

COAL PREPARATION PROCESSES

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ABSTRACT

Coal preparation is a series of unit operations interconnected by a material handling system. The material handling system, for the most part, is a slurry transport system. At the heart of coal preparation are the actual cleaning processes. This paper will review the main coal preparation cleaning processes and how slurry transport systems make them work.

INTRODUCTION TO COAL PREPARATION

Coal preparation is both a science and an art. It deals with taking raw coal and producing a saleable product that meets contract specifications by removing the impurities. Coal preparation, as commonly practiced today, is carried out in water based processes, and makes heavy use of slurry transport principles and procedures.

Coal preparation is regarded as the processing of raw coal to yield marketable products and waste (refuse) by means that do not destroy the physical and chemical identity of the coal. Coal is a very heterogeneous material made up of different coal types and varying amounts of mineral matter. As mined, it normally contains all the layers of coal and impurities found in the seam, plus portions of the strata above and below the coal seam. The preparation plant sizes, crushes and removes impurities so that the coal may be shipped as a saleable product.

There are four basic types of operations used in cleaning the coal. To these may be added a number of auxiliary operations which are not directly involved in the coal cleaning. The four basic operations are comminution, sizing, concentration, and dewatering.

Comminution means reduction to a smaller size.

Depending on the sizes involved, the coal is either crushed, broken, or ground. Breaking is commonly used on the largest sizes, crushing on the mid-range sizes, and grinding is used on the very finest sizes. Grinding or pulverizing is normally done just prior to utilization. There are no hard and fast rules as to what these size ranges are. Adjacent coal preparation facilities may have different size ranges for similar coals.

Sizing is the separation of coal into products characterized by difference in size. This can be accomplished by screening or by classifying, the latter being a sizing method dependent upon the relationship existing between the size of coal particles and their settling velocity in a fluid medium, generally water.

Concentration is the separation of coal into products characterized by some physical difference such as specific gravity. Concentration is the heart of coal preparation, where the actual cleaning occurs and the refuse is separated from the coal. It is normally accomplished in jigs, dense medium vessels, on tables, in dense medium cyclones, water-only cyclones, or flotation cells. It also can be accomplished during other unit operations, such as sulfur removal by crushing to liberate the sulfur particles (pyrite) and then screening or classifying to achieve separation (pyrite being normally smaller and heavier than coal).

Dewatering is the removal of surface moisture that clings to the coal's surface area. The finer the coal, the greater the surface area and surface moisture. Dewatering by mechanical means is generally conducted only to the extent of producing a damp cake. If further dewatering is desired, dryers requiring fuel for evaporation of moisture are essential. Thermal dryers also produce a large amount of dust that must be scrubbed from the air and then disposed. A common byproduct of dewatering is the removal of super

fine coal which in most coals is high in ash, sulfur, and surface moisture; this is referred to as desliming.

Auxiliary operations are by nature quite diverse. They involve storing (in bins, silos, or open piles), material transport (by conveyors, feeders, elevators, or pumps), sampling, weighing, chemical reagent feeding, feed distribution and such other operations needed to move or control the coal from one cleaning operation to another.

In this presentation, a certain amount of technical jargon is unavoidable. A brief definition of some of the terms employed is presented below.

The terms "preparation" and "cleaning" are used interchangeably in referring to the processing of the raw, or "run-of-mine" (ROM) coal. The "feed" to a cleaning plant or equipment is the material received for processing. "Near gravity" material is that material which is within $\pm .10$ specific gravity units of a desired specific gravity (e. g. at 1.60 Sp. Gr., near gravity would be material that sinks at 1.50 Sp. Gr. and floats at 1.70 Sp. Gr. The products are the concentrate and the tails (a final tailings is called "refuse" if dry and "slurry" if wet and pumpable). If more than two products are made, the other is called a "middlings." To process the coal in a piece of equipment, it is necessary to have the coal moving through the machine. The depth of the coal moving is referred to as the thickness of the "bed." In some processes (notably breaking or screening), the process efficiency can be increased by removing the material which is smaller ("minus") the product size. This is called "scalping," and on larger sizes is done with a large opening screen ("grizzly"). The clean product is referred to as "clean coal," or "washed coal," interchangeably. Material going over or out the top of a machine is called the "overflow." Similar material coming out the bottom of a machine is called the "underflow."

