove Grindability Index. Grindability is determined by the amount of new material that will pass through a 200 mesh sieve. A 50-g air-dried sample sized to greater than

16 mesh and less than 30 mesh is placed in the Hardgrove machine with eight 1-in. steel balls. A weighted race is placed on the balls, and the machine turned for 60 revolutions. The resultant coal size is then compared to an index and a value assigned from the index.

Key Technical Point

The design rating on all Alstom RB pulverizers is based on a grindability index of 55 with 70% passing through a 200 mesh screen.

6.3 Mill Capacity

Figure 6-2 shows the relationship between grindability and mill capacity.

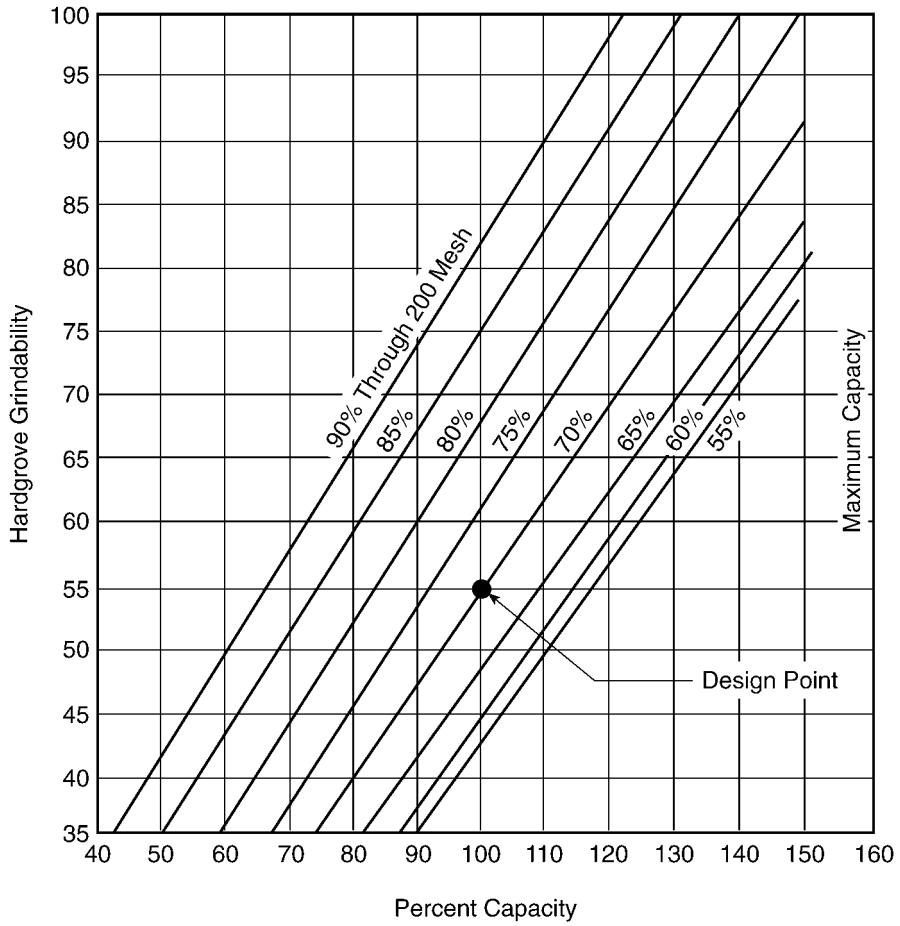


Figure 6-2
Grindability Versus Mill Capacity [4]

Moisture can affect the mill capacity. The moisture limit and effect on capacity are controlled by the temperature of the hot air supply. A chart that combines the effects of grindability and moisture is shown in Figure 6-3.

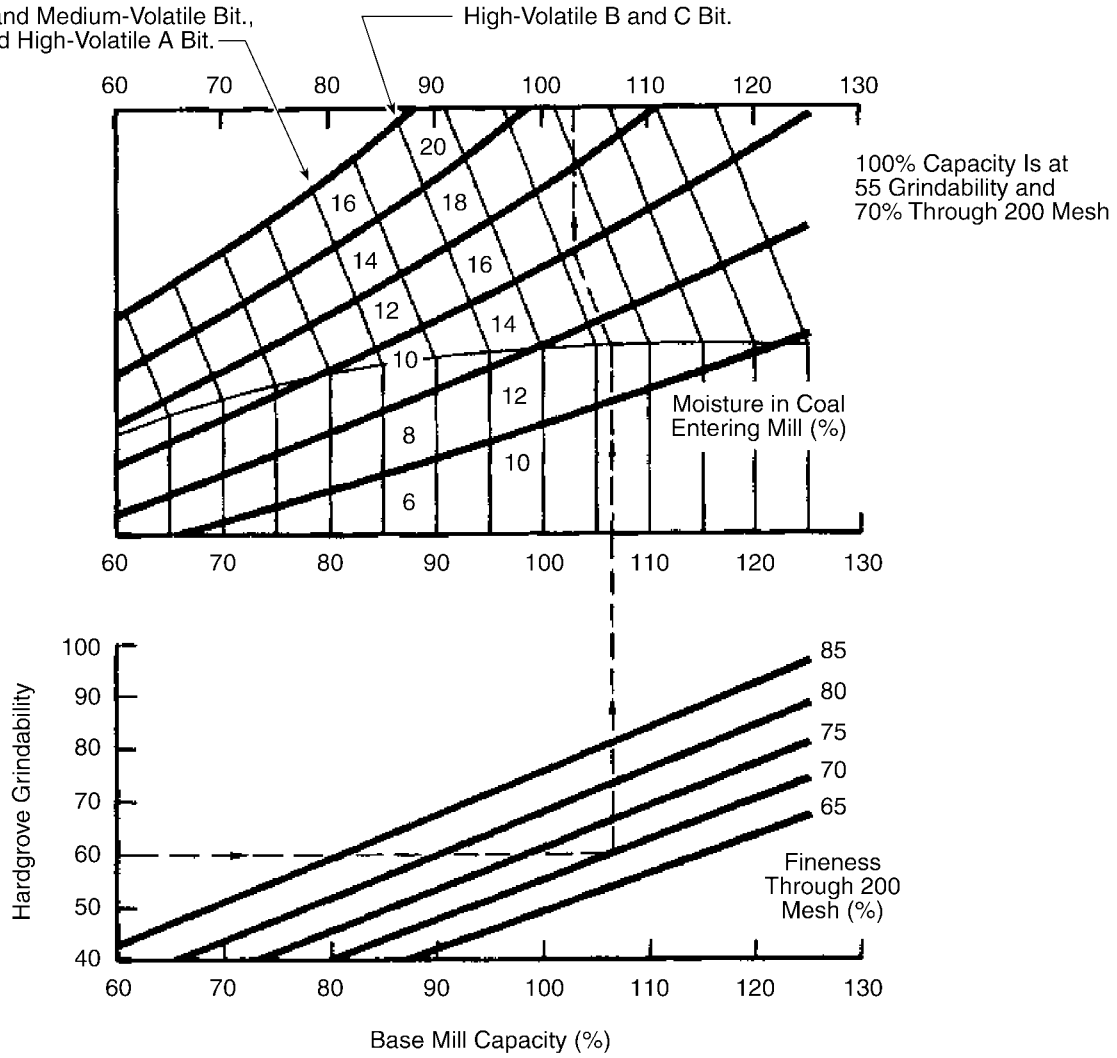


Figure 6-3
Moisture and Grindability Effects on Mill Capacity [4]

The example shown in this figure is a coal with a grindability index of 60 and the pulverizer set up to provide 70% on a 200 mesh screen. With a moisture range of 10–14% total moisture, the capacity is approximately 103% of the design rating.

O&M Cost Key Point

Desired fineness also affects the mill capacity. Increasing fineness from 70–75% reduces the pulverizer capacity by approximately 10%.

High levels of unburned carbon in the fly ash can be caused by an unbalanced flow to the boiler burners. This unbalance can lead to increased NO_x levels. To determine if unbalanced flows are occurring, air flow testing must be conducted. A major test is the Air Flow Calibration Test from the *ASME PTC 4.2-1969, Coal Pulverizers.* One part of the test is clean air testing, which is performed to quantify the total air flow supply and the distribution of that air flow through the

piping system. Clean air operation is characterized by no coal flow, no hot air flow, the grinding bowl not turning, ambient air present, exhauster damper full open, and all coal pipes open.

Another part of the test is called dirty air testing. This test is conducted during full-load operation of the mill. This requires special probes to handle the hot air and coal particles. Dirty air testing results are used to determine any unbalance in the primary air flows to the burners.

6.4 Rejects

The amount of pulverizer rejects is one indication of mill performance. The pulverizers can be set up to grind almost all pyrites or almost no pyrites depending on the throat velocity and direction of air flow in the bowl area. Pyrites are the common mineral iron disulfide (FeS_2) that has a pale brass-yellow color and metallic luster. However, it is not economical to attempt to grind and burn pyrites and rock.



Technical Key Point

If only pyrites and rocks are observed in the reject hopper, some pyrites and rocks are probably being ground. If there is a large percentage of coal in the reject hopper, too much coal is not being ground and is lost for combustion. The suggested compromise is to have a minimum amount of coal in the pulverizer rejects.

For more information on performance of the mills, refer to the following EPRI guides:

- *Guidelines for Fireside Testing in Coal Fired Power Plants*. EPRI, Palo Alto, CA: 1988. CS-5552.
- *Addendum to Guidelines for Fireside Testing*. EPRI, Palo Alto, CA: 1995. TR-111663.
- *Pulverizer Interest Group (PIG) Interim Report, PIG Research Activities. June 1996 to December 1999*. EPRI, Palo Alto, CA: 1999. TR-113825.
- *Coal Flow Control System Development*. EPRI, Palo Alto, CA: 2000. 1000433.
- *Pulverizer Interest Group (PIG) Interim Report, PIG Research Activities. January 2000 to October 2000.* EPRI, Palo Alto, CA: 2000. 1000434.
- *Pulverizer Interest Group ABB Deep Bowl Mill Modification Demonstration*. EPRI, Palo Alto, CA: 2000. 1000659.
- *Coal and Air Flow Measurement Study*. EPRI, Palo Alto, CA: 2001. 1001206.
- *Pulverizer Interest Group (PIG) Interim Report, PIG Research Activities. November 2000 to October 2001*. EPRI, Palo Alto, CA: 2001. 1004070.
- *Evaluation of a Southwestern Corporation High Performance Static Classifier*. EPRI, Palo Alto, CA: 2002. 1007532.

7
FAILURE MODES ANALYSIS

This section [6] covers mill failure data, failure mechanisms, and failure modes and effects.

7.1 Mill Failure Data

During the development of this guide, a survey of participant issues on pulverizers was conducted. Table 7-1 contains a failure summary based on the results from the survey.

Table 7-1
Failure Summary

Failure Type	Failure Mode	Number of Failures in Last 24 Months
Shaft failures	Vertical shaft breakage	1
	Shaft breakage	3 per 13 mills
	Upper shaft bearing crawled up shaft	1
	Upper shaft bearing crawled up shaft	1
	Input shaft failures	3
Lubrication issues	Lubrication contamination	Continuous
	Lube oil mechanical seal failures	12
	Main gearbox oil air entrainment causing foaming	5
	Loss of oil flow to upper bearing	1
Exhauster issues	Top of exhauster housing wearing	Repaired each, will overhaul
	Top of exhauster housing wearing	Repaired each, will overhaul
	Exhauster breakage	2 per 13 mills
	Exhaust bearings	32
	Exhauster fan pedestal bearing failure	2
Roll journal Issues	Mill roll bearing failures	4
	Mill roll wear	Repaired each, will overhaul
	Journal failures	12
	Roll failure	3
Wear issues	Wear in multiport and valves	
	Excessive liner wear	Event on 13 mills
	Liner wear	36
	Excessive body liner wear	
	Cone wear	
	Cone wear	
Other issues reported	Valves (discharge)	
	High LOI	20 per 13 mills
	LOI	Continuous
	High air in-leakage	3
	High air in-leakage	Ongoing
	Lack of coal and air mix uniformity	Ongoing
	Mill puffs	3
	Bowl cracking	1
	High reject rate on 4D mill	28
	Mill fires	12

Table 7-1 reorganizes information that was provided on a unit basis and is offered as a collection of plant and unit issues needing maintenance attention at this time.

Information from earlier studies of pulverizer components is noted in Figure 7-1 and Table 7-2.

The failure of the pulverizer components can be shown as the relative frequency of component failures. From the EPRI report *Component Failure and Repair Data for Coal-Fired Power Units, AP-2071, October 1981* [7], Figure 7-1 shows the frequency of component failures.

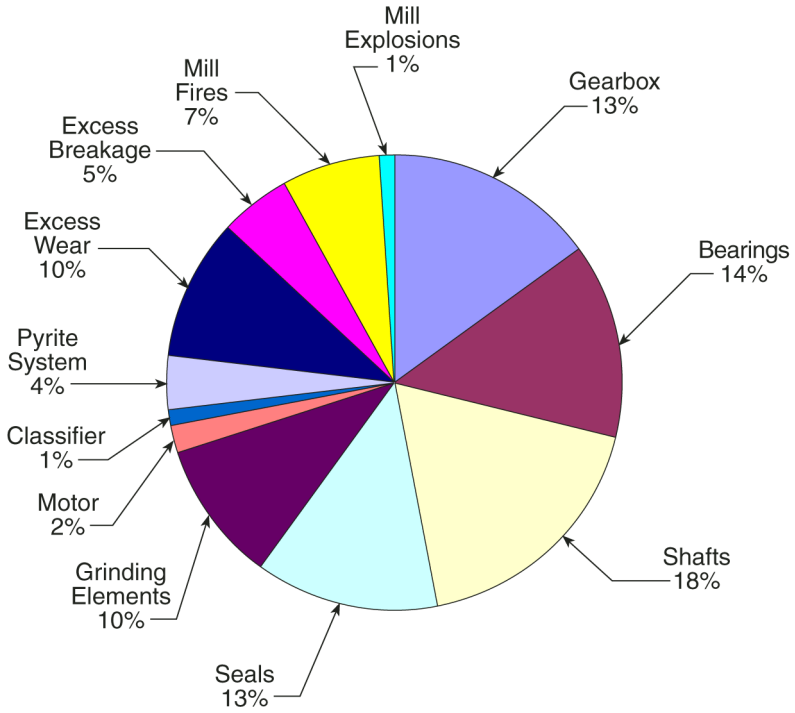


Figure 7-1
Pulverizer Component Failure Frequency [7]

As reported in FP-1226, *Pulverizer Failure Cause Analysis, December 1979* [8], Table 7-2 provides information on bowl mills representing 276 mills on 40 units.

Table 7-2
Bowl Mill Failure Data [8]

Component	Failure Mechanism	% Failure
Drive train	Oil contamination	54
	- Low seal air	
	- Burned seals	
	Excessive shaft breakage	
	- Improper roll adjustment	
	- Bearings	
Grinding area	Excessive wear	35
	- Rolls and/or rings	
	- Liners	
Air system	Excessive wear	13
	- Classifier	
	- Multiport outlet	
Mill fires and explosions	Liners	33
	- Coal accumulation	
Associated boiler problems	Slagging	13
	- Oversized particles	

The report noted that most of the drive component problems are associated with either improper spring compression settings and/or contamination of the lube oil. Excessive wear problems have been associated primarily with the rolls and liners. Excessive wear of the liners coupled with coal accumulation has been identified as the major cause of mill fires and explosions.

Because wear will continue as a result of mechanical techniques to pulverize coal, the information in Section 7.2 is provided to help understand abrasion failure modes.

7.2 Failure Mechanisms

Failure modes analysis is defined by failure mechanisms [6] and is the recommended action to reduce or eliminate the failure mechanisms. Three types of abrasion and erosion that occur in pulverizer equipment include:

- **Gouging abrasion:** Heavy plastic deformation of a surface by hard mineral fragments under heavy pressure or impact causing deep surface grooving or gouging and removal of relatively large wear debris particles. Examples of gouging abrasion are seen in jaw crushers and hammer mills.

- **High-stress grinding abrasion:** A three-body process caused by mineral fragments under sufficient contact stress to cause the scratches in the contacted surface. Examples of high-stress grinding abrasion are found in pulverizers and ball mills.
- **Low-stress scratching abrasion:** Wear by cutting or plowing of mineral fragments under contact stress below their crushing strength. Examples of low-stress scratching abrasion are found in coal chutes, sand pump impellers, and screens.

In coal pulverization, 5–20% of the material being crushed is abrasive mineral. A large part of the power in coal pulverization is used to crush coal. Coal is not abrasive by itself. The minerals in coal that are the most abrasive are quartz and pyrite, which cause a less severe high-stress grinding abrasion than the minerals alone. Because of the cushioning effect of coal powder, the size and shape of mineral particles found in coal probably influence the severity of the abrasion process.

Abrasion involves the sliding of particles under normal load over a surface. The abrasion rate is influenced by particle hardness and normal load of the abrasive medium. Removal of material during the abrasive wear process can occur by cutting or plowing. The cutting process is more efficient and results in severe wear. The probability of cutting by abrasive particles increases with sharpness and angularity of the particles. Therefore, quartz particles crushed in a mineral processor are more aggressive than rounded sand particles sliding over a metal surface. The angle of attack by each individual abrasive particle determines whether cutting will occur. When the angle between the leading facet and the plane of sliding reaches a critical value, cutting will occur. The critical angle for cutting is influenced by metal alloy properties; for example, the critical angle for cutting abrasion for nickel is 60–70º.

One of the parameters that influence abrasion resistance is the quantity of carbides in the metal part. Some materials that contain massive carbides are Ni-Hard, high chromium cast iron, and Stellite. The Ni-Hard and high chromium white cast iron materials are considered the most resistant to mineral abrasion in high-stress grinding abrasion conditions.

Alloying elements are important in the design of abrasion resistant alloys. Carbon content is the most effective parameter in abrasion control. As carbon content increases, abrasion resistance increases. Increasing silicon content will significantly improve fracture toughness in a cast material. Molybdenum in quantities up to 1% will improve abrasion resistance with no discernable effect on toughness. However, usually an increase in abrasion resistance is accompanied by a decrease in toughness.

High chromium cast iron materials are used for improved abrasion resistance. These alloys have a variety of compositions from which to choose. The alloy could be selected on the basis of optimizing required toughness, hardenability, corrosion resistance, and abrasion resistance. In comparing wear coefficients for several materials having wear data available, the values shown in Table 7-3 have been obtained.

Table 7-3
Abrasive Wear Coefficients [6]

Material	Wear Coefficient
High chrome cast iron (18 Cr, 2 Mo)	1.2×10^{-4}
Ni-Hard (3C, 4Ni, 2Cr)	1.5×10^{-4}
Stellite No. 6 hardfacing	2.4×10^{-4}
Star J (Stellite) hardfacing	5.4×10^{-4}
1090 Steel (Rockwell C hardness 55)	8.0×10^{-3}

Erosion by mineral particles picked up in the air stream carrying pulverized coal through the mill, classifier, exhauster, and transport pipe is a recognized problem. The erosion process is more selective than the abrasive wear and tends to remove metal in localized areas. Erosion can produce holes in steel liners and deep depressions in large section cast parts. Localized attack is typical of erosive damage because of the sensitivity of the material removal rate to the angle of impingement and the impingement velocity.

The following parameters affect erosion rates:

- **Velocity:** The erosion rate increases exponentially with velocity. For ductile materials, the exponent is about 2.3; for brittle materials, the exponent ranges between 1.4 and 5.
- **Impingement angle:** Maximum erosion rates occur at 30º for ductile materials and at 90º for brittle materials.
- **Particle size:** Erosion rates increase with particle size up to a critical size. Particle sizes larger than the critical size do not increase the erosion rate. For very small particles, all materials act like ductile materials. EPRI studies have determined that pyrite particles above the 200 micron size cause pronounced damage [6].
- **Particle hardness:** Hard particles relative to the surface being eroded are more aggressive. EPRI studies have determined that the mill wear is primarily dependent on the quartz and to a lesser extent the pyrite content of the coal. In general, the effect of quartz is about 2–3 times that of pyrite.
- **Material structure:** Single phase materials improve erosion resistance with increasing hardness. Multiphase materials are insensitive to hardening.

The approach to erosion control requires using wear-resistant materials for an expected impingement angle. There has been success in the industry using ceramic materials. Ceramics are ideal for erosion corrosion conditions because of their inertness in the corrosive environment and their ability to handle the low impingement angle erosion.

7.3 Failure Modes and Effects

Table 7-4 shows the failure modes and effects for components of the pulverizer. The chart was developed by Duke Energy, and comments were added from the utility TAG members. The problem areas for each component are listed, and the corresponding degradation mechanism is given for each problem area. Applicable modifications are listed for each degradation mechanism.

Table 7-4
Failure Modes and Effects Chart
(Courtesy of Duke Energy)

Drive Train			
Component	**Problem Area**	**Degradation Mechanism**	**Applicable Modifications**
Bull gear	Wear	Age	Reverse gears
		Poor lubrication	
		Misalignment	
	Chipped or broken tooth	Misalignment	
	Fatigue	Poor lubrication	
	Improper hub-to-gear fit	Improper fitup during installation	
		Lock nut loose	
Vertical shaft	Broken and/or bowed	Unequal loading on rolls	Change rolls in sets
		Misalignment	Extreme duty shaft
		Bowl out of round	
	Cracked in keyway	Improper fit of bearing	Extreme duty shaft
		Improper fit of gear hub	Extreme duty shaft
		Shaft locking nut not holding	Extreme duty shaft
	Key and/or keyway fit insecure	Improper fit of bearing	Extreme duty shaft
		Improper fit of gear hub, out of round, insufficient taper advance	Extreme duty shaft
Vertical thrust bearing	Vibration bearing defects	Age	
		Insufficient lubrication	
		Lubrication contamination	
		Severe impact due to something big going through mill	V-Flat thrust bearing
		Improper clearances during installation	
		Misalignment	V-Flat thrust bearing
		Packed with old oil sludge	
Vertical radial bearing	Vibration bearing defects	Age	
		Insufficient lubrication	
		Packed with old oil sludge	
		Severe impact due to something big going through mill	
		Improper clearances during installation	4-piece radial bearing
		Misalignment	4-piece radial bearing

Table 7-4 (cont.)
Failure Modes and Effects Chart
(Courtesy of Duke Energy)

Drive Train			
Component	**Problem Area**	**Degradation Mechanism**	**Applicable Modifications**
Worm gear	Wear	Age	
		Insufficient lubrication	
		Lubrication contamination	
	Fatigue	Lack of lubrication or hot lubrication	
	Chipped or broken tooth	Misalignment	
Worm thrust bearing	Vibration bearing defects	Age	
		Insufficient lubrication	
		Lubrication contamination	
		Severe impact due to something big going through mill	
		Improper clearances during installation	
		Misalignment	
		Packed with old oil sludge	
Worm radial bearing	Vibration bearing defects	Age	
		Insufficient lubrication	
		Severe impact due to something big going through mill	
		Improper clearances during installation	
		Misalignment	
		Packed with old oil sludge	
Oil pump	Excessive clearance	Age	
		Excessive vibration and/or misalignment	
Cooler	Waterside deposits	Water chemistry	
	Outside deposits	Unfiltered oil	
	Leak	Age	
	Head gasket leak	Age	
		Improper gasket and head installation	
Gearbox housing bolts	Fatigue break	High vibration	
		Misalignment	
		Age	
Oil seal	Coal leak	Age	
		Misalignment	
		Low seal air pressure and/or flow	
		Worn seals	

Table 7-4 (cont.)
Failure Modes and Effects Chart
(Courtesy of Duke Energy)

Grinding and/or Beneath Bowl Area			
Component	**Problem Area**	**Degradation Mechanism**	**Applicable Modifications**
Scraper assembly	Wear	Age	
		Abnormal pyrites	
	Breakage	Foreign material	Horizontal pivot scraper assembly
		Liner coming loose	
Liners	Wear	Age	
		Abnormal pyrites	
	Fire and and/or or explosion	Abnormal pyrites	
		Foreign material	
Pyrite gate	Binding	Foreign material	
		Worn bushings	
	Blown out	Explosion	
Tempering air damper	Binding	Worn bushing	
		Pyrites buildup	
	Blown out	Fire and and/or or explosion for foreign material or pyrite buildup	
Tempering air damper drive	Electrical problems	Age and and/or or coal dust	
	Calibration errors	Age and and/or or coal dust	
		Weights missing	
Hot air blast gate	Binding	Age of packing	
		Coal dust buildup	
	Proximity and limit switches	Age and/or coal dust	
Hot air blast gate drive	Solenoid valve	Age and/or air leak	
	Air leakage in air cylinders	Age and/or air leak	
Rolls	Wear	Age	Reweld with combustalloy material
		Misalignment	
		Foreign material	
	Bearing defects	Age	
		Lack of lubricant	
		Contamination of lubricant	
		Severe impact on roll and/or foreign material	Double bearing design
		Incorrect fit during installation	
	Locking ring coming off roll	Improper installation	

Table 7-4 (cont.)
Failure Modes and Effects Chart
(Courtesy of Duke Energy)

Grinding and/or Beneath Bowl Area			
Component	**Problem Area**	**Degradation Mechanism**	**Applicable Modifications**
Journal assembly	Springs out of adjustment	Fatigue and/or age	
	Springs cracked	Age	
	Journal shaft damage	Installation of bearings and/or roll	
Bull ring	Wear and/or cracked	Age	
		Misalignment	
		Foreign material	
	Segments coming out	Improper installation	
Extension ring	Wear and/or cracked	Age	
		Coal properties and/or improper fineness	
		Improper clearance between inner cone and outer cone	
Bowl	Warped	Overheated	
Air and/or Coal Flow Systems			
Component	**Problem Area**	**Degradation Mechanism**	**Applicable Modifications**
Classifier cone	Wear	Age	Ceramic liners
		Coal properties and/or improper fineness	Ceramic liners
		Improper clearance between inner cone and outer cone	
Restriction angles and/or body liner	Wear	Age	Ceramic liners
		Coal properties	Ceramic liners
	Fire and/or explosion	Coal buildup	
Separator top and bottom	Wear	Age	Ceramic liners
		Coal properties	Ceramic liners
Inner cone and feed pipe	Wear	Age	Ceramic liners
		Coal properties	Ceramic liners
		Improper fineness	
	Warped and/or sitting to one side	Improper installation	
		Overheated	
Classifier	Wear	Age	Ceramic liners
	Loss of performance	Foreign material	
Vane	Wear	Age	Crown 700 material
		Coal properties	
		Improper fineness	

8
TROUBLESHOOTING

Table 8-1 was developed from input from the TAG for this guide. Items specific to the pulverizer are shown in **bold** type.

Table 8-1
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
High boiler LOI (fly ash)	**Coal grind too coarse**	Adjust classifiers to increase fineness.
	Tilts pointed up	Adjust sootblowing to allow furnace to be dirtier.
	Too much over-fired air flow	Redistribute air flow.
	Improper fuel distribution pipe to pipe	Run clean air and dirty air tests to reset orifice sizes; inspect for riffle damage.
	Improper distribution inside the firebox	Investigate air biases and perform tests to determine oxygen readings at furnace outlet versus oxygen analyzer readings.
	Air in-leakage in lower dead air space	Inspect for and repair air leaks, especially below the ash hopper tubes.
	Air in-leakage in upper dead air space	Inspect for and repair air leaks, especially through the boiler skin.
	Air in-leakage from bottom ash hopper	Inspect and repair seals, manways, sight glasses and other connections.
	Air in-leakage from penthouse	Inspect and repair through ceiling penetrations, sidewall-to-ceiling junctions, and refractory damage.
	Air in-leakage through sidewalls	Monitor for hot spots using thermography and upgrade to pumped refractory to form an airtight seal.
	Unbalanced secondary air flow	Rebalance through biasing or set point changes.
	Coal water content	Consider coal drying.
	Coal nozzle slag buildup	Monitor and control.
	Coal nozzle damage	Monitor and repair during each scheduled outage.
	Coal constituent quality issues	Pay close attention to absorbed water content.
	Unbalanced mill air flow pipe to pipe	Inspect coal pipe orifices for wear or improper design.
	Improper fuel distribution mill to mill	Biasing more coal flow to the top mill reduces residence time in the furnace and results in carryover.

Table 8-1 (cont.)
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
High boiler LOI (fly ash) - cont.	Too much water flow to cannons	If water cannon flow is excessive, it has the potential to quench burning in an area of the furnace, and unburned carbon will be carried over. If this happens, there will be an impact on furnace draft.
	High air in-leakage	Perform a survey to find and fix air leaks into the furnace.
	Excess air too low	If the indication is too low, increase the set point on the process control computer.
	Excess air too high	If the indication is too high versus an oxygen profile, look for and patch air leaks. If the actual oxygen is too high, reduce the process set point to compensate.
	Inverted cone area plugged	Take the mill offline and clean out the debris.
	Excessive slag deposits in convection passes	Increase the sootblowing frequency to maintain a cleaner area. Boost the air set pressure to allow online cleanup of the area.
	Hole in cone or deflector leading to internal bypassing	Take the mill offline and repair and/or line the cone or repair the liner.
	Air to fuel too high	Run isokinetic coal sampling and air flow testing and adjust the exhauster curve in the process computer.
High boiler LOI (bottom ash)	**Coal grind too coarse**	Adjust classifiers to increase fineness.
	Tilts pointed down	Adjust sootblowing to allow furnace to be cleaner.
	Tilt arm(s) broken	Shut down for internal repairs.
	Too much over-fired air flow	Redistribute air flow.
	Improper fuel distribution pipe to pipe	Run clean air and dirty air tests to reset orifice sizes; inspect for riffle damage.
	Air in-leakage in lower dead air space	Inspect for and repair air leaks, especially below the ash hopper tubes.
	Air in-leakage from bottom ash hopper	Inspect and repair seals, manways, sight glasses, and other connections.
	Unbalanced secondary air flow	Rebalance through biasing or set point changes.
	Coal water content	Consider coal drying.

Table 8-1 (cont.)
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
High boiler LOI (bottom ash) - cont.	Coal constituent quality issues	Pay close attention to absorbed water content.
	Unbalanced mill air flow pipe to pipe	Inspect coal pipe orifices for wear or improper design.
	Improper fuel distribution mill to mill	Bias more coal flow to the top mill, which will reduce residence time in the furnace and results in carryover.
	High air in-leakage	Perform a survey to find and fix air leaks into the furnace.
	Excess air too low	If the indication is too low, increase the set point on the process control computer.
	Hole in cone or deflector leading to internal bypassing	Take the mill offline and repair and/or line the cone or repair the liner.
	Air-to-fuel too low	Run isokinetic coal sampling and air flow testing and adjust the exhauster curve in the process computer.
Contaminated oil in drive	**Coal leakage past seals**	Shut down and replace seals.
	Water leak in cooler	Shut down and repair cooler.
	Water aspirating through reservoir breather	Install desiccant breathers on reservoir.
	Seal air system plug	Clean and clear seal air system.
	EP type oil attacking bronze parts	Switch to non-EP type oil.
High reject rate	Coal contains high amount of debris	Be aware that magnetic separators are useful in removing metal debris, but plastic, gravel, and granite can cause damage.
	Plugged or damaged throat	Take the mill offline to inspect and/or repair the throat.
	Feed rate too high	Reduce feed rate.
	Air-to-fuel too low	Increase airflow by changing air-to-fuel curve in process computer.
	Worn roll/ring mechanism	Replace roll and/or ring and adjust.

Table 8-1 (cont.)
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
High reject rate (cont.)	**Roll-to-ring clearance**	Adjust roll-to-ring clearance.
	Damaged side inlet chute	Take mill offline for inspection and repair.
Coal spill from reject chute	Plugged coal outlet lines	Shut down unit to safely unplug.
	Failed discharge coal gate(s)	Repair coal gates.
	Plugged or damaged throat	Take the mill offline to inspect and/or repair the throat.
Mill fire	Feed rate too high	Reduce feed rate.
	Plugged coal outlet lines	Shut down unit to safely unplug.
	External coal dust buildup	Maintain an active housekeeping program.
	Damaged oil piping	Add as a preventive maintenance task a routine inspection of the oil system.
	Leaking Victaulic couplings in piping	Upgrade Victaulic O-rings to high temperature instead of using standard BUNA O-rings.
Mill explosion	Fire suppression system multiple failure	Include fire protection testing in PM program.
	Plugged carbon dioxide or water deluge nozzles	Include fire protection testing in PM program; inspect nozzles for plugging routinely.
Exhauster vibration	**Rotor ceramic tiles missing**	Inspect and repair.
	Loose spider	Inspect and replace using Locktite.
	Loose bearing cap	Tighten bearing cap.
	Fan imbalance	Balance fan.
	Bowed fan shaft	Replace rotor and straighten shaft.
	Water and/or debris in casing	Rod casing drains to ensure there is no water before start-up; inspect before closing the inspection manway to make certain all debris and tools are removed.

Table 8-1 (cont.)
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
Mill rumbles when empty	**Roll tensions not matching**	Change rolls as a matched set or check spring tensions.
	Roll pitches different	Align pitch to match the bowl at top and bottom.
	Eccentric rolls	Review shop quality controls and receiving quality controls if rebuilds are outsourced.
Mill noisy under load	**Roll-to-ring clearance**	Adjust-roll to-ring clearance.
	Non-matching roll tensions	Change rolls as a matched set or check spring tensions.
	Roll pitches different	Align pitch to match the bowl at top and bottom.
	Eccentric rolls	Revisit shop quality controls and receiving quality controls if rebuilds are outsourced.
	Roll pieces in bowl	Take mill offline for inspection and replacement of rolls.
	Liner pieces in bowl	Take mill offline for inspection and replacement of liners.
Broken main drive shaft	**Roll tensions don't match**	Change rolls as a matched set or check spring tensions.
Journal bearing failure	**Welding on shaft caused bowing**	Take mill offline and heat treat to draw into alignment.
	Improper lubrication	Use a synthetic mill gear oil.
	Improper pitch	Align pitch to match the bowl at top and bottom.
	Improper spring tension	Change rolls as a matched set or check spring tensions.
	Loss of seal	Take mill offline and replace roll set. Rebuild old set.
	External contamination of oil	Avoid adding water through wash downs. Avoid keeping reservoirs exposed to ambient (dusty and moist) conditions, and so on.
	Lubricant contaminated	Ensure seal air system is functioning.
	Bearing clearances too small	Correct bearing clearances.
Mill temperature high	Control valve malfunction	Eliminate binding, sticking, and actuator problems.
Mill temperature low	Tempering air damper control	Remove blockages and re-grease the stem with a moly-based grease to avoid baking into the bearings.
	Excessive air in-leakage through pyrites chute	Rebuild pyrites seal.

Table 8-1 (cont.)
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
Mill temperature low (cont.)	Excessive air in-leakage through coal feed chute	Seal all cleanouts while allowing easy removable and resealable access for cleaning chutes.
	Excessive air in-leakage through cleanouts	Seal all cleanouts while allowing easy removable and resealable access for cleaning feeders.
	Excessive air use on coal chute inlet air cannons	Be sure the air blasters have adequate delay between blows to allow pressure to rebuild.
	Excessive air-to-fuel ratio	Reset process control computer air-to-fuel curve.
	Hot air damper malfunction	Remove blockages and re-grease the stem with a moly-based grease to avoid baking into the bearings.
	Excessive coal moisture	Consider coal drying.
	Hot air too cool (air heater plugged)	Ensure air heater sootblowing is effective. Ensure inlet air temperature is normal.
Oil temperature high	**Oil viscosity too high**	Allow warm-up time on start-ups and ensure that the proper oil is being used to top off mills.
	Oil viscosity too low	Allow warm-up time on start-ups and ensure that the proper oil is being used to top off mills.
	Oil cooler plugged	Schedule inspection and cleaning as a routine PM.
	Oil cooler water flow too low	Gather water flow measurement information periodically to monitor degradation.
	Oil cooler water supply line plugged	Gather water flow measurement information periodically to monitor degradation.
	Oil supply lanes plugged with coal	Inspect periodically to monitor degradation and control temperatures to avoid varnishing.
	Oil flow to bearings too low (relief valve relieving)	Monitor oil header pressure and relief valve discharge temperature for flow (temperature should be ambient).

Table 8-1 (cont.)
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
Oil temperature high (cont.)	**Oil pump worn**	Low flow from the pump usually means a low discharge pressure, too. Take the mill offline and repair the pump.
	Oil cooler undersized	Add supplemental cooling, at least for summertime cooling.
	Mill outlet temperature high	Consider adding supplemental cooling if outlet temps are driving up oil temp.
Oil leaks	**Mill vibration**	Take vibration readings and analyze data. Determine cause of vibration and correct and/or repair to minimize vibration.
	Sample valve left opened or vibrated opened	Do not use quarter-turn valves as sample valves without locking the handle or removing it.
	Portable oil filtration cart hose fitting leaks	Schedule inspection and cleaning as a routine PM.
	Portable oil filtration cart fittings jarred loose.	Select the proper oil viscosity for the unit and disregard the oil of convenience.
	Failed seals and gaskets	Use correct seals and gaskets for temperature and type of oil.
Oil temperature low	Oil viscosity low	After header replacement, throttle flow to avoid a too cool oil condition.
	Cooling water too cool	Transient conditions can be avoided with proper warm-up period.
	Start-up condition	Make sure operator captures it on rounds sheets.
	Thermostat on booster cooler malfunction	Wash down on a load drop when the mill can be shut down because quenching the oil temperature on a running mill can cause high vibration.
	Mill wash down	Make this a transient event.
Water in oil	Operating temperature too low	Raise operating temperature.
	See Contaminated Oil in Drive in earlier section of this table	

Table 8-1 (cont.)
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
Fineness test result out of specification	No fit on Rosin-Rammler Curve	Not a representative sample; consider performing isokinetic testing instead of grab samples.
	Plugged sieve	Review the test procedures and equipment.
	Improper sampling	Not a representative sample; consider performing isokinetic testing instead of grab samples.
	Excessive moisture	Consider coal drying.
	Improper test procedure	Not a representative sample; consider performing isokinetic testing instead of grab samples.
Too coarse	**Plugged mill cone**	Take the mill offline and clean out the debris.
	Classifiers opened too far	Adjust classifier settings.
	Riffles blocked	Unstop riffles.
	Riffles eroded	Repair riffles.
	Exhauster discharge layered (classification of fines)	Clean out exhauster discharge. Determine what deposits are. Check fineness.
	Roll wear excessive	Repair and/or replace rolls.
	Air-to-fuel ratio too high	Adjust air-to-fuel ratio.
	Inverted cone clearance too small	Adjust cone clearance.
	Hole in mill cone	Repair and/or replace cone.
	Hole in classifier deflector	Repair and/or replace deflector.
	Roll-to-ring clearance	Adjust roll-to-ring clearance.
Too fine	**Inverted cone clearance too large**	Adjust cone clearance.
	Classifiers closed too far	Adjust classifier settings.
	Riffles blocked	Unplug riffles.
	Riffles eroded	Repair riffles.

Table 8-1 (cont.)
Pulverizer Troubleshooting Guidelines

Problem	Probable Cause	Recommendation
Too fine (cont.)	Exhauster discharge layered (classification of fines)	Clean out exhauster discharge. Determine composition of deposits. Check fineness.
	Roll spring tension too high	Adjust spring tension.
	Air-to-fuel ratio too low	Correct air-to-fuel ratio.
Mill not carrying full load; motor current below normal	Operator at a comfortable load on the unit	Change operational procedures.
	Coal too coarse (no recycling)	See Too Coarse in earlier section of this table.
	Plugging then unplugging in coal feed chute	Shut down unit to safely unplug.
Mill current too high	Plugging and/or unplugging in coal feeder	Shut down to inspect and/or repair feeder.
	Weak springs or worn leveling gate in rotary feeders	Repair and/or replace springs and gates.
	Coal contamination	Shut down to determine contamination.
Feeder running fast	Plugging in feeder rotor boosting speed requirement for same amount of fuel	Unplug feeder.
	Manual operation	Adjust operation.
	Instrumentation malfunction	Correct instrumentation problem.

9
PREDICTIVE MAINTENANCE

Effective predictive maintenance [4] [9] detects equipment problems early enough for repairs to be completed before catastrophic failure occurs. Some advantages of detecting equipment problems early include:

- **Reduce catastrophic failure rate:** This rate is reduced by diagnosing equipment conditions and taking action before the equipment fails.
- **Reduce forced outage rate:** By detecting equipment problems early, the inspection and repairs can be performed during scheduled outage time and not during a forced outage.
- **Increase inspection and/or overhaul intervals:** The inspection and overhaul interval can be increased by knowing the equipment condition and not basing the interval on elapsed time alone.
- **Reduce maintenance outage length:** The time to perform inspection and repairs is reduced when adequate planning for the outage can occur. This can include having the correct parts and tools on site, the labor force planned, isolation tags requested, and so on.

The main technologies used in predictive maintenance are vibration analysis, oil analysis, and thermography. This section covers the vibration analysis and oil analysis. In addition, some current developments in the predictive maintenance area are listed.

Thermography may be used on the mill motors to detect overheating, loose connections, and so on. For more information on thermography for use on motors, see EPRI report *Electric Motor Predictive Maintenance Program*, TR-108773-V2 [10]. Other EPRI guides available for maintenance on motors are listed in Section 11.7 of this guide.

9.1 Vibration Analysis

For exhauster bearings, velocity sensors (20 milliamp) can be installed, and the vibration monitored continuously or periodically. For continuous monitoring, the horizontal reading is recommended. For periodic monitoring, the exhauster vibration should be taken weekly. Horizontal and vertical vibration readings should be taken on the inboard and outboard bearings, and axial vibration readings should be taken on the outboard bearing. Readings should be trended. A time waveform analysis can be performed on the exhauster readings.

The rotational speed of the exhauster is equal to the speed of the mill motor and the pulverizer mill input shaft. Balancing of the exhauster is critical for the smooth operation of the mill motor exhauster arrangement.

Check the mill motor vibration weekly. Horizontal and vertical vibration readings should be taken on the inboard and outboard bearings. Axial vibration readings should be taken on the outboard bearing. Readings should be trended.

Check the mill gearbox vibration weekly. Depending on the gearbox arrangement, horizontal and vertical readings should be taken on the inboard worm bearing; horizontal, vertical, and axial vibration readings should be taken on the outboard worm driven gear. Readings should be trended. A time waveform analysis can be performed on the gearbox readings.

For the RS-type mills, quarterly vertical shaft axial readings can be taken at the bottom of the gearbox at the oil pump cover bolt circle. These readings can detect thrust bearing defects.

9.2 Oil Analysis

A general discussion of lubricant testing [1] [9] [11] [12] is given in this section.



Technical Key Point

Lubricant testing is recommended for the following reasons:

- To study the condition (wear, and so on) of the machine being lubricated. If there is a problem with the lubricant, there is a strong possibility that the machine will need maintenance.
- To determine if the lubricant is meeting the specifications.

There are numerous lubricant tests that can be performed on an oil sample. The task is to perform the minimum tests that produce the optimal condition of the oil and condition of the machine. The first and most crucial step in lubricant testing is to get a representative sample. Recommendations for taking samples are:

- Take the sample when the system is stabilized, not before or just after makeup lubricant has been added.
- Take the sample ahead of filters so that contaminants are still in the lubricant.
- Put the oil sample in a suitable, clean, well-labeled container.
- Take the sample using a consistent method. Take the sample from the same location and under the same operating conditions.

The following are laboratory tests [11] performed on oil samples:

- **Particle count** (International Standards Organization [ISO] 4405, 4406): Particles have long been recognized as the main cause of failure in hydraulics and rotational machinery. Particles are also a leading indicator of a machine's condition. Because all contaminants in the oil are counted as particles, the particle count includes wear particles, soot, dirt, and other contaminates. This test provides information on lubricant cleanliness.

As oil cleanliness becomes more important, particle counters have taken on an increasingly important role in maintenance strategies. Most particle counters use light or infrared energy to illuminate individual particles and are referred to as optical particle counters.

The ISO Solid Contaminant Code (ISO 4406:99) is probably the most widely used method for representing particle counts (number of particles/mL) in lubricating oils and hydraulic fluids. The current standard employs a three-range number system. The first range number corresponds to particles larger than 4 μm, the second range number for particles larger than 6 μm, and the third for particles larger than 14 μm. As the range numbers increment up one digit, the associated particle concentration roughly doubles. A typical ISO Code for a turbine oil would be ISO 17/15/12.

Particle counts can be obtained manually using a microscope or an automatic instrument called a particle counter. There are many different types of automatic particle counters used by oil analysis laboratories. There are also a number of different portable and online particle counters on the market. The performance of these instruments can vary considerably depending on the design and operating principle.

Table 9-1 shows the particle count range numbers and the corresponding number of particles.

Table 9-1
Particle Count Range Numbers [9]

Number of Particles per Milliliter Sample		
Greater Than	**Up to and Including**	**Range Number (R)**
80,000	160,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
80,000	160,000	24

- **Fourier transform-infrared analysis** (FT-IR): The FT-IR monitors the chemical composition of the oil in certain key wavelengths. The infrared absorption spectrum of a lubricant furnishes a means of fingerprinting organic compounds and functional groups. Test results are trended and quantitative and qualitative determinations can be made. Infrared analysis is often used for identifying additives and their concentrations, reaction products, and contamination by organic materials in used lubricants. Oxidation (carboxylic acids and esters), nitrate esters, water, soot, and glycol can be quantified.

- **Spectrometric analysis/emission spectroscopy/rotrode filter spectroscopy** (RFS): Elemental analysis is performed in accordance with atomic emission spectroscopy (AES). A specific volume of lubricant is energized using an electrical arc. The light frequencies and intensities are measured and reported in parts per million of various elements. Elemental analysis is useful for identifying contamination, confirming additive content, and indicating system wear. The following elements are analyzed: Fe, Cr, Al, Pb, Sn, Cu, Ag, Ni, Na, V, Cd, Ti, Mo, Ca, Ba, P, Zn, B, K, Mg, and Si.
- **Additive package condition:** Additives present in a lubricant improve and strengthen the performance characteristics. Chemically active additives are able to interact with metals and form a protective film with the metallic components present in the machinery.

  The designer of the additive package must ensure that the additives will not produce unacceptable side effects. If an additive is present in excessive levels or interacts in an unsatisfactory manner with other additives that are present, it can be detrimental to the equipment. Over time, additive packages can deplete, leaving machinery unprotected and vulnerable to failure.

  The additives in a lubricant can also be referred to as the performance package. Some of the more commonly used additives include:

  - **Antifoam agents:** Almost every lubricant foams to some extent because of the agitation and aeration that occurs during operation. Air entrainment due to the agitation encourages foam formation. The presence of some detergent and dispersant additives tends to promote foam formation. Foaming increases oxidation and reduces the flow of oil to the bearings. In addition, foaming may cause abnormal loss of oil through orifices.

    Antifoam agents are used to reduce the foaming tendencies of the lubricant. Foam inhibitors can be added to a lubricant in service if a foaming problem is detected. The lubricant and equipment manufacturers should be consulted before adding foam inhibitors.