COAL PROCESS SELECTION

The selection of the processing flowsheet is probably the single most important step in the plant design process. Design of physical structure, placement of equipment, etc., will stem from the flowsheet and be influenced by the flow selected. The question "What are we trying to accomplish?" must continually be asked, and each answer scrutinized to make sure that basic purposes are not being lost in the enthusiasm of the designing.

Prior to selecting the flowsheet, the following questions must be asked in determining the basic purpose of the plant:

- (1) What characteristics of the raw coal make it necessary to install preparation facilities? Why?
- (2) What sizes of raw coal must be cleaned?
- (3) To what degree must the percentage of ash and sulfur be reduced to insure a saleable product?
- (4) Will further reduction of ash and/or sulfur improve saleability? Utilization?
- (5) What limit must be placed on preparation cost per clean ton due to reject losses, operations, maintenance and depreciation?

Analysis of the foregoing considerations guides the choice of the best way to clean the specific coal in question. Most non-coal impurities have specific gravities greater than coal. So the density of a coal particle is a direct measure of its purity; and differences in specific gravity provide the basis for the mechanical separation of coal from non-coal refuse.

Coal preparation processes fall into two general types: (1) those conducted in water-only medium, and (2) those conducted in a mixture of water and a high-gravity material such as magnetite (dense medium systems). The general guideline for selecting the applicable process is based on the sink-float data for coal under question. Dense medium is normally used when the separating gravity is 1.50 or below, or if there is more than 10% near gravity material. Water-only processes are normally used when the separating gravity is above 1.60 and there is less than 10% near gravity material.

COARSE COAL

Jigging has been the most widely used means of cleaning coarse coal for more than a half century. The first coal jigs were direct copies of ore jigs, in which a basket loaded with mixed particles was moved up and down in a tank of water. Thus agitated, the particles became rearranged in layers of increasing density from top to bottom. The same principle is used in modern coal jigs to stratify and separate usable and unusable products. Highly refined versions exist of the Baum type jig, based on an air impulse concept in which the water is cyclically jiggled by air pressure from an adjacent sealed chamber. Jigging is more preferably applied to a wide size-range of particles with top sizes up to eight inches than to a closely sized fraction.

Dense medium separation provides more accurate separation and higher recovery of saleable coal than jigging. Coal is slurried in a medium with a specific gravity close to that of the desired separation. The lighter coal tends to float and the refuse to sink. The two fractions are then mechanically separated. While other media have been used, most coal cleaned by the dense medium process is separated in suspensions of magnetite in water. The process is versatile, offering easy changes of specific gravity to meet varying market requirements, and the ability to handle fluctuations in feed in terms of both quantity and quality. In practice, feed sizes may range from a bottom size of 1/4 inch to a top size of six inches or larger.

FINE COAL

Fine coal concentrating processes generally include those processes which clean 3/8-inch top size coal. This is an arbitrary size which seems most consistent with actual practice, although certainly these processes can effectively clean coarser or finer coal.

The feasibility of cleaning fine coal was enhanced with the development in Europe around 1946 of the first efficient centrifugal (cyclone) cleaners. In the United States, the first cyclone installation was made in 1961. Inclusion of cyclones in coal cleaning circuits has grown in numbers as their profitability in applicable situations became proved.

Essentially the same considerations involved in the selection of means for cleaning coarse coal apply in specifying the proper cyclone cleaner for fine coal. Analysis of adequate washability samples, feed tonnages, size analysis and other data should precede the design of all stages of the coal cleaning circuit.

Further specific data needed to select the optimum type and size of cyclones for a given installation include:

1. Type of solids in feed
2. Gallons per minute of feed pulp
3. Size of solids in feed

4. Percent of solids by weight in feed pulp
5. Specific gravity of the solids
6. Classification desired

For hard-to-clean coal in a size range of 28M to 1-3/4 inch, the dense medium cyclone is likely to prove best suited. In its operation, a slurry of coal and medium (magnetite dispersed in water) is admitted at a tangent near the top of a cylindrical section that is affixed to a cone-shaped lower vessel. The slurry forms a strong vertical flow; and under gravitational forces, the refuse with its higher specific gravity moves along the wall of the cone and is discharged below at the apex. The coal particles of lesser specific gravity move toward the longitudinal axis of the cyclone and finally through the centrally positioned vortex finder and the upper overflow chamber to the discharge outlet as clean coal. The dense medium cyclone functions efficiently regardless of the amount of near gravity material in the feed.