    The foaming characteristics of lubrication oils are tested per the ASTM D892 standard. The test makes a determination of the foaming characteristics of lubricating oils at a specific temperature. The test results monitor the foaming tendency and stability of the foam.

  - **Antiwear and extreme-pressure (EP) additives:** Both antiwear and EP additives form a protective layer on metal parts by decomposition and absorption. Antiwear additives function in moderate environments of temperature and pressure, and EP additives are effective in the more extreme environments.

    Molybdenum disulfide and graphite additives are a special form of antiwear additives known as anti-seize agents. They form a protective layer on the metal parts by deposition of the graphite or molybdenum disulfide. Anti-seize agents work independently of temperature and pressure.

Typical applications include engine oils, transmission fluids, power steering fluids, and tractor hydraulic fluids. EP additives are common in gear oils, metalworking fluids, and some hydraulic fluids.

Technical Key Point



Some EP additives can increase wear on the copper components. For example, Duke Energy added oil filtration systems to reduce wear from particle contamination. The copper levels remained high. The oil manufacturer (Mobil) recommended changing from a standard EP gear oil (Exxon Spartan EP) to either a PAO synthetic (Mobil SHC 600 series) or a cylinder oil (Mobil 600 W Super Cylinder Oil). These oils provided the EP property without the high chemical reactivity of the standard EP additives. After changing to these oils, the wear metals showed a significant reduction. In addition, the lowest wear metals were achieved with continuous filtration.

- **Dispersants:** The purpose of this additive is to suspend or disperse harmful products within the lubricant, thereby neutralizing the effect of these products. Harmful products include contaminates (such as dirt, water, fuel, and process material) and lube degradation products (such as sludge, varnish, and oxidation products).

  Typical applications include diesel and gasoline engine oils, transmission fluids, power steering fluids, and in some cases, gear oils.

- **Detergents:** Detergents, like dispersants, are blended into lubricants to remove and neutralize harmful products. In addition, detergents form a protective layer on the metal surfaces to prevent deposition of sludge and varnish. In engines, this can reduce the amount of acidic materials produced.

  A detergent's protective ability is measured by the total base number or the reserve alkalinity. The metallic basis for detergents includes barium, calcium, magnesium, and sodium. Typical applications for detergent additives are primarily diesel and gasoline engines.

- **Friction modifiers:** Friction modifiers are lubricant additives blended with the base stock to enhance the oil's natural ability to modify or reduce friction. Friction modifiers reduce wear, scoring, and noise.

  Typical applications include gasoline engine oils, automatic transmission oils, power steering fluids, metalworking fluids, and tractor hydraulic fluids.

- **Antioxidants:** Antioxidants, also known as oxidation inhibitors, interfere with the oxidation process by chemically converting oxidation products to benign products. In addition, some oxidation inhibitors interact with the free catalytic metals (primarily copper and iron) to remove them from the oxidation process. Almost all modern lubricants contain antioxidation additives in varying degrees.

Lubricants for extreme operating conditions, such as diesel and gasoline engines, for high-temperature situations, and for applications that involve high lubricant agitation require higher levels of anti-oxidants than other lubricants.

- **Pour point depressants:** The pour point is the lowest temperature that a lubricant will flow. In order to obtain flow of oil at low temperature (fluidity), pour depressants are added to the lubricating oil to lower the pour point. These additives tend to inhibit the formation of wax at the low temperatures. In many formulations, especially those containing viscosity improvers, supplemental pour depressants are not needed because other additives also have pour point depressant properties.

  Typical applications include diesel and gasoline engine oils, transmission fluids, tractor fluids, hydraulic fluids, and circulation fluids.

- **Rust and corrosion inhibitors:** Rust and corrosion are the result of the attack on the metal surfaces by oxygen and acidic products and are accelerated by the presence of water and impurities. Rust and corrosion inhibitors work by neutralizing acids and forming protective films. These inhibitors must work in the lubricant and on surfaces above the liquid level.

  The rust-preventing characteristics are tested per the ASTM D665 standard. The test evaluates the ability of inhibited mineral oils to aid in preventing the rusting of ferrous parts should water become mixed with the lubricant.

  Typical applications include engine oils, gear oils, metalworking fluids, and greases.

- **Viscosity index improvers:** Mineral lubricants tend to lose their lubricating ability at high temperatures due to viscosity reduction. Viscosity improvers are added to a lubricant to retain satisfactory lubricating capabilities at the higher temperatures. At low temperatures, the viscosity characteristics of the base stock prevail, but at high temperatures the viscosity improver maintains the viscosity at satisfactory levels.

  In addition to these additives, there are numerous other ones, such as dyes to mark lubricant types, seal-swell agents to counteract the adverse effect of other additives on seals, and biocides to retard or prevent bacterial growth. Additive packages are proprietary information, and lubricant manufacturers do not offer detailed information on the additives present in their products.

  There are, however, several laboratory tests available to determine additive depletion or loss in a lubricant. It is important to monitor an additive package through laboratory tests. When an additive package depletes, the lubricant's performance decreases, and the equipment is left unprotected.

Common elements found in lube oil additives are shown in Table 9-2.

Table 9-2
Elements in Oil Additive Package [12]

Common Elements	Additive Function
Barium	Detergent or dispersant
Boron	Extreme pressure
Calcium	Detergent or dispersant
Copper	Antiwear additive
Lead	Antiwear additive
Magnesium	Detergent or dispersant
Molybdenum	Friction modifier
Phosphorus	Corrosion inhibitor, antiwear
Silicon	Antifoaming
Sodium	Detergent or dispersant
Zinc	Antiwear or anti-oxidant

- **Viscosity testing (ASTM D445):** Viscosity is one of the most important characteristics of an oil because it ensures that the proper film strength is present to minimize metal-to-metal contact and machine wear. Viscosity is a factor in the formation of lubricating films under both thick and thin film conditions. It affects heat generation in bearings, cylinders, and gears. It governs the sealing effect of the oil and the rate of consumption or loss. It determines the ease that machines may be started in cold conditions. For any piece of equipment, the first essential for satisfactory results is to use oil of proper viscosity to meet the operating conditions.

  If the viscosity is too low, the oil may not have the necessary film strength required to maintain a proper oil film. An inadequate oil film results in excessive wear. A decrease in viscosity may indicate contamination with a solvent or fuel or with lower grade viscosity oil.

  If the viscosity is too high, additional fluid friction is generated. This increases the operating temperature of the bearings and increases the rate of oxidation.

  A change in viscosity over time can indicate oxidation, shearing, the presence of contamination, and additive depletion. However, in most cases, an out-of-specification viscosity value indicates the use of an incorrect oil or the addition of an incorrect oil during refilling of the reservoirs.

  Viscosity testing is performed to characterize a fluid's flow and/or resistance to flow at a given temperature. Almost all industrial lubricating oils are specified by the ISO viscosity grade system. The system specifies standard viscosities at 40°C from 2 to 460 centistokes (cSt). The most common viscosity grades for bearing applications are 32, 46, 68, 100, 150, and 220 cSt. To meet the specifications of the ISO viscosity grade system, oils must be within ±10% of the viscosity grade from the lube oil suppliers.

From the ASTM D445/446 standard, kinematic viscosity is measured by adding a small portion of sample oil to a calibrated capillary tube viscometer in a temperature-controlled bath. The time it takes the fluid to flow between two fixed points in the viscometer is measured and then compared to the standard. From this, viscosity is calculated and reported in centistokes.

Mobil has recommended that the gearbox oil for the Duke Energy Alstom mills be changed from the Alstom recommended ISO 320 viscosity to an ISO 460 viscosity.

- **Total acid number** (TAN) (ASTM D664 and D974): Acidity indicates the extent of oxidation of a lubricant and its ability to neutralize acids from exterior sources, such as combustion gases. The acidity of lubricants is measured by the amount of potassium hydroxide required for neutralization (mg KOH/g), and the resultant number is called the TAN. The additives in most new oils contribute a certain TAN or acidity; therefore, it is critical to determine and monitor changes from the new oil reference. An increase in TAN may indicate lube oxidation or contamination with an acidic product. A severely degraded lubricant indicated by a high TAN may be very corrosive.
- **Total base number** (TBN) (ASTM D4739, D664, D974, and D2896): The TBN is determined by titration of a known substance, such as HCl, in order to determine an unknown quantity. Weighed samples are titrated using an automatic titration system. TBN of a used lubricant is a measurement of its ability to neutralize the acid using basic buffers.
- **Crackle test/Karl Fischer water test** (ASTM D-4928 and D1744): Water in a lubricant not only promotes corrosion and oxidation, but also it may form an emulsion having the appearance of a soft sludge. In many bearing applications, even a small amount of water can be detrimental, especially in journal-bearing applications where the oil film thickness is critical. Some of the major causes of water in the oil include seal leaks, heat exchanger leaks, and condensation. The sources of these leaks must be identified if the reoccurrence of this problem is to be prevented.

  The purpose of the crackle test is to monitor the lubricant for water contamination. Because the presence of water can cause accelerated oxidation, corrosion, and excessive wear, it is essential that the oils are monitored for water.

  In the crackle test, a drop of oil from an eyedropper is placed on a hot plate heated to 100°C, and monitored for the characteristic crackle that occurs as water explodes into steam. This test is a simple go-no go test that indicates either a positive or negative for the presence of water. If the drop of oil crackles, it indicates that at least 0.1% water or greater is present. The lab will report this as a positive test. Typically, a Karl Fisher test is then performed to quantify the amount of water.

  The Karl Fisher test is a quantitative measure of moisture in oil, reported in parts per million or as a percentage. According to the ASTM D1744 standard, a fixed amount of water reactive reagent is added to a mixture of sample and solvent to achieve a preselected electric response. The instrument calculates the amount of water present based on the amount of reagent required.

- **Smells:** EPRI has been working with Cyrano Sciences to develop a library of composite smells of lube oils, both for new oil fingerprinting and additive concentration and also for used oil degradation without ever having to sample the equipment.

  The technology consists of individual thin-film carbon-black polymer composite detectors configured into an array. The collective output of the array is used to identify an unknown vapor using standard data analysis techniques. The sensor array, along with data analysis algorithms, forms the main components of the electronic nose. The output from the device is an array of resistance values as measured between each of the two electrical leads for each of the detectors in the array. When the detector is exposed to vapors, the polymer matrix acts like a sponge and swells up while absorbing the vapors.

  Moreover, for well-defined applications, the polymers used in the detector array can be chosen to maximize chemical differences between target compounds to increase the discrimination power of a smaller array. This underscores the power of Cyrano Sciences' polymer composite sensor technology because it is not reliant on any particular polymer type or limited to a particular set of polymers. Additionally, the simplicity of reading resistance values and the low cost of materials of the detectors makes this an ideal technology for a low-cost, hand-held electronic nose.

  By establishing a library of the composite smells of oxidized oils in different degrees of oxidation, a library can be established that allows for a quick check of a sample using the electronic nose to determine the state of degradation of the oil. Because of the desire to concentrate the vapors in an available headspace, the vented areas of storage drums and operating equipment reservoirs become the ideal location to perform *in situ* analysis of the condition of the lubricants. Without sampling the oil from equipment or drums, an evaluation of the vapors present in the headspace can provide important information about the condition of the lubricating oil present.

- **Flash point** (ASTM D92): Flash point indicates the presence of highly volatile and flammable materials in a relatively nonvolatile or nonflammable material. An example is that an abnormally low flash point on a test specimen of engine oil can indicate fuel contamination. The lubricant sample temperature is raised at a constant rate as the flash point is approached. At specified intervals, a small test flame is passed across the cup containing the sample. The flash point is the lowest temperature at which the application of the test flame causes the vapors above the surface of the liquid to ignite.
- **Oxidation stability test** (ASTM D2272): This was formerly called the rotating bomb oxidation test, and it is used to assess the remaining oxidation test life of in-service lubricants. The test lubricant, water, and a copper catalyst coil contained in a covered glass container are placed in a pressure vessel equipped with a pressure gauge. The vessel is charged with oxygen to a pressure of 620 kPa, placed in a constant-temperature oil bath set at 150°C and rotated axially at 100 rpm at an angle of 30° from the horizontal. The number of minutes required to reach a specific drop in gauge pressure is the oxidation stability of the test sample.

- **Demulsibility** (ASTM D1401-96): This test provides a guide for determining the water separation characteristics of oils subject to water contamination and turbulence. A 40 ml sample and 40 ml of distilled water are stirred for 5 minutes at 54°C in a graduated cylinder. The time required for the separation of the emulsion thus formed is recorded for volumes of water, oil, and emulsion remaining after 30 minutes.
- **Pour point** (ASTM D97): The pour point is the determination of the lowest temperature that a petroleum product may be used if fluidity is necessary to the application. After preliminary heating, the petroleum sample is cooled at a specified rate and examined at intervals of 3ºC for flow characteristics. The lowest temperature that movement of the specimen is observed is recorded as the pour point.
- **Foam test** (ASTM D892-95) Sequence I, II, III: The foam test is the determination of the foaming characteristics of lubricating oils at specified temperatures. It is a means of empirically rating the foam tendency and the stability of the foam. A defined volume of air is forced through a set volume of sample lubricant at a specified temperature. The resulting volume of foam is measured.
- **Cone penetration of lubricating grease** (ASTM D 217): This test measures the consistency of grease. Harder grease will have a low National Lubricating Grease Institute (NLGI) rating number, such as 00 or 1. Most industrial greases penetrate in the 265–295 ranges and have a NLGI rating of 2.

  A measured amount of a grease sample is placed under a cone apparatus. The cone is attached to a gauge that measures from 85 to 475. The cone is dropped into the grease sample from a specified height and at a specific time. The measured amount that the cone penetrates into the grease is the cone penetration.
- **Dropping point of lubricating greases** (ASTM D566): This test is a determination of the maximum operating temperature of grease. A grease sample is heated in the dropping point apparatus. The dropping point is the temperature, measured in degrees Celsius, that the grease starts separating and the oil drops out of the apparatus.
- **Percent sediment in lubricating oils:** This test is an excellent determination of sediments suspended in lubricating oil. Excessive amounts of sediments can impede oil capability and can clog filters.

9.2.1 Oil Sampling

Initial sampling frequency for oil is given as 30,000 tons/mill. Table 4-3 lists the lubrication parameters for the mills. The following samples should be taken:

- Roll journal
- Pulverizer gearbox
- Exhauster bearing
- Motor bearings

Oil should be changed on these components based on the test results of the oil samples.

The elements found in the gearbox oil analysis are indications of the condition of the gearbox components. Some diagnostic facts concerning these elements are listed as follows:

- Copper comes from thrust washers, bronze gears, bearing cages, and other bronze or brass components.
- Iron comes from gears, bearings, worm shaft, and piping. The iron may appear as rust after the storage period.
- Foreign materials, such as silicon and water, can be introduced into the gearbox. Silicon can come from sand, dust, or dirt. Water can come from external washing, internal leaks, and condensation.
- Thirty ppm of lead in an oil sample indicates excessive babbitt bearing wear and possible failure. Many of the roller bearing cages are leaded bronze. With the Alstom mills, lead usually means a bearing problem. As an example, Duke Energy detected problems with an upper radial bearing on an Alstom RS763 mill and a radial thrust bearing on an Alstom RS-863 mill.
- Three ppm of chromium and nickel in an oil sample may indicate abnormal wear of rolling element bearings.
- Water content of 200–300 ppm in an oil sample indicates problems.
- Copper counts above 400 ppm can allow clogging of oil passages to the upper radial bearing.
- The ISO 4406 Solid Contaminant Code is used to quantify contaminants in the oil.

9.3 Current Developments

Two current developments in the use of vibration analysis to detect mill problems are discussed in this section. One is an analysis technique by Engineering Consultants Group, Inc., and another is an EPRI-sponsored demonstration of online monitoring for the mills.

The first development is a dynamic analysis technique developed by Engineering Consultants Group, Inc. This integrated system is called Roll-Bowl COP (RBC) and was first installed at the Ohio Edison W. H. Sammis Generating Station in 1993. Vertical shaft failures on RB-633 mills had been a major cost and availability problem at the plant. The dynamic analysis system was initially used to determine the major stresses affecting the fatigue life of the vertical shaft. With these stresses known, specific maintenance adjustments were made.

The RBC system continues to be enhanced through analysis refinements to address specific problems. RBC claims to be able to set the mill grinding elements and drive to the minimum stress levels and optimal performance after maintenance events. This mill setup capability allows tuning of the mills to account for variations inherent in the mill components (for example, roll geometry, spring-K, clearances, and wear patterns). Distributed wear and the lower stress levels allow projections of the maximum component life and the longest intervals between maintenance activities.

The RBC dynamic characteristics are acquired through high-resolution displacement transducers installed on the journal assemblies. These signals are collected on local direct-attached storage (DAS) and processed through cabling or wirelessly to a dedicated personal computer. Other inputs (for example, feed rate, motor amps, and vibration monitors) are also collected and processed on a personal computer.

With RBC signatures taken over a spectrum of load conditions and with supporting inputs, analysis can determine many mill characteristics. These characteristics include roll wear, broken springs, journal-to-spring gaps, ring-to-roll gaps, vertical shaft integrity, component eccentricity, relative journal work, vertical shaft bending stresses and bearing degradation.

A portable unit for snapshot analysis or an online, permanently installed system is available. The online RBC system provides continuous trending data and alarms for significant real-time events. An upgrade is available that ties into the plant data historian.

Figure 9-1 shows the resultant bending force on one vertical shaft from a First Energy plant.

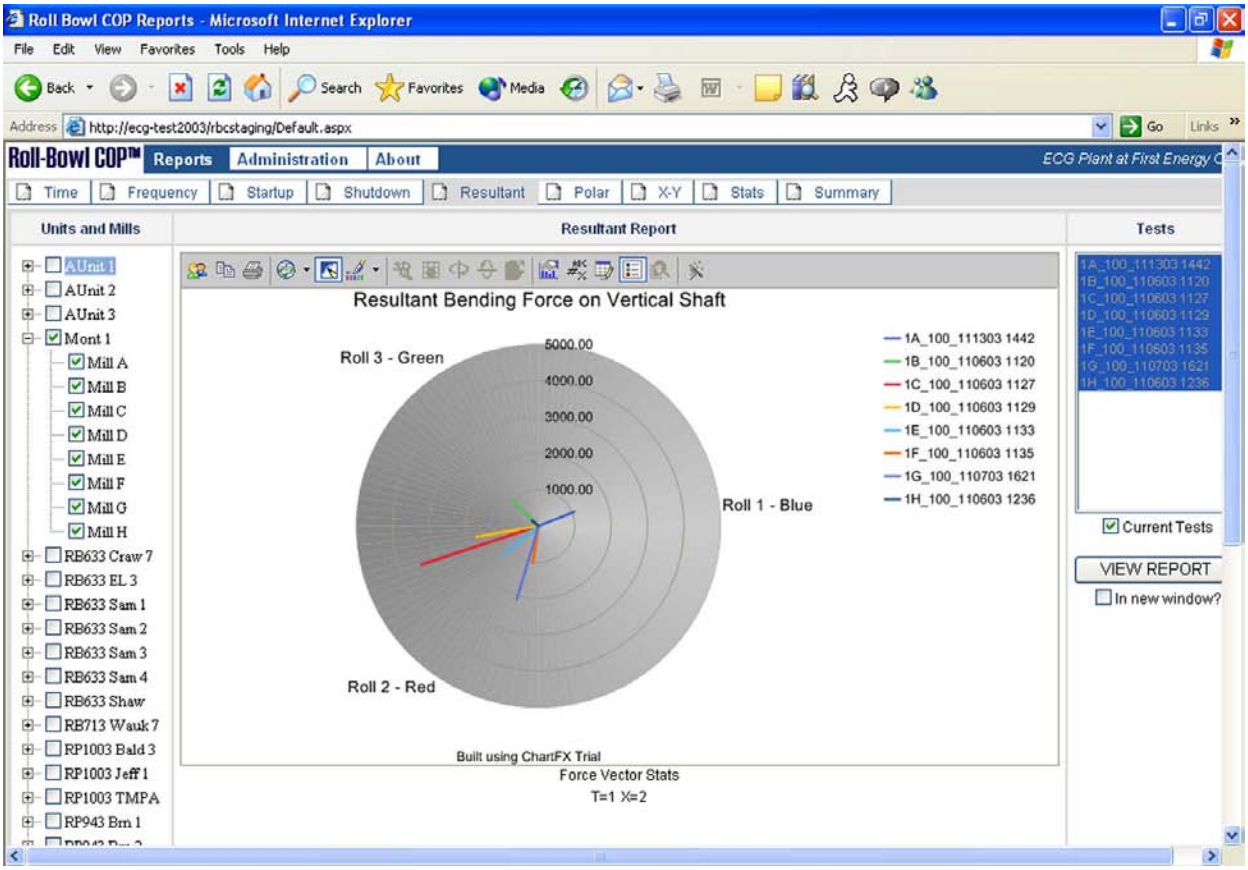


Figure 9-1
Vertical Shaft Fatigue Forces
(Courtesy of Engineering Consultants Group, Inc.)

Figure 9-2 is a finite element model of an Alstom coal mill used to detect resonance problems.

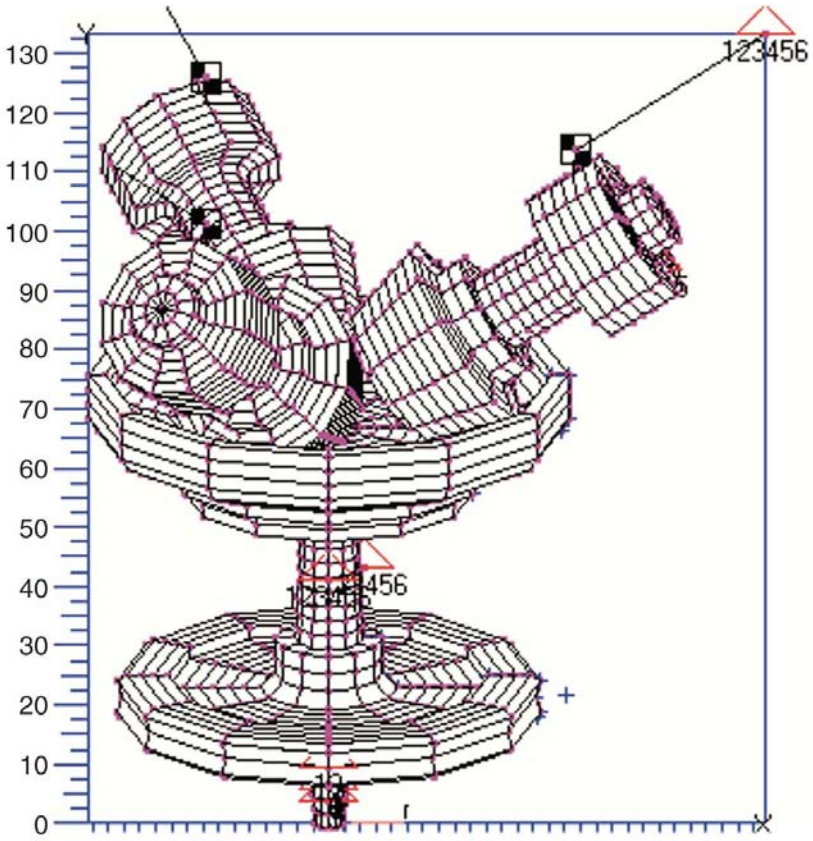


Figure 9-2
Finite Element Model of Alstom Mill
(Courtesy of Engineering Consultants Group, Inc.)

Figure 9-3 shows a frequency spectrum versus roll loading.

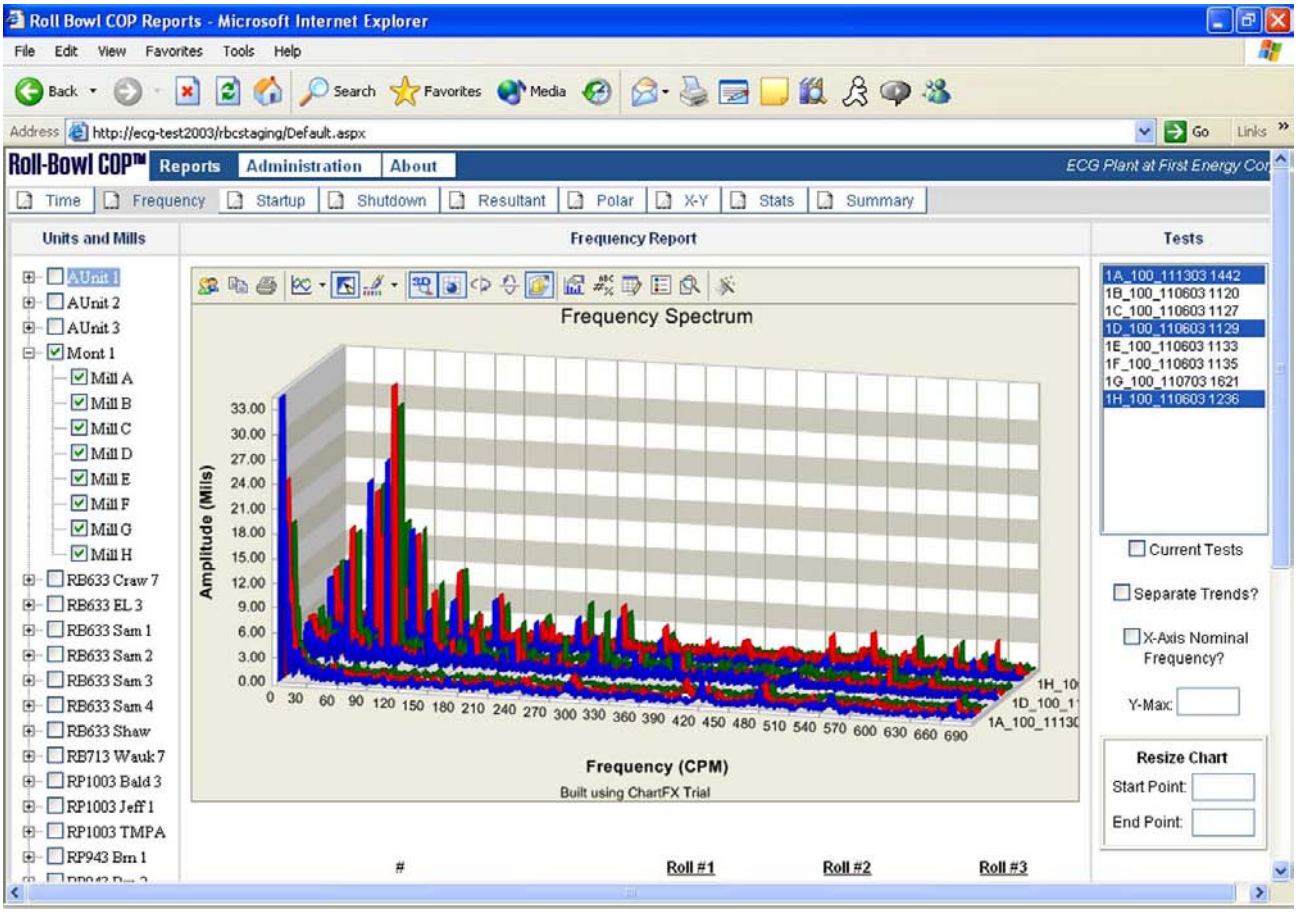


Figure 9-3
Frequency Spectrum Versus Coal Loading
(Courtesy of Engineering Consultants Group, Inc.)

The RBC technology has been deployed on over 150 Raymond shallow and deep bowl mills. Additional RBC product information is available at www.ecg.bz.

A second development is an EPRI-sponsored demonstration of online monitoring of the six RP-923 pulverizer mills at the Dynegy Baldwin Energy Complex Unit #3. It was determined that the areas of value for failure detection in the mill are:

- Grinding problems, such as roller journal bearing seizing and insufficient fineness. Early detection of grinding problems would allow interval extension between pulverizer overhauls.
- Motor problems relating coal grind rate to current and motor vibration. Knowledge of motor problems would allow a shift from unplanned to planned maintenance on the motors.
- Sensor plugging of the pressure differential signal. Detection of sensor plugging would avoid operational impact and unnecessary unit derating.

The existing instrumentation was monitored for failure detection of the pulverizer. The parameters are as follows:

- Opacity
- Cold air damper demand
- Hot air damper demand
- Coal flow
- Air flow
- Motor amps
- Air differential pressure
- Bowl differential pressure
- Base pressure
- Feeder speed demand
- Inlet air temperature
- Fuel air temperature
- Cold air damper driver position
- Hot air damper driver position
- Feeder speed

Early detection of grinding element and motor problems could not be detected using the existing instrumentation. It was decided to add the following instrumentation:

- Motor outer bearing vibration
- Motor inner bearing vibration
- Worm drive gear inner bearing vibration
- Worm drive gear outer bearing vibration
- Vertical shaft lower bearing vibration
- Roller vibration

The instrumentation that was added consisted of accelerometers on an epoxy and/or pad mount. A wireless system receiver used an Ethernet connection with the plant's local area network (LAN). A dedicated desktop personal computer received the data and provided an interface with the plant data server. A transmitter was mounted on a structural I-beam within a few feet of the mill. The wireless system receiver was mounted approximately 270 ft away in a maintenance shop with a nearby Ethernet connection. The eight channels within the receiver were individually configured to provide proper signal conditioning, data sampling rates, units of measure, and frequency range for the application.

A software system called SmartSignal eCM V. 2.5 was used to provide real-time analysis of the sensor signal data. The software system receives the raw data and generates expected values using models built from historical data of the mills. The software determines for each sensor whether the actual values deviate significantly from the estimates and, if so, produce an alert. Alerts are passed through user-configurable rules that determine whether to create an incident and automatically notify users that the mill must be watched. Rules can also be used to diagnose the cause of the incident and classify it according to severity and confidence of diagnosis.

For more information on this demonstration, see the *Online Predictive Condition Monitoring System for Coal Pulverizers*, EPRI, Palo Alto, CA: 2003 1004902 [10].

10
PREVENTIVE MAINTENANCE

This section covers the following topics:

- Inspection criteria
- Inspection tasks
- PM Basis

10.1 Inspection Criteria

Part of the preventive maintenance program [4] is to perform equipment inspections. The following inspection parameters are critical for mill performance:

- Classifier internal condition
- Deflector ring length
- Inverted cone clearance
- Journal assembly condition
- Grinding roll-to-bowl clearance
- Spring pressure for rolls
- Pyrite scraper clearance
- Pyrite rejects chute and/or damper condition
- Barometric damper condition
- Primary and secondary riffle condition
- Exhauster clearances
- Feeder settings
- Air in-leakage sources

The following is a discussion of the assembly parameters. Figure 10-1 is shown as a reference to this discussion.

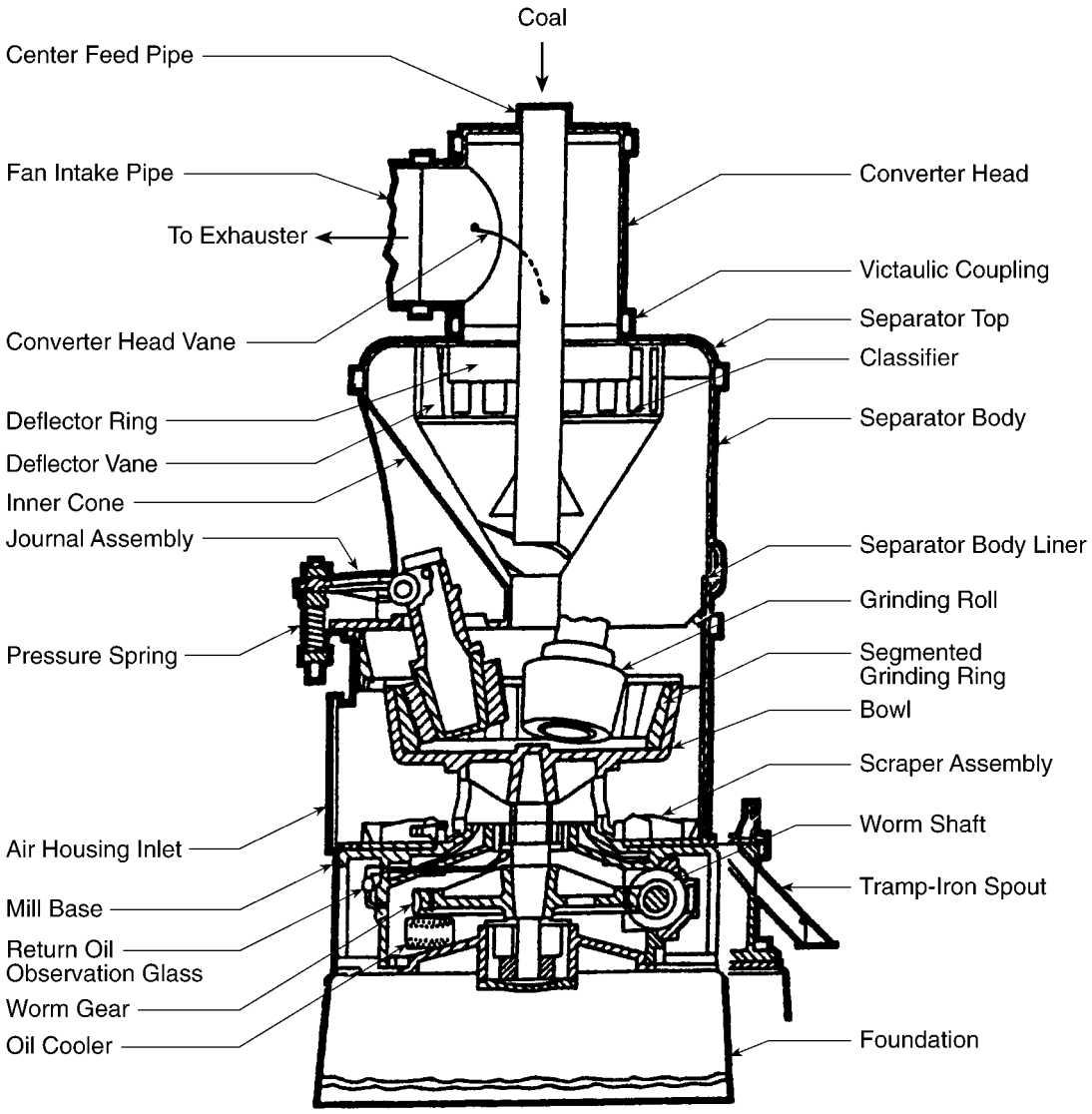


Figure 10-1
Deep Bowl Mill [4]

- **Classifier internal condition:** The bottom of the cones should be inspected for holes, uneven positioning of the inverted cone, and vanes out of alignment. It may be necessary to pull the separator top for more access to the vanes.

  For rotating classifiers, all of the external indicators should be set the same, and all classifier blades should be oriented the same. Figure 10-2 shows a classifier deflector regulator assembly.

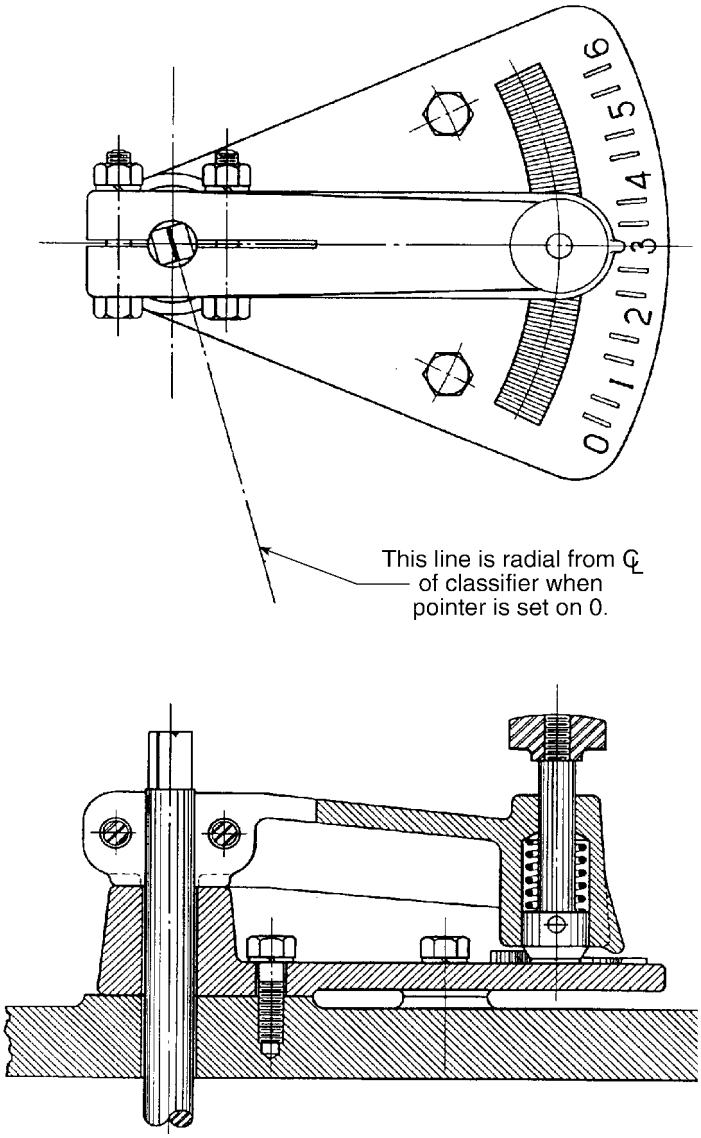


Figure 10-2
Classifier Blade Timing [4]

Blades that are not adjusted properly affect fineness and mill capacity.

- **Deflector ring length:** The ring should not have any holes. The original designed deflector ring extends down the length of the classifier vane about 40%.

O&M Cost Key Point

Extending the deflector ring down the full length of the classifier vanes has been shown to significantly improve the mill performance (specifically 50 mesh fineness) with no loss in capacity.

- **Inverted cone clearance:** The inverted cone prevents reverse flow of coal out of the bowl. The largest diameter of the cone should be set at 3.5 +0.0, -0.5 in. distance to the classifier cone. If the clearance is too small, bridging of coal between the inverted cone and the classifier cone can occur, which can result in fires or a capacity reduction. If the clearance is too large, high velocity air can carry the large particles out of the mill and not back into the grinding zone. This results in poor fineness.

  The latest recommendation by Alstom is that the distance between the end of the feed pipe and the classifier cone is equal to the distance between the inverted cone and the classifier cone. Alstom will calculate the inverted cone clearance for customers, if needed.

- **Journal assembly condition:** The roll wear or material should be limited to 1 1/4 in. measured on the radius for the standard grinding roll. For the welded or Ni-hard tread grinding roll, the maximum wear of 1 3/4 in. on the large radius, 3/4 in. on the small radius, with a center average radial loss of 1 1/4 in. is given.

  To predict roll wear, roll wear must be correlated with the amount of coal that went through the mill. The rolls should turn freely.

  Figure 10-3 shows a worn journal roll.



Figure 10-3
Worn Journal Roll
(Courtesy of Great River Energy)

Technical Key Point

Changing out one roll and leaving two worn rolls in place will result in uneven spring compression and capacity problems. Maintaining three rolls with equal wear patterns is very important for mill performance.

The rubber boot or journal opening air seal should be replaced if the seal is dried out, cracked or if a gap exists between the seal and the journal head. The air seal can be a major source of air in-leakage on a large number of machines.

Figure 10-4 shows the journal assembly clearance drawing and Figure 10-5 shows dimensions and an assembly procedure for the journal assembly.

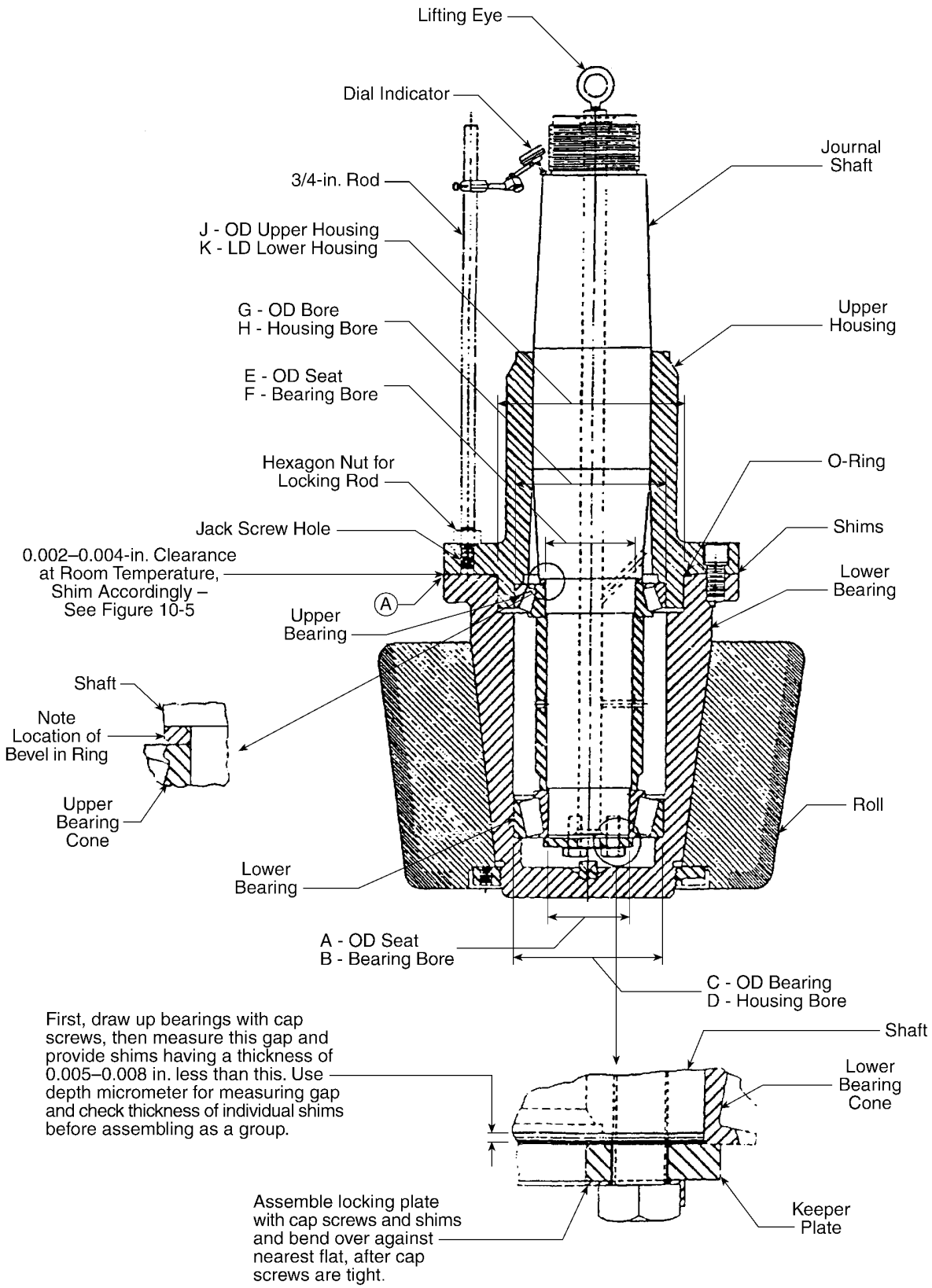


Figure 10-4
Journal Assembly Clearance Drawing [4]

MLL Size	A	B	C	D	E	F	G	H	J	K
412, 452 and 453	3.501 to 3.500	3.501 to 3.500	6.376 to 6.375	6.374 to 6.373	4.251 to 4.250	4.251 to 4.250	6.501 to 6.500	6.499 to 6.498	7.874 to 7.873	7.876 to 7.875
473, 493 and 533	4.001 to 4.000	4.001 to 4.000	7.501 to 7.500	7.499 to 7.498	4.501 to 4.500	4.501 to 4.500	7.501 to 7.500	7.499 to 7.498	9.374 to 9.373	9.376 to 9.375
573, 593, 613 and 633	4.501 to 4.500	4.501 to 4.500	8.376 to 8.375	8.374 to 8.373	5.001 to 5.000	5.001 to 5.000	8.501 to 8.500	8.499 to 8.498	10.374 to 10.373	10.376 to 10.375
673	5.501 to 5.500	5.501 to 5.500	11.626 to 11.625	11.624 to 11.623	6.001 to 6.000	6.001 to 6.000	10.5635 to 10.5625	10.5615 to 10.5605	12.874 to 12.873	12.876 to 12.875
703, 713, 723, 733 and 753	6.001 to 6.000	6.001 to 6.000	12.127 to 12.125	12.124 to 12.123	6.876 to 6.875	6.876 to 6.875	12.252 to 12.250	12.249 to 12.248	14.874 to 14.873	14.876 to 14.875

1. Assemble the upper bearing ring, upper bearing cone, bearing spacer sleeve, lower bearing cone, shims, keeper plate, and locking plate on the lower end of the shaft. See cross section in Figure 10-4.
2. Lower shaft assembly into the lower housing and roll assembly. Roll must be on housing.
3. Let the upper journal housing (with bearing cup pressed in) down over the shaft and secure lightly to the lower housing with four of the cap screws (no lock washers) evenly spaced in the flange. Do not draw the screws up too tightly.
4. Rotate the shaft, and draw up on the cap screws uniformly until the bearings just begin to bind.
5. Check the gap at point A between upper and lower housings in three or four places with a feeler gauge. Record the readings, and average them.
6. Disassemble the upper housing and place the neoprene O ring in the recess of the lower housing flange. Then place sufficient shims on the flange to obtain a running clearance of 0.002–0.004 in. The shims necessary are usually 0.004–0.005 in. more than the average reading from the feeler gauge check referred to in #5 because in the final assembly the cap screws are pulled down tight.
7. Reassemble the upper housing using the eight cap screws and lock washers, drawing them uniformly tight.
8. Fasten a 3/4 in. diameter rod threaded at its lower end in one of the jack screw holes in the flange of the upper housing. Lock the rod with the hex nut.
9. Install a dial indicator at the top of the rod, resting the contact button on the shaft shoulder as shown.
10. Rotate the journal shaft back and forth a few times by hand to be sure that the lower bearing is seated.
11. Carefully hoist the shaft by the eye bolt, and take a reading on the dial indicator; it should read at least 0.002 in. and not more than 0.004 in. Repeat the lifting several times, turning the shaft each time. Readings should check.
12. If the clearance is more or less, remove or add shims as required and recheck, following the procedure in #11.

Note: The use of molykote (molybdenum disulfide) is suggested for coating bearing seats to facilitate subsequent disassembly.

Figure 10-5
Journal Assembly Dimensions and Procedure [4]

- **Grinding roll-to-bowl clearance:** The roll-to-bowl clearance should be set to 1/4 in. parallel for the entire length of the roll. The roll being parallel to the bowl affects the performance of the mill and the wear parts. As the roll and bowl wear, adjustments need to be made to maintain the proper clearance. The adjustments should be made when the mill performance or capacity starts to deteriorate. Figure 10-6 shows the grinding roll-to-bowl clearance.