Original research on cyclones led to the development of the water-only, or hydrocyclone, which performs a specific gravity separation employing only water and centrifugal force. Its design feature which permits the use of water only is the wide angle, or angles, in its conical bottom. This promotes the formation of a hindered settling bed, as the dense particles move down the side wall under the impetus of gravity. Less dense particles cannot penetrate this heavy bed, and move back into the main hydraulic current to be discharged out the top of the unit through the vortex finder. Applied in easier cleaning situations than dense medium devices, water-only cyclones have been used to wash coals with a top size range of 1 1/4" to 28M, sometimes as a scalping device to reduce the load on other equipment. Those water-only cyclones washing 28M x 0 coal are generally specified because of the presence of pyrite or oxidized coal which has proved difficult to wash by other means.

Another commonly used fine coal cleaning device is the concentration table. Tables have been used for cleaning coal for over 70 years. The most generally accepted explanation of the action of a concentrating table is that, as the material to be treated is fanned out over the table deck by the differential motion and gravitational flow, the particles become stratified in layers behind the riffles. This stratification is followed by the removal of successive layers from the top downward by cross-flowing water as the stratified bed travels toward the outer end of the table. The cross-flowing water is made up partly of water introduced with the feed and partly of dressing water fed separately through troughs along the upper side of the table. The progressive removal of material from the top toward the bottom of the bed is the result of the taper of the table riffles toward their outer end, which allows a successively deeper layer of material to be carried away by the cross-flowing water as the outer end of the table is approached. By the time the end of the table is reached, only a thin layer, probably not thicker than one or two particles, remains on the surface of the deck, this layer being finally discharged over the end of the table.

The above processes are all based on the differential specific gravity of coal and refuse. The last process I will discuss is based on the surface chemistry of the various constituents in the feedstream. Froth flotation is a chemical process that depends on the selective adhesion to air of some solids and the simultaneous adhesion to water of other solids. A separation of coal from coal waste then occurs as

finely disseminated air bubbles are passed through a feed coal slurry. Air-adhering particles (usually the coal) are separated from non-adhering particles, floated to the surface of the slurry, and then removed as a concentrate. This process involves the use of suitable reagents to establish a hydrophobic or air-adhering surface on the solids to be floated, and to render the other solids hydrophilic or waterloving. To gain an understanding of the flotation system, it is necessary to study the chemical and physical properties of the three interfaces — solid-gas, solid-liquid, and liquid-gas.

Flow Scheme Development

After analyzing the coal and selecting the applicable processes, the overall concept is combined into a flowsheet. Figure 1 shows the major process areas found in a coal preparation plant. Like any other process industry, coal preparation is a group of unit operations interconnected by a materials handling system. Let us now take a look at the operations and their interconnections found in a coal preparation plant. Any particular plant will not have all of these operations, of course, but rather will be a selection of various ones, dependent on the type of analysis listed above.

COAL PREPARATION CIRCUITS

Each block shown in figure 1 is composed of several separate pieces of equipment performing the various unit operations required. Often, when coal preparation is discussed, the discussion fixes upon the concentrating equipment, and it is forgotten that none of this equipment can function by itself. This equipment is all interrelated and supported by other equipment. Table 1 covers the major blocks shown on figure 1 and what type of equipment would be used for the appropriate unit operations. Table 1 also lists some of the appropriate material handling equipment required. Let us now open up some of the boxes on figure 2 and see how the equipment interrelates.

Raw Coal Handling

The raw coal handling is similar to any bulk material process whether it is coal, iron ore, phosphate, wheat, fish, or what have you. Adequate treatment of this is found elsewhere, and will not be discussed here.

Coal Cleaning Circuits

There are six basic circuits used in processing coal. These are:

- o Jig
- o Dense Medium Vessel
- o Dense Medium Cyclone
- o Water-Only Cyclone
- o Table
- o Froth Flotation

These circuits are combined in various combinations, as shown in Table 1.

The following is a brief description of each of these circuits.