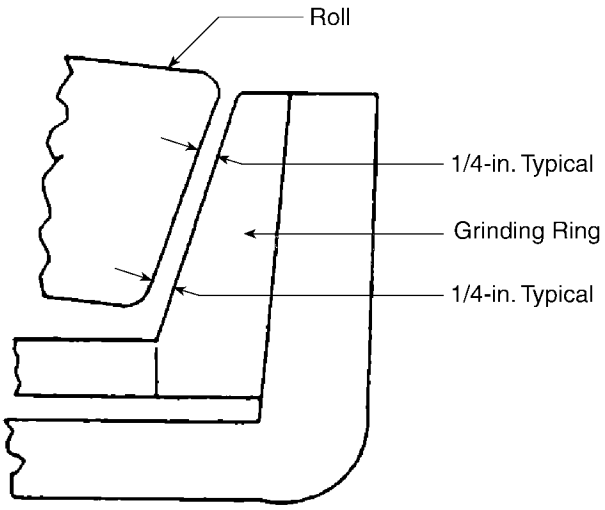


Figure 10-6
Grinding Roll-to-Bowl Clearance [4]

Figure 10-7 is shown to provide guidance on adjusting the roll to be parallel to the grinding ring.

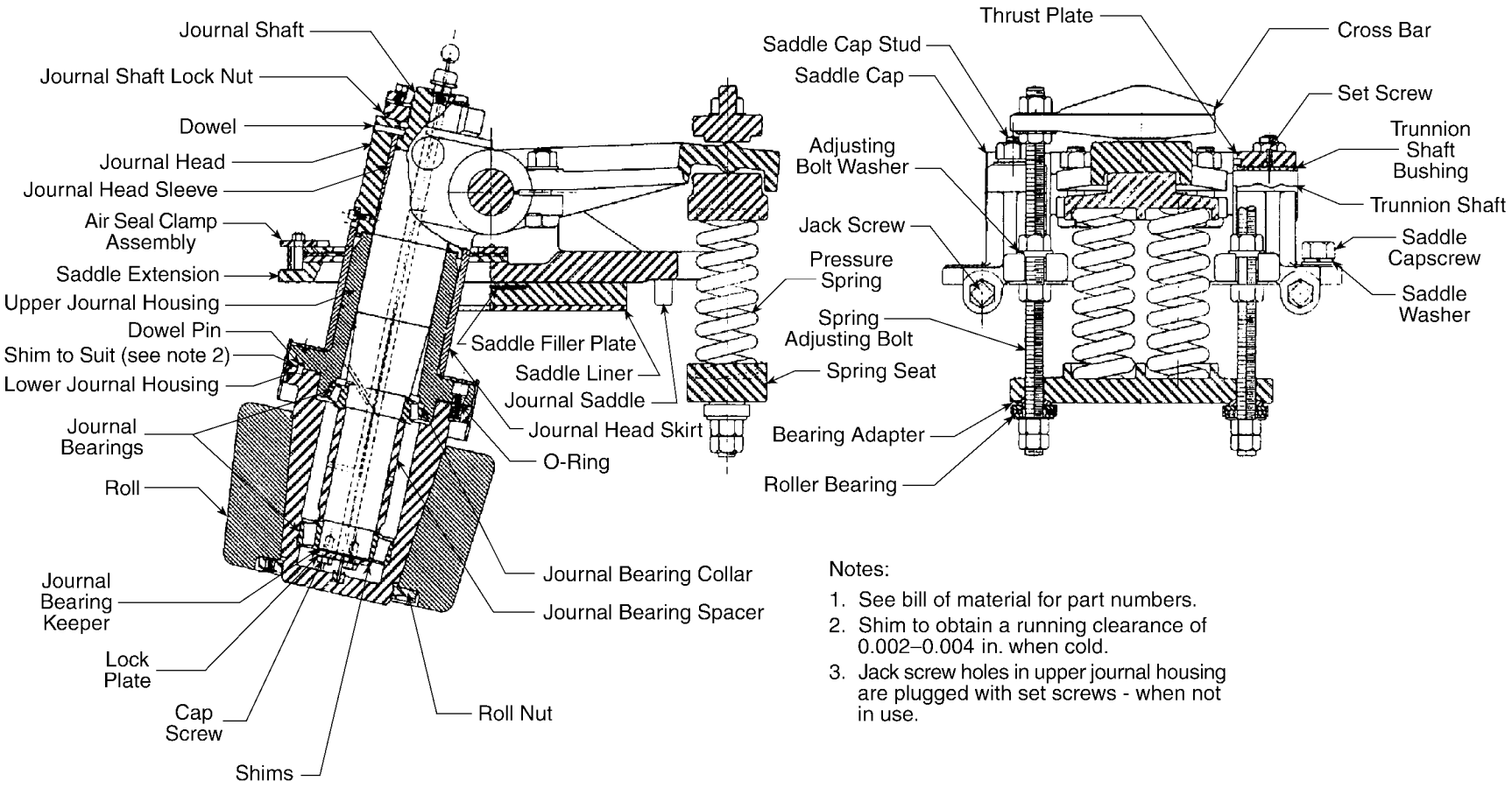


Figure 10-7
Roll Adjustment [5]

When making a roll adjustment, turn the lower spring adjusting screw nuts until the spring is not compressed. Measure the distance between the ears of the lower spring seat and the saddles adjacent to the adjusting screws. This distance should be the same at both ends to ensure that spring bearing surfaces are parallel.

Low grindability coals require more pressure, and high grindability coals require less pressure. If the coal entering the mill is consistently fine, less clearance between the rolls and ring is needed. If the coal is a larger size, a larger clearance is needed.

When the mills have been operating for a long time, the space between the bottom of the roll and the ring is larger than the space at the top of the roll. If the space at the bottom of the roll becomes too large, the mill capacity will decrease. The rolls will have to be adjusted to make the faces parallel.

Only two or three adjustments would be made on the roll-to-grinding ring clearance in the life of the parts. Too frequent adjustment causes excessive wear at the bottom of the roll and ring. A decrease in mill capacity or excessive coal spillage is an indication that an adjustment is needed.

- **Spring pressure for rolls:** Observe the spring compression of the rolls when the unit is in operation. If one journal oscillates or deflects differently than the others, further inspection is needed.

The spring compression on the three journals in one mill should be as equal as possible. For example, the spring rate for the RB-633 mill pair of springs is 18,000 lb/in. The resultant roll pressure is 12,600 lb/in. Unequal or non-uniform spring pressures can result in capacity loss and vertical shaft failures.

When using a hydraulic jacking fixture to measure the spring pressure, the following formula is used:

$$P = F / A$$

where,

P = the gauge pressure of the hydraulic system in lb/in^2
F = the desired spring pressure set point (lb)
A = the area of the hydraulic ram (in^2)

Figure 10-8 shows a spring assembly.

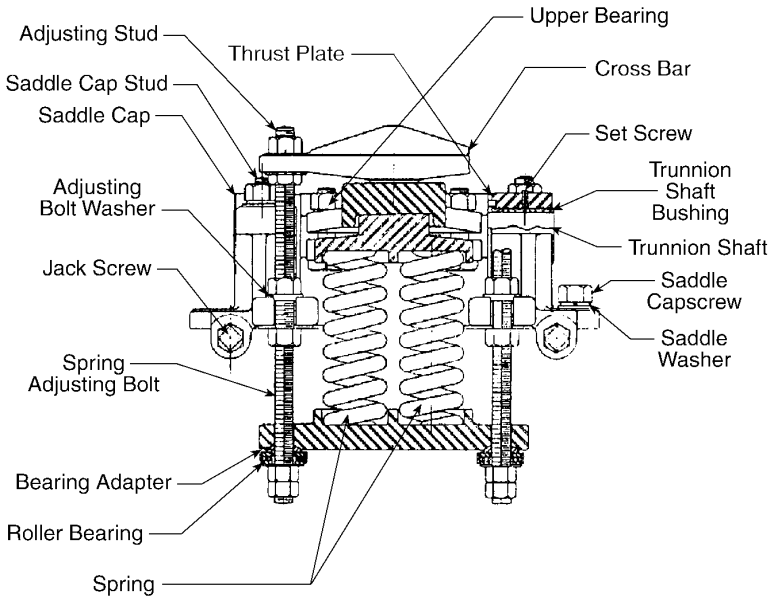


Figure 10-8
Spring Assembly [4]

For example, on a RB-633 mill, the desired spring setting is 11,250 lb or 5/8-in. compression. The desired spring setting for a RB-700 series mill is 20,000 lb or 1-in. compression. Figure 10-9 shows a typical configuration for a hydraulic jacking fixture.

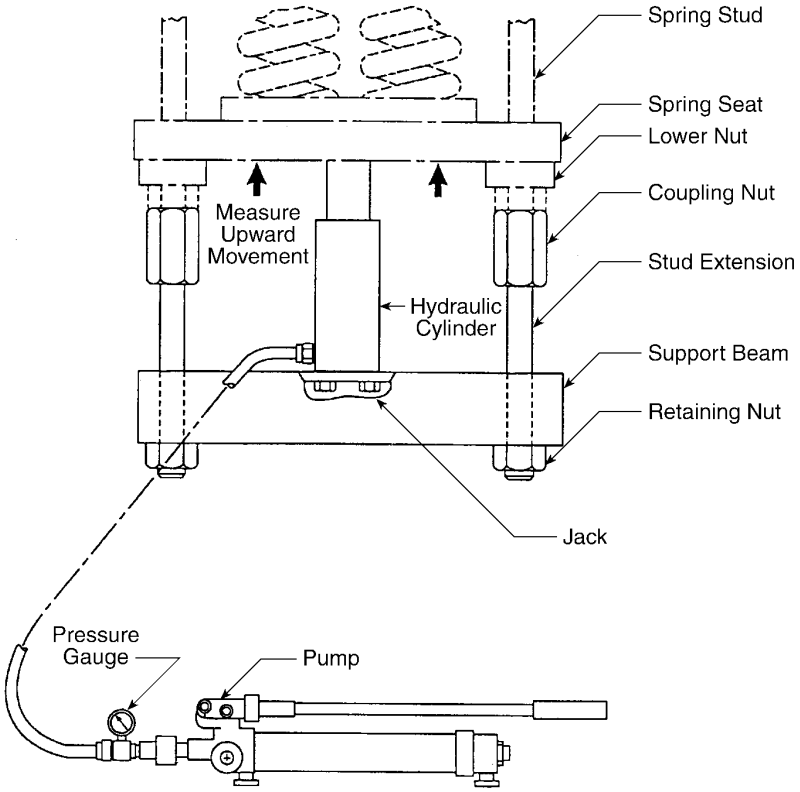


Figure 10-9
Typical Hydraulic Jacking Fixture [4]

The pump is activated until the desired gauge pressure is reached. Then the nuts and jam nuts are tightened.

A properly adjusted spring pressure will result in a 1/4-in. to 1/2-in. gap between the stop bar and the journal head at normal operating conditions. At minimum load the gap should be 1/16 in.

Technical Key Point

One indication that the spring pressure is too high is a rumbling noise at low loads. If the spring pressure is too low, the rumbling noise can occur at high loads.

Insufficient spring compression allows the journal head level arm to move too far away from the stop bar when the mill is loaded. This distance should normally be 1/4–1/2 in. Grindability of the coal, moisture content, raw coal size, and fineness of the pulverized coal affect the clearance dimension. The clearance should be checked at the lowest mill capacity. If there is no clearance when operating at the lowest capacity, the spring compression should be reduced by lowering the bottom spring seat until the clearance at the stop bar is 1/16 in.

For more details on setting the compression spring rates for the Alstom mills, see Section 11.3.1.2.

- **Pyrite scraper clearance:** The pyrite clearance should be set to 1/4 to 3/8 in. from the bottom of the scraper to the mill bottom. Figure 10-10 shows a scraper and guard assembly.

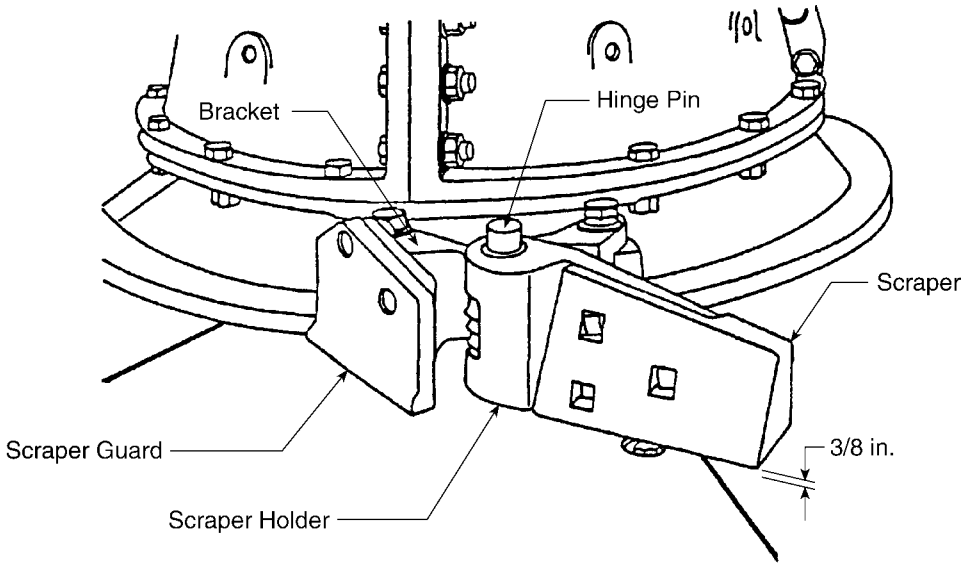


Figure 10-10
Scraper and Guard Assembly [4]

If the mill bottom cover is warped, the gap should be set at the high point to prevent dragging and sparking. Replace the scraper if excessively worn. Bolts holding the scraper to holder should be Grade 5 or higher material.

If the clearance between the mill bottom liner and the scraper is greater than 1 in., the mill bottom liner should be replaced. On some of the 803 RP and 903 RP mills, the amount of 0.5 in. is used for replacement. The thickness of the bedplate for these mills is 0.5 in.

Coal accumulation in the under bowl area can result in fires and explosions. Coal buildup in this area of the mill can be exposed to air temperatures as high as 500ºF. In addition, the rubbing of the scraper can cause sparks and a fire can ensue.

If the end play in the scraper is greater than 3/8 in., the hinge pin and/or bushing should be replaced. This can be checked by grabbing the end of the scraper and moving it up and down. If the pin is worn, remove the assembly, drill out the pin hole, and install a bushing and new hardened pin.

Check the scraper guard condition. This component protects the hinge pin from damage and wear, breaks up big chunks of material that the scraper may not be able to move, and provides the initial push of the material being discharged.

Section 11.4.3 in this guide gives the instructions for replacing the scraper, hinge pin, and scraper guard and adjusting the scraper to mill-bottom clearance. In addition, a cable-type pyrite sweeper can be used.

- **Pyrite rejects chute and/or damper condition:** The pyrite dampers should operate freely with the counterweight in place for the RB/RS style mills. Figure 10-11 shows a pyrite reject chute for the RB/RS mill designs.

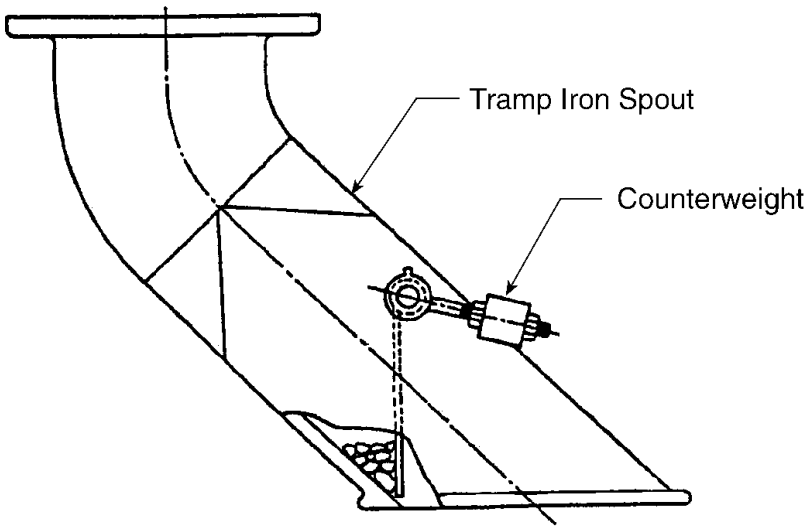


Figure 10-11
Pyrite Reject Chute [4]

The dampers can be a major source of air in-leakage into the mill. The air in-leakage can interfere with controlling mill outlet temperature and cause a heat rate penalty. The air in-leakage can also affect the mill capacity by cooling the fuel/air outlet temperature and the fineness by adding air that is uncontrolled or unaccounted for.

The RPS/RP style mills have a seal door into a hopper where the pyrites are stored for slurry transfer away from the mill. If excessive coal is discharged, pluggage can occur and prevent the slurry system from operating. An annual inspection of the slurry system should be performed.

- **Barometric damper condition:** The barometric damper should be free to move through the entire range with the counterweight applying force to hold the damper in the closed position. This is a source of air in-leakage that can affect the mill performance.
- **Primary and secondary riffle condition:** Figure 10-12 shows a distributor box or riffle for the coal pulverizers.

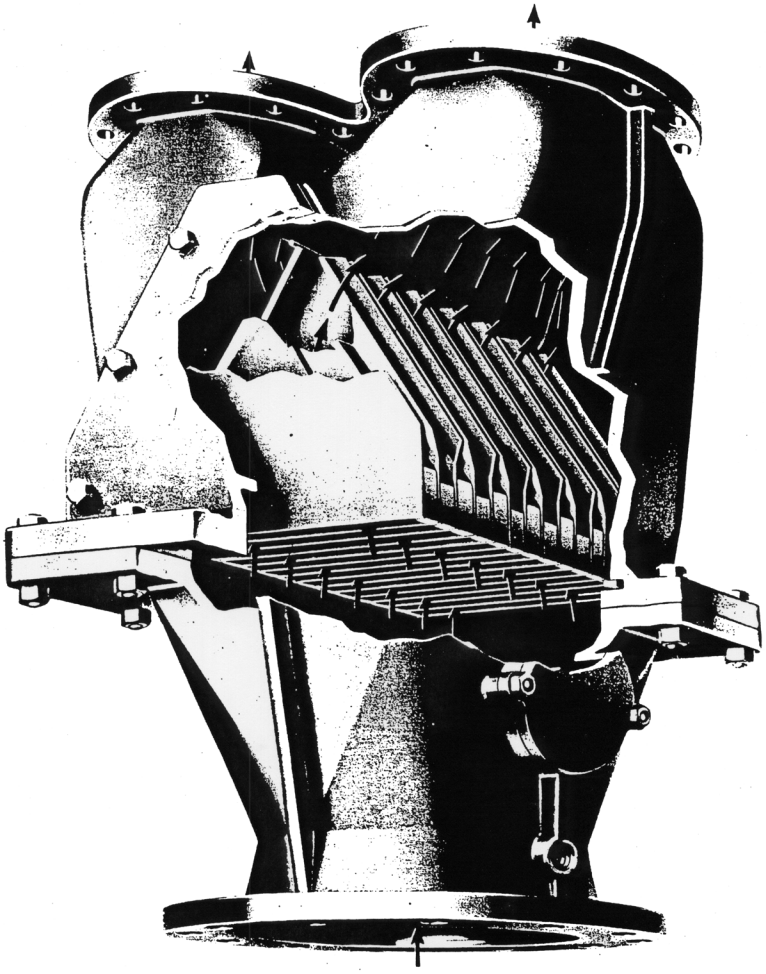


Figure 10-12
Riffles [4]

Riffles are distribution housings that receive the coal and airflow mixture from the exhausters and divide the flow for separate entrance into the boiler burners. Riffles provide even distribution of coal to the boiler. A standard recommendation is to use a 1-in. riffle width for the primary riffle and a 2-in. riffle width for the secondary riffle.

Alstom recommends inspection of the riffle elements for wear and pluggage during every major outage. Riffle elements with more than 3 in. of wear are recommended for replacement. The riffle elements should be inspected if the results of the airflow tests indicate an imbalance in the coal and airflow to the boiler.

- **Exhauster clearances:** Figure 10-13 shows a standard exhauster fan.

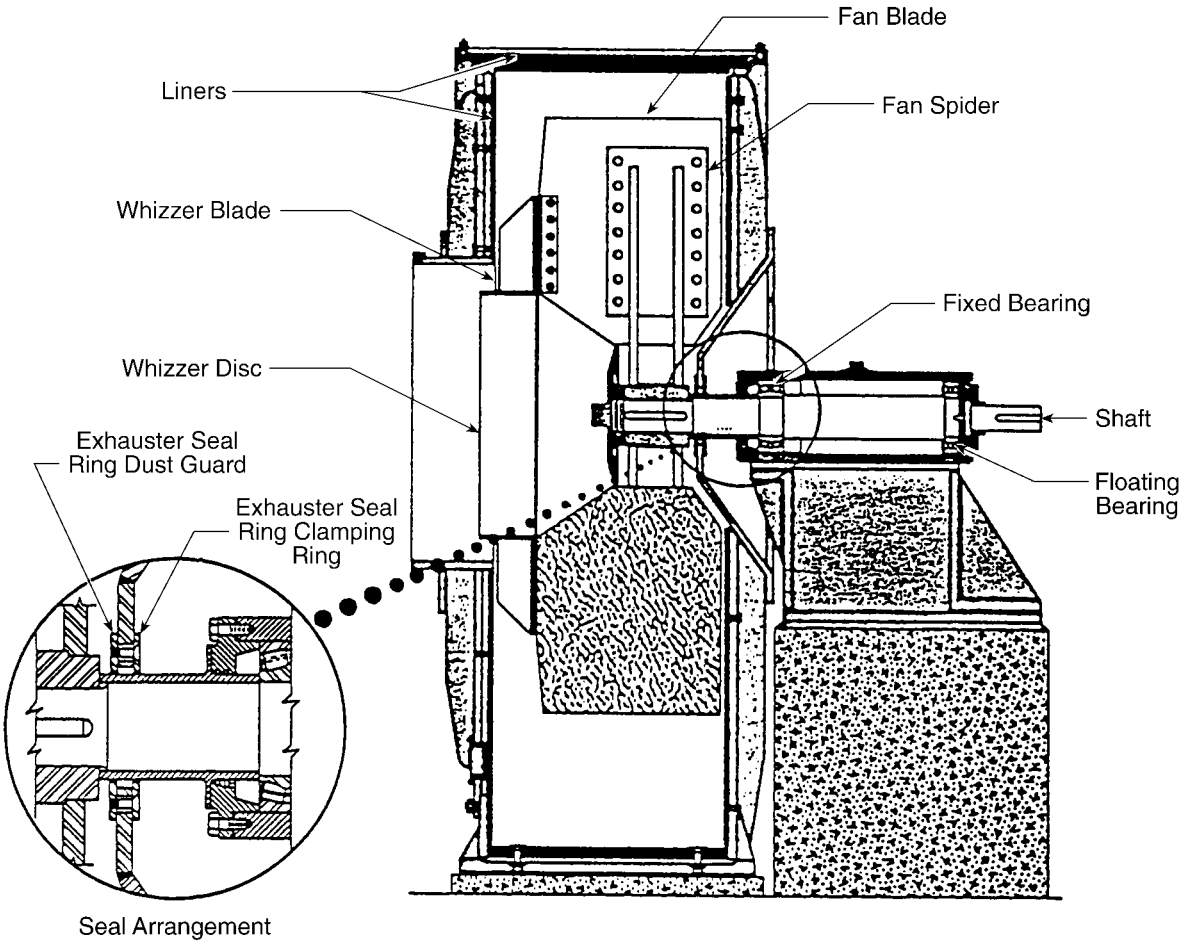


Figure 10-13
Standard Exhauster Fan [4]

Alstom recommends that the whizzer blade clearance be adjusted to 3/8–1/2 in. The fan design is a relatively inefficient design; therefore, the exhauster inlet damper should be set up with a minimum number of stops to ensure minimum velocity through the exhauster. See Section 5.1 for guidance on setting this damper.

Because Duke Energy was having problems with coal buildup on the inlet ring to the whizzer disk, the length of the ring was changed from the original 8 in. to 4 in. Less than 4 in. causes excessive fan blade wear.

A high-efficiency exhauster is available that increases the airflow by as much as 30%. One design is shown in Figure 10-14.

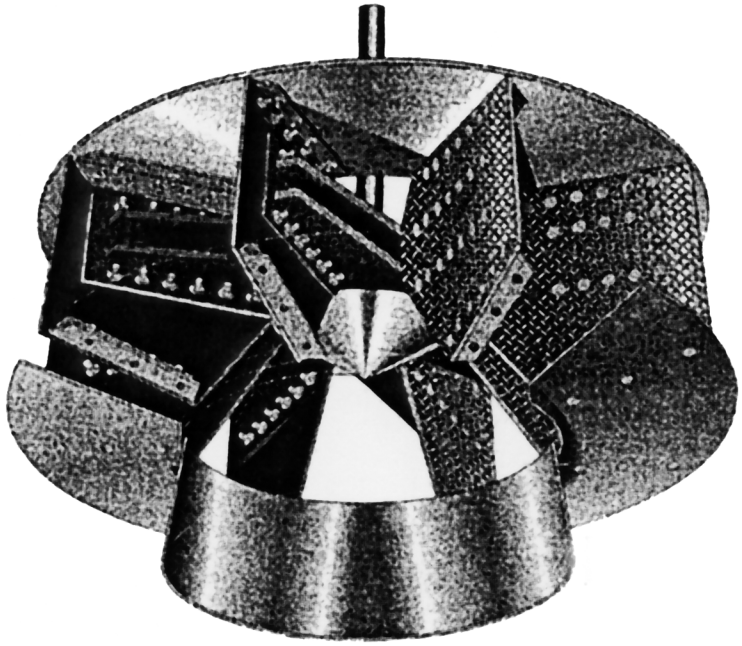


Figure 10-14
High-Efficiency Exhauster [4]

The exhauster discharge valve on the RB/RS/RPS-style mills and the mill discharge valve on the RP-style mills should be inspected annually for positive sealing. The valve stroke, test valves, and limit switches should be tested annually.

Feeder settings [13]: Feeder accuracy is measured by the following:

- **Repeatability:** Repeatability reports the consistency of the feeder's discharge rate and is measured by taking a series of timed same consecutive catch samples from the discharge stream. The samples are weighed, and a standard deviation of sample weights (expressed as a percentage of the mean value of the samples taken) is determined.
- **Linearity:** Linearity determines how accurately the feeder discharges the requested rate. To perform a linearity measurement, several groups of timed catch samples are taken from the feeder's discharge stream. The catch samples are taken at different flow rates. Each weight-based deviation is then expressed as a percent by dividing by the expected sample weight and multiplying by 100. The result is a set of error values, reflecting the average feed rate performance over the unit's operating range.
- **Stability:** Stability indicates the performance degradation over time. Drift is detected by calibration checks and is typically remedied by a simple weight span adjustment. The frequency of stability checks is determined by the plant, based on equipment experience.

Figure 10-15 shows the coal feeder assembly, and Figure 10-16 shows the leveling gate for a volumetric feeder.

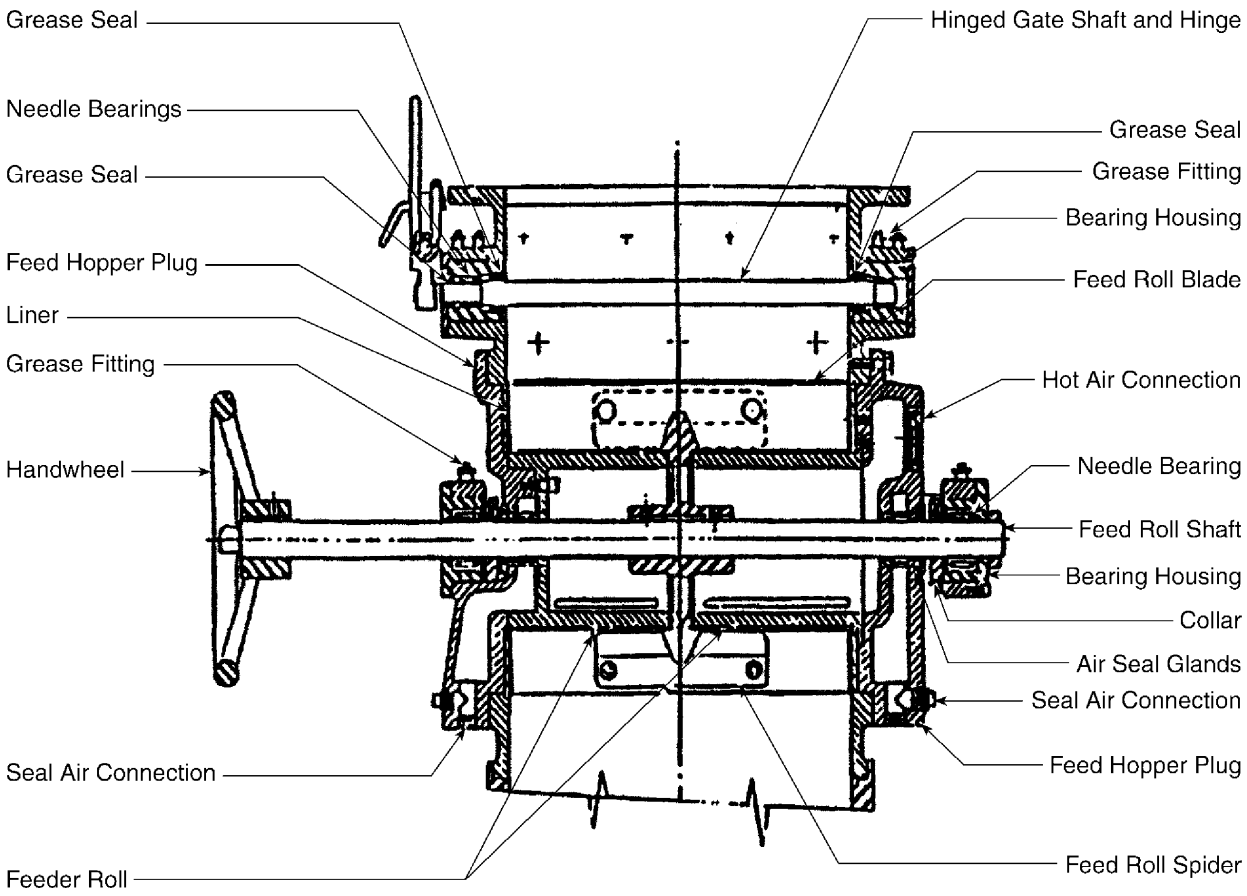


Figure 10-15
Coal Feeder Assembly [4]

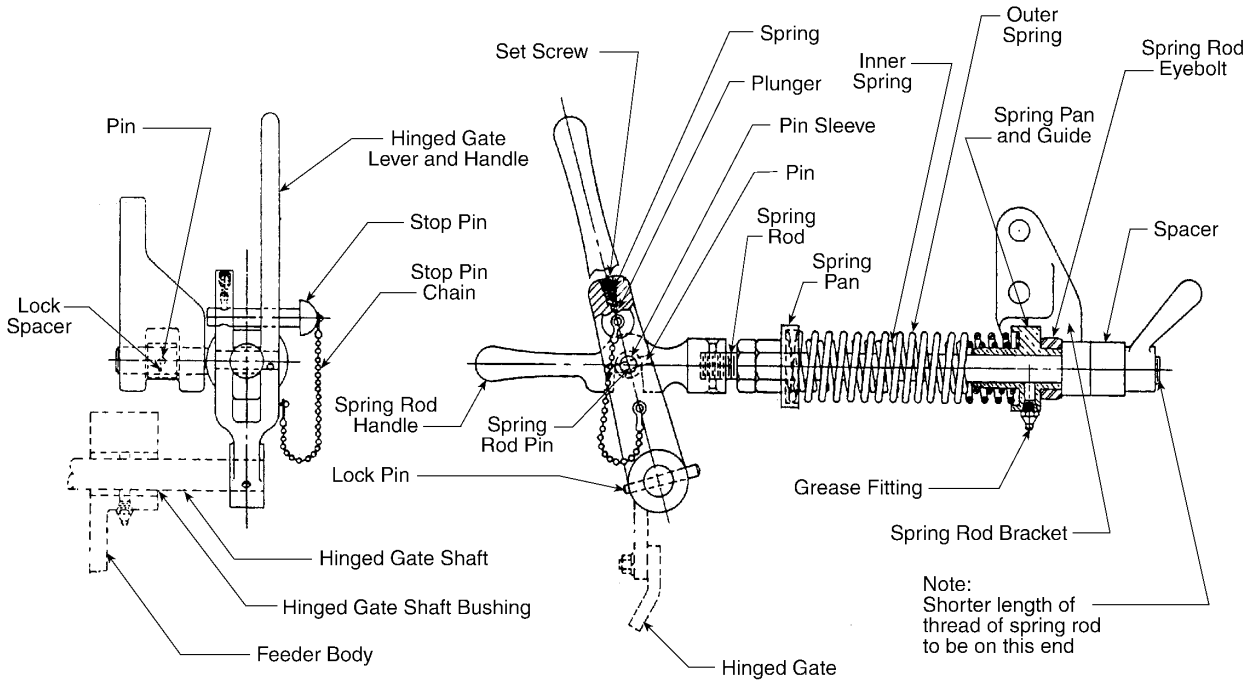


Figure 10-16
Leveling Gate [4]

The lock pin shown in Figure 10-16 was removed in a later revision. The lock pin is prone to breakage, and when the lock pin breaks, the hinged gate opens and overfeeds the mill.

Typical problems for the gravimetric feeder are associated with managing the belt itself. Keeping the belt clean, tracking properly, and in constant tension is a concern for the weigh belt gravimetric feeders. The inlet gate is set to produce a material bed of a certain height and width for the given coal. Adjustment to the inlet gate may be required to avoid material spilling off the belt or coming in contact with the channeling side skirts.

The proper belt loading value must be established. Automated sampling is used to reliably determine the feeder accuracy.

- **Air in-leakage sources:** Sealed journal type pulverizers typically have 8–12% air in-leakage. The three main sources of air in-leakage for the pulverizer mills are the reject door, journal seals, and journal to pulverizer case.

These areas should be examined for any openings that would allow air to flow into the pulverizer. There are numerous methods for detecting the leakage on line, such as soap bubbles, plastic wrap, and shaving cream. The idea is to coat the surface with a substance that will indicate air flowing through the surface into the mill. Repairs to these surfaces include cleaning and establishing a flat surface for sealing.

10.2 Inspection Tasks

For the deep bowl mills, Alstom [4] recommends completely disassembling the mill after 25,000 hours of operation to check the bearings, bushings, gears, and lubricating system. The lubricating system should be thoroughly cleaned at that time.

The time between complete disassembly of the mill depends on the pulverizer design, the type of coal used, the tons of coal pulverized, and other factors. Many plants have experienced much greater overhaul intervals than the 25,000 hours given by Alstom. For example, Hong Kong Electric, Lamna Plant has gone over 100, 000 hours between overhauls. Great River Energy, Coal Creek Plant plans overhauls at 2,000,000–2,500,000 tons of coal processed.

Table 10-1 is a checklist of mill preventive maintenance inspection tasks, Table 10-2 is a checklist for a volumetric feeder, Table 10-3 is a checklist for a gravimetric feeder, and Table 10-4 is for exhauster preventive maintenance inspections. The initial frequency of these inspections is given as 35,000 tons of coal and can be adjusted higher or lower based on the roll wear and roll-to-bowl clearance.

Table 10-1
Checklist for Mill Preventive Maintenance Inspections [4]

	Mill Preventive Maintenance Inspection Tasks
1.	Check roll wear by measuring roll diameter. Maximum roll wear should not be >1 1/4 in. off the radius. Rolls should be uniform in diameter. Record as found and final diameters of each roll.
2.	Check roll-to-bowl clearance. The nominal clearance is 1/4 in. Adjust the roll-to-bowl clearance if the clearance is ≥3/8 in. Record as found and final clearance for each roll.
3.	Check segmented bull ring for wear. Measure using template made from new segment section. Record wear at greatest point. If the wear depth >3/4 in., schedule weld repair or replacement of segments. Record final dimensions.
4.	Check pressure springs for annealing and studs for cracks or breakage.
5.	Verify spring tension. Set spring tension using the hydraulic setting technique. All springs on one mill should be compressed equally. Record final spring tension for each roll.
6.	Check mill for trash. Remove any trash.
7.	Check mill liners for holes and/or wear. Document final condition of the mill liners.
8.	Check hold-down ring segments for broken bolts. Replace any broken bolts.
9.	Check classifiers for proper movement and consistent vane settings. The as-found and final vane settings should be recorded on a chart or drawing.
10.	Check the condition of the deflector ring. Record any breakage or significant wear.
11.	Check classifier cones for holes, pluggage, and missing bolts. The inverted cone to classifier cone clearance should be 3-1/2 in. minimum and 5 in. maximum. Record the as-found and final clearance. The minimum clearance may be increased to 4 in. for less pluggage with high moisture coals.
12.	Check the pyrite kicker and/or scrapers, guards, and holders for wear. Record the final condition. Bolts holding scrapers, scraper holders, and scraper guards should be Grade 5 or higher material and tack welded.

Table 10-1 (cont.)
Checklist for Mill Preventive Maintenance Inspections [4]

Mill Preventive Maintenance Inspection Tasks	
13.	Check the pyrite scraper hinge pin and bushing for wear. Check by moving the end of the scraper up and down. End play of ≥3/8 in. indicates replacement of the pin, and bushing or a pyrite scraper is needed. Record the as-found and final end play. Note that the pins should be of a hardened material.
14.	Check the pyrite kicker and/or scraper clearances. Adjust the clearance if it is >3/4 in. The adjusted clearance should be 5/8 in. ±1/8 in. Record the as-found and final clearance. If the pyrite chamber floor is warped, set the scraper clearance at the highest point. Tighten the bolts to 310 ft-lb and weld the lock bar to the bolt heads.
15.	Check the pyrite chamber floor for buckling and holes. Pyrite chamber floors should be replaced when worn through or buckled enough to bind the scrapers. Record all significant wear and final condition.
16.	Check converter head vanes and support pin wear. Support pins can become worn and shear off. Hardened pin materials should be used for replacement pins. Record final condition.
17.	Change oil for the roll journal, gearbox, and exhauster bearing if lube analysis indicates.
18.	On the gearbox, check the pinion bearings and bull gear for wear and proper mesh. Measure the gear backlash. Adjust as necessary. Record all significant wear, the as-found and final gear backlash. See Section 11.4.4.1 for more information on checking the worm gear alignment.
19.	Check the thrust gear clearance. Adjust the clearance if it is >0.013 in. Record the as-found and final clearance.
20.	Check all thermocouple connections for proper function.
21.	Check the pitot tube for pluggage. Clean or replace as needed. Record the as-found condition.
22.	Record any other actions taken on the mill.

Table 10-2
Checklist for Volumetric Feeder Preventive Maintenance Inspections [4]

Volumetric Feeder Preventive Maintenance Inspection Tasks	
1.	Check the housing, feeder chute, feeder paddle wheels, and feeder liners for wear. Record any significant wear.
2.	Check feeder drive for proper adjustment.
3.	Check vane wheel and/or shed plate for wear. Record all wear conditions found.
4.	Check feeder leveling gate to paddle wheel clearance. Adjust clearance if needed. Check leveling gate for function. Record as-found and final clearance.

Table 10-3
Checklist for Gravimetric Feeder Preventive Maintenance Inspections [13]

	Gravimetric Feeder Preventive Maintenance Inspection Tasks
1.	Inspect the inlet gate height and width for condition. Repair as needed.
2.	Inspect the channel side skirts for erosion and repair as needed.
3.	Inspect belt tension and adjust as needed.
4.	Calibrate the load cell as needed.

Table 10-4
Checklist for Exhauster Preventive Maintenance Inspections [1]

	Exhauster Preventive Maintenance Inspection Tasks
1.	Check exhauster wheel, exhauster liner, and exhauster housing for wear. If ceramic tiles are used, inspect for looseness or wear. Replace any excessively worn, loose, or missing ceramic tiles. Fill any gaps with an abrasive resistance compound. Record the as-found and final conditions.
2.	Check the inlet ring assembly and replace if severe wear is found.
3.	Inspect the fan blades, whizzer blades, the whizzer disc, and the fan spider. Replace any worn or cracked parts. Record the as-found and final conditions.
4.	Replacing any broken or missing bolts on the exhauster wheel. Use Grade 5 bolt material or better and tack weld the bolts in place. Record the as-found and final conditions.
5.	Remove the top half of the bearings and inspect for condition and clearances. If the bearing or shaft is damaged, bearing replacement is necessary. See Section 11.4.2 for bearing replacement tasks.
6.	Check exhauster damper for damage or broken or bent linkage. Record the as-found and final condition.
7.	Check the exhauster shutoff valve adjustment. Record the as-found and final condition.
8.	Check the hot air damper for damage and alignment. Record the as-found and final condition.
9.	Check the riffle distributor for wear and pluggage. Riffle elements with >3 in. wear should be replaced. Record all significant wear.

10.3 Preventive Maintenance Basis

A PM Basis document for the Alstom RB mills is established in this section.

Many power plants are in the process of reducing preventive PM costs and improving equipment performance by matching PM tasks with the functional importance of the equipment. For this to succeed, utilities require information on the most appropriate tasks and task intervals for the important equipment types in addition to accounting for the influences of functional importance, duty cycle, and service conditions.

Preventive Maintenance

An early approach to optimizing the preventive maintenance activities was the use of reliability centered maintenance (RCM). RCM was developed in the 1960s by the commercial airline industry to apply reliability concepts to maintenance and the design of maintenance programs. The RCM approach to preventing equipment failure is to perform maintenance tasks that are specifically aimed at preventing component failure mechanisms from occurring. Many nuclear power plants used the RCM process to improve their PM programs.

In 1991, the Nuclear Regulatory Commission issued 10CRF50.65, *Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants*, also called the Maintenance Rule. In brief, the Maintenance Rule required nuclear power plants to develop a reliability and availability monitoring program for the systems, structures, and components considered to be within the scope of the rule. The monitoring part of the rule included determining the effectiveness of the maintenance performed on the components. In addition, the Maintenance Rule required the utility to evaluate industry operating experience and to use that experience when modifying the maintenance program. When maintenance practices have been changed, the most common action is to modify the PM tasks for the components.

Initially, PM tasks were assigned based on vendor recommendations and plant experience. In modifying or optimizing the PM tasks, one vital piece of information was missing, that is, the time to failure for the components. Because the time to failure was not known, it was difficult to justify the PM task intervals. Also missing was the understanding of the factors that influence the progression of the degradation mechanisms for the component.

As a result of the need to comply with the Maintenance Rule and to optimize the PM tasks for more effective maintenance, the PM Basis project was proposed by EPRI. The PM Basis objective was to:

- Provide a summary of industry experience on which the PM tasks and task intervals were based
- Establish the relationship between the degradation mechanism, the progression of the mechanisms to failure, and the opportunities available to discover the failure mechanisms before component failure occurred

During the 1996–1998 timeframe, 39 PM Basis documents were developed for major components in the nuclear power plants. The components included various style valves, switchgear, motor control centers, motors, pumps, compressors, heating, ventilation and air conditioning (HVAC) components, inverters, batteries, relays, heat exchangers, turbines, transformers, and I&C components. The PM Basis documents can be found in the EPRI document *Preventive Maintenance Basis* (TR-106857, Volumes 1-38).

Currently, there are over 65 component types in an electronic preventive maintenance database. The database can be accessed by logging onto www.epri.com, and searching for the EPRI *Preventive Maintenance Database Version 5.0,* 1009275. The product can be downloaded from www.epri.com; however, it is best to order the CD from the EPRI Orders and Conferences Center at 1-800-313-3774 (press 2).

Although the fossil power plants do not have the same regulatory requirements as the nuclear power plants, the establishment of the PM Basis for critical components provides valuable information for the optimization of the maintenance program. The information used in the development of the PM Basis was gathered from the manufacturer, industry literature, and input from utility maintenance personnel. The following describes the tables generated by the PM Basis document. The first table (Table 10-5) contains the:

- **Failure locations:** A list of the most common components
- **Degradation mechanisms:** The cause of the component failing at the specified failure location
- **Degradation influence:** Aspects of the environment, plant operations, maintenance, or design that can cause the initiation of degradation processes or can affect how rapid the degradation progresses
- **Degradation progression:** Whether the degradation progress is present most of the time (continuous) or whether it would not normally be present but might exist or initiate in a haphazard (random) way
- **Failure timing:** The relevant time period that the component would be free from failure
- **Discovery opportunity:** Reasonable, cost-effective opportunities for detecting the failure mechanism
- **PM strategy:** The choice of PM tasks in which the discovery of the failure mechanism can occur

The next table (Table 10-6) contains the PM tasks and intervals. The PM tasks and the degradation mechanisms are listed from the previous table. The corresponding PM task interval is then given for each applicable PM task.

The last table (Table 10-7) is a PM template that summarizes the program of PM tasks and intervals for the equipment type. There are eight sets of conditions that correspond to the combined choices of critical or non-critical equipment, high or low duty cycle, and severe or mild service conditions. Time intervals for the performance of each task are entered at the intersections of the task row and columns. A description of the PM tasks is included.