Jig

The jig circuit (figure 2) is the simplest circuit generally found in a coal preparation plant. Raw coal enters the preparation plant on the plant feed belt conveyor. The raw coal, after discharging from the conveyor, is sluiced into a Baum jig. The jig produces

a refuse product, a clean coal product, and a middling product. Refuse and middlings are removed from the jig box by means of a bucket elevator, with perforated buckets to allow drainage of the excess water. The middling product is crushed to liberate coal, and is then returned to the jig feed sluice for reprocessing via a sump and pump. The clean coal screen separates the coal from the jig into three size fractions. The top size coal is crushed to size and then placed on the clean coal conveyor. The middle size fraction is dried in a centrifugal dryer and then placed on the clean coal conveyor. The fine coal flows into a sump, where it is pumped to further processing as required. Besides the raw coal and electricity for the motors, a jig requires a constant makeup water stream and a low pressure air supply to operate. The major portion of the water is added as push water at the head end of the jig, and the rest is added to each cell of the jig. The water is one of the control items in jig operation. Low pressure air from centrifugal blowers is used as the motivating force behind the pulsations in a Baum jig. It is controlled by a series of valves to give a moving pulsation through the jig. The interaction of the raw coal feed and recirculated middlings, water addition, and air pulsations is used to control the jig capacity. Separating specific gravity is controlled by floats which open and close the refuse and middlings discharge gates.

Dense Medium Vessel

Dense medium vessel circuits (figure 3) (trough or drum type) are used for more difficult to clean coals. Raw coal and pre-wet screens will separate at 30 mm. The oversize fraction will flow by gravity to the dense medium vessel, to be combined with the media, where separation of clean coal and refuse products will take place. The major quantity of media used in the process will be drained by screens for both clean coal and refuse, and will return directly to the recirculation medium sump. The remaining media adhering to the coal and refuse products will be rinsed on the rinse section of the screens, and will be treated as dilute media. The top deck product from the clean coal drain and rinse screen will be crushed to desired product size. The second deck product will be dewatered in mechanical centrifuges. Refuse material will only be screened and conveyed to a refuse bin.

The dilute media will be treated in double-drum magnetic separators. The magnetite (most commonly used media) concentrate from the separators will be returned to the dense media circuit. The tailings from the magnetic separators will go to the raw coal feed as push water.

Magnetite makeup will be fed on demand from the magnetite storage bin directly into the heavy media sumps.

Also required is a constant supply of fresh water for sprays and makeup. Control circuitry is commonly by pneumatic means from a 100+ PSI instrument air compressor.

Dense Media Cyclone

Dense media cyclone circuits (figure 4) are used where applicable on the next size range below dense media vessels. Desliming sieve bends and screens will separate at 28 mesh. The oversize fraction will flow by gravity to the dense media cyclone sump, to be combined with the media and then pumped to the dense media cyclones, where separation of clean coal and refuse products will take place. The major quantity of media used in the process will be drained by sieve bends and

screens for both clean coal and refuse, and will return directly to the heavy media sump. The remaining media adhering to the coal and refuse products will be rinsed on the rinse section of the screens, and will be treated as dilute media. The product from the clean coal drain and rinse screen will be dewatered in mechanical centrifuges. Refuse material will only be screened and conveyed to a refuse bin.

The dilute media will be treated in double-drum magnetic separators. The magnetite concentrate from the separators will be returned to the heavy media circuit. The tailings from the magnetic separators will go to the raw coal distributor.

Magnetite makeup will be fed on demand from the magnetite storage bin directly into the heavy media sumps.

Water Only Cyclone

Water-only cyclone (other terms being hydrocyclones or concentrating cyclones) circuits (figure 5) are commonly used for easy to separate coals. The coal in slurry form flows into a sump, where it is pumped to primary water-only cyclones. The underflow from these cyclones is collected in a sump and pumped to secondary water-only cyclones. The overflow from these secondary cyclones is recycled to the primary water-only cyclone sumps. The underflow from the secondaries, which is refuse, is dewatered by a screen and then combined with the other refuse material (if available) and is collected by conveyor. The screen underflow is piped to the refuse dewatering circuit. The overflow slurry from the primary water-only cyclone contains clean coal as well as uncleaned fine material. The two are separated by classifying devices such as Vor-Sivs, making the desired size separations. After separation, the clean coal is dewatered by centrifugal dryers, and then joins the other (if available) clean coal on the clean coal conveyor.

Tables

Concentrating table circuits (figure 6) are used for the same application as water-only cyclones.

The solids wet-screened from the raw coal feed will be slurried and directed to a sump under the raw coal screens. Each pump will pump this slurry to two Vor-Sivs with 1/4-mm screen openings. A bypass valve will be provided to bypass a part of the Vor-Siv feed to each table distributor as desired.

The distributors will split the solids into equal streams. Each of these streams will feed a single-deck Deister table, where the actual separation of the clean coal and refuse products will take place.

The undersize slurry from the raw coal Vor-Sivs will flow by gravity into the refuse sump. The clean coal product from the tables will gravity flow via pipes and launders into clean coal Vor-Sivs, equipped with 1-mm baskets which will size the product at 28-mesh and will dewater the resultant 3/8-in x 28-mesh clean coal slurry to a moisture content of approximately 20 percent. The 3/8-in x 28-mesh clean coal will be further dewatered to about 7 percent surface moisture by basket centrifuges.

Centrifuge effluent, after passing over tell-tale screens, and the fine slurry from the clean coal Vor-Sivs will discharge into a fine coal sump for further processing.

Froth Flotation

Fine coal cleaning circuits (figure 7) are becoming increasingly more common as coal product specifications become tighter. One circuit that has been appearing quite frequently of late is a combination of

a single-stage water-only cyclone and froth flotation. This combination is interactive and requires careful planning as to how they relate to each other.

The desliming underproduct, consisting of fine coal material, will be pumped to the cyclones. The overflow of the cyclones will be fed to rapped sieve bends, which will deslime the clean coal products. The oversize coal product from the sieve bends will be fed to the vacuum filters. The sieve bend underflow, which will consist of the fine fraction of the coal, will be fed to the froth flotation circuit. Cyclone underflow will flow by gravity to the flotation circuit to recover any misplaced coal, or it can be bypassed to the flotation tailings.

The flotation circuit will process the undersize of the rapped sieve bend, which consists of the fine size fraction and the water-only cyclone underflow.

The float product, together with the coarser water-only cyclone product from the sieve bend, will be fed to the vacuum filter. The filtrate will combine with the flotation cell tails and flow to the refuse thickener.

In addition to the equipment shown on figure 7, flotation also requires a reagent system consisting of storage tanks, reagent feed pumps, and a reagent material system. Certain flotation also requires, or is enhanced by, addition of low pressure air. Clean coal handling from the flotation system must also consider that the product is aerated and hard to handle.

Refuse Dewatering

Refuse dewatering circuits (figure 8) are used to reclaim water for process use and to dewater the fine refuse prior to disposal. A refuse thickener will be provided to remove most of the fine solids in the process water. Sources of water to the refuse thickener are: tailings from the flotation cells and filtrate from the vacuum filter. Thickener overflow will be pumped back into the plant as raw coal slurry water, and spray water. A thickener underflow pump will be provided to pump the slurry to settling ponds or to a vacuum filter or centrifuge for solids dewatering. If the solids are dewatered, they are combined with the coarse refuse.

MATERIAL HANDLING IN A COAL PREPARATION PLANT

Like any process industry, coal preparation is a group of unit operations interconnected by a materials handling system. The materials handling system involves those dry process steps, such as the conveyor system and the slurry process steps, which include the pumping system and the launderers. There are also process steps that are neither dry nor slurry; this last area is normally classed with the slurry handling system, as it usually runs to wet rather than to dry. In a typical coal preparation plant, most material handling streams are slurry flow, except for the initial feed and the last three products (two clean coal and one dry refuse), which are dry flow. Slurry is either piped (motivating force by pump or gravity) or flumed and laundered. Even in those areas such as sieve bend discharge, which are commonly chutes, the material is a very thick slurry.

Coal plant operators' problems with material handling systems fall into five basic and interrelated categories: accessibility, maintainability, availability, corrosion, and abrasion. The first three categories are related to plant design, and the problems normally can be resolved through the use of good engineering practices. The last two categories

(corrosion and abrasion) related to the characteristics of the coal and how they affect the plant operation.

While coal is relatively soft as minerals go (~ 50 on the Hardgrove grindability scale), it still can give operators problems in their slurry systems. Problems arise from several factors, one being that while coal is soft, it is also very friable, and tends to break into fresh surfaces instead of becoming rounded.

Because the coal particles break and do not round, this means that the final processing steps are as subject to wear or abrasion as the first steps. Actually, they are subject to higher wear, due to the increase in the number of particles handled. An example of this would be that the fine coal discharge chutes need the same amount of wear protection as the fine coal underflow pans at the raw coal screens. The fine coal discharge chute from the basket centrifuge is usually lined with polished stainless steel, because the product is relatively dry (18% by weight surface moisture), while the raw coal screen underflow pan is lined with cementitious liner, because the product is in a true slurry form (10% by weight solids).