Table 10-5
Failure Locations, Degradation Mechanisms, and PM Strategies for Alstom RB Mills

Failure Location	Degradation Mechanism	Degradation Influence	Degradation Progression	Failure Timing	Discovery Opportunity	PM Strategy
Venturi outlet	Wear	Age	Continuous	Based on amount of coal processed	Visual inspection	Visual inspection
Classifier cone	Wear	Age	Continuous	Based on amount of coal processed	Visual inspection	Visual inspection
	Impact damage	Foreign material	Random	Random	Visual inspection	Visual inspection
Inverted cone	Wear	Age	Continuous	Months - years	Fineness test	Performance testing
Classifier blades	Wear	Age	Continuous	Based on amount of coal processed	Visual inspection, fineness test	Visual inspection, performance testing
Journal rolls	Wear	Age	Continuous	Based on amount of coal processed	Visual inspection, fineness test, check amount of coal in reject bin	Visual inspection, performance testing, operation checks
		Foreign material	Random	Random	Visual inspection	Visual inspection

Table 10-5 (cont.)
Failure Locations, Degradation Mechanisms, and PM Strategies for Alstom RB Mills

Failure Location	Degradation Mechanism	Degradation Influence	Degradation Progression	Failure Timing	Discovery Opportunity	PM Strategy
Journal springs	Impact damage	Foreign material	Random	Random	Spring tests, fineness test	Calibration, performance testing
	Fatigue	Age	Continuous	Based on amount of coal processed	Spring tests, fineness test	Calibration, performance testing
Journal roll assembly - shaft	Bearing failure	Lubrication contamination, seal air system	Random	Random	Visual inspection, check seal air system	Visual inspection, operations check
		Incorrect bearing installation	Random	Random	Visual Inspection, vibration analysis	Visual inspection, vibration analysis
		Age	Continuous	Based on amount of coal processed	Visual inspection	Visual inspection
Separator body liners	Wear	Age	Continuous	Based on amount of coal processed	Visual inspection	Visual inspection
		Foreign material	Random	Random	Visual inspection	Visual inspection

Table 10-5 (cont.)
Failure Locations, Degradation Mechanisms, and PM Strategies for Alstom RB Mills

Failure Location	Degradation Mechanism	Degradation Influence	Degradation Progression	Failure Timing	Discovery Opportunity	PM Strategy
Grinding ring	Wear	Age	Continuous	Based on amount of coal processed	Visual inspection	Visual inspection
		Foreign material	Random	Random	Visual inspection	Visual inspection
	Cracked and/or broken segment	Foreign material	Random	Random	Visual inspection	Visual inspection
Grinding bowl	Warped	Fire or explosion	Random	Random	Visual inspection	Visual inspection
Pyrite scraper assembly	Wear	Age	Continuous	Based on amount of coal processed	Visual inspection	Visual inspection
		Foreign material	Random	Random	Visual inspection	Visual inspection
	Breakage	Foreign material	Random	Random	Visual inspection	Visual inspection
Pyrite discharge chute	Pluggage	Flapper failure	Random	Random	Operations check	Operations check

Table 10-5 (cont.)
Failure Locations, Degradation Mechanisms, and PM Strategies for Alstom RB Mills

Failure Location	Degradation Mechanism	Degradation Influence	Degradation Progression	Failure Timing	Discovery Opportunity	PM Strategy
Gearbox bronze gear	Wear	Age	Continuous	Based on amount of coal processed	Visual inspection, oil analysis	Visual inspection, oil analysis
		Lack of lubrication	Random	Random	Check oil level	Operations check
		Lubrication contamination, seal air system	Random	Random	Check seal air system, oil analysis	Operations check, oil analysis
		Mis-alignment	Random	Random	Visual inspection	Visual inspection
	Damaged tooth	Mis-alignment	Random	Random	Visual inspection	Visual inspection
	Fatigue cracks	Lubrication issues	Random	Random	Visual inspection	Visual inspection
Gearbox steel worm gear	Wear	Age	Continuous	Years	Visual inspection, oil analysis	Visual inspection, oil analysis
		Lubrication contamination, seal air system	Random	Random	Check seal air system, oil analysis	Operations check, oil analysis
		Lack of lubrication	Random	Random	Check oil level	Operations check
	Misalignment	Improper bearing installation	Random	Weeks to months	Visual inspection	Visual inspection

Table 10-5 (cont.)
Failure Locations, Degradation Mechanisms, and PM Strategies for Alstom RB Mills

Failure Location	Degradation Mechanism	Degradation Influence	Degradation Progression	Failure Timing	Discovery Opportunity	PM Strategy
Gearbox steel worm gear bearings	Wear	Age	Continuous	Years	Visual inspection	Visual inspection
		Lubrication contamination, seal air system	Random	Random	Oil analysis, operations check	Oil analysis, operations check
		Lack of lubrication	Random	Random	Check oil level	Operations check
Gearbox oil cooler	Tube side deposits	Fouling	Continuous	Seasonal	Check water temperature	Operations check
	Shell side deposits	Fouling	Continuous	Seasonal	Check oil temperature	Operations check
Gearbox oil pump	Wear	Age	Continuous	Years	Oil analysis	Oil analysis
Vertical shaft	Broken and/or bowed shaft - fatigue	Misalignment	Continuous	Months to failure	Vibration analysis Visual inspection	Vibration analysis Visual inspection
	Broken and/or bowed shaft - shock	Foreign material	Random	Random	Vibration analysis Visual inspection	Vibration analysis Visual inspection

Table 10-5 (cont.)
Failure Locations, Degradation Mechanisms, and PM Strategies for Alstom RB Mills

Failure Location	Degradation Mechanism	Degradation Influence	Degradation Progression	Failure Timing	Discovery Opportunity	PM Strategy
Vertical shaft Bearings	Wear	Age	Continuous	Years	Visual inspection	Visual inspection
		Lubrication contamination, seal air system	Random	Random	Oil analysis, operations check	Oil analysis, operations check
		Lack of lubrication	Random	Random	Visual inspection	Operations check
	Misalignment	Improper bearing installation	Random	Weeks to months	Vibration analysis, oil analysis	Vibration analysis, oil analysis
Foundation	Loose bolts	Vibration	Continuous	Months	Vibration analysis	Vibration analysis
		Corrosion	Continuous	Months–years	Visual inspection	Visual inspection
	Cracked grout	Age	Continuous	Years	Visual inspection	Visual inspection
	Cracked concrete	Age	Continuous	Years	Visual inspection	Visual inspection
Crossover pipe	Wear	Age	Continuous	Years	Visual inspection	Visual inspection
Exhauster fan	Wear	Erosion	Random	Random	Fineness tests, visual inspection	Performance testing, visual inspection
		Age	Continuous	Months–years	Visual inspection	Visual inspection

Table 10-5 (cont.)
Failure Locations, Degradation Mechanisms, and PM Strategies for Alstom RB Mills

Failure Location	Degradation Mechanism	Degradation Influence	Degradation Progression	Failure Timing	Discovery Opportunity	PM Strategy
Exhauster fan bearings	Wear	Age	Continuous	Months to years	Vibration analysis	Vibration analysis
		Lubrication contamination, seal air system	Random	Random	Oil analysis, operations check	Oil analysis, operations check
		Lack of lubrication	Random	Random	Check oil level	Operations check
Exhauster housing	Wear	Erosion	Random	Random	Visual inspection	Visual inspection
		Age	Continuous	Based on amount of coal processed	Visual inspection	Visual inspection
Exhauster damper	Binding	Lubrication issues	Random	Random	Check damper movement, visual inspection	Operations check, Visual Inspection
Feeder	Wear	Age	Continuous	Years	Calibration	Calibration
	Obstruction	Foreign material	Random	Random	Check coal flow, visual inspection	Operations check, visual inspection
	Incorrect coal flow	Controls failure	Random	Random	Calibration	Calibration

Table 10-5 (cont.)
Failure Locations, Degradation Mechanisms, and PM Strategies for Alstom RB Mills

Failure Location	Degradation Mechanism	Degradation Influence	Degradation Progression	Failure Timing	Discovery Opportunity	PM Strategy
Mill motor	Electrical failure	Age and breakdown of insulation	Continuous	Years	Check temperature, thermography	Operations check, thermography
	Bearing failure	Lubrication	Random	Random	Check temperature, vibration analysis	Operations check, vibration analysis
	Overheating	Clogged air vents	Continuous	Years	Check temperature	Operations check

Table 10-6
PM Tasks and Their Degradation Mechanisms for Alstom RB Mills

Component - Time of Failure	Location and/or Degradation	PM Task and Interval						
		Calibration	Oil Analysis	Operations Check	Performance Testing	Thermography	Vibration Analysis	Visual Inspection
		1–2 Years or Amount of Coal Processed	6 Months	Daily	Monthly	Annual	3 Months	Amount of Coal Processed
Venturi outlet	Wear							X
Classifier cone - amount of coal processed	Wear							X
	Impact damage							X
Inverted cone	Wear				X			
Classifier blades	Wear				X			X
Journal rolls	Wear and/or age			X	X			X
	Wear and/or foreign material							X
Journal springs	Impact damage	X			X			
	Fatigue	X			X			
Journal roll assembly - shaft	Bearing failure and/or lubrication			X				X
	Incorrect bearing installation						X	X
	Age							X
Separator body liners	Wear and/or age							X
	Wear and/or foreign material							X

Table 10-6 (cont.)
PM Tasks and Their Degradation Mechanisms for Alstom RB Mills

Component - Time of Failure	Location and/or Degradation	PM Task and Interval						
		Calibration	Oil Analysis	Opera-tions Check	Perform-ance Testing	Thermog-raphy	Vibration Analysis	Visual Inspection
		1–2 Years or Amount of Coal Processed	6 Months	Daily	Monthly	Annual	3 Months	Amount of Coal Processed
Grinding ring	Wear and/or age							X
	Wear and/or foreign material							X
Grinding bowl	Warped							X
Pyrite scraper assembly	Wear and/or age							X
	Wear and/or foreign material							X
	Breakage							X
Pyrite discharge chute	Pluggage			X				
Gearbox bronze gear	Wear and/or age		X					X
	Wear and/or lack of lubrication			X				
	Wear and/or lubrication contamination		X	X				
	Wear and/or mis-alignment							X
	Damaged tooth							X
	Fatigue cracks							X

Table 10-6 (cont.)
PM Tasks and Their Degradation Mechanisms for Alstom RB Mills

Component - Time of Failure	Location and/or Degradation	PM Task and Interval						
		Calibration	Oil Analysis	Opera-tions Check	Perform-ance Testing	Thermog-raphy	Vibration Analysis	Visual Inspection
		1–2 Years or Amount of Coal Processed	6 Months	Daily	Monthly	Annual	3 Months	Amount of Coal Processed
Gearbox steel worm gear	Wear and/or age		X					X
	Wear and/or lubrication Contamination		X	X				
	Wear and/or lack of lubrication			X				
	Misalignment							X
Gearbox steel worm gear bearings	Wear and/or age							X
	Wear and/or lubrication contamination		X	X				
	Wear and/or lack of lubrication			X				
Gearbox oil cooler	Tube deposits			X				
	Shell deposits			X				
Gearbox oil pump	Wear		X					
Vertical shaft	Broken and/or fatigue						X	X
	Broken and/or shock						X	X

Table 10-6 (cont.)
PM Tasks and Their Degradation Mechanisms for Alstom RB Mills

Component - Time of Failure	Location and/or Degradation	PM Task and Interval						
		Calibration	Oil Analysis	Opera-tions Check	Perform-ance Testing	Thermog-raphy	Vibration Analysis	Visual Inspection
		1–2 Years or Amount of Coal Processed	6 Months	Daily	Monthly	Annual	3 Months	Amount of Coal Processed
Vertical shaft bearings	Wear and/or age							X
	Wear and/or lubrication contamination		X	X				
	Wear and/or lack of lubrication			X				
	Misalignment		X				X	
Foundation	Loose bolts						X	
	Cracked grout							X
	Cracked concrete							X
Crossover pipe	Wear and/or age							X
Exhauster fan	Wear and/or erosion				X			X
	Wear and/or age							X
Exhauster fan bearings	Wear and/or age						X	
	Wear and/or lubrication contamination		X	X				
	Wear and/or lack of lubrication			X				
Exhauster housing	Erosion							X
	Wear							X
Exhauster damper	Binding			X				X

Table 10-6 (cont.)
PM Tasks and Their Degradation Mechanisms for Alstom RB Mills

Component - Time of Failure	Location and/or Degradation	PM Task and Interval						
		Calibration	Oil Analysis	Opera-tions Check	Perform-ance Testing	Thermog-raphy	Vibration Analysis	Visual Inspection
		1–2 Years or Amount of Coal Processed	6 Months	Daily	Monthly	Annual	3 Months	Amount of Coal Processed
Feeder	Wear	X						
	Obstruction			X				X
	Incorrect coal flow	X						
Mill Motor	Electrical			X		X		
	Bearing			X			X	
	Overheating			X				

Table 10-7
PM Template for Alstom Mills

	Conditions		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Critical	Yes	X	X	X	X				
		No					X	X	X	X
	Duty Cycle	High	X		X		X		X	
		Low		X		X		X		X
	Service Condition	Severe	X	X			X	X		
		Mild			X	X			X	X
PM Tasks			**Frequency Interval**							
Calibration			1–2 yrs	1–2 yrs	1–2 yrs	1–2 yrs	2 yrs	2 yrs	2 yrs	2 yrs
Oil Analysis			6 months	6 months	6 months	6 months	6 months	6 months	6 months	6 months
Operations Check			Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
Performance Testing			Monthly	Monthly	Monthly	Monthly	2 months	2 months	2 months	2 months
Thermography			Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual
Vibration Analysis			3 months	3 months	3 months	3 months	6 months	6 months	6 months	6 months
Visual Inspection			6 months–1 year	6 months–1 year	6 months–1 year	6 months–1 year	1–2 years	1–2 years	1–2 years	1–2 years

The PM tasks used for the PM Basis are as follows:

- **Calibration:** This includes the setting and verification of instruments and components. Instruments include thermocouples, resistance temperature detectors (RTDs), pitot tubes, and pressure gauges. The calibration of components involves setting the clearances and/or tolerances for the mill springs and load system, classifier blades, rolls, throat ring, dampers, feeders, and so on. The frequency for calibration can be time based or initiated based on equipment condition. For example, if mill fineness testing indicates a drop in performance, the classifier blades should be adjusted. New on-line monitoring techniques may trigger an instrument that needs calibration.

- **Oil Analysis:** This is a very valuable predictive maintenance technology for detecting problems in equipment before failure occurs. For the Raymond Bowl mills, oil samples should be taken and analyzed for the rolls, gear box, exhauster bearings, and mill motor bearings. Samples should be analyzed for contamination and oil properties. The results of the oil analysis can alert personnel that bearings are failing, and plans can be made to monitor the operation of the equipment, take more frequent samples, or shut the equipment down.

- **Operations Check:** This includes an external visual inspection of the mills by listening for noises, smelling for smoke, checking temperatures, checking pressures, seal oil system flow, damper movements, and so on.

- **Performance Testing:** This includes fineness, airflow, and fan tests. Fineness testing is especially important with the mills to determine the efficiency or effectiveness of the mill.

- **Thermography:** This is recommended to check electrical connections and motor temperature conditions. Looking for hot spots and temperature differences on electrical connections can detect problems before failure occurs.

- **Vibration Analysis:** Vibration analysis on rotating equipment is very valuable in detecting bearing problems before the bearings fail. Vibration analysis is recommended for the vertical shaft, grinding ring, gear box, and motor bearings.

- **Visual Inspection:** A visual inspection is an internal inspection of mill components to determine their condition. For normal operation, the frequency of the visual inspection should be based on the amount of coal processed by the mill. This can be a six-month or annual interval. An interval of greater than one year would indicate low operating hours. An abnormal operation includes a mill fire, explosion, and so on. Components to be inspected include classifier blades, classifier cone, rolls, spring loading system, throat, grinding ring, pyrite plow, pyrite box, vertical shaft and bearings, feeder, mill motor, and motor. Inspections include taking physical measurements and assessing the general condition for wear areas, existence of foreign material and/or debris, and so on.

11
COMPONENT MAINTENANCE

The components of the pulverizer were divided into the converter section, separator section, and millside section. Any modifications or upgrades by the original equipment manufacturer are included in the component topic. This section [5] [14] [15] covers the following items:

- General philosophy
- Mill converter section (venturi outlet and flat type discharge valve on the RP mill)
- Mill separator section (classifier, journal assembly, mill liners, and grinding ring)
- Mill millside section (vane wheel assembly, vertical shaft, pyrite removal system, gearbox, and external lubrication system)
- Exhauster
- Feeder
- Mill motor

11.1 General Philosophy

Pulverizer mills and exhausters are high-maintenance cost equipment in the plant. A large coal-fired plant is usually designed with more capacity in the mills than the plant's output. This over-capacity design allows one or two mills to be out of service for maintenance with the unit still maintaining full load.

One maintenance philosophy is to rebuild the mills one at a time so that capacity for the unit production is maintained. This may mean having one mill out of service for rebuilds during the spring and fall of the year or other non-peak operational times. This approach ensures that full-capacity mills are being brought back into service, and the reliability of the mills as a group is being maintained.

Another maintenance philosophy is to rebuild the mills during the major outages associated with turbine and boiler repairs. This approach brings full capacity mills into service after a major outage. The wear and degradation of the mills will then occur at some rate during the interval between major outages. The performance of the mills toward the end of this time interval may affect the reliability of the mills.

The major maintenance problem with pulverizers is wear of the grinding components. Table 11-1 shows the general maintenance problems and some common solutions.

Table 11-1
Pulverizer Maintenance Items [14]

Pulverizer Problems	Common Solutions
Wear of grinding components – rolls, grinding ring	Hard facing rolls, harder grinding surfaces
Vertical shaft breakage	Bearing replacements, worm gear and worm shaft replacements, adequate lubrication
Lube oil contamination	Install lube oil filtration, increased seal air flow
Classifier wear	Install ceramic liners
Exhauster fan wear	Install ceramic liners
Exhauster housing wear	Install ceramic liners



Technical Key Point

In general, grinding rings last twice as long as grinding rolls for medium- and low-abrasive coals. For high-abrasive coals the ratio is less than 2 to 1.

There are several tables in this section that contain tasks for disassembly and reassembly of the mill components. These tables refer to the use of shims in alignment. Table 11-2 lists some general guidelines for using shims.

Table 11-2
General Guidelines for Shims

Guidelines
• Shims should be clean and composed of corrosion- and crush-resistant material.
• Most commercial pre-cut shim manufacturers supply 4 sizes of shims in 13 standard thicknesses. Typically, Size A is a 2-in. by 2-in. shim used for machines from 0.25–15 hp. Size B is a 3-in. by 3-in. shim used for machines up to 60 hp. Size C is a 4-in. by 4-in. shim used for machines 50–200 hp, and Size D goes up to 1,000 H.P. The best shim makers also supply sizes G and H for very large machines. Sizes A, B, C, and D, are manufactured in thickness of 0.001 in., 0.002 in., 0.003 in., 0.004 in., 0.005 in., 0.010 in., 0.015 in., 0.020 in., 0.025 in., 0.050 in., 0.075 in., 0.100 in., and 0.125 in.
• For less expensive shims, always check for actual thickness with a micrometer. Higher cost shims usually need to be checked for thicknesses of 0.050 in. and above. The larger size shims are usually nominal and are subject to standard material variations.
• The shims should be free from burrs, bumps, nicks, and dents of any kind. Size numbers or trademarks should be etched into the shim, not printed or stamped.
• For most situations, use the smallest commercial shim that will fit without binding. The smaller the shim, the more accurate the alignment corrections will be. Even the smallest Size A Stainless Steel 304 shim will support enormous equipment loads.
• Use no more than three shims under any foot if possible, and four is a maximum.
• When inserting the shims under the machine load, NEVER let your fingers get under the load.

An example of a mill rebuild is given in the next section.

11.1.1 Mill Rebuild Example

The bowl mill design is rugged and built for continuous operation over an extended period of time. Iron pyrites and other abrasive materials can shorten the life of the rolls, grinding rings, mill liners, scrapers, bowl deflectors, exhauster blades, and exhauster liners. Figure 11-1 shows a RB style mill.

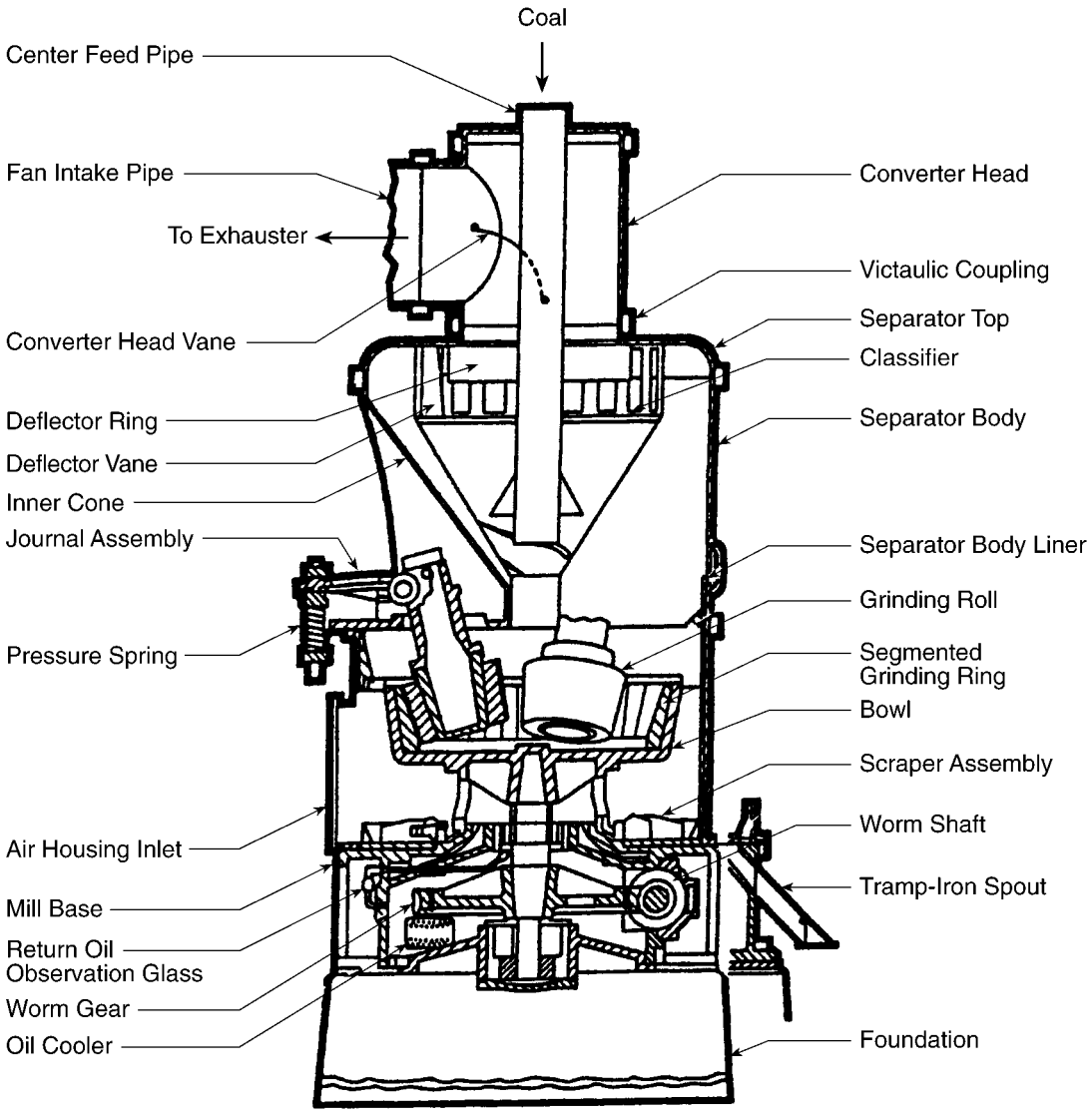


Figure 11-1
Alstom RB Pulverizer Mill [4]

The lower section of the classifier body can be removed so that the upper part of the mill is accessible for replacement of the grinding ring, upper mill side liners, and the bowl deflectors.

The journals should be removed before the classifier body is taken apart. Tapped holes are provided in the horizontal flange of the classifier top, adjacent to the split line, and the top and bottom of the vertical flanges of the feeder section. These holes are provided for jack screws to use in the disassembly of the classifier section. With the classifier body off, the mill side liners, deflectors, and air direction vanes can be repaired and/or replaced. The bowl deflectors have to be removed before the grinding ring can be removed.

The feeder inlet pipe, converter head, and the exhauster intake pipe can remain connected when changing the grinding ring, liners, and bowl deflectors. The converter head cover plate can be removed to provide access to the inner cone of the classifier. On the smaller mills, it is necessary to remove the vane inside the converter head to provide adequate space for personnel access to the inner cone.

To remove the rolls and grinding ring for repairs, it is necessary to lift these components out of the mill. Chain falls, cable slings, snubbing lines, or cables and a mounted steel beam are required. Ensure that the weight of these components is known for rigging and lifting by checking the mill instruction book and drawings. In order to remove the complete journal assembly from the mill, the cap screws that hold the assembly to the classifier base have to be removed. The journal assembly can then be lifted with a sling under the bosses of the journal head and lowered to the floor.

11.2 Mill Converter

This subsection covers the venturi outlet and the flat type discharge valve on the RP mill.

11.2.1 Venturi Outlet on the RP Mill

The outlet venturi is located at the top of the mill just below the mill discharge valves. The original design and new design outlet venturi are shown in Figure 11-2.

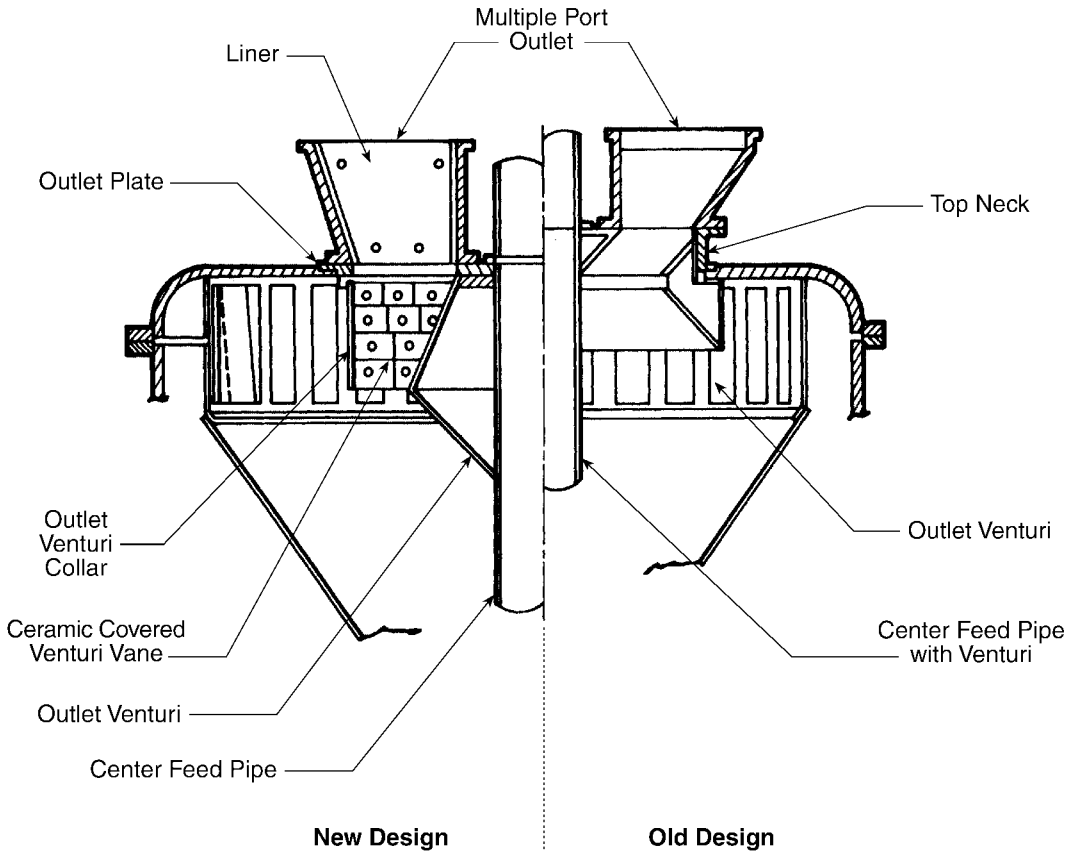


Figure 11-2
Outlet Venturi Arrangement [15]

The venturi distributes the pulverized coal into the fuel lines as the coal exits the mill. The new design outlet venturi distributes the coal and air mixture more evenly and with less turbulence to the fuel outlets. The less turbulent flow reduces the wear on the venturi components and the discharge valve bodies.

11.2.2 Flap Type Discharge Valve on the RP Mill

The flapper type mill discharge valve is located on the top of the mill just above the multi-port outlet. A flapper type discharge valve is shown in Figure 11-3.

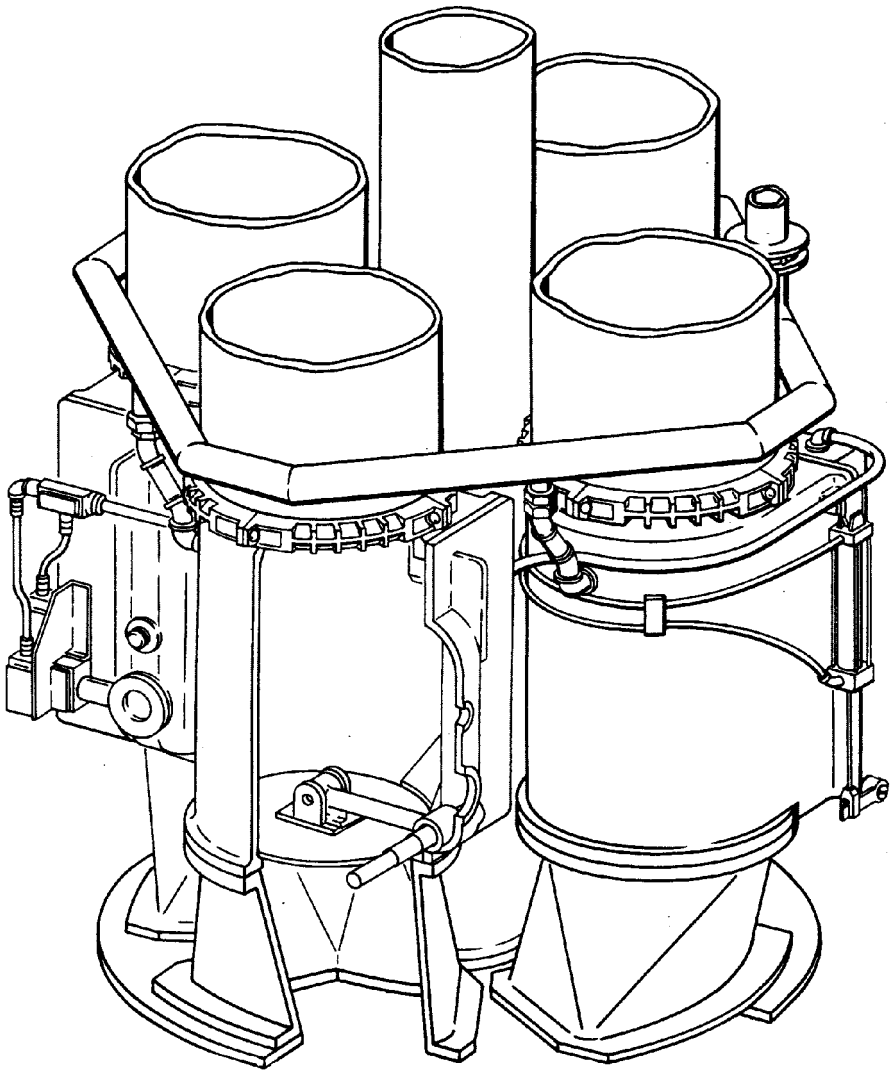


Figure 11-3
Flapper Type Discharge Valves [15]

The discharge valves prevent the boiler gas from returning to the mills. The flapper type valve uses a disc that is removed from the coal stream when the valve is open. Removing the disc during operation eliminates disc wear and maintains a positive barrier between the mill and boiler when the valve is closed.

Figure 11-4 shows a flapper discharge valve for an RP-1043 mill.



Figure 11-4
Flapper Discharge Valve
(Courtesy of Great River Energy)

11.3 Mill Separator

This subsection covers the classifier, journal assembly, mill liners, and grinding ring.

11.3.1 Classifier

There is a picture of the RB/RS/RPS separator top and classifier.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a picture of the RP separator top and classifier.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

Based on the space available adjacent to and above the mill, the classifier can be disassembled in the following ways:

- The separator body, separator top, and classifier section remain in place, with removal of components as required for repair or replacement
- The separator body, separator top, and classifier section are unbolted from the millside and slid along the rail system to another work area
- The separator top and classifier section only are unbolted from the separator body and lifted off to another work area.

Figure 11-5 shows a classifier cone with ceramics installed.



Figure 11-5
Classifier Cone with Ceramics Installed
(Courtesy of Great River Energy)

There is a table that lists the disassembly tasks for the classifier.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There are two ways to disassemble the classifier. One way is to remove the separator top and classifier section and the other way is to remove the entire classifier assembly. After disassembly, damaged or worn classifier deflector blades can be removed and repaired or replaced. The deflector blades are attached to the hinge shaft by four bolts. After the blades are repaired or replaced, the blades should be calibrated. Figure 11-6 shows the old style deflector regulator.

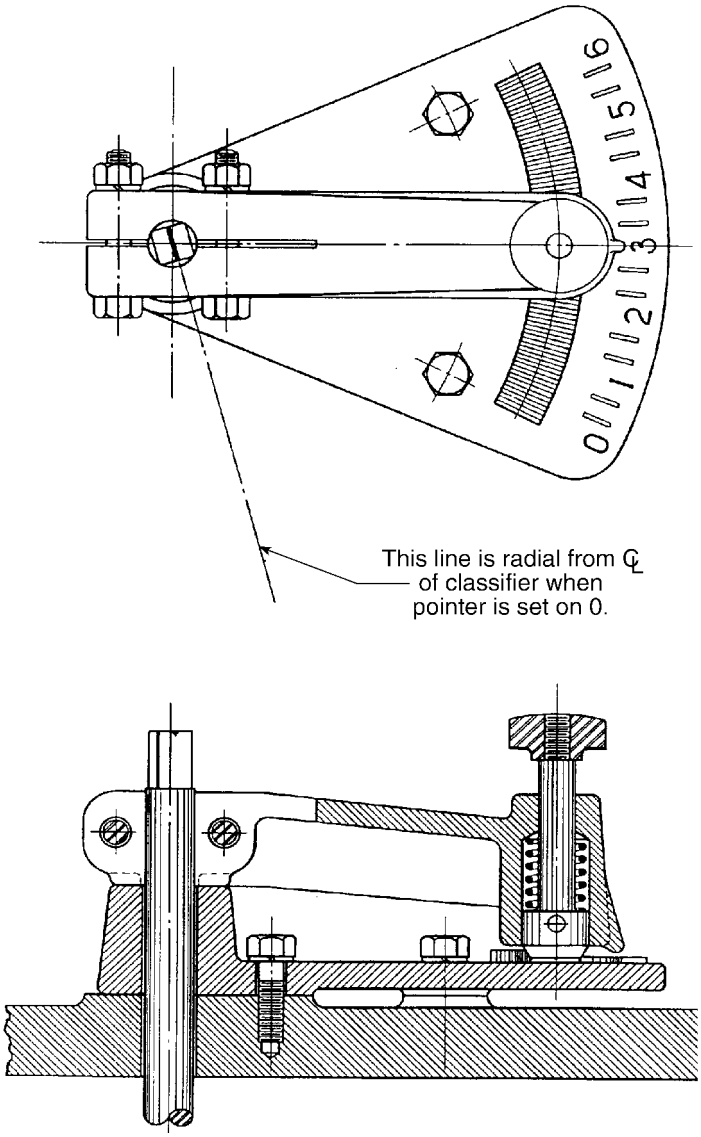


Figure 11-6
Old Style Deflector Regulator [4]

There is a figure that shows the newer style ganged deflector regulator.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

11.3.1.1 Classifier Deflector Blades

The classifier deflector blades have been upgraded to use Crown 700 material. The Crown 700 alloy is part of the Ni-Hard or nickel-hardened cast iron family with added graphite. The minimum hardness of the Crown 700 alloy is 700 Brinell Hardness Number and provides improved wear resistance. The use of this material allows the classifier to maintain the desired opening for the coal particles for a longer period of time before degradation.

There is a figure that shows the new classifier blade material.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.3.1.2 Dynamic Classifier

The dynamic classifier is a rotating classifier that increases the fineness of the pulverized coal exiting the mill.

There is a figure that shows a dynamic classifier for the RB, RS, and RPS style mills and a dynamic classifier for the RP style mill. The classifier rotor is driven by a variable speed motor and adjustable frequency drive. By modulating the speed, the fineness can be tuned for all feed rates without unnecessary over grinding.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.3.2 Journal Assembly

For a complete journal assembly, the following are approximate ranges in weight:

- Style 533–753 mills 4,000–7,000 lb
- Style 703–863 mills 5,000–9,000 lb
- Style 883–1003 12,000–18,000 lb

Human Performance Key Point

It is important not to underestimate the weight of the journal assemblies. Cables and shackles should be selected based on the weight of the journal assembly.

There is a table that lists the removal tasks for the RB style journal assemblies.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a table that lists the removal tasks for the RS/RPS/RP style journal assemblies.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a figure that shows the journal rigging diagram with a come-along.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

Figure 11-7 shows the lifting of a journal for an RP-1043 Mill.

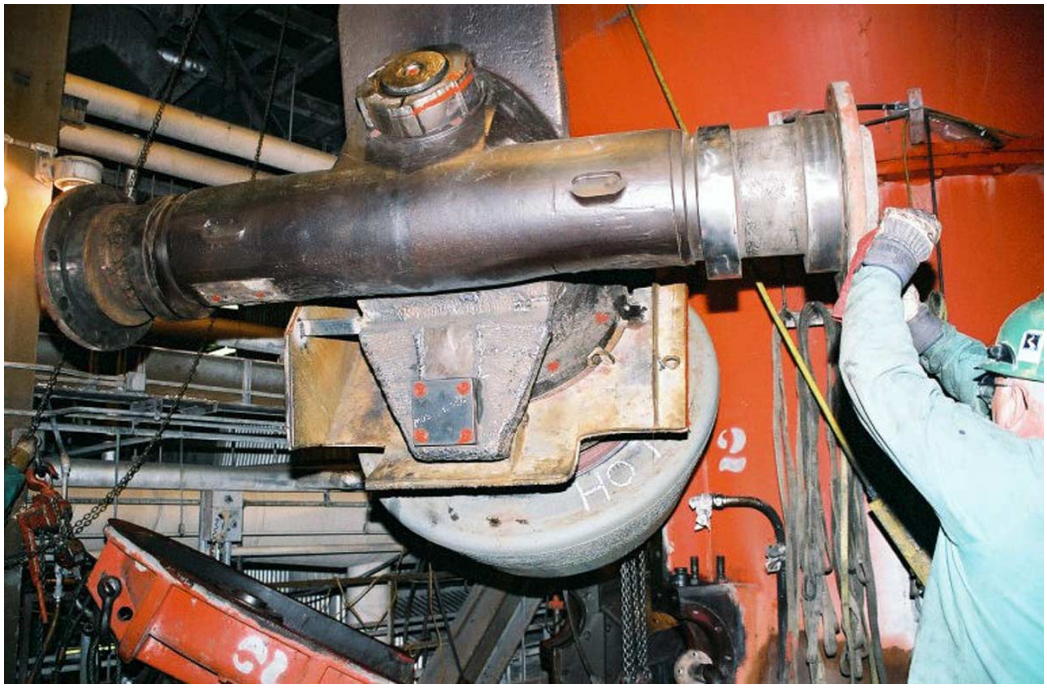


Figure 11-7
Lifting a Journal for an RP-1043 Mill
(Courtesy of Great River Energy)

For further reference, Appendix B in this guide contains a series of pictures showing the assembly of a cover and roll on an RP-1043 mill after a rebuild.

There is a table that lists the journal disassembly tasks for the RB/RS/RPS/RP mills.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

Figure 11-8 shows a fixture used at Coal Creek Generating Station for removing and tightening the journal shaft locknut.



Figure 11-8
Fixture for Shaft Locknut
(Courtesy of Great River Energy)

There is a figure that shows the vertical journal rigging diagram with a crane or overhead hoist and a come-along.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

Figure 11-9 shows the new roll template.

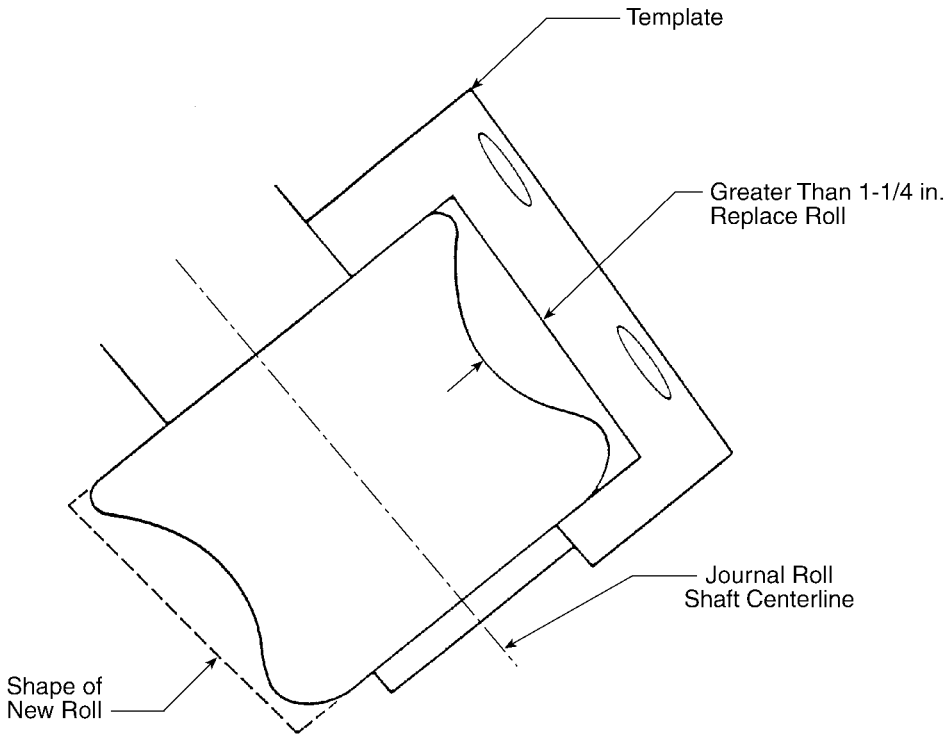


Figure 11-9
New Roll Template [1]

Figure 11-10a shows the journal assembly clearance drawing and Figure 11-10b shows dimensions and an assembly procedure for the journal assembly.

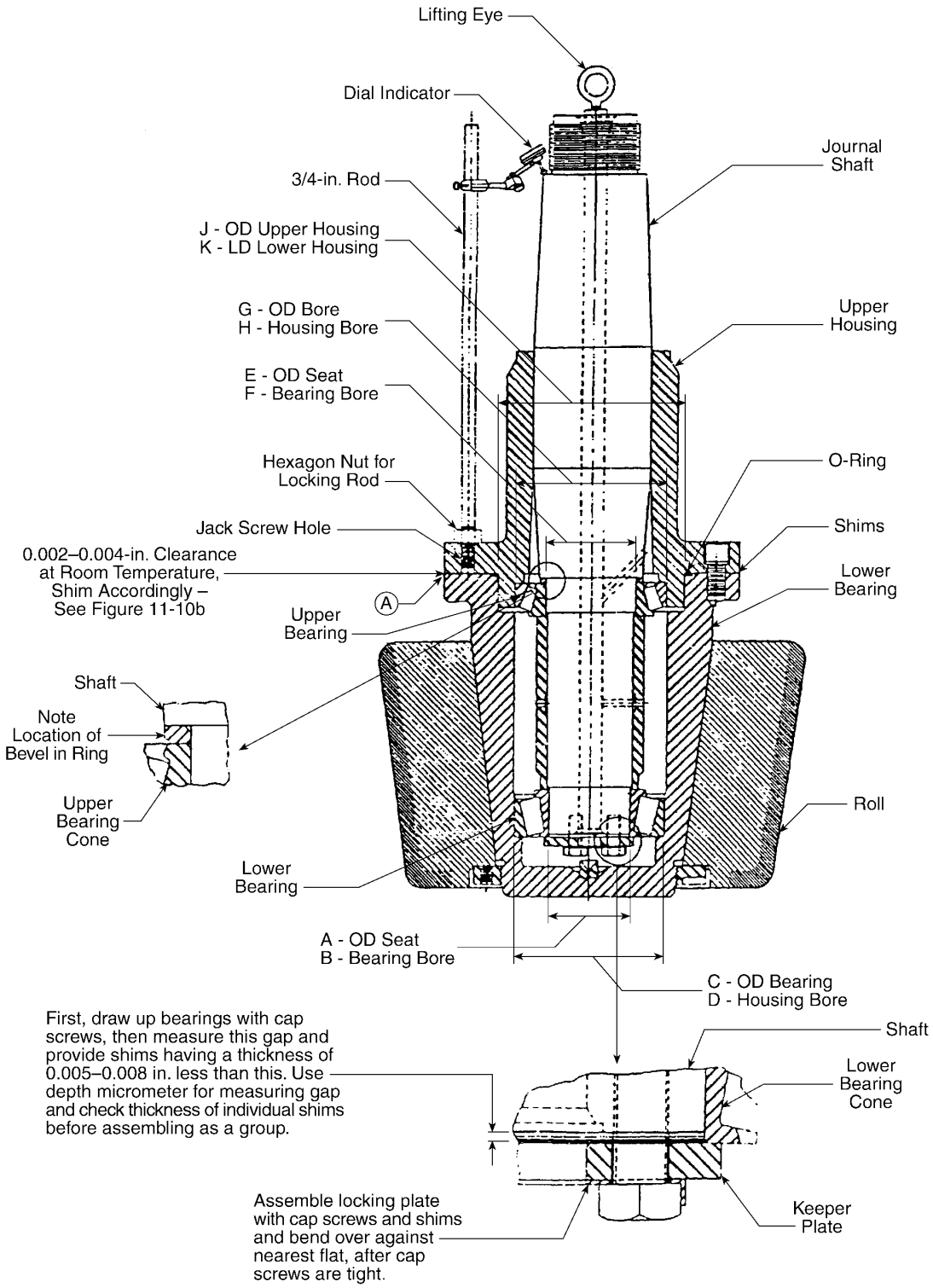


Figure 11-10a
Journal Assembly Clearance Drawing [4]

MLL Size	A	B	C	D	E	F	G	H	J	K
412, 452 and 453	3.501 to 3.500	3.501 to 3.500	6.376 to 6.375	6.374 to 6.373	4.251 to 4.250	4.251 to 4.250	6.501 to 6.500	6.499 to 6.498	7.874 to 7.873	7.876 to 7.875
473, 493 and 533	4.001 to 4.000	4.001 to 4.000	7.501 to 7.500	7.499 to 7.498	4.501 to 4.500	4.501 to 4.500	7.501 to 7.500	7.499 to 7.498	9.374 to 9.373	9.376 to 9.375
573, 593, 613 and 633	4.501 to 4.500	4.501 to 4.500	8.376 to 8.375	8.374 to 8.373	5.001 to 5.000	5.001 to 5.000	8.501 to 8.500	8.499 to 8.498	10.374 to 10.373	10.376 to 10.375
673	5.501 to 5.500	5.501 to 5.500	11.626 to 11.625	11.624 to 11.623	6.001 to 6.000	6.001 to 6.000	10.5635 to 10.5625	10.5615 to 10.5605	12.874 to 12.873	12.876 to 12.875
703, 713, 723, 733 and 753	6.001 to 6.000	6.001 to 6.000	12.127 to 12.125	12.124 to 12.123	6.876 to 6.875	6.876 to 6.875	12.252 to 12.250	12.249 to 12.248	14.874 to 14.873	14.876 to 14.875

1. Assemble the upper bearing ring, upper bearing cone, bearing spacer sleeve, lower bearing cone, shims, keeper plate, and locking plate on the lower end of the shaft. See cross section in Figure 11-10a.
2. Lower shaft assembly into the lower housing and roll assembly. Roll must be on housing.
3. Let the upper journal housing (with bearing cup pressed in) down over the shaft and secure lightly to the lower housing with four of the cap screws (no lock washers) evenly spaced in the flange. Do not draw the screws up too tightly.
4. Rotate the shaft, and draw up on the cap screws uniformly until the bearings just begin to bind.
5. Check the gap at point A between upper and lower housings in three or four places with a feeler gauge. Record the readings, and average them.
6. Disassemble the upper housing and place the neoprene O ring in the recess of the lower housing flange. Then place sufficient shims on the flange to obtain a running clearance of 0.002–0.004 in. The shims necessary are usually 0.004–0.005 in. more than the average reading from the feeler gauge check referred to in #5 because in the final assembly the cap screws are pulled down tight.
7. Reassemble the upper housing using the eight cap screws and lock washers, drawing them uniformly tight.
8. Fasten a 3/4 in. diameter rod threaded at its lower end in one of the jack screw holes in the flange of the upper housing. Lock the rod with the hex nut.
9. Install a dial indicator at the top of the rod, resting the contact button on the shaft shoulder as shown.
10. Rotate the journal shaft back and forth a few times by hand to be sure that the lower bearing is seated.
11. Carefully hoist the shaft by the eye bolt, and take a reading on the dial indicator; it should read at least 0.002 in. and not more than 0.004 in. Repeat the lifting several times, turning the shaft each time. Readings should check.
12. If the clearance is more or less, remove or add shims as required and recheck, following the procedure in #11.