Abrasion appears in the preparation plants as equipment, chute and pipe wear. Depending on flow conditions, some items have been known to wear out in less than 500 hours. A coal preparation plant in Illinois was changing baskets on a fine coal centrifuge processing 28 mesh x 0 coal every 80 to 100 hours. The same plant was getting 1500-2000 hours on pumps before having to replace the casing and the impeller. Chute liners and pipe, in high wear areas, were lasting about 1000 hours.

There was no way to minimize the wear on the centrifuge basket, but through the proper design of the installation, the downtime required to change the basket was minimized. This was accomplished by allowing plenty of work area around the centrifuge and placing a lift beam over the centrifuge. Feed chutes to the centrifuge were thereby easily removed.

The high wear pumps were operating at 1170 RPM. By replacing these pumps with low-speed (800 RPM) hard iron pumps, the operating life was tripled to 6000+ hours.

The chute and pipe wear problem was lessened by using ultra-high molecular weight polyethylene wherever possible, i. e., in non-impact areas. Areas subject to impact were fixed with easily removable or bolt-on liners. A side note of interest was that A.R. special alloy plate was only lasting about 100 hours longer than mild steel plate. The large cost difference strongly favored replaceable mild steel.

Another factor is the mineral content of the coal, which can be leached into the water used for processing and eventually cause corrosion problems.

Corrosion in a preparation plant occurs only on the nonwearing surfaces, as the wearing surfaces do not last very long. Historically, the primary source of corrosion has been from the leaching of sulfur to form sulfuric acid, or "coal mine drainage" water--the typical reddish runoff from old coal wash piles.

The best cure for corrosion is a good paint job. This is more difficult than it sounds, as most equipment manufacturers and plant erectors do not follow steel structure painting council specifications. Strict adherence to SSPC standards would solve a lot of problems. A fairly new corrosion-related problem has begun to appear in the coal industry, and this is a buildup of ions in the processing water. This buildup has been occurring as more plants are closing their water circuits and only adding sufficient water for makeup product losses. Some very exotic, to the coal

industry, solutions to this problem have been suggested. Inasmuch as this problem is fairly new, the best method of handling it has probably not been developed yet.

Some slurry transport problems faced by the coal preparation plant operator are directly related to plant design. These problems include pumps located in out-of-the-way parts of the plant, pipe runs that look like a plate of spaghetti, and angled elbows and joints. Coal preparation plants have tended to be the type of operation where the maximum amount of equipment is shoe-horned into the minimum space and then all the pipe is "field-fit." The operator is usually using the cheapest capital cost equipment without any thought as to how much it will cost to maintain it.

As the cost of coal is rapidly increasing, coal operators are now beginning to look at the overall cost of operating their plants. This change is the opening needed to push for the best possible slurry transport system inside the plant. It can truly be said that the coal operator is coming out of the dark ages when the engineering of his slurry system is considered. The coal operator is highly resistant to change, and a strong argument must be made to sell him any new idea.

This resistance to change makes it tough going for the man with a new idea to sell to the coal industry. Add to this the fact that the coal industry has traditionally been a low-dollar-per-unit-volume industry. The people in the decision-making positions of most coal companies are still unwilling to spend money for maintenance improvement items. The materials handling engineer needs to know and understand the basic processes and problems that the coal plant operator faces. With this knowledge he can then do a better selling job for his services.

TABLE 1
TYPICAL COAL PREPARATION PROCESSES

<u>Material</u>	<u>Process Method</u>	<u>Material Handling Method</u>
Raw Coal	Comminution	Belt Conveyors
Run-of-Mine	Crushers	Mobile Equipment
Reduced to 6" or finer	Rotary Breakers	Chutes
	Sizing	Chutes
	Screens	
Coarse Coal +1"	Concentration	Sluices
	Dense Med. Vess.	Pumping (Aux. to Process)
	Jig	
	Dewatering	Sluices
	Screens	Chutes
1" x 1/4"	Concentration	
	Jig	Sluices
	Dense Med. Cycl.	Pumping
	Water-Only Cycl.	
	Tables	
	Dewatering	
	Screens	Sluices
	Centrifuges	Chutes
Fine Coal 1/4" x 28 mesh	Concentration	
	Water-Only Cycl.	Pumping
	Dense Med. Cycl.	Sluices
	Tables	
	Sizing/Dewatering	
	Class. Cyclones	Pumping
	Screens	Sluices
	Centrifuge	Chute
	Filter	
28 mesh x 0	Concentration	
	Froth Flotation	Pumping
	Water-Only Cycl.	Sluices
	Dewatering	
	Filters	Sluices
	Screens (Fine)	Chutes
	Centrifuges	
Fine Refuse 28 mesh x 0	Dewatering	
	Thickeners	Pumping
	Filters	Sluices
	Centrifuges	Chutes
Clean Coal	Handling	Belt Conveyor
		Slurry Pipeline
		Mobile Equipment
Refuse	Handling	Belt Conveyor
		Slurry Pipeline
		Mobile Equipment