Note: The use of molykote (molybdenum disulfide) is suggested for coating bearing seats to facilitate subsequent disassembly.

Figure 11-10b
Journal Assembly Dimensions and Procedure [4]

There is a table listing the journal re-assembly tasks for the RB/RS/RPS/RP mills.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a figure that shows the details on checking the journal end play.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

There is a figure that shows an exploded view of a typical journal.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

11.3.2.1 Journal Rolls

After the journal rolls [16] have worn, a standard practice is to weld repair the rolls to re-establish the roll dimensions. A roll template was shown in Figure 11-16 to determine the amount of material missing from wear. The guideline given by Alstom is wear of 1 1/4 in. requires replacement.

Materials used for weld repair include high chrome hard-surfacing materials, Ni-Hard, and the Alstom Combustalloy material. The high chrome rolls have a minimum hardness of 650 Brinell Hardness Number and good impact properties. Ni-Hard is a nickel-hardened cast iron material. Ni-Hard has a hardness in the range of 550–600 Brinell Hardness Number. The Combustalloy is an Alstom patented hard-surfacing material.

There is a figure that shows a comparison of weld materials.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

For the Combustalloy material, weld wire is applied in a submerged arc process to produce a weld overlay wear tread with good abrasion resistance.

There is a figure that shows the journal housing for wear tread to be applied.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information

concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

Figure 11-11 shows a rebuilt roll for an RP-1043 mill.



Figure 11-11
Rebuilt Roll
(Courtesy of Great River Energy)

There is a figure that shows a ribbed roll.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

Controlled deposition welding (CD-W™) is a welding process developed by EPRI and Euroweld, Ltd. that permits layer-by-layer control over weld composition. By using a high deposition submerged arc or electroslag welding, the composition of weld deposits can be tailored for specific service conditions. This process could be used in the weld buildup on mill rolls.

With controlled deposition, the composition of the individual weld layers using primary wire or strip filler along with additional filler(s) provides the alloying or compositional control for each layer. This approach allows the composition of weld buildup to be altered gradually over successive layers. For instance, the first layer could be a low-alloy steel component and then change over succeeding layers to a hard facing alloy. Applications include corrosion resistant overlay, hard facing, and deposition for structural or shape welding purposes.

11.3.2.2 Journal Springs

The journal springs provide a uniform compressive force at the grinding roll to break up coal chunks. The force exerted by the spring(s) should be consistent. In the life of a journal spring, the heat and cyclic fatigue experienced tends to relax the spring and change the stiffness. If the springs are not set equally, uneven loading on the bowl can cause stresses on the vertical shaft.

For journal spring compression on the RB mills, a pre-tensioning tool is shown in Figure 11-12.

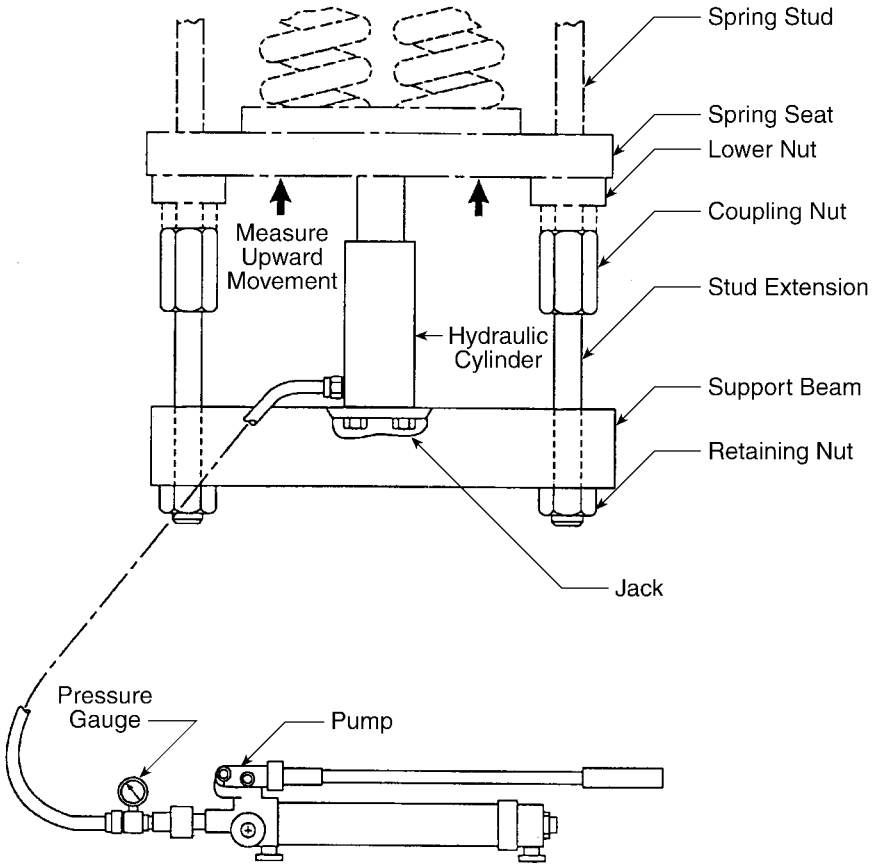


Figure 11-12
RB Mill Spring Compression Tool [1]

The original method for setting springs was to measure the coils, ensuring they were the same length and the same K factor. The springs were then tightened to equal lengths. This method is only accurate to within several hundred pounds. Uneven pressure has a negative impact on many aspects of mill structural stress and on overall milling performance. The preferred, more accurate method is to use hydraulic pressure to set the springs to ensure even work at the three journals.

There is a table that lists the tasks for journal spring compression setting for the RB mills.

There is a figure that shows the spring assembly for the RS/RPS mills.

There is a figure that shows the spring assembly for the RP mills.

There is a table that lists the spring compression and free length for the springs in each mill type.

There is a table that lists the removal and disassembly tasks for the RS/RPS/RP spring assemblies.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

Spring compression adjustment is set using a hydraulic compression fixture as shown in Figure 11-13.

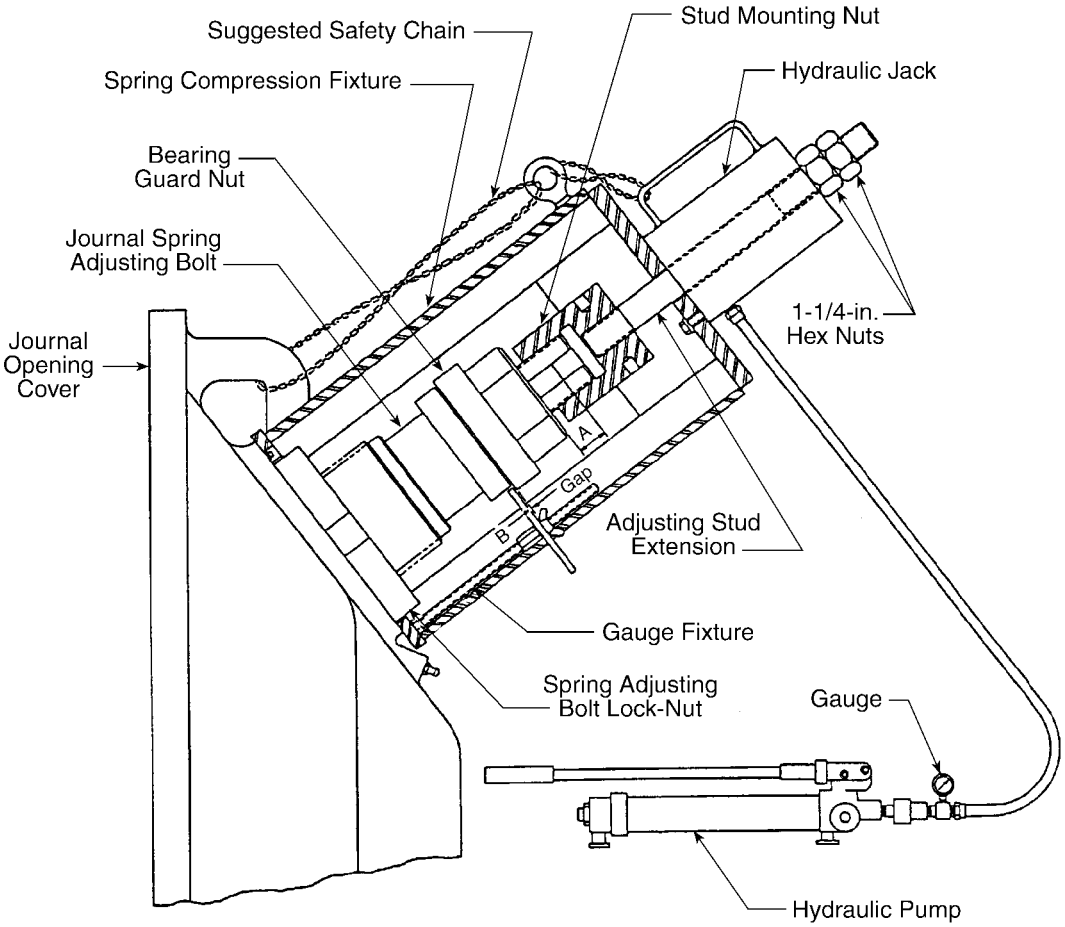


Figure 11-13
RS/RPS Hydraulic Compression Fixture [1]

The spring compression is set hydraulically with the spring assembly in position in the journal opening cover.

There is a figure that shows the hydraulic compression fixture for the RP mill that has the spring inside the mill.

There is a figure that shows the hydraulic compression fixture for the RP mill that has the spring outside the mill.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

For some of the RP series pulverizers, the journal springs are replaced with a hydraulically loaded journal system. The hydraulic system includes hydraulic cylinders, accumulators, a control unit, and a power unit. The control unit regulates journal pressure in proportion to pulverizer loading. The power unit pressurizes the system by supplying all three journals with the same pressure, which enables the grinding bowl to be loaded evenly. The accumulators act as shock absorbers in the system and minimize the effects of large tramp iron in the mill. Figure 11-14 shows the hydraulic connection to the journal housing.

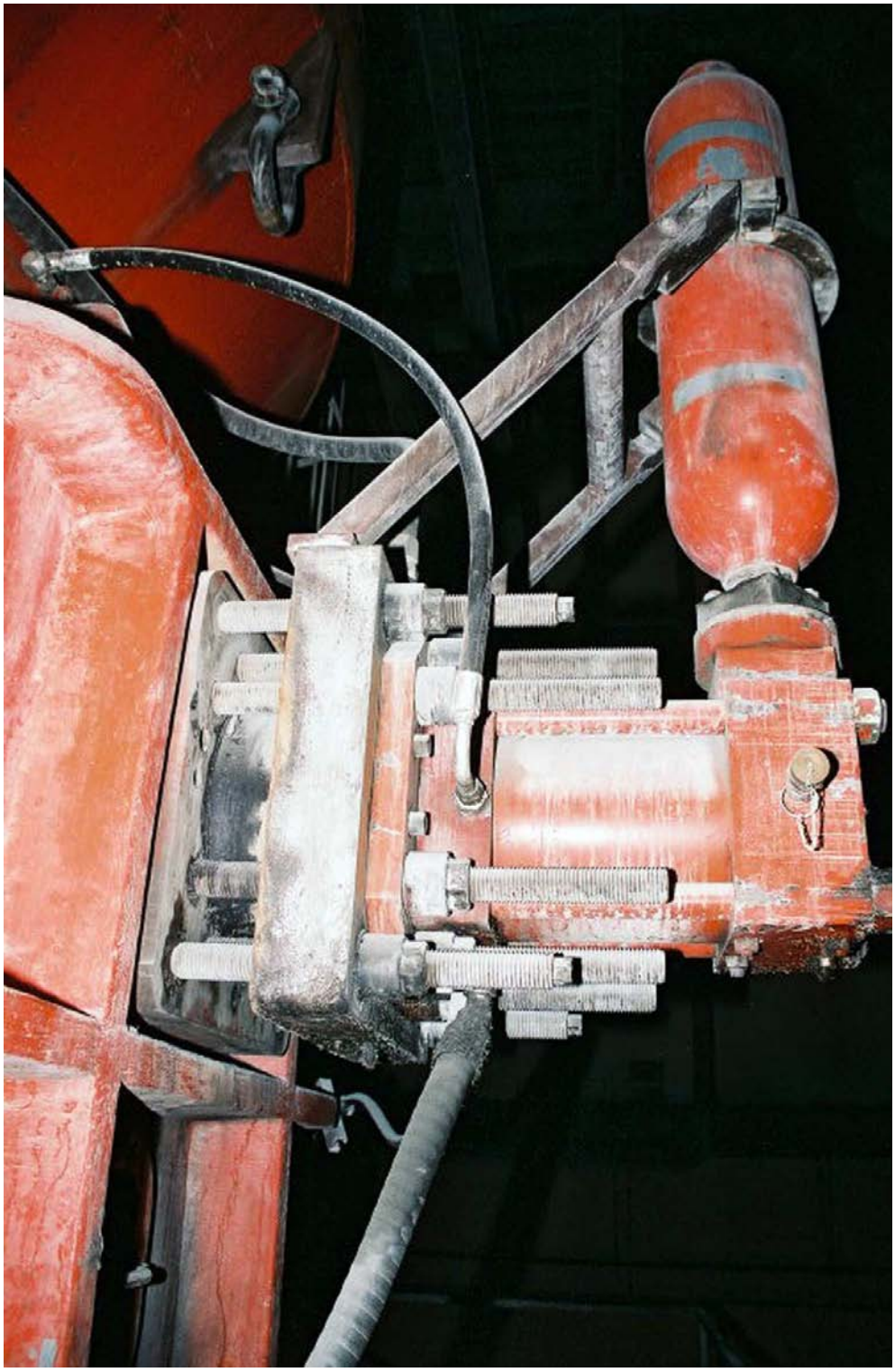


Figure 11-14
Hydraulic Connection to the Journal Housing
(Courtesy of Great River Energy)

11.3.2.3 Roll-to-Ring Adjustment

Adjustment of the roll to the grinding ring is necessary to provide adequate clearance for the formation of a coal bed suitable for attrition grinding.

The amount of clearance or gap is dependent on the size of the coal. Uneven grinding ring or roll surfaces determine what the final gap setting will be. Changes to the original setting should only be made based on the results of a fineness test.

The roll-to-ring gap is usually set to parallel and in the range of 1/8–1/4 in. initially. This gap setting may be changed based on the fineness test results.

There is a table that lists tasks for setting the roll to grinding ring clearance.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

The final adjustment should be made with the mill operating in an unloaded condition. There should not be any contact between the roll and the grinding ring. One suggestion is to have each roll set by the same person to ensure uniformity in the setting.

Figure 11-15 shows an example of an air impact wrench and cart for adjusting the roll clearance on an RP-1043 mill.



Figure 11-15
Air Impact Wrench and Cart for Adjusting Roll Clearance on an RP-1043 Mill (Courtesy of Great River Energy)

11.3.2.4 Double Bearing Journal Assembly

The original design mills used a single upper radial bearing. A modification was made to replace the single upper radial bearing with a double row tapered bearing and move the location of the bearing. Figure 11-16 shows the original and current design.

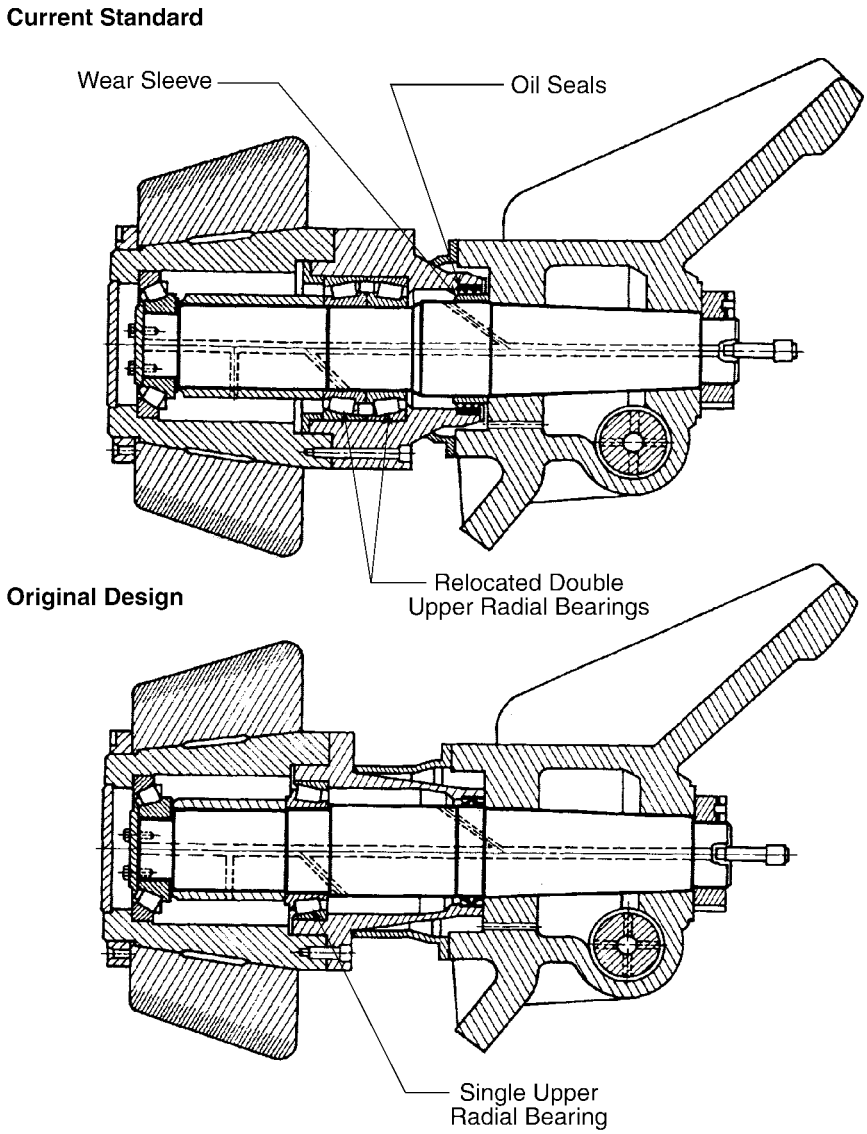


Figure 11-16
Upper Bearing Assembly [15]

The relocation of the bearing decreased the load on the upper and lower bearings. The oil seal is a three medium-pressure lip seal with additional dust lips. The seals ride on a hardened replaceable wear sleeve. A seal retainer prevents the seal from working out of the housing. The air seal is a tapered adjustable seal.

11.3.2.5 Journal Lip Seal

A labyrinth seal is used to form a barrier for the lubricant in the journal and the contaminants on the outside of the journal. In the journal assembly, the stator remains motionless on the shaft, while the rotor spins with the upper journal. With the lip seal, nothing contacts the shaft, which prevents wear and/or grooving. Sealing is maintained when the journal is not in operation, as captured lubricants exit through the expulsion ports. The labyrinth seal is a self-lubricating seal.

There is a figure that shows a new designed lip seal by Alstom for the RB mills journal assemblies.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.3.3 Mill Liners

In order to protect non-consumable pulverizer components, various abrasion-resistant liners are installed in areas of anticipated wear. Figure 11-17 shows liner applications for a shallow bowl mill.

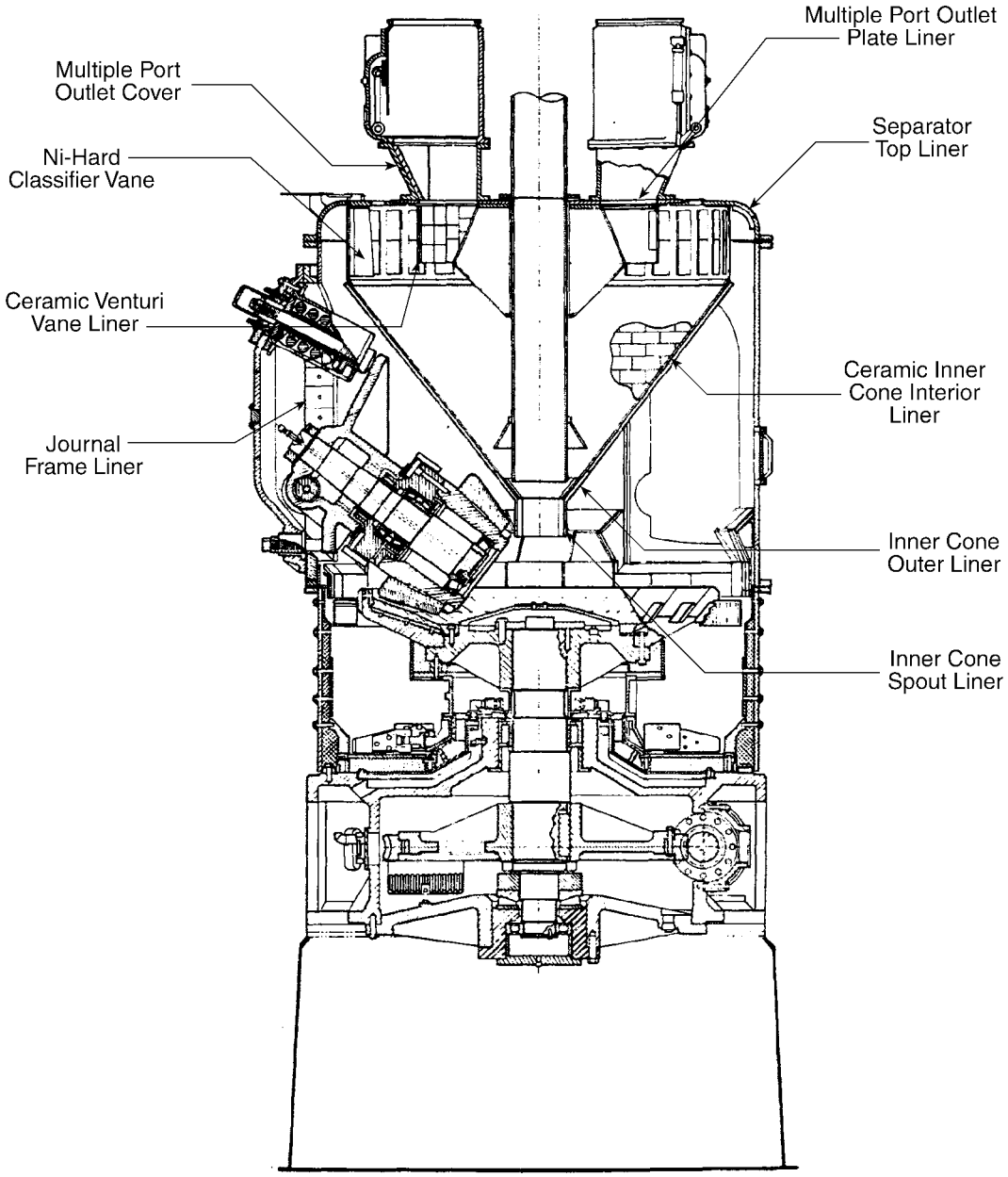


Figure 11-17
Mill Liner Applications [15]

Figure 11-18 shows a ceramic liner on an inner cone. Figure 11-19 shows a spout liner plate.



Figure 11-18
Inner Cone Ceramic Liner
(Courtesy of Great River Energy)



Figure 11-19
Spout Liner Plate
(Courtesy of Great River Energy)

Figure 11-20 shows the installation of the spout liner plate.



Figure 11-20
Installation of a Spout Liner Plate
(Courtesy of Great River Energy)

The liners commonly used in the shallow bowl mill are listed in Table 11-3.

Table 11-3
Shallow Bowl Mill Liners [15]

Liner Location	Liner Material
Journal frame liner	Crown 700
Inner cone spout liner	Crown 700
Separator top liner	Crown 700
Multiport liner	Crown 700
Multiport plate liner	Cast nitride bonded silicon (ceramic)
Inner cone outer liner	Steel
Inner cone interior liner	85% Alumina (ceramic)
Venturi vane	Cast nitride bonded silica (ceramic)
Exhauster periphery	Pressed oxide bonded silica (ceramic)
Exhauster throat	Pressed oxide bonded silica (ceramic)

Crown 700 material is similar to premium Ni-hard with added graphite. Crown 700 material has a minimum hardness of 700 Brinell Hardness Number.

In addition, a millside bottom wave liner modification is available from Alstom. The liner is a replacement for all the Raymond Bowl mills. The wavelike shape of the liner redirects the pyrites back toward the center of the floor and into the path of the scrapers. The wave liner is taller and provides more wear coverage. The material liner can be made from Crown 700 material.

There is a figure that shows the original and new design liner.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.3.4 Grinding Ring

Depending on the available space, rigging, and blocking available, the grinding ring segments can be together or separate. The bowl deflectors, bowl extension ring, and clamping bolts from the bowl top should be removed first. There are two holes for eyebolts tapped in the top of the grinding ring. Place eye bolts in the tapped holes and insert a sling through the eyebolts. Connect the sling to the lifting hook. Lift the sling until there is a light load on the sling. Wedge under the grinding ring to break it loose from the bowl. It may be necessary to burn a V slot through the ring to remove it. It is important not to cut the bowl in this attempt. When the ring is broken free of the bowl, the ring can then be lifted out of the bowl.

Clean the inside tapered bowl surface and the outside tapered surface of the new ring. The new ring is then lowered into place. Clamp down the bowl extension ring and hammer its flange while tightening the bolts to ensure the ring is held tight in the bowl.

Weld repair can be performed on the grinding ring. The top or outer 2 in. of the ring should not be welded because this part of the ring does not wear. This outer surface can be used as a reference dimension.

11.3.4.1 Bull Ring Material

There is a figure that shows an improved material for the segmented bullring on the RB series mills.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

There is a figure that shows the high chrome bull rings.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.4 Mill Millside

This subsection covers the vane wheel assembly, vertical shaft, pyrite removal system, gearbox, and external lubrication system.

11.4.1 Vane Wheel Assembly

The original separator body liner can be replaced with a Ni-hard vane wheel arrangement with liners. The location of the vane wheel is shown in Figure 11-21.

Ni-Hard Vane Wheel Arrangement with Liners

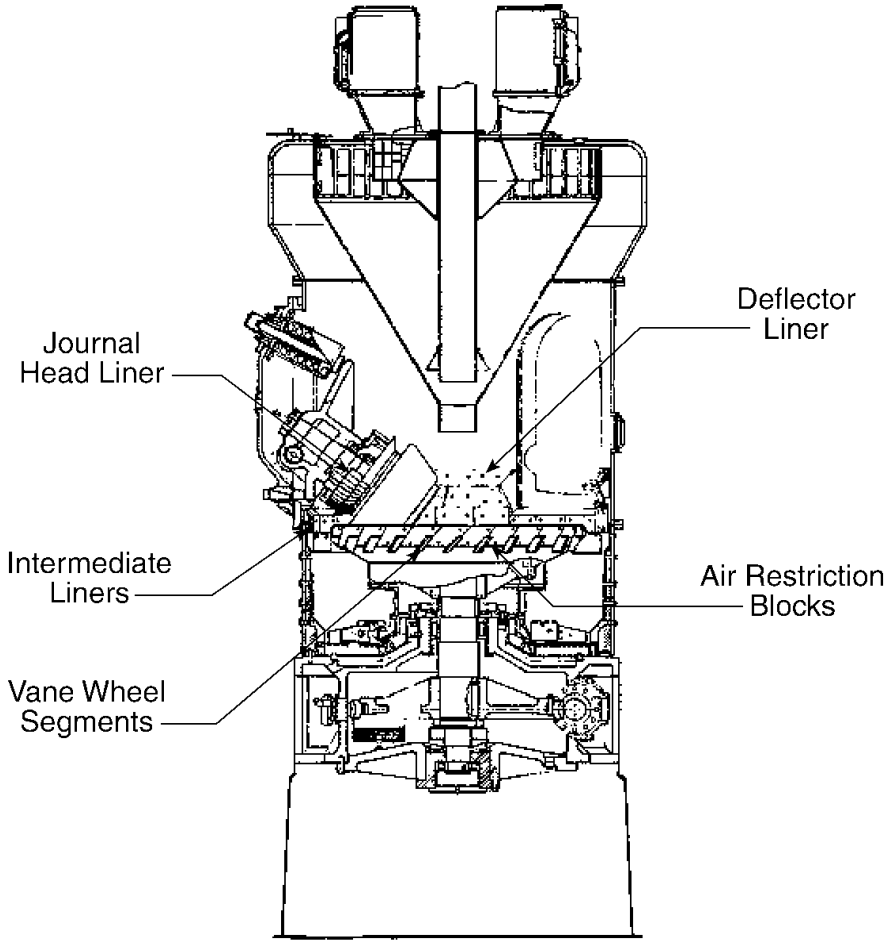


Figure 11-21
Vane Wheel Arrangement [15]

The vane wheel assembly is shown in Figure 11-22.

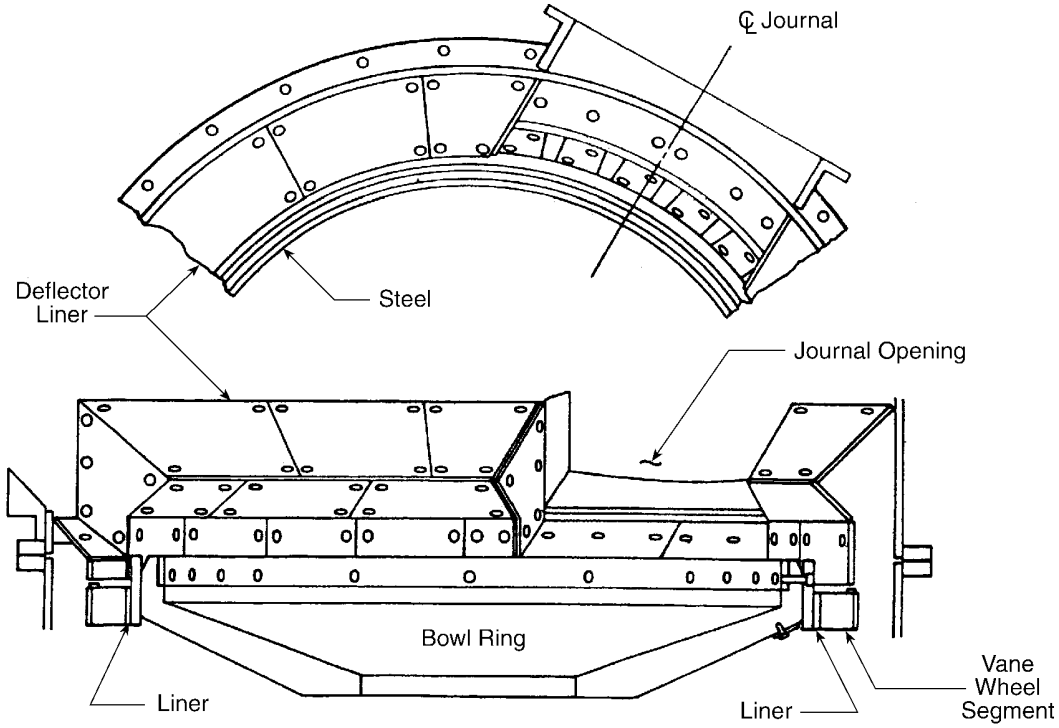


Figure 11-22
Vane Wheel Assembly [15]

The vane wheel segment assembly is shown in Figure 11-23.

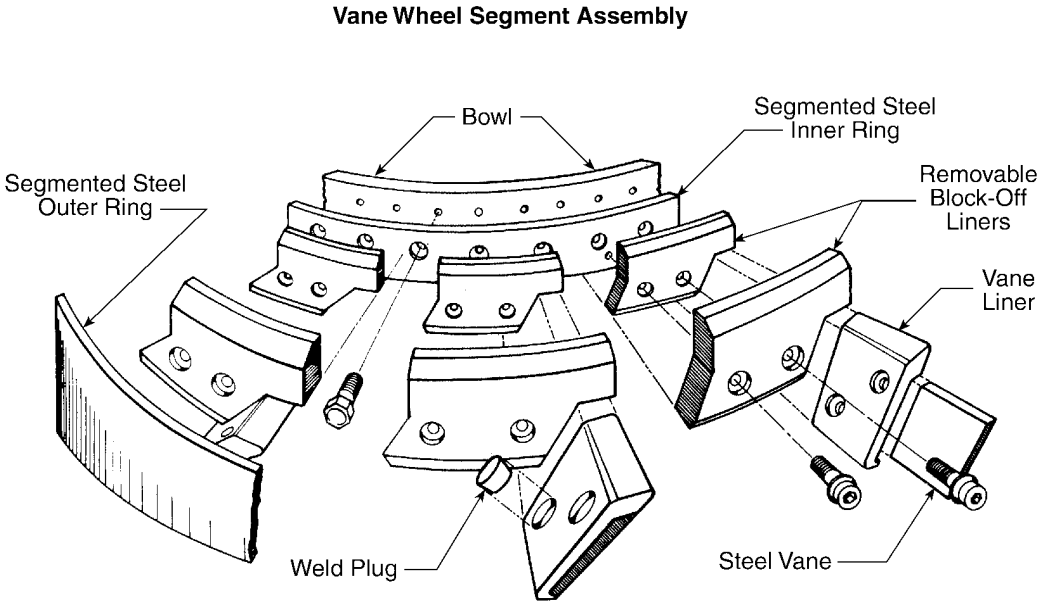


Figure 11-23
Vane Wheel Segment Assembly [15]

Figure 11-24 shows the vane wheel for an RP-1043 mill.



Figure 11-24
Vane Wheel for an RP-1043 Mill
(Courtesy of Great River Energy)

The vane wheel assembly provides a more uniform distribution of the coal and air mixture to the classifier. The deflector liners do not extend beyond the outside diameter of the bowl, which allows freedom of movement during routine inspections.

A newer improvement for the RS, RPS, and RP bowl mills is the use of a steel vaned wheel and Crown 700 vane liners that mount on and rotate with the bowl.

There is a figure that shows the newer designed vane wheel assembly.

There is a figure that shows the vane segments.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.4.1.1 Air Restriction Blocks

There is a figure that shows the air restriction blocks that are used to set the air inlet openings around the bowl.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

The original blocks were made from fabricated carbon steel. An upgrade exists to replace the blocks with a Ni-Hard or nickel-hardened cast iron material. Alstom offers a material known as Crown 700 that has a Brinell Hardness Number of 700. This material promises improved wear life up to 10 times longer than carbon steel.

11.4.2 Vertical Shaft

The most common causes of premature failure of the vertical shaft [1] are spring imbalance and tramp iron on the bowl.

Vibration readings can give early indications of a crack in the shaft. In addition, ultrasonic inspections are used to detect cracks. A shaft could have a crack 25% through its cross-section before the final fracture occurs.

The following tasks are given in this section:

- Vertical shaft oil seal replacement
- Upper radial bearing replacement
- Thrust bearing replacement
- Oil pump bushing replacement

Access to the oil seal is restricted by the close clearance between the upper gear housing and mill base hub. The gearbox has to be lowered by separating the vertical shaft from the bowl hub or by removing the separator body and bowl hub. The oil seal should be replaced whenever the gearbox is removed for overhaul. The procedure to replace the oil seal is given in Table 11-4.

Table 11-4
Vertical Shaft Oil Seal Replacement Tasks [1]

Tasks
After access to the oil seal is achieved, the tasks for oil seal replacement are as follows:
1. Remove the dust guard if applicable. Remove the set screws, unbolt the cap screws, and then remove the two halves of the dust guard.
2. The oil seal is split and can be removed from the upper bearing cover assembly.
3. Lubricate the new seal's lips and cavities with Molykote 33 silicone grease and install.
4. Reassemble the dust guard. Apply a thin coating of RTV-106 in the dust guard bore. The O-ring is not needed. Ensure a gap of 3/32 in. (+1/32 in., -0 in.) between the bottom lip of the dust guard and the upper bearing cover.

Access to the gearbox components can be from the side, top, or bottom depending on the style of the gearbox and the component to be accessed. The RB mills and some of the smaller RS/RPS/RP mills are arranged for removal of the worm gear through the bottom of the gear housing. Larger RS/RPS/RP mills are accessed only from the top, which requires removal of the separator and the bowl assemblies.

For the larger mills, removal of the upper radial bearing requires top access. This means removing the journals, inner cone, and/or entire separator body.

Table 11-5 shows the tasks for replacement of the vertical shaft upper radial bearing for a separate designed gearbox.

Table 11-5
Vertical Shaft Upper Radial Bearing Replacement Tasks [1]

Removal Tasks
1. Lower the gearbox by separating the vertical shaft from the bowl hub or by removing the separator body and bowl hub.
2. Remove the upper bearing housing cover.
3. Remove the bearing outer race using a puller. The outer race has a loose fit in the housing.
4. Remove the bearing inner race using a puller. The inner race has a tight fit on the shaft.
(An optional method is to remove the upper bearing housing assembly from the upper gear housing. Place the housing assembly on a workbench before starting the bearing disassembly. Remove the bearing housing assembly. Use a puller to remove the inner bearing race from the shaft.)
Assembly Tasks
1. Heat the inner bearing race to 250ºF and install the race on the shaft.
2. Install the outer bearing race in the housing. If necessary, cool the outer race to fit in the housing. Apply grease to the bearing to prevent rusting.
3. Install the bearing cover but leave the bolts loose.
4. Reinstall the upper bearing housing in the upper gear housing. Install lock bars on the housing bolt heads if used.
5. Tighten cover bolts finger tight, then check the gap between cover and housing with a feeler gauge. The required gap is 0.008–0.010 in. If the gap is less, machine the bearing cover flange. If the gap is greater, install steel shims to reduce the gap.
6. Apply Locktite 515 or Permatex #3 to bearing cover. Apply Locktite 271 to the bolts. Install with flat washers and tighten. Apply lock bars if used, but do not apply split lock washers.

Vertical shaft thrust bearing replacement is best accomplished by removing the gearbox from the pulverizer. If it is necessary to replace the shaft thrust bearings with the gearbox in place, Table 11-6 shows the tasks for replacement.

Table 11-6
Vertical Shaft Thrust Bearing Replacement Tasks [1]

	Tasks
1.	For disassembly, drain the gear case oil. Check the contact of the worm gear for reference.
2.	Open the millside access door and drive tapered wedges between the lower skirt and the mill bottom cover at three or four places equally spaced around the perimeter of the skirt.
3.	Remove the cap screws from the inner bolt circle of the bearing housing cover, then remove the hex head screws from the outer bolt circle and lower the bearing housing cover and shims. The cover can be lowered using two or three long-threaded rods and nuts.
4.	Replace the four gearbox attachment studs with the long removal studs and install nuts on them to the bottom of the gearbox bolt flange.
5.	Remove all bolts holding the upper and lower gear housings together. Remove all cap screws holding the lower gear housing to the worm shaft bearing housings. Do not remove the cap screws holding the worm shaft bearing housings to the upper gear housing.
6.	Back off equally on the nuts of the threaded attachment rods to lower the cover. Ensure the threaded rods do not turn.
7.	Lower the cover until it clears the thrust bearing housing. Provide adequate support for the cover and move it aside to gain access to thrust bearing housing.
8.	The vertical shaft and gear hub are now hanging from the bowl hub and may fall if the shaft is cracked or damaged. Place blocking or supports under the gear hub before continuing.
9.	Place supports under the thrust bearing housing.
10.	Unbolt the bearing keeper ring and lower the thrust bearing housing.
11.	For gearboxes equipped with the internal oil pump, remove the oil pump hub from the shaft by removing the two socket head cap screws and the keeper. Use care as the oil pump hub and bearings may come off with the plate. Place a jack stand under the pump to lower. The oil pump and bearings are heavy and could cause injury if they fall. Remove the oil pump hub key if used. For gearboxes equipped with an external oil pump, remove the bearing locknut by unscrewing it. Use care as the bearings may come off with the plate.
12.	Remove both thrust bearings using a puller. The bearings have a tight fit on the shaft. Then remove the remaining top bearing outer race and the bearing keeper ring.
13.	Remove the lower bearing outer race from the bearing housing using a puller. The race has a loose fit in the housing.
14.	Prior to reassembly, assemble both bearings in the bearing housing. Install the bearing keep ring with the original shims and tighten the cap screws. Do not apply Locktite.
15.	Measure the gap between the top bearing outer race and the bearing keeper ring using a feeler gauge. The required clearance is 0.005–0.008 in. Adjust the shims as needed.
16.	Disassemble the bearings from the bearing housing from Step 14.

Table 11-6 (cont.)
Vertical Shaft Thrust Bearing Replacement Tasks [1]

	Tasks
17.	Using straps, place the bearing keeper ring, shims, and top bearing outer race on the vertical shaft and support from the gear hub.
18.	Heat both bearing inner races to 250ºF and install the inner races back to back on the shaft. Support the races in place using the locknut or oil pump hub and key.
19.	Install the lower bearing outer race in the bearing housing.
20.	For gearboxes having an internal oil pump, support the oil pump hub or spacer with a jack. Remove the keeper plate and then measure the gap between the end of the shaft and the face of the oil pump hub or spacer. Install shims with a total thickness of 0.003–0.005 in. less than the measured gap. Replace the keeper plate, apply Locktite 271 to the hex socket head cap screws and tighten. Recheck bearing clearance per Step 15 and re-shim if needed. For gearboxes with the external oil pump, remove the bearing locknut. Clean the threads and apply Locktite 271. Reinstall the locknut and tighten.
21.	Install the bearing housing on the bearing and support with cribbing. Install the top outer race, shims, and bearing keeper ring. Ensure the oil hole in the housing and keeper ring align. Apply Locktite 271 to the cap screws and tighten.
22.	Remove the supports from under the gear hub.
23.	Reinstall the lower gear housing. Apply Locktite 515 Gasket Eliminator to the bolt flange for sealing.
24.	Check the location of the bearing housing bolt holes. Then, using the original shims, replace the lower bearing housing cover. Replace and tighten four equally spaced cap screws on the outer bolt circle and three cap screws on the inner circle. Remove the wedges from under the lower skirt.
25.	Check the gear contact pattern from the tasks in Table 11-12 (checking of worm gears). Adjust if necessary to match the original pattern.
26.	If the contact pattern is acceptable, reinstall wedges under the lower skirt. Remove the lower cover. Apply Locktite 515 Gasket Eliminator or a thin gasket to the cover bolt flange and reinstall with all bolts. Remove wedges from under the lower skirt.



Human Performance Key Point

For gearboxes equipped with the internal oil pump, remove the oil pump hub from the shaft by removing the two socket head cap screws and the keeper. Use care as the oil pump hub and bearings may come off with the plate. **Place a jack stand under the pump to lower. The oil pump and bearings are heavy and could cause injury if they fall.** Remove the oil pump hub key if used. For gearboxes equipped with an external oil pump, remove the bearing locknut by unscrewing it. Use care as the bearings may come off with the plate.

Table 11-7 shows the tasks for replacement of the oil pump bushing.

Table 11-7
Oil Pump Bushing Replacement Tasks [1]

Tasks
1. For disassembly, drain the gear case oil. Check the contact of the worm gear for reference.
2. Open the millside access door and drive tapered wedges between the lower skirt and the mill bottom cover at three or four places equally spaced around the perimeter of the skirt.
3. Remove the cap screws from the inner bolt circle of the bearing housing cover. Then remove the hex head screws from the outer bolt circle and lower the bearing housing cover and shims. The cover can be lowered using two or three long-threaded rods and nuts.
4. Unbolt and remove the old bushing. Install the new bushing. If necessary, remove the oil pump hub for access. Ensure the oil hole in the bushing aligns with the oil holes in the housing.
5. Apply Locktite 515 Gasket Eliminator to the lower cover bolt flange.

11.4.2.1 Vertical Shaft Improvements

Figure 11-25 shows the original design and changes made to the vertical shaft.

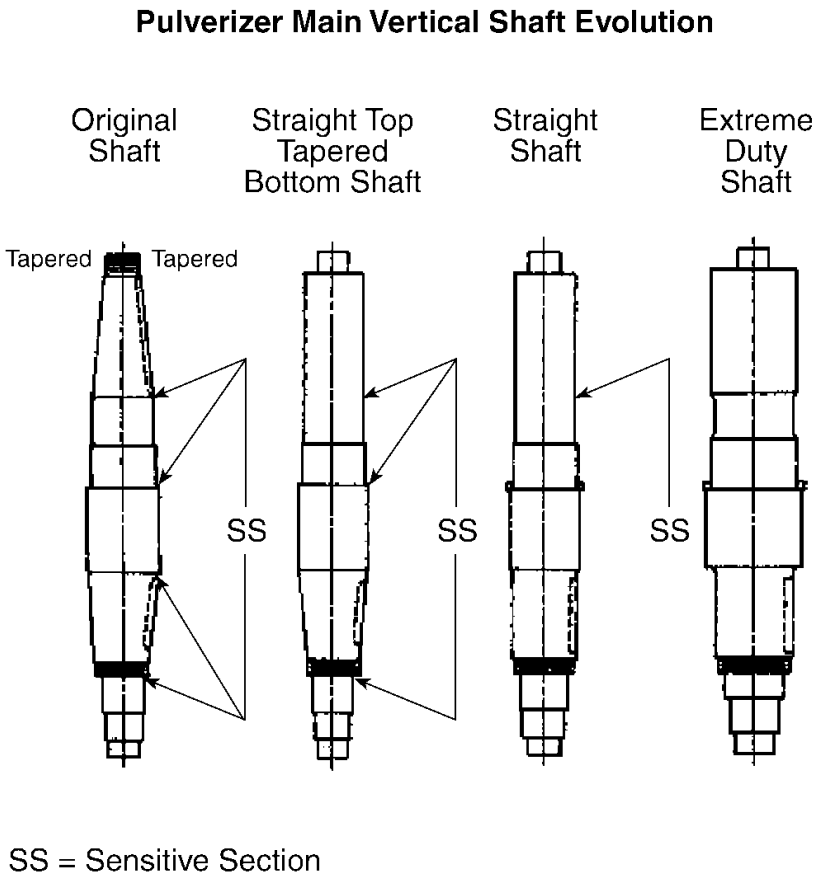


Figure 11-25
Vertical Shaft Design Changes [15]

The original design of the shaft used a tapered fit-key connection to the bowl hub. A number of shaft failures occurred with this design because of the combined effects of a poor fit to the bowl hub and high stress concentration in the keyway.

The next design eliminated the top keyway and tapered section and used a full section diameter through the bowl hub. The bowl hub to vertical shaft interference fit provided a positive driving force. This design shaft eliminated failures because of the top taper. However, other problems occurred with the bottom taper and sharp fillet radii in the critical transition areas.

The next design change used a cylindrical shrink fit connection to the bowl hub and worm hub gear. The diameter of the cylindrical and tapered shaft at the upper radial bearing was the same, but the elimination of the keyways and increased fillet radii of the cylindrical design produced a shaft with an 80% increase in fatigue strength. The shaft is also four times less sensitive to load imbalance. Use of this design has greatly reduced the number of shaft failures. However, there

was a concern that the shaft is not tolerant of long-term load imbalance conditions caused by journal spring imbalance.

The extreme duty shaft design has a 200% increase in fatigue strength and is twenty times less sensitive to load imbalance. The reason for the higher fatigue strength and resistance to load imbalance is the relatively large increase in shaft diameter.

Two other features incorporated into this design are improved oil seal wear sleeve and air seal. An oil seal wear sleeve prevents the inner race of the upper radial bearing from moving upward and damaging the oil seals. The wear sleeve has a chrome-plated surface that prevents the oil seals from wearing grooves on the vertical shaft. The sleeve is positively driven by the bowl hub and replaces the old style dust guard that was driven by the vertical shaft by set screws. The number of air seal blades was increased from two to three. This increased the resistance to air and coal flow in the direction of the oil seals. The improved air seal design, coupled with a tighter internal clearance upper radial bearing and an upper bearing housing that is a an interference fit into the gear case upper bore, reduces the amount of shaft runout and increases the air seal life.

11.4.2.2 Flat Thrust Bearing

The vertical shaft thrust bearing supports the weight of the mill rotating parts and the downward grinding force exerted by the grinding rolls. The thrust bearing is not designed to withstand any radial loading. The V-flat thrust bearing is shown in Figure 11-26.

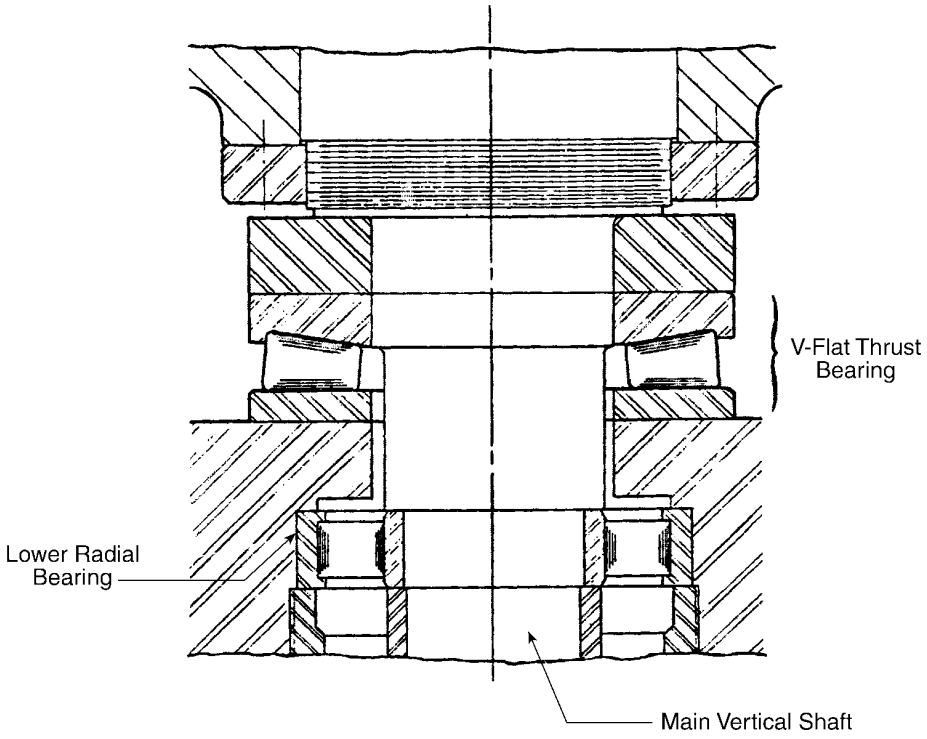


Figure 11-26
V-Flat Thrust Bearing [15]

11.4.2.3 Upper Radial Bearing

The radial bearing assembly provides support and a location for the vertical shaft. The new design is a four-piece bearing containing the inner race, outer race, roller and cage assembly, and a removable shoulder. The new design radial bearing is shown in Figure 11-27.

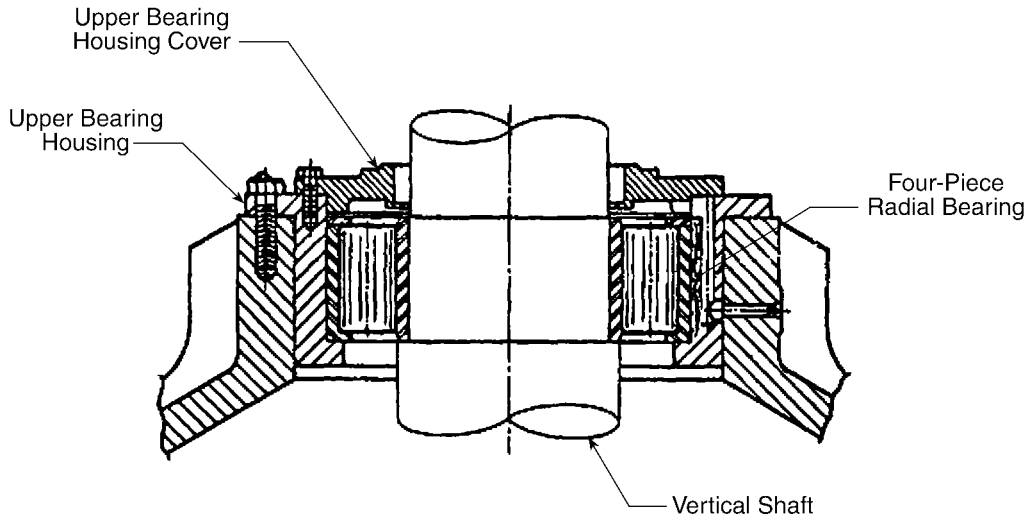


Figure 11-27
Upper Radial Bearing [15]

The bearing has closer tolerances between the mating parts. This tolerance reduces the radial play in the assembly and provides a more even load distribution on the rollers. The bearing is loaded less and lasts longer than the original design.

11.4.2.4 Split Upper Radial Bearing Cover

The split upper radial bearing housing cover is a two-piece cover plate used to clamp down the outer race of the upper radial bearing and hold the upper radial bearing oil seals. The housing cover has been designed in two pieces so that the cover can be removed without removing the bowl hub. This facilitates inspection of the shaft oil seals and upper radial bearing.

11.4.2.5 Vertical Shaft Oil Seal Wear Sleeve

The lip type oil seal that was originally designed allowed the vertical shaft to become grooved from coal and oil rubbing the shaft. The new design seal is shown in Figure 11-28 and is an oil seal wear sleeve that is 1/16-in. thick.

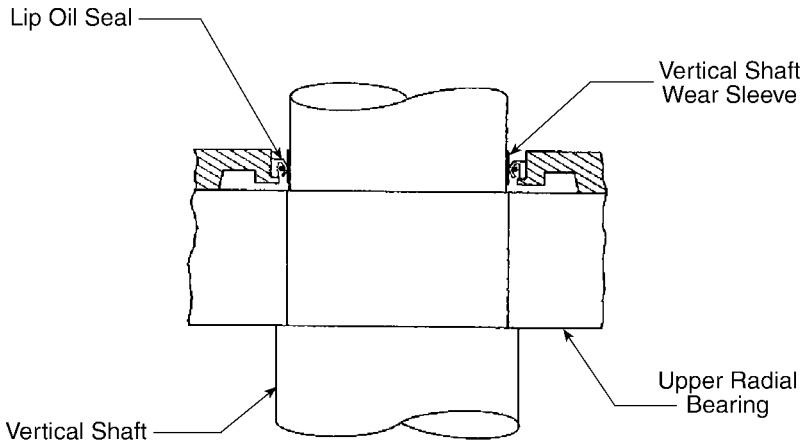


Figure 11-28
Oil Seal Wear Sleeve [15]

The sleeve uses an interference fit to lock the sleeve to the shaft. The sleeve has a phosphate coating to reduce wear on the seal.

11.4.2.6 Mechanical Face Seal

Originally, the mills were supplied with a double-blade clearance seal. The clearance seal relies on the clean seal air between the blades to protect the gearbox from contamination. As the shaft runout wears the seal blades, the clearance allows coal and oil to enter the gearbox.

The new seal is called the mechanical face seal and is shown in Figure 11-29.

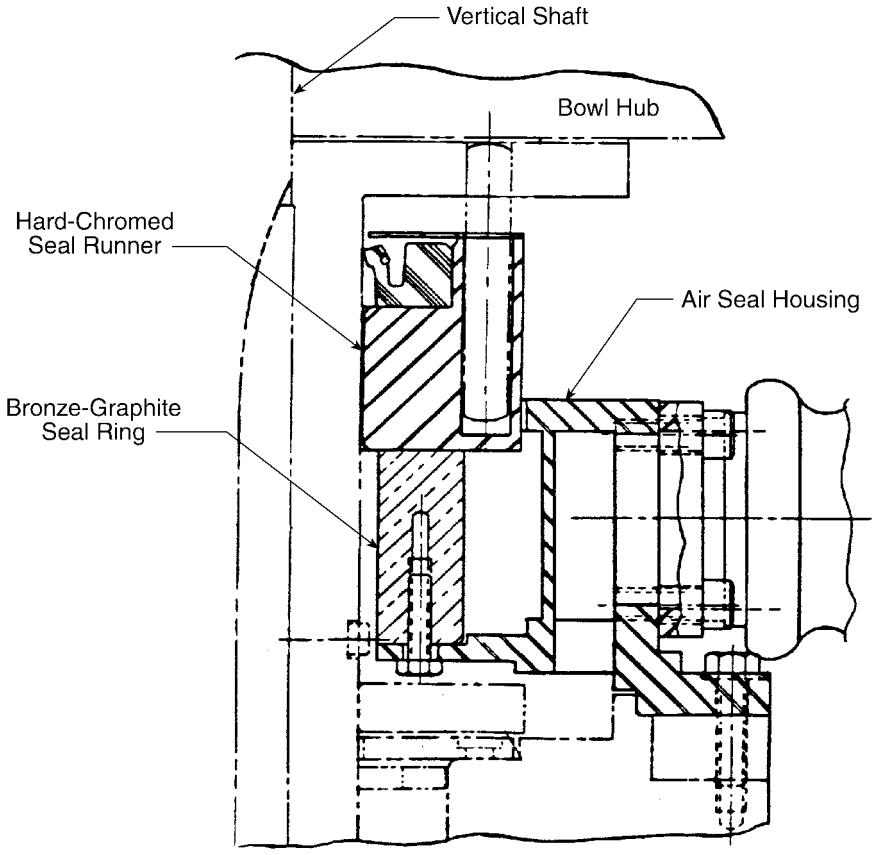


Figure 11-29
Mechanical Face Seal [15]

A chrome-plated seal runner driven by the bowl hub rides on a stationary graphite plugged bronze seal ring. As the bronze seal wears, the seal runner slides downward, maintaining continuous contact with the seal ring. The seal runner moves down a chrome-plated wear sleeve that is also driven by the bowl hub. The seal runner has a lip seal that contacts the wear sleeve, providing a barrier between the seal runner and wear sleeve. Seal air is introduced in an annulus outside the air seal housing and the wear sleeve.

11.4.3 Pyrite Removal System

Figure 11-30 shows a typical scraper and guard assembly.

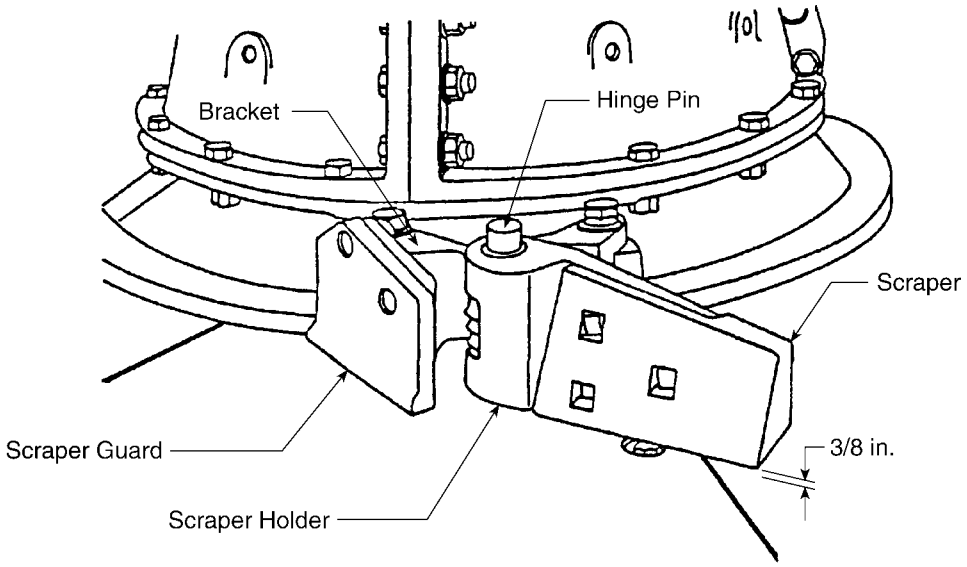


Figure 11-30
Scraper and Guard Assembly [1]

There is a table that lists the replacement tasks for the scraper.

There is a table that lists the replacement tasks for the scraper hinge pin.

There is a table that lists the scraper guard replacement tasks.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

The pyrite scraper assembly has been redesigned to include a hardened stainless steel scraper pin and replaceable hardened stainless steel bushings in the scraper holder. Figure 11-31 shows a picture of the new pyrite scraper assembly.

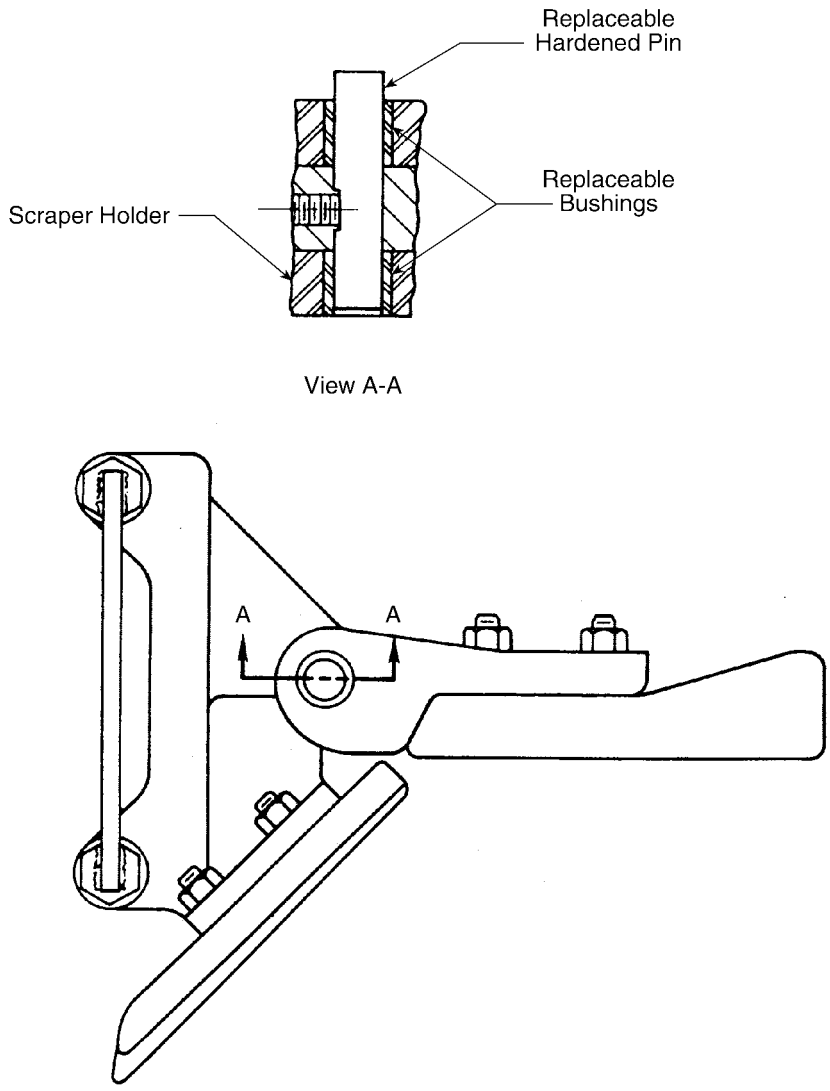


Figure 11-31
New Pyrite Scraper Assembly [15]

The replaceable hardened bushings reduce scraper pin and holder wear. An interference fit between the scraper and guard bracket and the scraper pin prevents any relative movement and resulting wear. In the retrofit package, two bushings must be installed in the existing bracket and drilled and reamed according to the assembly instructions. The scraper and guard bracket bushings are non-hardened stainless steel.

A new horizontal pivot scraper assembly is available from Alstom.

There is a figure that shows a picture of the new horizontal pivot scraper assembly.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

Figure 11-32 shows a scraper assembly for an RP-1043 mill.



Figure 11-32
Scraper Assembly For An RP-1043 Mill
(Courtesy of Great River Energy)

11.4.4 Gearbox

Alstom recommends an annual gear case inspection. Items to check during this inspection include:

- Gear case oil
- Oil flow channels
- Air and oil seals
- Oil cooler
- Worm gear contact pattern

Access to the gear case components can be from the side, top, or bottom, depending on the extent of the inspection and the style of mill. The RB mills and some of the smaller RS/RPS/RP mills allow removal of the bull gear through the bottom of the gear housing. Bottom access is used for removal or inspection of the lower bearing housing shims (to set gear contact pattern), lower radial bearing, thrust bearing, worm gear removal, main vertical shaft, and oil pump hub.

Larger RS/RPS/RP mills are accessed only from the top. Access from the top of the gear case requires the removal of the separator and bowl assemblies. Top access is used for removal or inspection of the air seal assembly, oil seals, and upper radial bearing. To remove the upper radial bearing, the bowl must be removed, which involves removing the journals, inner cone, and/or entire separator body. On the larger mills, top access is used for removal of the main vertical shaft, lower shaft bearings, and the bull gear assembly.

Side access is used for removal or inspection of the worm shaft, worm shaft radial bearing, and worm shaft thrust bearing.

The gearbox can be removed as an assembly or in separate parts. If possible, the assembly removal is the preferred method. Table 11-8 shows the tasks for removing the gearbox as an assembly for mills with bottom access; Table 11-9 shows the tasks for removing the gearbox in separate parts; Table 11-10 shows the tasks for gearbox reassembly.

Table 11-8
Gearbox Removal Tasks as an Assembly [1]

	Tasks
1.	Drain the gearbox oil and disconnect the oil cooler water lines and motor couplings.
2.	Place three or four wood wedges between the bowl hub skirt bottom and the mill base plate.
3.	Remove the journal assemblies.
4.	Replace the four gearbox attachment studs with the long removal studs. Install a nut on the stud and position it against the bottom of the gearbox bolt flange.
5.	Remove the bowl hub locknut and guard.
6.	Back off equally on the nuts of the threaded attachment rods to lower the cover. Ensure the threaded rods do not turn. If the vertical shaft is stuck in the bowl hub, remove it by using the hydraulic jack and strong back procedure in the manufacturer's literature. If heating is required, it can be done from under the mill base plate, positioning the torches to heat the bowl hub bottom. Do not exceed 400ºF.
7.	Remove the vertical shaft nut guard (if used) and oil seal.
8.	Remove the upper radial bearing housing with a bearing or disassemble bearing as described in Table 11-5 for vertical shaft upper radial bearing replacement.
9.	Remove the upper gear housing.
10.	Remove the worm shaft assembly by unbolting it from the lower gear housing. Before lifting the assembly, disengage it from the gear teeth by moving it away from the gear and into the chamber in the gear housing provided for this. Failure to disengage the gear teeth before lifting the worm or worm gear will damage the gear teeth.
11.	Note: An optional method is to lift the worm shaft and vertical shaft/gear hub together.
12.	Lift the vertical shaft with the gear hub and the thrust bearing housing as an assembly out of the lower gear housing. Place the assembly on a work stand, supported by the gear hub, to continue disassembly.
13.	Place supports under the thrust bearing housing.
14.	Unbolt the bearing keeper ring, and lower the thrust bearing housing.
15.	For gearboxes equipped with an internal oil pump, remove the oil pump hub from the shaft by removing the two socket head cap screws and the keeper. Use care because the oil pump hub may come off with the plate. **Place a jack stand under the pump to lower. Both are heavy and could cause injury if they fall.** Remove the oil pump hub key (if used). For gearboxes equipped with an external oil pump, remove the bearing locknut by unscrewing it.
16.	Remove both thrust bearings using a puller. The bearings have a tight fit on the shaft. Then remove the remaining top bearing outer race and the bearing keeper ring.
17.	Remove the gear hub locknut.
18.	Lift the vertical shaft out of the gear hub. The gear hub has a loose fit on the shaft.

Table 11-9
Gearbox Removal Tasks as Separate Parts [1]

	Tasks
1.	Drain the gearbox oil; disconnect the oil cooler water lines and motor couplings.
2.	Place three or four wood wedges between the bowl hub skirt bottom and the mill base plate.
3.	Remove the journal assemblies.
4.	Replace the four gearbox attachment studs with the long removal studs. Install a nut on each stud and position it against the bottom of the gearbox bolt flanges.
5.	Remove all bolts holding the upper and lower gear housings together. Remove all cap screws holding the lower gear housing to the worm shaft bearing housings. Do not remove the cap screws holding the worm shaft bearing housings to the upper gear housing.
6.	Back off equally on the nuts of the threaded attachment rods to lower the cover. Ensure that the threaded rods do not turn when turning the nuts.
7.	Lower the cover until it clears the thrust bearing housing. Provide adequate support for it and move it aside to gain access to the thrust bearing housing.
8.	Note: The vertical shaft and gear hub are now hanging from the bowl hub and may fall if the shaft is cracked or damaged. Place blocking or support under the gear hub before continuing.
9.	Place supports under the worm shaft and install rigging to lower it. Then remove the remaining cap screws attaching it to the upper gear housing.
10.	Before lowering the worm shaft assembly, move it away from the gear in order to disengage it. A chamber in this upper gear housing provides space for moving it. Failure to do this will result in damage to the gear teeth.
11.	Lower the worm shaft assembly and remove it.
12.	Place supports under the thrust bearing housing.
13.	Unbolt the bearing keeper ring and lower the thrust bearing housing.
14.	For gearboxes equipped with an the internal oil pump, remove the oil pump hub from the shaft by removing the two socket head cap screws and the keeper. **Use care because the oil pump hub and bearings may come off with the plate. All are heavy and could cause injury if they fall.** Remove the oil pump hub key (if used). For gearboxes equipped with an external oil pump, remove the bearing locknut by unscrewing it. **Use care because the bearings may come off with the plate. All are heavy and could cause injury if they fall.**
15.	Remove both thrust bearings using a puller. The bearings have a tight fit on the shaft. Then remove the remaining top bearing outer race and the bearing keeper ring.
16.	Before removing the gear hub, place supports under it. Then remove the gear hub locknut and lower the gear hub off the shaft. The gear hub has a loose fit on the shaft.
17.	Before removing the vertical shaft, place supports under it. Remove the bowl hub nut guard and locknut. Then install lifting gear on the shaft locknut threads. Remove the supports from under the shaft and lower the shaft with the radial bearing inner race out of the upper gear housing.
18.	Unbolt the upper gear housing from the mill base hub, and lower it using the long-threaded rods installed in Step 1.

Table 11-10
Gearbox Assembly Tasks [1]

	Tasks
1.	Note: Check the contact fit of tapered vertical shaft with the bowl hub before assembly. A 60% minimum contact fit is required.
2.	Install the gear hub with gear on the vertical shaft. The hub has a loose fit on the shaft.
3.	Apply Locktite 277 to the gear hub locknut. Install the locknut and tighten securely.
4.	For disassembly, drain the gear case oil. Check the contact of the worm gear for reference.
5.	Open the millside access door and drive tapered wedges between the lower skirt and the mill bottom cover at three or four places equally spaced around the perimeter of the skirt.
6.	Remove the cap screws from the inner bolt circle of the bearing housing cover. Then remove the hex head screws from the outer bolt circle, and lower the bearing housing cover and shims. The cover can be lowered using two or three long-threaded rods and nuts.
7.	Replace the four gearbox attachment studs with the long removal studs, and install nuts on them to the bottom of the gearbox bolt flange.
8.	Remove all bolts holding the upper and lower gear housings together. Remove all cap screws holding the lower gear housing to the worm shaft bearing housings. Do not remove the cap screws holding the worm shaft bearing housings to the upper gear housing.
9.	Back off equally on the nuts of the threaded attachment rods to lower the cover. Ensure that the threaded rods do not turn.
10.	Lower the cover until it clears the thrust bearing housing. Provide adequate support for the cover and move it aside to gain access to thrust bearing housing.
11.	The vertical shaft and gear hub are now hanging from the bowl hub and may fall if the shaft is cracked or damaged. Place blocking or supports under the gear hub before continuing.
12.	Place supports under the thrust bearing housing.
13.	Install the small gear housing cover on the lower gear housing.
14.	Install the vertical shaft assembly and the worm shaft assembly in the lower gear housing. If the parts are installed separately, move the worm shaft away from the gear to prevent damaging the gear teeth.
15.	Apply Locktite 515 or Permatex 3 to the lower gear housing bolt flanges and worm shaft bearing housings. Install the upper gear housing. Apply Locktite 271 to all bolts and cap screws. Install all fasteners and tighten.
16.	Install the vertical shaft upper radial bearing. See Table 11-5 for the upper radial bearing replacement tasks.
17.	Install the vertical shaft oil seal. See Table 11-4 for the oil seal replacement tasks.
18.	Check the gear contact pattern. See Table 11-12 for the setting of worm gears.
19.	Install the bowl hub key in the vertical shaft.
20.	For gearbox installation, position the gearbox under the mill base, and install the four long removal studs through the housing flange bolt holes.
21.	Raise the gearbox using wrenches to turn the nuts on the four long removal studs.

Table 11-10 (cont.)
Gearbox Assembly Tasks [1]

	Tasks
22.	Ensure that the bowl hub key in the vertical shaft is aligned with the bowl hub keyway.
23.	When the upper gear housing studs fit into the mill base hub bolt holes, install the nuts with Locktite 271, and tighten carefully to keep the gearbox level.
24.	Check the angularity alignment of the coupling. If necessary, shift the gearbox by loosening the nuts, then tightening the nuts. When alignment is correct, drill and ream to install both anti-rotation dowel pins. If the existing holes are reused, it may be necessary to ream each hole and use a larger diameter pin.
25.	Replace the four long-threaded rods with the attachment studs and nuts, and apply Locktite to the studs and nuts. On each stud, tighten the bottom nut first, and then tighten the top nut.

Table 11-11 gives the tasks for replacement of the mill base hub.

Table 11-11
Mill Base Hub Replacement Tasks [1]

	Tasks
1.	Remove the separator body, bowl, and gearbox with the vertical shaft.
2.	Unbolt and remove the mill base hub.
3.	Install the new base hub.
4.	Install the gearbox and check angularity alignment of the coupling. If necessary, shift the gearbox or mill base hub to obtain the required alignment.
5.	Drill and ream two holes into the mill base for the anti-rotation dowel pins.
6.	Install the dowel pins with a 0.001–0.002 in. tight fit.

11.4.4.1 Worm and Worm Gear

This section covers worm gear alignment check, worm thrust bearing replacement, and worm shaft radial bearing.

The worm (steel driving gear) and the worm gear (bronze driven gear) are shown in Figure 11-33. The worm shaft contains the worm.



Figure 11-33
Worm and Worm Gear

- **Worm gear alignment check:** When the centerline of the bronze gear is raised above the centerline of the worm, a full-face contact pattern is established on the drive side of the gear tooth. When the gear case is installed on the true center distance, the full-face contact covers approximately 90% of the length of the tooth, and the contact pattern extends down from the top edge of the gear. This position is the starting point for establishing the final setting of the gear contact.

Shift is the amount of axial gear adjustment or shim change required to change the contact pattern. The gear set is manufactured on true centers to meet a specific shift, depending on the center distance of the gear set. On true centers, the contact will change from a nominal full-face pattern of approximately 90% to a nominal leaving pattern of approximately 40% when adjusted by the nominal shift. The purpose of adjusting the gear shift is to compensate for deflections that the gear set will experience under load and to provide adequate lubrication to the gear mesh.

Skew is an axial misalignment of the worm relative to the worm gear in the horizontal plane. It can affect both contact and backlash. Backlash is the amount of clearance between the worm threads and the gear tooth flank. Backlash is measured with a dial indicator at the pitch diameter of the gear (half the depth of the gear tooth) with the worm locked against rotation. The amount of backlash machined into the gear (as checked on true center distance) is stamped on the side face of the gear. Higher backlash readings indicate wide center distance and/or skew, while lower readings indicate tight center distance and/or skew.

Pattern wander is a cyclic change in the length of the contact pattern with the full rotation of the gear. It is best evaluated at the full-face contact setting and is the result of gear face runout in the assembly. The full-face contact pattern should be within a range of 95% maximum to 75% minimum. If these contact limits are exceeded, excessive runout is the most probable cause.

The original supplied worm gearing is designed to last more than 15 years. Obtaining the maximum life from the gearing is based on proper lubrication practices, the integrity of the gear bearings, and the gear contact settings.

A condition known as corrective pitting of bronze worm gears is the result of surface fatigue. When the gear is initially placed in service, the normal high spots or peaks of the gear carry the load. Small surface cracks evolve from localized surface loading. Lubricating oil is then forced into these cracks through the sliding action of the worm and bronze particles are removed from the surface by hydrostatic action. The pitting process continues until the peaks are reduced and there is sufficient gear tooth surface area available to carry the load. Generally, the corrective pitting stops within the first year of service. Pitting that starts after the initial time indicates another problem, possibly with lubrication practices. In cases of severe pitting, one utility (Duke Energy) had success by changing the oil to Mobil 600 W Super Cylinder Oil or the Mobil SHC 634 synthetic oil.

Another condition that might occur is heat checking. Heat checking occurs when heavy localized operating stress is placed on the worm because of a flaw in the gear tooth contact. The worm overheats as it leaves the bronze gear and is quenched in the oil sump. The thermal stresses produced by this action result in cracks or heat checks. Heat checks can lead to spalls developing and failure of the gear set. Heat checks can be caused by improper contact of the gear teeth, operating deflections from grinding tramp iron, low oil levels, high oil temperatures, or low oil viscosity.

The bronze gear and worm can be reversed as a set to extend their useful life. After replacement of the worm gears, the thrust bearing or vertical shaft, checking the alignment of the worm gear and worm is recommended. Table 11-12 gives the tasks to check the alignment of the worm gears.

Table 11-12
Worm Gear Alignment Check Tasks [1]

Tasks	
1.	Assemble the gearbox with all bearings in place. Remove the oil coolers. The worm gear should be approximately centered with the worm. The worm and all gear teeth should be clean and dry. Insure all bearings receive a small amount of oil.
2.	Remove the gearbox inspection covers.
3.	Apply a thin coating of Prussian-blue dye to the leading or left face of all the worm teeth through the worm cover inspection opening. Spread the Prussian-Blue dye uniformly over the entire tooth face. A thick coating will spread and give a false contact pattern. While applying this coating, turn the worm so that the gear advances counterclockwise when viewed from above.
4.	For improved visibility, apply a light uniform coating of a dry paste mixture of red lead or chalk dust and SAE 50 oil to the trailing or right face of the gear teeth as they are being turned.
5.	Place two wooden blocks 180° apart between the bowl and the liners to create resistance when turning the worm.
6.	Rotate the worm so that the gear turns clockwise when viewed from above, and inspect the gear teeth contact from the inspection opening. Apply additional blueing as needed.
7.	Adjust the contact pattern until it is centered on the gear teeth. The pattern may vary between teeth because of runout, variations in gearbox center dimensions, and gear hobbing. Then remove 0.005–0.008 in. of shims. This will lower the gear and prove the proper running clearance during operation.
8.	To change the contact pattern, add or remove shims from between the lower bearing cover and the thrust bearing housing. Adding shims will increase the contact pattern, and removing shims will reduce it. Perform the following tasks to change the contact pattern.
	8.1 Insert three or four wood wedges between the bowl hub skirt and the mill base.
	8.2 Remove two of the large cap screws from the lower cover and replace with two threaded rods and nuts. Remove all remaining large and small cap screws.
	8.3 Lower the lower cover using the nuts until the shims are accessible. Ensure that the threaded rods do not turn while turning the nuts.
	8.4 Change the shims as required. Raise the cover back up to the gearbox using the nuts. Ensure that the dowel pin engages into its hole in the lower thrust bearing housing.
	8.5 Install several more large and small cap screws.
	8.6 Remove the wedges installed in Step 8.1.
	8.7 Recheck the contact pattern from Steps 3–6.
	8.8 When the contact pattern is acceptable, lower the cover, apply Locktite 515 to the flange, and reinstall. Install all large and small cap screws with Locktite 515, and tighten as required.
	8.9 Remove the blueing from the worm and gear and reinstall the inspection covers.

Worm thrust bearing replacement: Table 11-13 shows the replacement tasks for the worm thrust bearing.

Table 11-13
Worm Shaft Thrust Bearing Replacement Tasks [1]

Tasks	
1.	For disassembly, remove the drive coupling if necessary.
2.	Release the pressure on the packing by backing off the nuts on the gland studs, if necessary.
3.	Remove the socket head cap screws holding the thrust bearing housing cover. Then remove bearing housing cover.
4.	Slide the thrust bearing housing off the bearing and onto the worm shaft.
Note: The outer race of one bearing may remain in the housing. Use care when removing this race.	
5.	Release the hex socket set screw or lock pin in the thrust bearing locknut and then back the nut off the shaft.
6.	Remove the bearing from the shaft with a suitable puller.
7.	Remove the thrust bearing housing from the shaft. Remove the remaining bearing outer race from the housing. The race has a loose fit in the housing.
Note: Replacement thrust bearings may be supplied with a separate spacer for each bearing or the spacer may be integral with the bearing inner race. If separate spacers are supplied, ensure that the spacer is installed correctly in order to prevent binding with the rollers. For most separate spacers, this requires the spacer's large diameter to be installed away from the roller.	
8.	For assembly, support the worm in the horizontal position.
9.	If separate spacers were supplied with the bearings, install one on the shaft.
10.	Assemble one of the bearing outer races into the thrust bearing housing. Place the thrust bearing housing on the worm shaft, and let it hang in position.
11.	Heat both inner assemblies to 250ºF. Assemble each inner race on the worm, pushing it firmly against the shaft shoulder. Follow this immediately with the remaining bearing spacer (if used) and the locknut, drawing it up tightly against the bearing. When the bearing has cooled, the nut should be drawn up further and then locked by means of the radial set screw or lock pin.
12.	After the bearing has cooled, assemble the bearing housing on the bearings. Install the other outer bearing race into the housing and then install the bearing housing cap.
13.	Assemble four short through bolts in the bearing cover and housing flanges, spacing these as uniformly as possible. Tighten the bolts a little at a time, lightly and evenly, until a slight drag is noticed when rotating the entire assembly.
14.	Carefully measure the gap between the bearing housing flange and the mating flange of the bearing cap with a feeler gauge in at least four places around the outside of the flanges. Then average the measurements, and select shims having a total thickness of 0.005 in. greater than the average feeler gauge measurement.
15.	Install the shims between the large flanges where the gap measurement was just determined. Reinstall the bearing housing cover.
16.	Install the worm gear assembly in the lower gear case. Install cap screws in all lower bearing housing bolt holes and through bolts in all upper bearing housing bolt holes not covered by the lower gear housing.

Table 11-13 (cont.)
Worm Shaft Thrust Bearing Replacement Tasks [1]

	Tasks
17.	Rotate the worm gear several revolutions to seat the thrust bearing. Measure the gap between the lip of the bearing housing and the upper outer bearing race with a dial indicator, using a bar or a small hydraulic ram and strong back placed at each end of the worm shaft to move it back and forth. Note: Excessive force will damage the bearings. An optional method is to use feeler gauges to check between the bearing housing shoulder and the rear outer race in at least four places and to average these readings.
18.	If the clearance is greater than 0.006 in. or less than 0.004 in., add or remove shims to produce a clearance within this range. After the upper gear housing is installed, apply Locktite 271 to the bolts and Locktite 515 to the bearing cap. Tighten the bolts.

11.4.4.2 Worm Shaft Radial Bearing

The worm gear bearing replacement tasks are shown in Table11-14. The worm gear assembly must be removed from the gearbox for the bearing replacement.

Table 11-14
Worm Shaft Radial Bearing Replacement Tasks [1]

	Tasks
1.	For disassembly, remove the drive coupling if necessary.
2.	Remove the packing gland and packing.
3.	Remove the radial bearing housing from the worm shaft.
4.	Remove the inner bearing race, retaining the ring from the worm shaft.
5.	Remove the inner race from the shaft using a puller. The race has a tight fit on the shaft.
6.	Remove the retaining ring holding the outer race in the bearing housing.
7.	Remove the outer race from the bearing housing using a puller. The race fit can be a tight fit or a loose fit.
8.	For assembly, heat the inner race to 250ºF and install it on the shaft. Immediately install the retaining rings.
9.	Install the outer race in the housing and install the retaining ring. If the retaining ring is held by cap screws, apply Locktite 271 to the cap screws at assembly. If necessary, coat the outer race with grease to prevent corrosion, and cool to aid in installation.
10.	Place the housing on the shaft and the assembly on the bearing.
11.	Secure the housing in place on the worm shaft with wire or straps to prevent it from sliding off when the worm shaft assembly is moved.
12.	Install the packing gland and packing.

11.4.4.3 Worm Shaft Lip Seal

The worm shaft lip seal assembly is shown in Figure 11-34 and replaces the worm shaft packing and packing gland assembly.

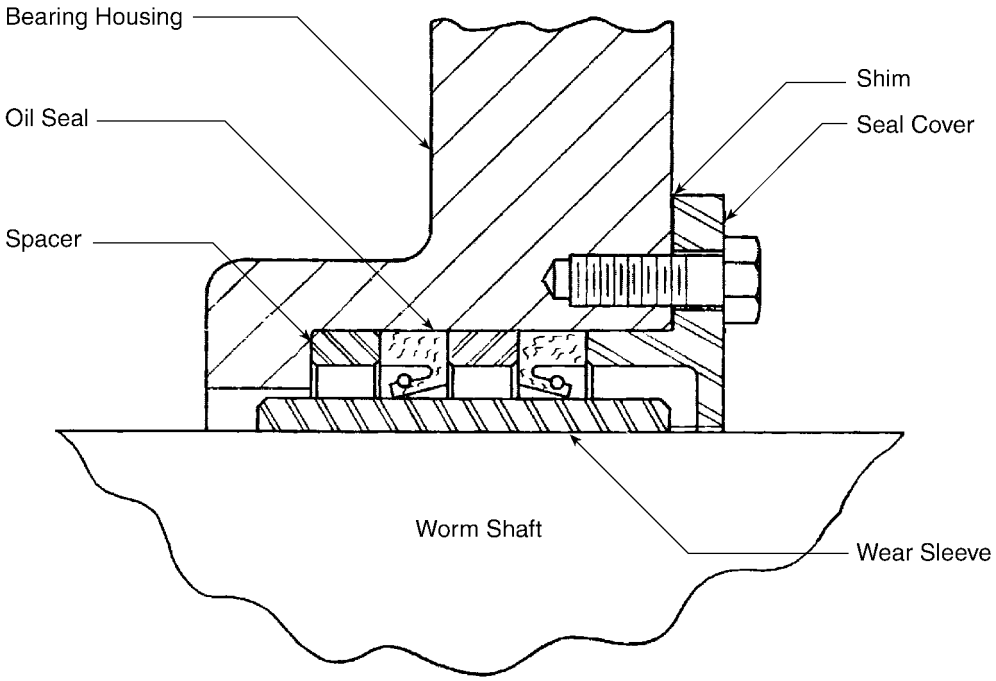


Figure 11-34
Worm Shaft Lip Seal [15]

A replaceable wear sleeve is provided for the worm shaft in the assembly.

11.4.4.4 Gearbox Improvements

The gearbox improvements that have been made are shown in Figure 11-35.

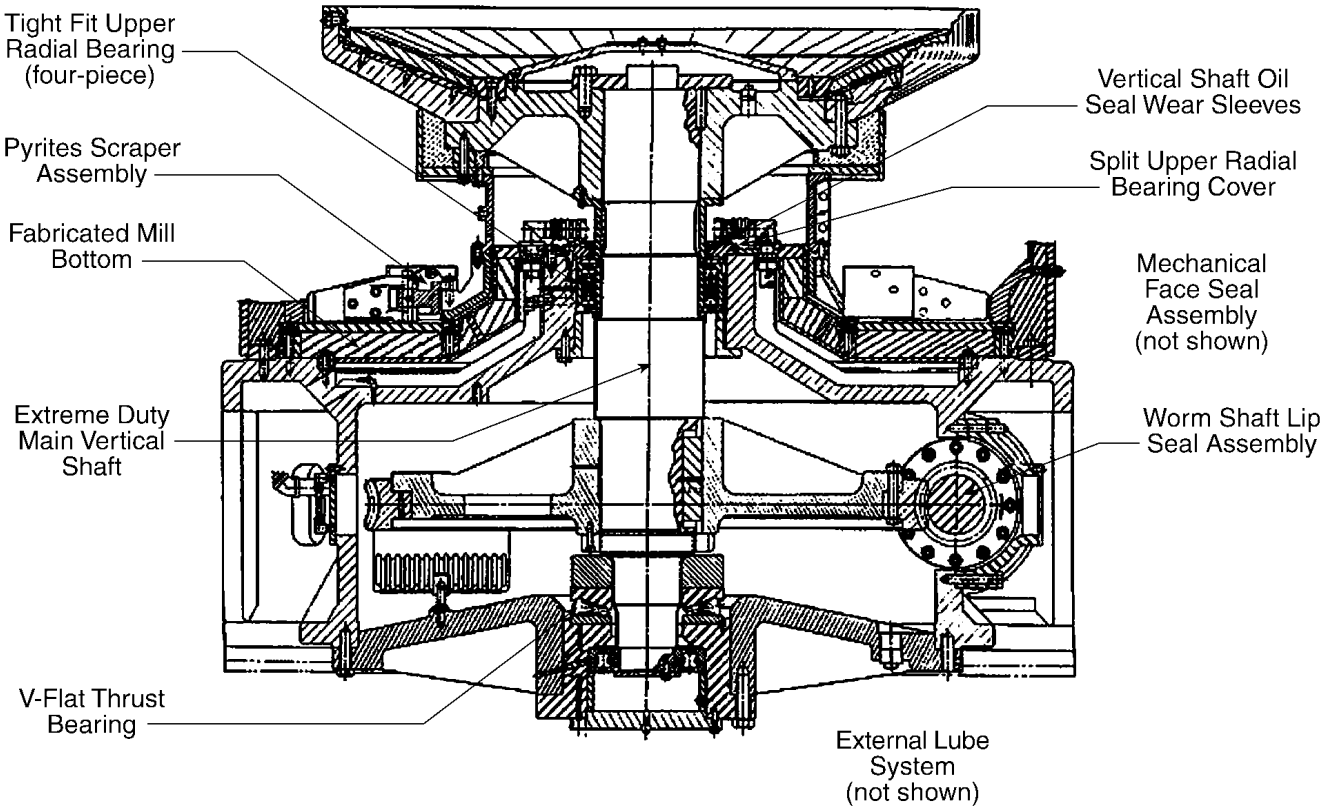


Figure 11-35
Gearbox Improvements [15]

A modification exists to improve the bearing lubrication. It consists of a separate floor-mounted filter unit with a motor-driven pump and duplex filter connected to the pulverizer gear housing. The pump receives oil from the gear housing reservoir through the existing drain port. A 40-micron duplex filter allows for on-line element replacement. Filtered oil is supplied through an existing port to the vertical shaft upper bearing at a higher flow rate. A new supply line is added to provide oil to the vertical shaft lower bearings.

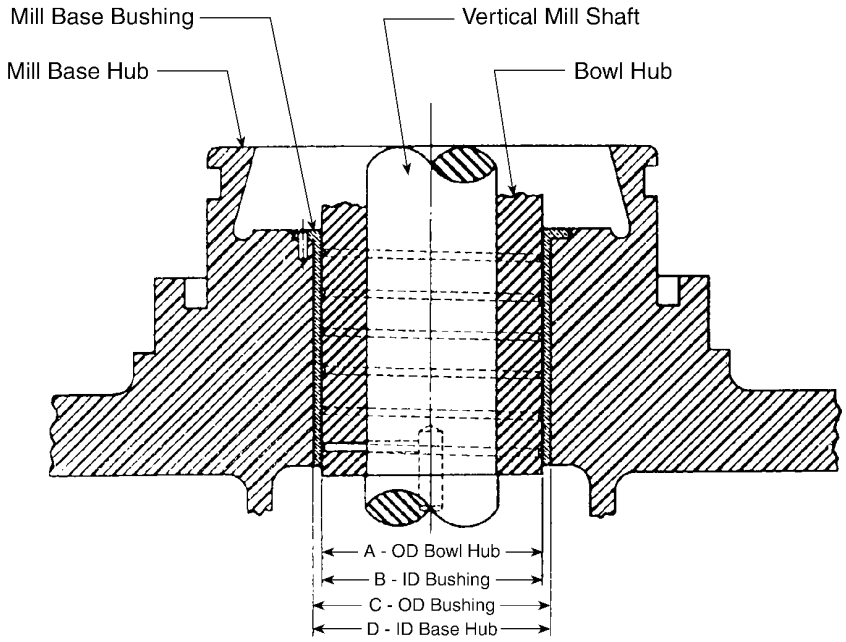
There is a figure that shows a picture of the auxiliary lubrication system.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.4.4.5 Raymond Bowl Gearboxes

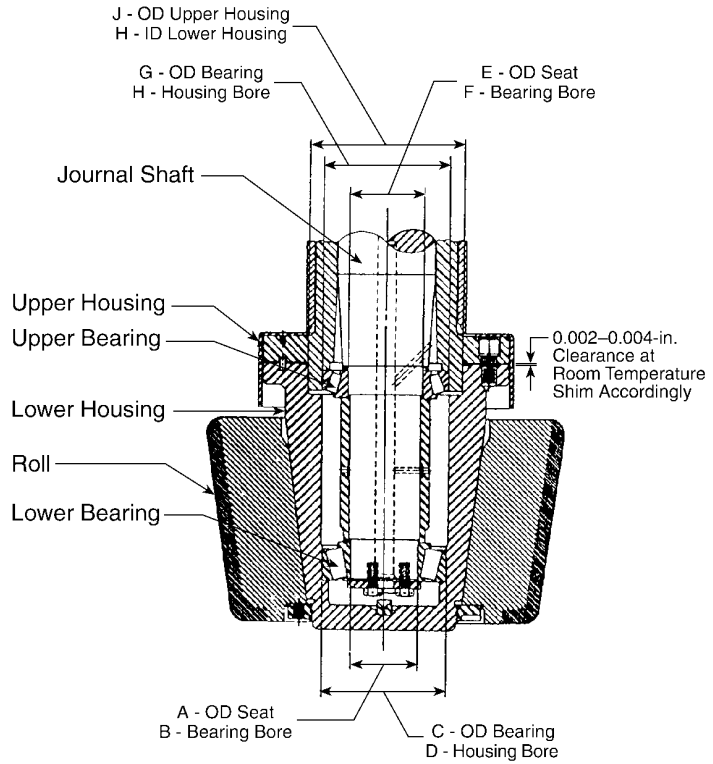
Many of the older Alstom Raymond Bowl type pulverizer gearboxes were designed with bushings to support the main vertical shaft. This shaft is rotated by the output of the worm gear. A modification exists to replace the bushings with rolling element bearings. Also, with the modification new oil seals, an air seal, pressure oil filtration, and a lip design, worm shaft seals can be incorporated.

Figure 11-36 shows recommended clearances for the bushings and bearings on the RB-593, 613, and 633-style mill.



Upper Mill Base Bushing

Data for Upper Mill Bushing				
Mill Size	A - OD Bowl Hub	B - ID Bushing	C - OD Bushing	D - ID Base Hub
593-613 and 633	11.877 to 11.875	11.896 to 11.893	12.748 to 12.746	12.751 to 12.750



Journal

Mill Size	A - OD Seat	B - Brg. Bore	C - OD Bearing	D - Hsg. Bore	E - OD Seat
593-613 and 633	4.501 to 4.500	4.501 to 4.500	8.376 to 8.375	8.374 to 8.373	5.001 to 5.000

Mill Size	F - Brg. Bore	G - OD Bearing	H - Hsg. Bore	U - OD Upper Hsg.	K - ID Lower Hsg.
593-613 and 633	5.001 to 5.000	8.501 to 8.500	8.499 to 8.498	10.374 to 10.373	10.376 to 10.375

Figure 11-36
Bushing and Bearing Clearances for the RB-593, 613, and 633 Style Mill [5]

11.4.5 External Lubrication System

The schematic for an external lube oil system is shown in Figure 11-37.

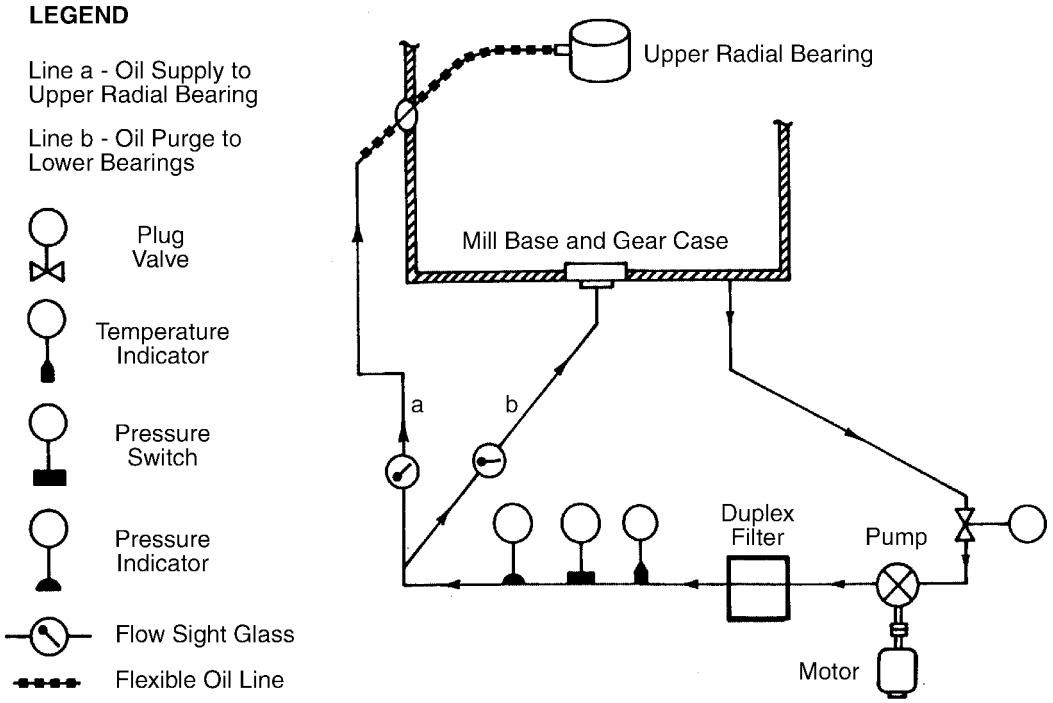


Figure 11-37
External Lube Oil Schematic [15]

This system allows conversion of existing pulverizers having internal shaft-driven oil pumps to a separate external lubrication system. Advantages of the external lube oil system are:

- The gearbox oil is continuously filtered.
- The vertical shaft upper bearing is supplied with a higher volume oil flow.
- Oil flow is provided before starting the mill.
- The higher volume of oil to the vertical shaft thrust and radial bearing area prevents accumulation and settling of contaminants.
- The dual filter arrangement allows cleaning of either element without interrupting the operation.

The existing oil coolers are used. Oil is gravity fed from the gear housing through a floor-mounted oil heater to the pump. After the pump, the oil flows to one side of a dual filter, then to a two-point distribution header, and finally through connecting piping to the pulverizer upper and lower bearing assemblies. A pump discharge relief valve dumps excess pressure back to the gear housing through a separate line.

11.4.6 Fabricated Mill Bottom

The fabricated mill bottom is shown in Figure 11-38.

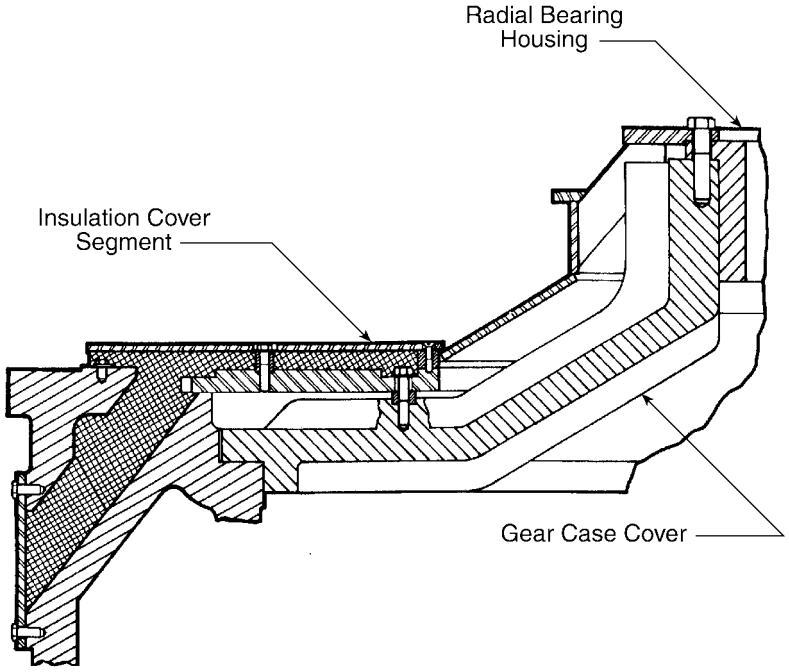


Figure 11-38
Fabricated Mill Bottom [15]

The fabricated mill bottom is a closure plate that separates the millside air housing from the mill drive assembly and prevents hot air leakage to the outside of the mill. The insulation in all the mill bottoms is improved to protect the gearbox from high temperatures. A standard insulated mill bottom is recommended for 80-in. diameter and smaller mills and 86-in. and larger diameter mills with inlet air temperatures lower than 600ºF. A heavy insulated mill bottom is recommended for 86-in. diameter and larger mills with inlet air temperatures higher than 600ºF.

11.5 Exhauster

This subsection covers the exhauster rebuilds, fan wheel balancing, exhauster bearing assembly replacement, and exhauster liners.

The most common fans used in the Raymond mill pulverizers are the paddle wheel or whizzer wheel type. Their purpose is to provide the motive energy to lift the coal and air mixtures from the top of the pulverizer and move that mixture through piping to the burners. A common problem is that contact between the fan blades and the coal particles results in rapid wear. Hard surface weld overlays are sometimes used to improve fan blade wear resistance. However, this approach increases the rotor weight and can cause mechanical problems with the fan.

There is a figure of an expanded view of the exhauster.

The major components of the exhauster are the fan blade, whizzer disc, and the whizzer blade.

There is a figure that shows a side view of the exhauster components.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.5.1 Exhauster Rebuilds

In the RS/RS/RPS style mills the exhauster pulls the pulverized coal and air mixture out of the mill and provides the force to deliver the mixture into the boiler. A typical exhauster is shown in Figure 11-39.

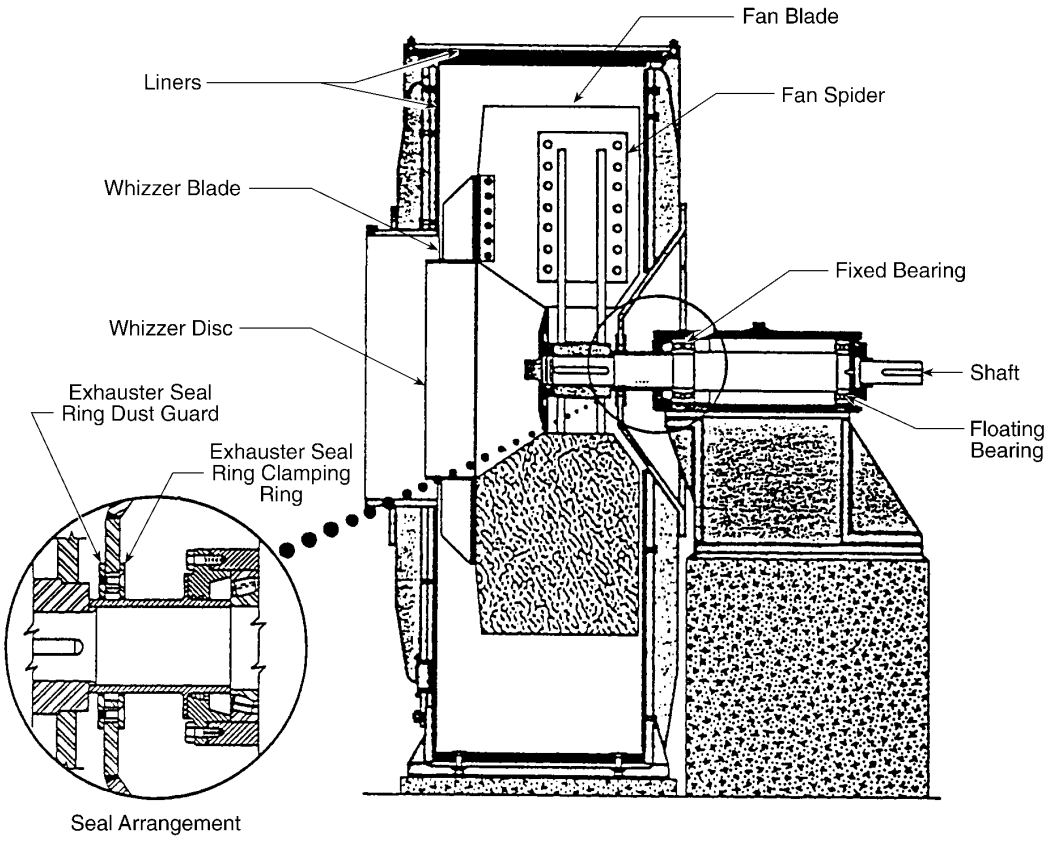


Figure 11-39
Typical Exhauster Fan [1]

Special fixtures are used for rebuilding an exhauster.

There is a figure that shows the exhauster inlet elbow lifting rig.

There is a figure that shows the exhauster inlet side lifting rig.

Abrasive resistant compounds are sometimes called patching epoxies and are used in exhausters for filling small voids to eliminate localized erosion and corrosion. The epoxies are designed to fill voids no greater than 4 square inches. The voids include small gaps between liners, spaces at broken tiles, and weld plug holes. Alstom recommends a maximum of a 2-in. patching thickness to avoid any spalling and subsequent plugging of pyrite chutes and chunks falling into the exhauster. The use of patching epoxies can eliminate flow eddies and prevent localized erosion and corrosion. They can be purchased with different curing times, finishes, and temperature applications.

There is a table that lists the tasks for rebuilding the exhauster.

There is a figure that shows the exhauster liner arrangement.

There is a figure that shows an exploded view of the RB/RS style Exhauster bearing housing assembly.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

11.5.2 Fan Wheel Balancing

The dynamic balancing of exhauster fan wheel assemblies is usually performed in a shop with high-speed balance equipment. It is possible to statically balance a fan wheel in the exhauster housing. All fan assemblies are recommended for balancing prior to installation.

For static balancing, the blades should be weighed and numbered before installation on the spider.

There is a table that lists the steps to balancing an exhauster fan.

There is a figure that shows the numbered positions of the spider with the starting upper and lower mark.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

Install the spider and mark the inside of the exhauster approximately 30° above and below the horizontal. The heavier blades can be found by slowly rotating the fan wheel and allowing the wheel to come to rest. The heaviest blade should be on the bottom. Record the time it takes for the wheel to come to rest. Attach a weight 180° from the heaviest blade. Continue this balance method until all rotation times are within 2% of each other.

11.5.3 Exhauster Bearing Assembly Replacement

There is a figure that shows the RPS style exhauster bearing arrangement.

There is a figure that shows the RPS style exhauster housing air seal housing, retaining ring, fan bearing, gasket, and dust slinger.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

11.5.4 Exhauster Ceramic Liners

Figure 11-40 shows ceramic liner applications for an exhauster.

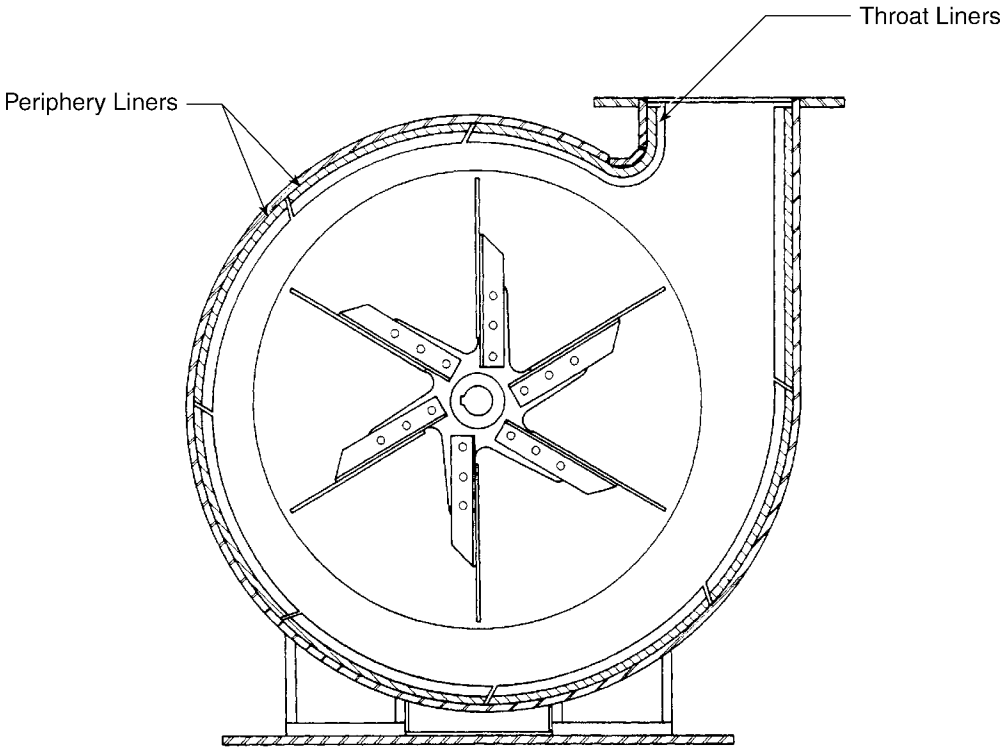


Figure 11-40
Exhauster Liner Applications [15]

Ceramic tiles have been successfully installed on the surfaces of the blades, shrouds, web, dust deflector and housing to protect against wear.

The addition of ceramic liners reduces the maintenance cost by decreasing the wear rate of the liners. This in turn extends the outage interval and reduces the cost of replacement parts. Ceramic materials that can be used as liners include alumina ceramics.

There is a figure that shows a picture of tile coverage on the exhauster fan.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.6 Feeder Drive

A conversion is available for most of the Alstom volumetric coal feeders using a Vari-Stroke drive and Hilliard clutch or adjusto-speed drive. The existing drive is replaced with an in-line variable speed motor drive coupled to the feed roll shaft through a chain drive.

There is a figure that shows a picture of the feeder drive conversion.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Information concerning this subject is available from Alstom through their internet website, http://www.service. power.alstom.com.

11.7 Mill Motor

The mill motor that drives the mill bowl and exhauster (if used) can be a 2300 V, 4160 V or 7-kV rated motor. The maintenance for the mill motors has not been covered in this guide. However, EPRI has produced several guides concerning the maintenance on the motors. Some of the EPRI guides are:

- *Electric Motor Tiered Maintenance Program*. EPRI, Palo Alto, CA: 2002. 1003095.
- *Maintaining Lube Oil System Cleanliness in Motor Bearing Applications*. EPRI, Palo Alto, CA: 2001. 1004001.
- *Electric Motor Predictive Maintenance Program*. EPRI, Palo Alto, CA: 1999. TR-108773-V2.
- *Electric Motor Predictive Maintenance*. EPRI, Palo Alto, CA: 1997. TR-108773-V1.
- *Electric Motor Predictive and Preventive Maintenance Guide*. EPRI, Palo Alto, CA: 1992. NP-7502.

There is a table that lists the final inspection task lists for the mills.

Additional information concerning this subject exists. The information is owned by Alstom. Alstom has elected not to make the information available for this guide. Please contact Alstom if needed.

12
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2. *Guidelines for Evaluating the Impact of Powder River Basin (PRB) Coal Blends on Power Plant Performance and Emissions*. EPRI, Palo Alto, CA: 1996. TR-106340.

3. T. B. Hamilton, A. Bogot, E. M. Powell, "Coal Handling – Bunker to Furnace," US-USSR Joint Project Group on Design and Operation of Thermal Power Plants, June 1976.

4. Pulverizer and Fuel Delivery System Optimization Seminar. EPRI, Palo Alto, CA. Presented to TVA in February 2001.

5. *Instructions for the Installation, Operation and Maintenance of CE-Raymond Bowl Mills No. 633*. Combustion Engineering, Inc. 1963.

6. *Evaluation of Coal Pulverizer Materials*. EPRI, Palo Alto, CA: 1988. CS-5935.

7. *Component Failure and Repair Data for Coal-Fired Power Units*. EPRI, Palo Alto, CA: 1981. AP-2071.

8. *Pulverizer Failure Cause Analysis.* EPRI, Palo Alto, CA: 1979. FP-1226.

9. *On-Line Predictive Condition Monitoring System for Coal Pulverizers*. EPRI, Palo Alto, CA: 2003. 1004902.

10. *Lubrication Guide.* EPRI, Palo Alto, CA: 2001. 1003085.

11. *Predictive Maintenance Guide Primer Revision.* EPRI, Palo Alto, CA: 2003. 1007350.

12. L. Robin, "Improving the Life and Capabilities of Lubricants," *Maintenance Technology*: May 1999. Internet web site http://www.pdma.com.

13. J. Winski, *Frequently Asked Questions on Feeder Performance.* K-Tron Americas. Internet web site http://www.powderandbulk.com.

14. *Productivity Improvement Handbook for Fossil Steam Power Plants, 3rd Edition.* EPRI, Palo Alto, CA: 2002. 1006315.

15. A. J. Seibert, "Combustion Engineering Pulverizer Improvements," *Proceedings: Symposium on Coal Pulverizers,* EPRI, Palo Alto, CA: 1992. TR-101692.

16. *New EPRI Technology Allows Greater Control Over Weld Deposit*, News Release, EPRI, Palo Alto, CA: November 8, 2001.

A
SURVEY

A survey was sent to the EPRI member plants to gather information on pulverizer mills. This appendix contains the results of the survey broken into the following four areas:

- General information
- Testing
- Preventive maintenance
- Maintenance

Survey

General Information

Company	Plant	Capacity	Start-Up Date	Pulverizer Manufacturer	Pulverizer Model #	Number of Mills per Unit	Contact	Phone number	Email
Arizona Public Service	Cholla 2	274 MW	1978	Combustion Engineering	CE 863 RS	5	El Pahi/Tim Vachon	928-288-1309	epahi@apsc.com
Arizona Public Service	Cholla 3	284 MW	1980	Combustion Engineering	CE 863 RS	5	El Pahi/Tim Vachon	928-288-1309	epahi@apsc.com
Arizona Public Service	Four Corners 1 and 2	170 MW	1963	Traylor	11-ft 6-in. Diameter X 16-ft Large Ball/Tube	3	Duane Pilcher	505-598-8406	vpilcher@apsc.com
Arizona Public Service	Four Corners 3	220 MW	1964	Foster Wheeler	D9F Ball/Tube	3	Duane Pilcher	505-598-8406	vpilcher@apsc.com
Arizona Public Service	Four Corners 4 and 5	750 MW	1969	Babcock and Wilcox	MPS-89	8	Duane Pilcher	505-598-8406	vpilcher@apsc.com
Dairyland Power	Alma 4	59 MW	1957	Riley Stoker	550E Single	3	Ted Mack	608-685-6695	tjm@dairynet.com
Dairyland Power	Alma 5	85 MW	1960	Riley Stoker	550E Single	4	Ted Mack	608-685-6695	tjm@dairynet.com
Dairyland Power Coop.	J. P. Madgett	367 MW	1979	Riley Stoker	Ball tube 1-ft 6-in. Dia X 16-ft 6-in. long	4	Brian Treadway	608-685-6649	blt@dairynet.com
Duke Energy	Marshall	Unit 1-2 400MW Unit 3–4 700MW	U1 1965, U2 1966, U3 1969, U4 1970	CE Raymond	U1-2 763, U3-4 863	U1-2 5Mills, U3-4 6Mills	Allen Sloop	828-478-7704	hasloop@duke-energy.com
Dynegy	Baldwin 3	602 MW	1975	Combustion Engineering	923 Rp	6	Greg Robert	618-785-2307	greg_robert@dynegy.com
Dynegy	Havana 6	450 MW	1978	Babcock and Wilcox	NPS-89	5	Randy Loesche	217-872-3551	randy_loesche@dynegy.com
Dynegy	Hennepin 1	78 GMW	1953	CE Raymond	RS-633	3	Dave Rohrssen	815-339-9256	dave_rohrssen@dynegy.com
Dynegy	Hennepin 2	255 GNW	1959	CE Raymond	RS-633	8	Dave Rohrssen	815-339-9256	dave_rohrssen@dynegy.com
Dynegy	Vermilion 1	77 MW	1955	CE Raymond Bowl	573	4	Randy Loesche	217-872-3551	randy_loesche@dynegy.com
Dynegy	Vermilion 2	105 MW	1956	CE Raymond Bowl	633	4	Randy Loesche	217-872-3552	randy_loesche@dynegy.com
Dynegy	Wood River 4	89 MW	1954	CE Raymond	633	4	Randy O'Keefe	618-462-9251	randy_o'keefe@dynegy.com
Dynegy	Wood River 5	375 MW	1964	Raymond	783	5	Randy O'Keefe	618-462-9241	randy_o'keefe@dynegy.com
Enel P	Brindisi SUD	660 MW	1991, 1993	Ansaldo/Babcock	MPS 89N	7	Marco Lauro	011-7783830	lauro.marco@enel.it

Company	Plant	Capacity	Start-Up Date	Pulverizer Manufacturer	Pulverizer Model #	Number of Mills per Unit	Contact	Phone number	Email
Enel P	Fusina 3–4, Genova 6	FS 320 MW, GE 155 MW	1974, 1960	CE Raymond/TOSI	Bowl-Mill 743 XRPS	FS #5, GE #3	Marco Lauro	011-7783829	lauro.marco@enel.it
Enel P	Sulcis 3	240 MW	1986	Ansaldo/Babcock	Ball Mill 8,5 E	6	Marco Lauro	011-7783829	lauro.marco@enel.it
Entergy Corp	Nelson	550 MW	30011	Combustion Engineering	RPB 1003	6	David Brawner	337-494-6083	dbrawne@entergy.com
Entergy Corp	White Bluff	U1 815MW, U2 844MW	U1 1980, U2 1981	Combustion Engineering	1103 RP-Triple Reduction Gear Box	8	Todd Bradberry	501-688-7066	bbradbe@entergy.com
Eskom	Arnot 1	350 MW	1972	Stein Industrie	3 950X6000	3	Willem Dreyer	013-297-9077	willem.dreyer@eskom.co.za
Eskom	Arnot 5	350	1971-1975	Loesche	LM18/1320D	6	Willem Dreyer	013-297-9077	willem.dreyer@eskom.co.za
Eskom	Duvha			Babcock and Wilcox, Loesche	12.9E, 26-30D	24,12	Remo Scheidegger	27-13-690-0195	remo.scheidegger@eskom.co.za
Eskom	Kendal	686 MW	1986	KVS		5	Tony Kuo	013-647-9175	tony.kuo@eskom.co.za
Eskom	Kriel	500 MW	1979	Babcock and Wilcox	U1-3 10.8E, U4-6 12E	6	Gerhard Holtshauzen	27-017-615-2671	gerhard.holtshauzen@eskom.co.za
Eskom	Lethabo	618 MW	1980s	Bateman Equipment	Allis Chambers Ball Tube	6	A Van Heerden	016-457-5131	
Eskom	Majuba	1–3 657 MW, 4–6 712 MW	96–01	Stein Industrie	BBD 4760 BIS	6	M. J. Jhetam	27-17-799-3609	mahomed.jhetam@eskom.co.za
Eskom	Matimba	665 MW	U1-2 1987, U3 1988, U4 1989, U5 1990, U6 1991	Stein Industrie	BBD4772 Tube Mill	5	W. H> Pretorius	014-7638004	henk.pretorius@eskom.co.za
Eskom	Matla	600 MW	1978	Babcock	12, 9E	6	N. M Crowe	017-612-6817	norman.crowe@eskom.co.za
Great River Energy	Coal Creek	590MW	U15/10/79 U2 6/28/80	Combustion Engineering	RP-1043	8	Steve Richter	701-442-7009	srichter@grenergy.com
Hongkong Electric Co.	Lamma 7–8	350 MW	U7 1995, U8 1997	MHI	MVM 24R	5	K. M. Luk	852-2982-6525	kmluk@hec.com.hk
Hongkong Electric Co.	Lamna Power	250 MW	U1 1982, U2 1982, U3 1983	Mitsubishi Heavy Industries	803 XRP	5	Ken Leung	852-2982-6850	ckleung@hec.com.hk
Hongkong Electric Co.	Lamna Power	250 MW	U1 1982, U2 1982, U3 1983	Mitsubishi Heavy Industries	803 XRP	5	K. M. Luk	852-2982-6525	kmluk@hec.com.hk
Hongkong Electric Co.	Lamna Power	350 MW	U4 1987, U5 1988, U6 1992	Mitsubishi Heavy Industries	903 XRP	5	Ken Leung	852-2982-6850	ckleung@hec.com.hk

Survey

Company	Plant	Capacity	Start-Up Date	Pulverizer Manufacturer	Pulverizer Model #	Number of Mills per Unit	Contact	Phone number	Email
Hongkong Electric Co.	Lamna Power	350 MW	U4 1987, U5 1988, U6 1992	Mitsubishi Heavy Industries	903 XRP	5	K. M. Luk	852-2982-6525	kmluk@hec.com.hk
Hoosier Energy	Merom Generating	2/530 MW	U1 7/1982 U2 11/1981	Riley Stoker	13-ft Dx 16-ft LG, double ended, pressurized ball tube mill	3	Ed Witt	812-356-4291x3177	ewitt@hepn.com
PacifiCorp	Cholla 4	410 MW	1981	Combustion Engineering	CE 903RP	5	El Pahi/Tim Vachon	928-288-1309	epahi@apsc.com
TVA	Gallatin	U1—2 240MW, U3–4 280MW	U1 1956, U4 1959	CE Raymond	U1—2 633, U3–4 673	8	Dennis Gowan	615-230-4050	degowan@tva.gov

Testing

		What testing do you perform on your mill and/or pulverizers?							
Plant		**Fineness**	**Dirty Air**	**Clean Air**	**Capacity**	**Air in Leakage**	**Pyrite Reject Rate**	**LOI**	**Online LOI Monitor**
Alma 4	**Test Interval**								
	Results								
Alma 5	**Test Interval**								
	Results								
Arnot 1	**Test Interval**	3 Monthly	N/A	N/A	As required	N/A	N/A	N/A	No
	Results	%75(90) %150(98) %300(99.7)			65 t/h				
Arnot 5	**Test Interval**	4 Monthly	N/A	+-5 700 hours	As required	Not done	As and when required	Not Done	No
	Results	%75(90) %150(98) %300(99.7)			30 T/h				
Baldwin	**Test Interval**	Every 2 weeks	2 years		Daily	N/A	N/A	Daily	No
	Results	%50(99) %200(70)	%Dif Air(10) %Dif Fuel(10)		68 t/h			0.25%	
Brindisi Sud	**Test Interval**	Monthly	Monthly	Yearly	Half yearly	No	Daily	Quarterly	No
	Results	%50(99.5) %100(96.5) %200(68)	%Dif Air(65) %Dif Fuel(100)	70%	48.6 t/h		0 t/d	7%	
Cholla 2	**Test Interval**	After mill O/H	N/A	After mill O/H	After mill O/H	N/A	N/A	N/A	No
	Results	%50(<2%) %100(90) %200(70)		3%	34 t/h				
Cholla 3	**Test Interval**	After mill O/H	N/A	After mill O/H	After mill O/H	N/A	N/A	N/A	No
	Results	%50(<2%) %100(90) %200(70)		3%	35 t/h				
Cholla 4	**Test Interval**	After mill O/H	N/A	After mill O/H	After mill O/H	N/A	N/A	N/A	No
	Results	%50(<2%) %100(90) %200(70)		3%	46 t/h				

Survey

		What testing do you perform on your mill and/or pulverizers?							
Plant		**Fineness**	**Dirty Air**	**Clean Air**	**Capacity**	**Air in Leakage**	**Pyrite Reject Rate**	**LOI**	**Online LOI Monitor**
Coal Creek	**Test**	500,000 tons			Only when questionable			Every load of fly ash	No
	Results	%50(1.6–2.2) %100(85–89) %200(63–67)			78 t/h			< .03%	
Duvha	**Test Interval**	6 monthly or on request	N/A	N/A	N/A	N/A	On request	Daily	No
	Results	%50(99.7) %100(88) %200(68–72)					1 t/d	3.5 % unburned carbon	
Four Corners 1 and 2	**Test**	Not regularly tested	N/A	N/A	N/A	N/A	N/A	Continuously	No
	Results				30 t/h			0.50%	
Four Corners 3	**Test Interval**	Not regularly tested	N/A	N/A	N/A	N/A	N/A	Continuously	No
	Results				40 t/h			0.55	
Four Corners 4 and 5	**Test Interval**	Not regularly tested	N/A	N/A	N/A	N/A	N/A	N/A	No
	Results				70 t/h			0.50%	
Fusina & Genova	**Test Interval**	Monthly	Monthly	No	Half yearly	No	Daily	Quarterly	No
	Results	%50(99.1) %100(93) %200(73)	%dif Air(100) %Dif Fuel(100)		27 t/h		0 t/d	5%	
Gallatin	**Test Interval**	Quarterly			Quarterly			Monthly	No
	Results								
Havana	**Test Interval**	Quarterly	Troubleshooting	Trouble-shooting	N/A	N/A	N/A	Monthly	No
	Results	%50(99.9) %200(66)							
Hennepin 1	**Test Interval**	Quarterly	Quarterly	Annual	Quarterly	Quarterly	Twice/shift	Daily	No
	Results	%50(97) %200(70–75)	%Dif Air(5) %Dif Fuel(10)	2%	18.4 t/h	N/A	N/A	<1%, automated sampler	
Hennepin 2	**Test Interval**	Quarterly	Quarterly	Annual	Quarterly	Quarterly	Twice/shift	Daily	No
	Results	%50(97) %200(70–75)	%Dif Air(5) %Dif Fuel(10)	2%	18.4 t/h	N/A	N/A	<1%, automated sampler	

		What testing do you perform on your mill and/or pulverizers?							
Plant		**Fineness**	**Dirty Air**	**Clean Air**	**Capacity**	**Air in Leakage**	**Pyrite Reject Rate**	**LOI**	**Online LOI Monitor**
J. P. Madgett	**Test Interval**	As needed	As needed	As needed	N/A	N/A		Daily	No
	Results	%50(81–98) %100(60–94) %200(49–80)	%Dif Air(5) %Dif Fuel(5)	5%				>1%	
Kendal	**Test Interval**	No Response							
	Results	No Response							
Kriel	**Test Interval**		N/A	N/A		N/A	N/A	N/A	Yes
	Results				50 T/h				
Lamma U1–U3	**Test Interval**	Before and after overhaul	N/A	Every mil overhaul	1,000 running hrs	N/A	1,000 running hrs	Weekly, at high load but not necessarily at full load	Yes
	Results	On average 65–75%,200 mesh, 95–99.9%<50 mesh		<5% among the four corners	30.9 t/h per mill		360 kg per day per mill	<5%, depends on coal type	Scantech CIFA 310
Lamma U4–U6	**Test Interval**	Before and after overhaul	N/A	Every Mil overhaul	1,000 running hrs	N/A	1,000 running hrs	Weekly, at high load but not necessarily at full load	Yes
	Results	70–80% <200 mesh 95–99.9% <50 mesh (on average)		<5% among the four corners	41.7 t/hr per mill for units 4&5, 40.7 t/hr per mill for Unit 6		480 Kg per day per mill	<5% depends on coal type	Scantech CIFA 310
Lamma 7–8	**Test Interval**	Before and after overhaul	N/A	Every Mil overhaul	2,000 running hrs	N/A	2,000 running hrs	Weekly, at high load but not necessarily at full load	Yes
	Results	70–80% <200 mesh 95–99.9% <50 mesh (on average)		<5% among the four corners	45 T/h		480 Kg per day per mill	<5% depends on coal type	Scantech CIFA 311

Survey

		What testing do you perform on your mill and/or pulverizers?							
Plant		**Fineness**	**Dirty Air**	**Clean Air**	**Capacity**	**Air in Leakage**	**Pyrite Reject Rate**	**LOI**	**Online LOI Monitor**
Lethabo	**Test Interval**	3 Monthly	N/A	N/A	Per unit	N/A	N/A		
	Results	1%>300 micron, 75%<75 micron			370–400 t/h			5% in fly ash of unburned carbon	
Majuba	**Test Interval**	Yearly							
	Results	75% 75micron mesh							
Marshall	**Test Interval**	5 Weeks	As required	As required	As required	Never	As required	1 Week	Yes
	Results	%50(.5) %100(92) %200(73)							
Matla	**Test Interval**	Monthly	N/A	N/A		N/A	Per shift	Never	Yes
	Results	%100(94) %200(72)			70–75 T/h				Peabody
Matimba	**Test Interval**	Ad hoc testing	N/A	N/A	N/A	N/A	N/A	Weekly	Yes
	Results	%50(99.7) %100(94.38) %200(74.8)						.52% unburned ash in carbon, 1.58% unburned carbon in rough	Keller
Merom	**Test Interval**	Quarterly	Quarterly	N/A		N/A	N/A	Semi-Annual	No
	Results	%50(98.7) %100(91.5) %200(76.2)	N/A		200 t/h			4.5	
Nelson	**Test Interval**	Wk	N/A	N/A	N/A	N/A	N/A	Daily	
	Results	%50(98–99.7) %100(88–97) %200(67–85) mesh thru						% Unburned Carbon (14)	
Sulcis 3	**Test Interval**	Monthly	Monthly	No	Half yearly	No	Daily	Quarterly	No
	Results	%50(99.8) %100(95.5) %200(74)	%Dif Air(80) %Dif Fuel(80)		21 T/h		0.1 t/d	7%	
Vermilion 1	**Test Interval**	Quarterly	18 Months	18 Months	N/A	N/A	N/A	Annually	No
	Results	%50(99.6) %100(94.1) %200(83.2)						2.03 with ROFA on	

		What testing do you perform on your mill and/or pulverizers?							
Plant		**Fineness**	**Dirty Air**	**Clean Air**	**Capacity**	**Air in Leakage**	**Pyrite Reject Rate**	**LOI**	**Online LOI Monitor**
Vermilion 2	**Test Interval**	Quarterly	18 Months	18 Months	N/A	N/A	N/A	Annually	No
	Results	%50(98.8) %100(91) %200(76)							
White Bluff	**Test Interval**	Monthly	Biannually	Biannually	Semi-annually	N/A	Only if a problem	Daily	No
	Results	%50(<2) %200 (65–70)	We do hot air test		100 Coal, 5,000 lb/min air flow			0.25–0.40	
Wood River 4	**Test Interval**	Quarterly	Annually	Annually	Annually	N/A	N/A	Daily	No
	Results	%50(99) %100(92) %200(79)	%Dif Air (+/-) 10 %Dif Fuel (+/-)10	(+/-) 5	14 T/h				
Wood River 5	**Test Interval**	Quarterly	Annually	Annually	N/A	N/A	N/A	Daily	No
	Results	%50(98) %100(90) %200(78)	%Dif Air (+/-) 8 % Dif Fuel (+/-) 10, 1.8 lb ail/1lb coal	(+/-) 6				0.70%	

Survey

Preventive Maintenance

Plant	Vibration Monitoring			Thermography			NDE		
	Frequency	Documentation	Success	Frequency	Documentation	Success	Frequency	Documentation	Success
Alma 4	Monthly	CSI database	Medium	No	No	No	No	No	No
Alma 5	Monthly	CSI database	Medium	No	No	No	No	No	No
Arnot 1	Monthly	Electronic data collection and down loaded by performance and testing	Medium	Other as and when required	Performance and testing department record in electronic data system	Medium	As and when required	Test reports	High
Arnot 5	Monthly	Electronic data collection and down loaded by performance and testing	Medium	Other as and when required	Performance and testing department record in electronic data system	Medium	As and when required	Test reports	High
Baldwin	Weekly	Computer database	Medium	Motor and gearbox every 6 months	Responsible person documents as indications warrant	Medium	UT testing of vertical shaft during overhauls	As problems are identified	Medium
Brindisi Sud	No	No	No	No	No	No	No	No	No
Cholla 2	Monthly	CSI data collector, analysis software	High	As Needed	ThemCAM P60 software	Medium	N/A	N/A	N/A
Cholla 3	Monthly	CSI data collector, analysis software	High	As Needed	ThemCAM P60 software	Medium	N/A	N/A	N/A
Cholla 4	Monthly	CSI data collector, analysis software	High	As Needed	ThemCAM P60 software	Medium	N/A	N/A	N/A
Coal Creek	Quarterly	Predictive Maintenance	High	N/A	N/A	N/A	N/A	N/A	N/A
Duvha	Monthly	Individual report per mill gearbox kept by the condition monitoring dept	Medium to high on bearing faults	N/A	N/A	N/A	N/A	N/A	N/A
Four Corners 1&2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Four Corners 3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Four Corners 4&5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Plant	Vibration Monitoring			Thermography			NDE		
	Frequency	**Documentation**	**Success**	**Frequency**	**Documentation**	**Success**	**Frequency**	**Documentation**	**Success**
Fusina & Genova	Continuous	Bearing housing exhauster	High	No	No	No	No	No	No
Gallatin	Monthly	RBM ware, plantview	High	Monitor quarterly	Plantview	No findings	N/A	N/A	N/A
Havana	Monthly	Database	Medium	N/A	N/A	N/A	N/A	N/A	N/A
Hennepin 1	6 times/year as requested	Entek odessy/Klingel	High	ARO	N/A	N/A	ARO	N/A	N/A
Hennepin 2	7 times/year as requested	Entek odessy/Klingel	High	ARO	N/A	N/A	ARO	N/A	N/A
J. P. Madgett	Monthly	CMMS-Monthly written report	Medium	As Needed	CMMS		WFMT as needed	CMMS, WO notes, QA report	High
Kendal	Monthly	Graphs	Medium	N/A	N/A	N/A	Outages	Report	High
Kriel	Monthly	Abnormal conditions detected immediately, results published on LAN	High	N/A	N/A	N/A	Only on new grinding media	Documentation	Medium
Lamma U1–U3	Every 3 Months	Vibration data kept by vibration monitoring team, report to O&M personnel by email if anomaly is found	High	When required for investigation	Report anomaly to O&M personnel by email if required	High	N/A	N/A	N/A
Lamma U4–U6	Every 3 Months	Vibration data kept by vibration monitoring team, report to O&M personnel by email if anomaly is found	High	When required for investigation	Report anomaly to O&M personnel by email if required	High	N/A	N/A	N/A
Lamma 7–8	Every 3 Months	Vibration data kept by vibration monitoring team, report to O&M personnel by email if anomaly is found	High	When required for investigation	Report anomaly to O&M personnel by email if required	High	N/A	N/A	N/A
Lethabo	Two weekly	Computer database at condition mon section	Medium	Occasionally Done	Computer database at condition monitoring section	Medium	Occasionally done	System engineer keeps records	Medium
Majuba	Monthly	SAP R/3 RCM, maintenance support	High	N/A	N/A	N/A	Outages 5000hrs	Outage report done by engineering and maintenance	Medium
Marshall	Monthly	Stored electronically	Med.–High	N/A	N/A	N/A	No	No	No
Matimba	Monthly	Acrobat electronic copy kept by system engineer	High	Monthly	Acrobat electronic copy kept by system engineer	High	N/A	N/A	N/A

Survey

Plant	Vibration Monitoring			Thermography			NDE		
	Frequency	Documentation	Success	Frequency	Documentation	Success	Frequency	Documentation	Success
Matla	Monthly	Report	Medium	N/A	N/A	N/A	N/A	N/A	N/A
Merom	Monthly	CSI database, PdM	Medium	Quarterly	Tech owner database, PdM report	Medium	As needed	Responsible individual keeps records	Medium
Nelson	Every 6 weeks	Responsible individual	Medium	N/A	N/A	N/A	N/A	N/A	N/A
Sulcis 3	No	No	No	No	No	No	No	No	No
Vermilion 1	Every 60 days	Database	Medium	No	No	No	No	No	No
Vermilion 2	Every 60 days	Database	Medium	No	No	No	No	No	No
White Bluff	Every 6 weeks	Included in plant vibration report	High	N/A	N/A	N/A	N/A	N/A	N/A
Wood River 4	Weekly	Maximo and Odessey	High	Semi-annually	Disk and Reports	Medium	N/A	N/A	N/A
Wood River 5	Daily	Maximo and Odessey	High	Semi-annually	Reports	Medium	N/A	N/A	N/A

Plant	Online Monitoring			Acoustic Ultrasonics			Monitoring Mill Tailings		
	Frequency	**Documentation**	**Success**	**Frequency**	**Documentation**	**Success**	**Frequency**	**Documentation**	**Success**
Alma 4	No	No	No			No			No
Alma 5	No	No	No			No			No
Arnot 1	Temperatures and pressures where applicable and effective	Operating logs/dcs	High	Othe r(as required)	Third party inspection reports	High	N/A	N/A	N/A
Arnot 5	Temperatures and pressures where applicable and effective	Operating logs/dcs	High	Other (as required)	Third party inspection reports	High	Not done, Included in performance tests to evaluate modifications	Test reports in project file	High
Baldwin	EPRI funded on 3A mill		Limited experience	N/A	N/A	N/A	Daily	Operations function	Medium
Brindisi Sud	Daily	Flow, temperature, differential pressure coal air mixture	Low			No	Three turns daily	Visual inspections	Medium
Cholla 2	Daily	Citect Screen	High	As Needed	UE Test Device	Medium	Daily	Visual Inspection by operations	High
Cholla 3	Daily	Citect Screen	High	As Needed	UE Test Device	Medium	Daily	Visual Inspection by operations	High
Cholla 4	Daily	Citect Screen	High	As Needed	UE Test Device	Medium	Daily	Visual Inspection by operations	High
Coal Creek	Bearing temperatures and motor KW	Honeywell system, control room operator	High			N/A			N/A
Duvha	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Four Corners 1 and 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Four Corners 3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Four Corners 4 and 5	N/A	N/A	N/A	Weekly	Responsible individual keeps records	Medium	At each pyrite pull 8/day	Increase is reported to control operator	Medium

Survey

Plant	Online Monitoring			Acoustic Ultrasonics			Monitoring Mill Tailings		
	Frequency	**Documentation**	**Success**	**Frequency**	**Documentation**	**Success**	**Frequency**	**Documentation**	**Success**
Fusina & Genova	Daily	Flow, temperature, differential pressure coal air mixture	Low			No	Three turns daily	Visual inspections	Medium
Gallatin	1 minute updates	Motor bearing temperatures, gear box oil temperature, pedestal bearing temperature	High			N/A			N/A
Havana	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hennepin 1	ARO	N/A	N/A	ARO	N/A	N/A	ARO	N/A	N/A
Hennepin 2	ARO	N/A	N/A	ARO	N/A	N/A	ARO	N/A	N/A
J.P. Madgett	Bearing temperatures and motor KW	Data recorder	Medium			No	N/A	N/A	N/A
Kendal	N/A	N/A	N/A	Outages	Reports	High	Daily	N/A	High
Kriel	Continuous	Documentation	Medium	N/A	N/A	N/A	N/A	N/A	N/A
Lamma U1–U3	Mill vibration level is monitored from control desk, vibration high alarm is provided	Vibration monitoring system	High			N/A			w/ 1,000 running hours after clearance adjustment/raise defect to maintenance if reject rate is high/High
Lamma U4–U6	Mill vibration level is monitored from control desk, vibration high alarm is provided	Vibration monitoring system	High			N/A			w/ 1,000 running hours after clearance adjustment/raise defect to maintenance if reject rate is high/High
Lamma 7–8	Mill vibration level is monitored from control desk, vibration high alarm is provided	Vibration monitoring system	High	N/A	N/A	N/A	2,000 running hours after clearance adjustment	Raise defect to maintenance if reject rate is high	High
Lethabo	No Online Monitoring	N/A	N/A	Outages	Computer database at condition monitoring	Medium	N/A	N/A	N/A

Plant	Online Monitoring			Acoustic Ultrasonics			Monitoring Mill Tailings		
	Frequency	**Documentation**	**Success**	**Frequency**	**Documentation**	**Success**	**Frequency**	**Documentation**	**Success**
Majuba	Continuous temperature, pressure, flows, position	Unit events and SAP defects, maintenance support	High	N/A	N/A	N/A	N/A	N/A	N/A
Marshall	Online ex. vibration					No			No
Matimba	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Matla	N/A	N/A	N/A	N/A	N/A	N/A	Per Shift	Unit log	High
Merom	Daily bearing temperatures, oil press, and so on	Operator logs	Low			As needed/responsible individual keeps records/low			N/A
Nelson	Daily	Responsible	Medium			N/A			N/A
Sulcis 3	Daily	Flow, temperature, differential pressure coal air mixture	Low			No	Three turns daily	Visual inspections	Medium
Vermilion 1	No	No	No	No	No	No	No	No	No
Vermilion 2	No	No	No	No	No	No	No	No	No
White Bluff	Gear box oil samples	Monthly	Medium	N/A	N/A	N/A	N/A	N/A	N/A
Wood River 4	N/A	N/A	N/A	N/A	Reports	Medium	N/A, visual	Operators	Medium
Wood River 5	Daily	Individual	Medium	N/A	Individual reports	Medium	N/A, visual	Individual	Medium

Survey

Plant	Visual Inspections			Other:		
	Frequency	**Documentation**	**Success**			
Alma 4			No	Other: PM is based on tonnage and availability		
Alma 5			No	Other: PM is based on tonnage and availability		
Arnot 1	Daily	Preventative Maintenance work packages	High	Oil analysis: monthly/performance and testing department with electronic data system/high	Wear measurements: Outages/maintenance department/high	
Arnot 5	Daily	Preventative Maintenance work packages	High	Oil analysis: Monthly/performance and testing department with electronic data system/high	Wear measurements: 700 hr/maintenance department, Electronic data system/high	
Baldwin	Daily	Operations function	Medium	Lubrication analysis: quarterly/lab reports, computer database/high		
Brindisi Sud	Half yearly	Survey wears and adjustment of: roll wheel, grinding ring segment, wear plates, loading assembly, throat assembly, classifier assembly, pyrite assembly, yoke seal, gear drive, swing valve assembly	High	Temperature checking: continuous/point and continuous thermocouples, acquisition and elaboration system/ putting into effect		
Cholla 2	Daily	By operation	High	Oil analysis: As needed, engineer keeps records/high		
Cholla 3	Daily	By operation	High	Oil Analysis: As needed, engineer keeps records/high		
Cholla 4	Daily	By operation	High			
Coal Creek	Every 6 hours	Operator	High	Pulverizer outlet temperature/Honeywell system, control room operator/high	Pulverizer outlet temperature/Honeywell system, control room operator/high	Pulverizer to furnace differential pressure/Honeywell system, control room operator/high
Duvha	Weekly plant walkdowns	N/A	N/A	Mill gearbox oil analysis: Monthly/individual records per gearbox/high when used in conjunction with vibration analysis		

Plant	Visual Inspections			Other:		
	Frequency	**Documentation**	**Success**			
Four Corners 1 and 2	As needed during scheduled or forced outages	Responsible individual keeps records	High	Monitor operation for reduced capacity: Weekly/responsible individual keeps records/High		
Four Corners 3	As needed during scheduled or forced outages	Responsible individual keeps records	High	Monitor operation for reduced capacity: Weekly/responsible individual keeps records/high		
Four Corners 4&5	Shift rounds by operator	Repots problems to control operator	Medium	Internal inspection: every 3000 hrs/responsible individual keeps records/high		
Fusina & Genova	Quarterly	Survey wears and adjustment of: rolls, bull ring segment, journal assembly with pressure spring, vane wheel, classifier assembly, scraper guards and holders, drive gear, swing valve assembly, exhauster fan feeder	High			
Gallatin	Each shift		Each shift			
Havana	Shift personnel daily	As problems are identified	Medium	Oil sample: Quarterly/database/medium		
Hennepin 1	Twice/shift	logbook	Medium	Oil analysis: quarterly/Endek Odessy, Trebs/High		
Hennepin 2	Twice/shift	logbook	Medium	Oil analysis: Quarterly/Endek Odessy, Trebs/high		
J. P. Madgett	Outages	CMMS	High	Other: Strobe/CMMS/high	Other: Each outage/measure depth to journal to indicate condition of trunion bearing/medium	Other: Quarterly/lubrication analysis/high
Kendal	Daily	N/A	High			
Kriel	Daily	Operating department checks status	Medium	Oil Analysis: Monthly/abnormal operations detected immediately, with results placed on LAN/high success		

Survey

Plant	Visual Inspections			Other:		
	Frequency	**Documentation**	**Success**			
Lamma U1–U3	Routine check every shift, open up for investigation if required	Raise defect to maintenance if anomaly is found	High	Internal inspection and resuming roll and segment clearance: w/ 2,000 running hours interval/in house check sheet/high	Lube Oil Analysis: Normally at half yearly interval the frequency will be increased if sign of deterioration is noted/record in a lube oil database, defect will be raised to maintenance if anomaly is found/high	Motor Prime Mover Partial Discharge Test: Conduct PD Online measurements yearly, for those high PD motors, the measuring interval will be reduced to every six months/Online partial discharge monitoring system/medium
Lamma U4–U6	Routine check every shift, open up for investigation if required	Raise defect to maintenance if anomaly is found	High	w/ 2,000 running hours interval/in house check sheet/high	Normally at half yearly interval the frequency will be increased if sign of deterioration is noted/record in a lube oil database, defect will be raised to maintenance if anomaly is found/high	Conduct PD Online measurements yearly, for those high PD motors, the measuring interval will be reduced to every six months/Online partial discharge monitoring system/medium
Lamma 7–8	Routine check every shift, open up for investigation if required	Raise defect to maintenance if anomaly is found	High	2,000 running hours interval/in house check sheet/high	Normally at half yearly interval, the frequency will be increased if sign of deterioration is noted/record in a lube oil database, defect will be raised to maintenance if anomaly is found/high	Conduct PD online measurements yearly, for those high PD motors, the measuring interval will be reduced to every six months/online partial discharge monitoring system/medium
Lethabo	Every 4000 hrs and during outages	System engineer keeps records	Medium	Operating shift check sheets: Every shift/downloaded to computer database/medium	Decommissioning check sheets: On completion of work, responsible individual keeps records, medium	
Majuba	Daily	SAP defects, maintenance support	High			
Marshall	Do major inspections 2/year		Do major inspections 2/year	Other: Do inspections if there is reduced load		
Matimba	5500 hrs	SAP system used for maintenance management and history stored on same system	High	Girth gear visual and crack inspections: 72 monthly/SAP system used for maintenance management and history/High		
Matla	Per shift	Unit log	High	Maintenance walk down: daily/report/high	Proactive maintenance: daily/report/high	
Merom	Yearly outages	Responsible individual keeps records, PdM Report	High			
Nelson	Daily	Responsible individual	Medium	Mill fineness: weekly/PM program/high		

Plant	Visual Inspections			Other:		
	Frequency	**Documentation**	**Success**			
Sulcis 3	Half yearly	Survey wears and adjustment of: ball, grinding rings, wear plates, loading assembly, classifier assembly, pyrite assembly, yoke seal, gear drive, swing valve assembly	High			
Vermilion 1	Operator rounds	Logs	Medium	Oil analysis: quarterly/database/high		
Vermilion 2	Operator rounds	Logs	Medium	Oil analysis: quarterly/database/high		
White Bluff	All components inspected	Annually	High			
Wood River 4	Daily	Individual operators	High			
Wood River 5	Daily	Individual operators	High	Vibration analysis: as needed/reports, maximum/high		

Maintenance

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Alma 4–5	Mill wear	4	Replace worn clips, pegs, hammers		
	Casing wear	1/40yrs	Complete rebuild, replace casing		
	Coupling/clutch	2	Replace shoes		
Arnot 1	Liner wear	2	Changed liners and screw conveyor flights	Changed girth gear lube system	2001
	Girth gear and pinion wear	4	Changed 1 girth gear and 4 pinions	Installed auto grinding media loading system	1999
	Pulverized fuel leaks	~ 100	Replace worn areas, use wear-resistant materials in high wear areas	Vibrating motors on raw coal pipes	2002
	Wear on primary air fan impellers		Monitor wear and repair		
	Seal air fan bearings	6	Replace cooper split bearings, monitor lubrication		
Arnot 5	Grinding element wear	~ 150 full replacement of wear elements	Test and evaluate wear-resistant materials. Protect high wear areas. Confident that new materials will extend time between overhauls	Material use for mill table segments	May 2003/Loesche
	Pulverized fuel leaks	~ 80	Replace worn areas, use wear-resistant materials in high wear areas	Replace static louvre ring with a rotating throat assembly	2001/2002/Loesche mills
	Gearbox failures	4	Refurbish gearbox according to quality plans and use OEM	Upgraded mill control system	1998/Units 4, 5, 6/Loesche mills
	Reject removal box air leaks and holes	~ 100	Repair reject box and seal doors for air leaks	Roller assembly bearing configuration	Feb 2003/Unit 2 B mill
	Seal air fan bearings	10	Replace bearings, balance fan, monitor lubrication		

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Baldwin	Vertical shaft breakage	1	Door springs are replaced whenever rolls are replaced	Vane wheel installation	1999–2001
	Lubrication contamination	Continuous	Improved oil seal, lubrication monitoring and oil change intervals	Pyrite skirt removal	1990
	Mill roll bearing failures	4	Improved oil seal to prevent lubrication contamination	Ceramic lining of cones and separator body	1995–2001
				Hard surfacing of grinding ring and rolls	1987–present
				Improved design coal valves	1980s
Brindisi Sud	Roll wheel tires breakage	5 per 28 mills	Riddling system improvement	Reduce the throat area by 16% (7 plugged ports)	2002
	Pulverized coal tubes obstruction	10 per 28 mills	Flow, temperature, differential pressure coal-air mixture and clean air checking, pulverized coal outlet balancing		
	Mill fires	2 per 28 mills	Point and continuous thermocouples, acquisition and elaboration system installation		
	Loading rod breakage	3 per 28 mills	Loading assembly checking, riddling system improvement, material and working rod checking		
	Inner and outer pyrite plow breakage	10 per 28 mills	Replace and adjustment		
Cholla 2	Top of exhauster housing wearing	Repaired each, will overhaul	Ceramic tile installed	Removed wear liners and replaced with ceramic tile	1996 CE863RS
Cholla 3	Top of exhauster housing wearing	Repaired each, overhauled	Ceramic tile installed	Ceramic tile exhauster housing	863RS
	Mill roll wear	Repaired each overhauled	We had hard face rod	Vane wheel modification	863RS

Survey

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Cholla 4	Journal Failures	12	Evaluated all assembly procedures. Had CE people here to help. Changed oil type. Seems to be ok at present	Southwest vane wheel	99 903RPB
	Wear in multiport and valves		Rebuild at overhauls, used metal spray and ceramic but little success	High temperature main vertical shaft air seal	98
	Valves (discharge)		Want to eliminate butterflies above the mill, preferably not by replacing with slide gates	Ceramic lining from vane wheel up	99
				Triple high temperature seals with wear sleeves on journal	99
				Southwest pyrite scrapers	90
				Temperature control of blast gate	99
				Fire suppression system	0
Coal Creek	Lube oil mechanical seal failures	12	Replaced seals, seals failed prematurely	Installed rotating vane wheels	1988–1996
	Main gearbox oil air intrainment causing foaming	5	Replaced lube oil seals, replaced gearbox vent filters, checked for oil piping leaks. Difficult problem	Modified pulverizer inlet vanes	1990–1996
				Replaced cold air damper in cold air duct to pulverizer	1992–1993
				Lined inner cone with ceramic tiles	Before 1989
				Replaced rubber boots on hydraulic cylinders with siding orifice seals	1996–1998

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Duvha	High gearbox bearing vibrations as GB are reaching end of life	12	Project to overhaul gearboxes over next 8 years has been approved. Gearbox bearing vibration limits are not clear. We regularly run over the OEM's limits.	Rotating throats	Babcock and Southwestern
	High grinding element wear due to high abrasive index coal	Continuous	Ongoing material tests	High chrome rings	Approximately 1992
	Mill reject fires	20	Rejects must be made easier to remove from the reject hopper. Access doors to be changed.	High chrome 985 mm balls	Jan-98
				3.5% chrome alloy 985 mm balls	Jun-05
Four Corners 1 and 2	Drum cracks	4	Ground out welded PWHT. Confidence is good; there are no reoccurrences. Cracks were completely through the shells and 12–20 ft long.	Removed crusher dryers	1975?
				Installed lube oil tanks/systems	1975?
Four Corners 3	Mill end casing erosion	3	Replaced 2 mills in 2003, 1 more to be replaced in 2006		
Four Corners 4 and 5	Gearbox replace	3 per year	100,000 hours Preventive maintenance	Lube oil system	Air coolers
	Wheel guards	12 per year	Using cast iron plate instead of ceramics	Mill throats	1995 to present
				Low profile tires	1996 to present
Fusina & Genova	Shaft breakage	3 per 13 mills	Changed and mixing quality carbon	Vane wheel	1988–1992
	Exhauster breakage	2 per 13 mills	Vibration monitoring on bearing housing exhauster, clean blades	Weld roll	1990
	Excessive liner wear	Event on 13 mills	Replace cast iron plates with ceramic plates	Replace exhauster blades by ceramics plates	1990
	High LOI	20 per 13 mills	Changed and mixing quality carbon		

Survey

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Gallatin	Liner wear	36	Last about 10 months	Silver bullet exhauster	1998
	LOI	Continuous	None		
	Exhaust bearings	32	Stopped electrolysis by grounding shaft		
Havana	No major issues			Installation of rotating throats on mills	1997
Hennepin 1	Upper shaft bearing crawled up shaft	1	Pushed back into place and tack welded, then tack welded all other mills, too	Sure alloy steel conversion	2002 Raymond 633
	Roll failure	3	PRB water deluge system over quenches hot mill and fractures hard liner. Reduced deluge time.	Posimetric feeders	2002 Raymond 633
	High air in-leakage	3	No actions taken at this time	CO2/Water Deluge system for PRB conversion	2001 Raymond 633 deep bowl roll mill
Hennepin 2	Upper shaft bearing crawled up shaft	1	Pushed back into place & tack welded, then tack welded all other mills too	CO2/Water Deluge system for PRB conversion	2001 Raymond 633 deep bowl roll mill
	High air in-leakage	Ongoing	No actions taken at this time, plan on air leakage sealing		
	Lack of coal/air mix uniformity	Ongoing	No actions taken at this time. Planning riffle work		
J. P. Madgett	Worn liners	4	Repair or replace	Added ceramic to classifier cones	Riley
	Pinion gear failures	2	Replace pinions; have not replaced or turned ring gears since new		
	Mill coal seals	6	Repair or Replace		
	High LOI	1	Following classifier repairs, performed dirty air and fineness test and adjusted classifiers as needed		
Kendal	Girth gear crack		Design analysis	Pinon bearing greasing	95 KVS
	Mill liner wear		New wear liner material	Standby girth gear pump	95 KVS

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Kriel	Feeder electric motor	28	Replaced DC motors with AC frequency driven electric motors	Rotating throats	
	White metal bearings	12	Initiated a fatal white metal bearing refurbishment program, leaving housings included	Air bags (loading cylinder)	1st test mill 1994
				Spider wear plates	2002
				Classifier core	2000
Lamma U1–U3	Worm gear pitting problem	On going monitoring during O/H. 5 mills were inspected in last 24 months	Continuous monitoring the growth. Worm gear of a few units were reversed and re-used. Pittings were again growing on the new surface. Synthetic lubricating oil has been applied to some of the units and pitting growing rate is slower.	Mill outlet temperature high trip interlock	April 1992 on Unit 1–3 mills (MHI 803 XRP)
	Vertical shaft thrust bearing failure	1	Replacement		
	Worm Shaft bearing failure	1	Replacement		
	Gearbox lube oil foaming problem	2	Add additive as recommended by lube oil supplier		
	Poor fineness	4	Internal recheck and further monitoring. There was one case when a piece of tramp iron jammed at the vent blade affecting the normal PA flow and resulted in poor fineness.		
Lamma U4–U6	High Reject	10	Internal check and adjustment. Also higher reject rate was due to specific type of coal supply.	Mill outlet temperature high trip interlock	August 1992 on Unit 4-6mills (MHI 903 XRP)
	Worm shaft bearing failure	1	Replacement		
	Poor fineness	4	Internal check and monitoring		

Survey

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Lamma 7–8	High reject	10	Internal inspection and monitoring, reject is highly related to coal supply properties	Mill outlet temperature high trip interlock	U7 1995, U8 1997, incorporated in design stage
	Vibration problem on the dynamic classifier gearbox	3	It happens only when the MRS speed is running above 80 rpm, condition is being monitored		
	Poor fineness	1	The MRS speed was too low, after operation adjusted the speed, fineness became normal, condition is being monitored		
Lethabo	Feeder Blockages due to rocks and foreign objects	69	Discussed with mine on a routine basis to prevent rocks from entering station. Sensitizing staff on damages caused by their actions (throwing foreign objects on coal belts and coal bunkers).		
	Mill trunnion lube system problems	58	Lube oil coolers cleaned and press tested. Lube oil heaters optimized to control at set temperature. Oil top-op activity revised to prevent contamination		
	PF leaks	42	Mill outlet boxes lined with High Alumina Ceramic Tiles to minimize outlet box casing wear. Box liner washers enlarged for improved sealing		
	Grease system pumpability	32	Drums installed inside acoustic hood to improve pumpability; Cartridge heaters fitted behind distribution blocks.		
Majuba					

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Matimba	Girth gear crack	8	Realign gear and pinions and replace the worse ones with spare sets	Mills are running out of inlet temperature under wet coal conditions due to large temperature differences between upper and lower inlet	1996–1998 on all matimba mills
	Feeder failures	50	Optimize maintenance on feeder and minor modification done with resulting increase in reliability	Mill outlet temperature. 150°F will cause the mill to trip	1994 on all matimba mills
	General wear	All mills	Wear compound protection, results not final yet	Mill fire protection damper philosophy change	
	Liner wear +/- 65,000 hour life per set	All mills	Different liners in test phase, results not final yet	Mill screw feeder modification by reducing hot air tube and ball charge increase	1996–1999 on all mills
	No spare mill available as a result of coal properties change, causing upper mill to be out of service, resulting load loss with all mill services		High performance classifier, burner repositioning, coal drying or stacking reclaiming process logistic management, no cost effective solution yet	Removal of rope destruction orifice at PF splitter inlets	1998 on all mills
				Installation of emergency trip push buttons	1996–1998 on all matimba mills
Marshall	Excessive body liner wear		Replaced liners and opened up vane wheel gap		
Matla	High maintenance on stationary segmented throats		Changing over to rotating throats	Rotating throats	12, AE mill
	Mill gearbox bearing failure		Refurbishment program to commence w/in 2004–2013		
Merom	Hot bearings			Mill Barrel support system-converted from trunion rollers to babbitt bearings	
	Chain breaks			Drive shaft modification to increase fatigue life	
	Shaft breakage				
	End box wear				

Survey

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Nelson	Bowl cracking	1	Installed new bowl	Fat Shaft, HD input shaft	80s
				High hats, vane wheels, deflectors, plow removal	80s
				Change tension to springs	80s
				Spring and upgrades	98–2003
				Remote oil	80s
Sulcis 3	Loading assembly breakage	2 per 6 mills	Replace hydro-pneumatic loading equipment	Grinding rings with hoop around	1990
	Excessive mill wear		Replace cast iron plates with ceramic plates	Cylinder improve	1985
	Ball breakage		Replace balls by balls NDE checking		
	Grinding rings breakage		Replace rings by ring with hoop around		
	Excessive yoke seal wear	2 per 6 mills	Replace and adjust		
	Gear drive breakage		Replace and improve		
Vermilion 1	Loss of oil flow to upper		Installed on line oil filtration units, high level of confidence	Oil filtration Units	2002
	Cone wear		Applied ceramic coating to worn areas		
Vermilion 2	Loss of oil flow to upper	1	Installed on line oil filtration units, high level of confidence	Oil filtration units	2002
	Cone wear	Ongoing	Applied ceramic coating to worn areas		
White Bluff	Mill puffs	3	All puffs happened after unit trips, RCAs are in progress	Installed new vane wheels with harden surface	All 16 mills replaced over last 6 years
	Input shaft failures	3	Rebuilt shafts with same material, no actions were taken to prevent future failures	Replaced hydraulics on journals with springs	All 16 mills replaced over last 6 years
	Bowl cracking	1	Replace bowl	Bowls are weld overlaid	Performed every 10 years
				Upgrade scrapper assemblies	All 16 mills replaced over last 6 years
				Installed Foxboro DCS controls	2003

Plant	What major pulverizer maintenance issues and/or problems are you experiencing at your plant?	Number of events in last 24 months	Actions taken to resolve the problem and confidence in success of actions	What modifications have you installed on the pulverizer/mill?	Installation Date and Mill Type
Wood River 4	High reject rate on 4D mill	28	Mill inspection, roll adjustment, tension adjustment, tighten clearances	Ceramic lined internals	Over the past 7 years
Wood River 5	Mill fires	12	Inspections, medium success	Ceramic line mill body & separator cone	Over 5 year period Raymond 863
	Exhauster fan pedestal brg. failure	2	Fan balance, frequent inspections, high success	Sure alloy steel vane wheel, classifier mod.	Over last three year period, Raymond 863
				Sure alloy steel high efficiency fan	2002
				Higher HP mill motors	2002

Survey

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Alma 4–5		Unit outage schedule, tonnage	Unit outage schedule, tonnage	On-site maintenance teams	No	No	Clips, pegs, hammers, clutch shoes, liners, grid bars
Arnot 1	Lower cost and reduced wear	Performance degradation limits	Performance, unit outage, schedule	OEMs	No	N/A	Replace bearings, reline cylinder, replace gears
	Lower labor cost, improved grinding media control						
	Reduced time to clear coal blockages, improved safety						
Arnot 5	Test segment life 14,500 hours compared to 2,700 hours life of previous segments	Performance degradation limits	Hours of operation	On-site maintenance teams	Yes	No	Replace bearings, weld bowls, replace grinding element, trunnion arms, roller assemblies
	Improved mill throughput by 12%						
	Improved control with data capturing						
	Still being tested						
Baldwin	Lower bowl differential pressure, improved fuel capacity and improved fineness	Unit outage schedule, performance degradation limits	Performance, unit outage schedule	On-site maintenance teams	No	Yes	Repair mill rolls, replace bearings, weld bowls, replace gears, seals, sweeps, classifiers
	No noticeable effect. Easier maintenance access for dust seal work						
	Less wear on components						
	Improved component life						
	Improved component life						

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Brindisi Sud	Modification reduced primary air flow to a level where significant coal spillage to the pyrites box occurs, increasing until the spillage stops and to improve fineness	Performance degradation limits	Performance	On-site maintenance teams, system-wide support maintenance teams	Yes	Yes	Replace mill rolls, replace bearings, replace roll wheel tires, replace grinding ring segment, survey with adjustment and contingent replace wear plates, adjustment loading assembly and contingent replace spring and loading cylinder, replace upper throat assembly, survey with adjustment and contingent replace classifier assembly, survey with adjustment and contingent replace pyrite assembly, survey and contingent replace yoke seal, survey gear drive, survey and contingent replace swing valve assembly
Cholla 2	Most areas have improved wear life. Top of exhauster is still a problem	2–3 years	Wear				Rebuild journals, exhauster bearing barrel, replace segmented ring (bowl) build up and hard face vane wheel
Cholla 3	Good						Repair tile, replace fan, rebuild dampers, replace riffle distributors
	Good						

Survey

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Cholla 4	Excellent, no failures, little wear, no repairs	2 1/2 years		Maintenance crew	Depending on coal quality		Replace grinding floor, repair pyrite floor, scrapers and air seal, classifier and cone repairs, multiports, discharge valves
	Fewer failures						
	Less wear, one-time expense, shorter overhaul lengths						
	No more journal shaft build up and repair						
	Less maintenance, easier to install, cheaper to purchase						
	No fires						
Coal Creek	Easier to maintain than the McDonald liners	2 million ton or approximately every 4 years	Tons of coal crushed	On-site maintenance teams	Yes	No	Repair mill rolls, replace bearings, weld bowls, reline cylinder, replace vane wheel wear liners
	Improved fineness distribution in the 4 outlet pipes						
	Reduced cold air leakage and raised pulverizer air inlet temperature.						
	Eliminated wear and holes in the inner cone						
	The rubber boot failed frequently. New seals last rebuild cycle of pulverizer						

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Duvha	Saving in maintenance costs, no performance benefit	Ball size and ring thickness related, approx every 4 years, three sets of balls are used for one set of rings, The loesche mills are rebuilt on approx an 8,000 hr cycle	Ball size and ring thickness related, approx every 4 years, three sets of balls are used for one set of rings, the loesche mills are rebuilt on approx an 8,000 hr cycle	OEMs	Yes, there is one spare mill at full load	No	Repair mill rollers, replace bearings, replace balls, install new rings, repair throats, tile high wear areas, replace hydraulic rams
	Excellent						
	Failed within 6 hours						
	30% added life to the balls, 15% drop in ring life						
Four Corners 1 and 2		Unit outage schedule	Unit outage schedule	On-site maintenance teams, contract labor	No	No	Replace bearings, replace balls, reclassify balls, replace liners as needed, build up wear areas
	Good, still have wiper systems as backup to pumps/tanks						
Four Corners 3		Unit outage schedule	Unit outage schedule	On-site maintenance teams, contract labor	No	No	Replace bearings, replace balls, reclassify balls, replace liners as needed, build up wear areas
Four Corners 4 and 5	Eliminate water in oil system	Performance degradation limits	Hours of operation	On-site maintenance teams	Yes	No	Replace bearings, replace gears, change rolls
	SAS rotating throats for fineness						
	Increased life improved fineness						

Survey

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Fusina & Genova	Modification to reduce unburned carbon and to improve capacity and fineness	Yearly outage schedule, performance degradation limits	Performance, unit outage schedule	On-site maintenance teams, system wide support maintenance teams	No	Yea	Repair mill rolls, replace bearings, replace rolls, replace bowl, survey with adjustment and contingent replace wear liners, adjustment journal assembly and contingent replace spring, survey with adjustment and contingent replace vane wheel, survey with adjustment and contingent replace classifier assembly, survey with adjustment and contingent replace scrapers, survey and contingent replace gear drive, survey and contingent replace swing valve assembly, survey with adjustment and contingent replace exhauster and feeder
	Improve life rolls						
	Improve life exhauster						
Gallatin	Bad	Yearly		On site maintenance teams	No	Yes	Repair mill rolls, replace bearings, replace gears
Havana	Decreased wear on throats	1,000,000–1,200,000 tons of coal	Coal tonnage	Vendors	Yes	No	Replace mill rolls, weld bowls, apply ceramic coating to wear areas, and other items based on inspections

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Hennepin 1	Noticeable increase in throughput	Unit outage schedule, performance degradation limits	Hours of operation, unit outage	Vendors	No	No	Repair mill rolls
	Noticeable decrease in O2 variability due to elimination of leveling gate						
	Risk of mill fires is greatly minimized						
Hennepin 2	Risk of mill fires is greatly minimized	Unit outage schedule	Hours of operation, unit outage	Vendors	No	No	Repair mill rolls
J. P. Madgett	Reduced classifier inverted cone wear	Have never rebuilt; reclassify balls periodically and repair/replace worn liners and seals	Unit outage schedule	On-site maintenance personnel and/or vendor	No	N/A Ball/tube Mill	Replace pinion gears, repair/replace liners, replace/reclassify balls
Kendal	Success	Unit outage schedule	Hours of operation	On-site maintenance teams	Yes		
	Success						
Kriel	Better throughout, huge maintenance saving	According to the condition of the mill rigs/mill balls are cycled	Every 5000 hrs	On-site maintenance teams	Yes	N/A	
	Some bags run maintenance free for 8 years						
	Replaced						
	Faster performance						
Lamma U1–U3	Risk of Mill fire reduced	Performance degradation limits	Performance and before high load season to ensure the reliability	On-site maintenance teams and contractors	Yes	Yes	Repair mill rolls, replace bearings of roll journals, weld bowls, gearbox inspection, lube oil filtration, check classifiers and inverted cone and eroded components for repair or replacement

Survey

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Lamma U4–U6	Risk of mill fire reduced	Performance degradation limits	Performance and before high load season to ensure the reliability	On-site maintenance teams and contractors	Yes	Yes	Repair mill rolls, replace bearings of roll journals, weld bowls, gearbox inspection, lube oil filtration, check classifiers and inverted cone and eroded components for repair or replacement
Lamma 7–8	Risk of mill fire reduced	Performance degradation limits	Performance and before high load season to ensure the reliability	On-site maintenance teams and contractors	Yes	Yes	Repair mill rolls, replace bearings of roll journals, weld bowls, gearbox inspection, lube oil filtration, check classifiers and inverted cone and eroded components for repair or replacement
Lethabo		Unit outages (every 18 months), Mill 4000 hour service intervals	Performance, calendar time, hours of operation, unit outage schedule	On-site maintenance teams, vendors, OEMs	Yes, 6 mills installed on each boiler with 5 needed for 100% MCR	N/A	Repair mill inlet and outlet box internals, renew shell and end liners. Refurbish drive gearboxes, turn girth gears, repair bottom and top coal gates, repair classifiers internals.
Majuba					Yes		

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Matimba	Control both inlet temperatures for maximum outlet temperature, increase bypass flow on low temperature side by up to 2 kg, Increase outlet temperature set point up to 80°C if there is an outlet temperature difference, balance inlet temperatures, optimize usage of primary energy is ensured during wet coal conditions	Yearly, outage	Performance, hours of operation, unit outage	On-site maintenance teams, OEMs	No	N/A	Reline cylinder, replace gears, feeder service, lubrication systems, pulverized fuel lines repair and wear protection, classifier wear protection, screw feeder replacements or wear protection
	Whenever a fire exists in the mill, the mill must be tripped by hand. Duration to trip mill could be 1–10 minutes. Due to duration between start of fire and mill trip, damage is caused to the classifiers and PF pipe work. No or very little damage to mill components						
	When mill lower/upper PF outlet temperature is >= 150°C the mill motor trip. None of the damper will close when the trip is initiated. Close PF outlet dampers when this trip is initiated.						
	Increase in throughput						
	Increase splitter box life from 25000H to 10,000 hr						
	Boiler trip by boiler master fuel trip when evaporator outlet temperature exceeds the trip valve. These trips are closely related to mill operation. Installation of a push button for emergency trip on each mill to allow the operating personnel activating of mill at level trip to prevent boiler trips. This modification also support modification 2 as it operates the dampers as mentioned in modification 3.						

Survey

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Marshall			Hours of operation	On-site maintenance teams	No	Yes	Repair mill rolls, weld bowls
Matla	Improved mill performance, reduced maintenance cost, reduced downtime	55,000 hrs	Hours of operation	OEM	Yes	No, replace rings or balls	N/A
Merom		Every other year we inspect and repair mill end boxes, seals, and expansion joints. Repairs are based on inspections	Usually unit outage schedule, maintenance history, PdM findings	Maintenance mechanics or mechanical contractors	No	N/A	Repair mill end boxes, ball classification, expansion joint repairs, liner replacements, bearing replacements, motor reconditioning, gearbox inspections
Nelson	Eliminate shaft breakage	Outage schedule	Outage schedule	Vendor	Yes	No	Inspect and repair as required, rotate 1 set journals and make planned improvements
	Improved performance						
	Reduce maintenance costs						
	Reduce spring bushing wear and maintenance						
	Reliability						

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
Sulcis 3	Breakage stop	Performance degradation limits	Performance, unit outage schedule	On-site maintenance teams, system wide support maintenance teams	Yes	Replace balls	Replace balls, reline cylinder, replace grinding rings, survey with adjustment and contingent replace wear plates, adjustment loading assembly and contingent replace loading cylinder, replace upper throat assembly, survey with adjustment and contingent replace classifier assembly, survey with adjustment and contingent replace pyrite assembly, survey and contingent replace yoke seal, survey gear drive, survey and contingent replace swing valve assembly
	Hydro-pneumatic loading equipment improvement						
Vermilion 1	Improved oil quality	Unit outage schedule	Unit outage schedule	Vendors	No	No	Repair mill rolls, replace bearings, replace bowls, apply ceramic coating to exhausters
Vermilion 2	Improved oil quality	Unit outage schedule	Unit outage schedule	vendors	No	No	Repair mill rolls, replace bearings, replace bowls, apply ceramic coating to exhausters

Survey

Plant	Results	How often do you rebuild your pulverizers?	What determines your mill rebuild cycle?	Who performs your mill rebuilds?	Do you have spare mills or excess mill capacity that allows you to rebuild mills online?	Do you repair mill rolls in house?	What typical repairs are performed during a mill rebuild?
White Bluff	Eliminated major spillage problems and extended life	4–5 years based on coal tonnage and unit outage schedule. Typically 2 million tons of coal	4–5 years based on coal tonnage and unit outage schedule. Typically 2 million tons of coal	OEMs-APCOM, formally Alstom	Yes, 6–8 mills are sent to Clad Tech for weld overlay, then sent to APCOM for mechanical rebuild	No	Repair mill rolls, replace bearings as needed, weld bowls, journal spring work, replace other parts based on visual inspection
	Spring requires less maintenance cost and less down time to repair						
	Less maintenance cost and extended life						
	Replace 2 original small scrappers with 1 heavy-duty scrapper that has a longer life						
	Better performance						
Wood River 4	Good						
Wood River 5	Good	Unit outage schedule, performance degradation limits	Performance, unit outage schedule	Vendors	No	Yes	Repair mill rolls, replace bearings, weld bowls, internal wear parts replacement
	Good						
	Medium						
	Good						

B
MAINTENANCE EXAMPLES

The following information is presented as examples of the mill maintenance items/tasks that were provided by the Technical Advisory Group for this guide.

1. Vertical shaft replacement tasks for a RB-633 mill for Dynegy Midwest Generation, Hennepin Plant, Table B-1

2. Example preventive maintenance task list for a RB-633 mill for Dynegy Midwest Generation, Hennepin Plant, Table B-2

3. Typical mill maintenance activities for a RP-1003 mill for Entergy, Nelson Plant, Table B-3

4. Typical parts list for rebuild of RP-1003 mill for Entergy, Nelson Plant, Table B-4

5. Series of pictures showing the assembly of a cover and roll after a rebuild of an RP-1043 mill at Coal Creek Generation Station

6. Tooling and support equipment for pulverizer maintenance activities

Table B-1
Vertical Shaft Replacement Tasks for a RB-633 Mill

Tasks
1. Remove mill doors
2. Remove rolls
3. Disconnect worm shaft coupling
4. Disconnect and raise coal piping
5. Remove worm shaft
6. Disconnect and remove seal air piping
7. Install coal valve removal table
8. Rig and remove coal valves
9. Rig and remove multi-port outlets
10. Rig chain falls to separator top
11. Remove horizontal separator body bolts
12. Raise separator body and install support beams
13. Set separate body on tracks
14. Remove floor
15. Remove vane wheels
16. Move separator body to north
17. Rig and remove bowl
18. Remove pyrite wear liners
19. Remove pyrite floor plates
20. Remove pyrite floor
21. Remove gear case cover
22. Rig and remove vertical shaft
23. Clean gear case
24. Install vertical shaft
25. Install gear case cover
26. Install upper radius bearing assembly
27. Install pyrite floor
28. Insulate and install pyrite wear plates
29. Install bowl, tighten locknut and cover
30. Move separator body over bowl
31. Install multi-port outlets
32. Perform blue checks on vertical shaft to bull gear to worm
33. Electric disconnects
34. Install rolls and doors
35. Do couple up and alignment
36. Fill mill with oil
37. Install oil pump shims
38. Replace mill door spring and test

Table B-2
Typical Preventive Maintenance Task List for RB-633 Mill

Task List	Hours
1. Observe proper safety precautions	
A. Obtain necessary clearances and/or lockout	
B. Observe standard safety practices	
C. Complete job plan briefing checklist	
-Hazards associated with job	
-Work procedures involved	
-Energy source controls	
-Personal protective equipment	
-Special precautions	
-Briefing date	
-Crew leader initials	
2. Obtain non-standard tools and equipment	
A. Obtain special, non-standard tools and equipment	
3. Obtain non-stock items	
A. Obtain any non-standard stock items	
4. Inspect mill work	
-Condition of rolls	
-Condition of liners	
-Condition of upper mill side liners	
-Check restrictions – should be 1/4" or less	
-Converter head and deflector valve	
-Riffle distributor uppers	
-Fuel piping and elbows	
-Lubricate mill to motor couplings lubrication	
-Lubricate mill to exhauster couplings lubrication	
Change gear case oil	
-Drain, clean, and check oil filter	
-Rod out oil coolers	
-Oil pump and bushing checked; record clearance	
-Oil pump suction inlet checked for chips or blockage	
5. Inspect pyrite section	
-Condition of liners	
-Pyrite chute and magnet	
-Hot air damper	
-Hot air damper drive and linkage	
-Condition of sweeps, pins, and guards	
-Clean hot air duct	
6. Inspect and clean hot air damper, damper drive, and linkage	

Table B-3
Typical Mill Maintenance Activities and Labor Hours for a RP 1003 Mill

Typical Mill Maintenance Activities	Estimated Labor Hours (Work-Hours)
Remove and install doors and journals	60
Install cone ceramics	100
Repair cone ceramic	10-20
Change out cone	240
Upgrade spring and classifier	270
Check spring bushings	50
Replace spring bushings	150
Replace bull ring segments	150
Replace bull ring segments, retainer, and clamping rings	180
Replace bowl	1200
Install crown 700 liner	200
Repair vane wheel deflector	120
Change out (36) deflector hinge blocks	10
Change out (13) deflector blade shafts (will need bearings)	40
Install new wall deflectors	150
Install new vane wheel	360
Replace vane wheel bolt	90
Replace heat shield bolts	40
Clean lube oil strainers	4
Repair scraper	25–48
Set ring to roll	4
Inspect and repair as required	20–80
Perform miscellaneous repairs (separator body, coupling, cone bolts)	20

Table B-4
Typical Parts List for Rebuild of RP-1003 Mill

Part/Material Description	Recommended Quantity
Heavy duty scraper assembly	1
Lifting lug application	2
Deflector hinge block	36
1-in. hex head cap screw x 8-in. long grade 5	24
1-in. disc spring, Belleville (2 per bolt)	48
1-in. plain washer	24
Bull ring segments	
Bull ring retainer	1
1-in. hex soc head cap screw x 3 3/4 in.-long type N	-
1-in. lock washers (clamping ring fasteners)	-
1-in. hex soc. head cap screw x 4-in. extension ring	-
1-ft² hex mesh tile	1
Stop key	2
Multiple port outlet plate	1
Deflector blade shafts	13
Deflector support	80
Deflector link lever	2
Spring stud bearing	3
Spring stud bearing	3
Journal spring conversion assembly	6
Vane wheel assembly	1
Intermediate liner	15
Deflector side liner	1
Deflector liner	13
Bowl extension ring	1
Vane wheel deflector assembly	1
Inner cone	1

The following series of pictures show the final assembly of the cover and mill roll for an RP-1043 pulverizer at Great River Energy's Coal Creek Generation Station.



Figure B-1
Cleaning Mating Surface in Preparation for Installation



Figure B-3
Cover Being Rigged into Position to Engage Hinge Pin



Figure B-2
Journal Cover Being Transferred from Lay Down Area



Figure B-4
Cover Being Positioned onto Hinge Pin



Figure B-5
Cover Being Lowered to Accept Roll Journal



Figure B-6
Roll Journal Being Transferred from Lay Down Area



Figure B-7
Roll Journal Being Moved over Cover



Figure B-8
Rigging Being Attached to Mill Housing to Support Roll Journal



Figure B-9
Rigging Installed to Support Journal



Figure B-11
Roll Journal Being Lowered onto Cover



Figure B-10
Roll Journal Rigging in Place Before Lowering onto Cover



Figure B-12
Rigging from Overhead and Mill as Journal Is Eased onto Cover



Figure B-13
Rigging Relaxed with Roll Journal in Place on Cover



Figure B-15
Door Closed and Roll in Position Just Above Table



Figure B-14
Cover Is Supported from Adjacent Column as Door Is Eased Closed to Place Roll in Mill

The following photos show tooling and support equipment for maintenance work on the RP-1043 pulverizers at Coal Creek Generation Station.



Figure B-16
Bolts Have Been Cleaned, Lubricated, and Stored for Use During Reassembly



Figure B-17
Owner Fabricated Ratchet Tool for Removal and Installation of Roll Shaft Nut



Figure B-18
Exhaust Fan Attached to Air Supply Duct to Draw Fresh Air into Pulverizer During Maintenance Activities.



Figure B-19
Exhaust Fan Pulling Air from Reject Hopper and Reject Region of Mill



Figure B-20
Rigging Is Organized and Stored in Cart. Cart Is Capable of Being Rolled or Lifted by Lifting Eye to the Work Site.

C
KEY POINTS SUMMARY

The following list provides the location of the Key Point information in this report.



Human Performance Key Point

Denotes information that requires personnel action or consideration in order to prevent personal injury, equipment damage, and/or improve the efficiency and effectiveness of the task.

Section	Page	Human Performance Key Point
4.3	4-18	The belts, skirts, leveling plates, and so on require some attention to maintain the integrity and reliability of the feeder and feed rate. Section 10 of this guide lists some areas for preventive maintenance checks. Consistency is required from feeder to feeder. Electronically, the calibration checks of the weighting elements need to be made on a regular basis to maintain the required accuracy. Verification tests must be developed and performed to maintain the correct interface signals between the weighting elements and the control system.
4.7	4-37	For the RPS/RP mills, the observation port handhold should never be opened when the hopper isolation valve is open. This will expose personnel to hot pulverizer air that can cause serious injury.
5.1	5-1	The manufacturer's recommendation is not to operate the mills below 40% of the design capacity without ignition support in the boiler. Below 40% design capacity, the air and/or fuel mixture can cause coal flame stability problems and boiler explosions. With ignition support the minimum feeder rate is 25% of the pulverizer capacity. At feed rates below 25% capacity, any momentary interruption of coal feed will allow the pulverizer to empty. This will cause a loss of boiler fire and a possible boiler explosion.
11.3.2	11-11	It is important not to underestimate the weight of the journal assemblies. Cables and shackles should be selected based on the weight of the journal assembly.
11.4.2	11-36	For gearboxes equipped with the internal oil pump, remove the oil pump hub from the shaft by removing the two socket head cap screws and the keeper. Use care as the oil pump hub and bearings may come off with the plate. Place a jack stand under the pump to lower it. The oil pump and bearings are heavy and could cause injury if they fall. Remove the oil pump hub key, if used. For gearboxes equipped with an external oil pump, remove the bearing locknut by unscrewing it. Use care as the bearings may come off with the plate.



O&M Cost Key Point

Emphasizes information that will result in overall reduced costs and/or increase in revenue through additional or restored energy production.

Section	Page	O&M Cost Key Point
3.4	3-14	The increases in LOI from NO_x combustion controls increases heat rate. The average industry loss is 12 BTU/kWh per 1% change in unburned carbon. This increase in LOI creates a need for greater fineness to compensate for the increased LOI. Some units have increased fineness from 70% passing a 200 mesh screen to 75–80% passing a 200 mesh screen and 99–99.5% passing a 50 mesh screen. The increase in fineness settings requires more work from the pulverizer.
6.1	6-1	A 70% coal sample passing through a 200 mesh screen indicates optimum mill performance. Values greater than 70% require the mill to perform more work. The mill wear and the power consumption are increased if the 70% value is exceeded. Values less than 70% mean higher carbon loss and increased fuel consumption.
6.3	6-4	Desired fineness also affects the mill capacity. Increasing fineness from 70–71% reduces the pulverizer capacity by approximately 2%.
10.1	10-3	Extending the deflector ring down the full length of the classifier vanes has been shown to significantly improve the mill performance (specifically 50 mesh fineness) with no loss in capacity.



Technical Key Point

Targets information that will lead to improved equipment reliability.

Section	Page	Technical Key Point
4.2	4-15	A replaceable oil seal and a labyrinth-type dust guard seal the gearbox top above the upper radial bearing and prevent dust contamination. Seal air drawn by the millside suction through labyrinth seal formed by the bowl hub skirt and the mill bottom casting prevents dust from accumulating on top of the oil seal. The labyrinth seal is not greased.
4.5	4-20	The pulverizer design airflow is 1.5 lb of air per lb of coal at full load. This number can be higher at lower loads.
5.1	5-1	Safely operating an Alstom mill means meeting the following criteria: • Minimum pipe velocity of 3300 ft/min • Exit temperature of mill is 150–180ºF • Air and/or fuel ratio is between 1.6 and 2.4
5.1	5-9	For the optimum mill operation, the classifier pointers should be set between 0 and 3. If the coal is too fine when the setting is on point 1, the spring pressure on the rolls may be too great. If the coal is too coarse when the setting is on 3, the spring pressure on the rolls may not be enough.

Section	Page	Technical Key Point
5.2	5-9	If the inverted cone is raised to a point that the clearance between the inverted cone and inner cone is greater than 4 in., coarse coal will be carried out of the mill and not returned to the bowl for grinding.
5.3.2	5-18	After a mill fire has been extinguished, the grinding rolls, grinding ring and liners should be inspected for cracks. The journal and gearbox lubricants should also be tested for carbonization.
6.2	6-3	The design rating on all Alstom RB pulverizers is based on a grindability index of 55 with 70% passing through a 200 mesh screen.
6.4	6-5	If only pyrites and rocks are observed in the reject hopper, some pyrites and rocks are probably being ground. If there is a large percentage of coal in the reject hopper, too much coal is not being ground and lost for combustion. The suggested compromise is to have a minimum amount of coal in the pulverizer rejects.
9.2	9-2	Lubricant testing is recommended for several reasons. These include: • To study the condition (wear, and so on) of the machine being lubricated. If there is a problem with the lubricant, there is a strong possibility that the machine will need maintenance. • To determine if the lubricant is meeting the specifications.
9.2	9-6	Some EP additives can increase wear on the copper components. For example, Duke Energy added oil filtration systems to reduce wear from particle contamination. The copper levels remained high. The oil manufacturer (Mobil) recommended changing from a standard EP gear oil (Exxon Spartan EP) to either a PAO synthetic (Mobil SHC 600 series) or a cylinder oil (Mobil 600 W Super Cylinder Oil). These oils provide the EP property without the high chemical reactivity of the standard EP additives. After changing to these oils, the wear metals showed a significant reduction. Also, the lowest wear metals were achieved with continuous filtration.
10.1	10-5	Changing out one roll and leaving two worn rolls in place will result in uneven spring compression and capacity problems. Maintaining three rolls with equal wear patterns is very important for mill performance.
10.1	10-12	One indication that the spring pressure is too high is a rumbling noise at low loads. If the spring pressure is too low, the rumbling noise can occur at high loads.
11.0	11-2	In general, grinding rings last twice as long as grinding rolls for medium and low abrasive coals. For high abrasive coals, the ratio is less than 2 to 1.

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