FIGURE 1
TYPICAL COAL PREPARATION PLANT
FLOW SCHEME

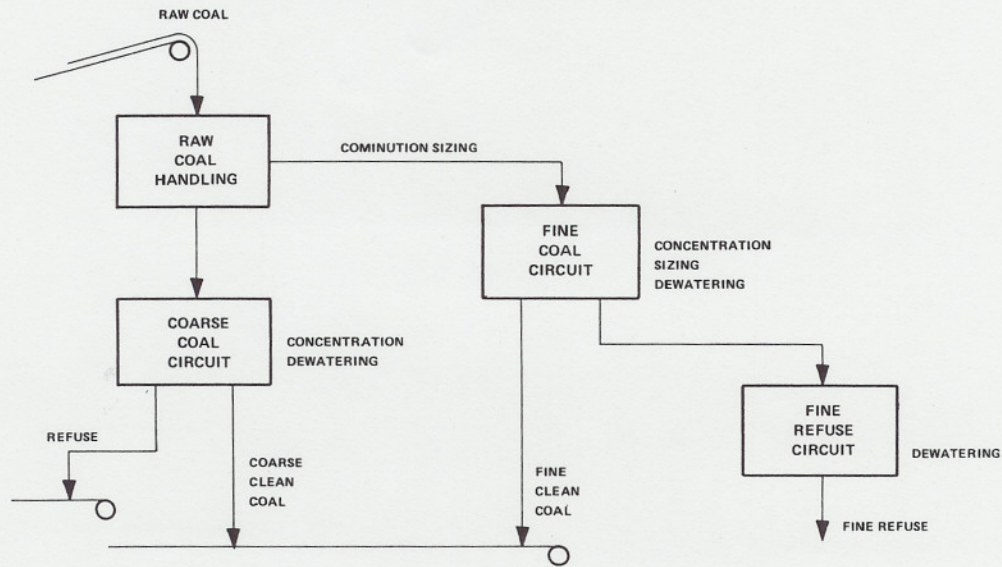


FIGURE 2
JIG CIRCUIT

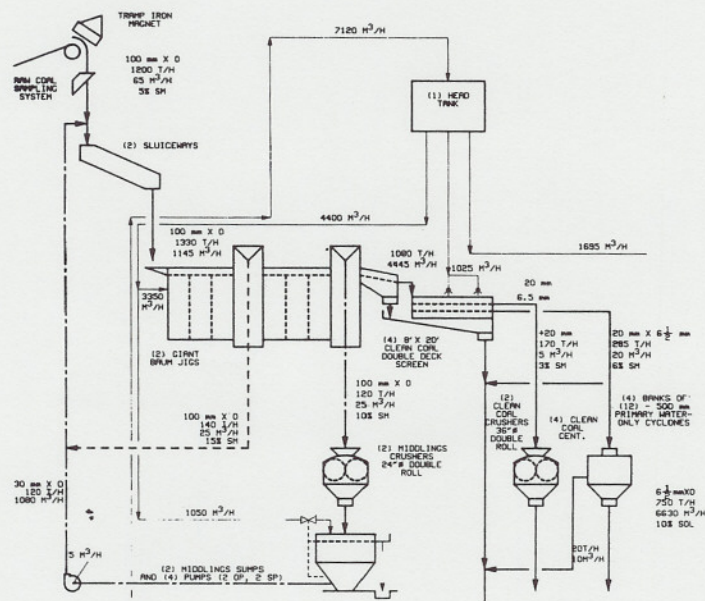


FIGURE 4
DENSE MEDIA
CYCLONE CIRCUIT

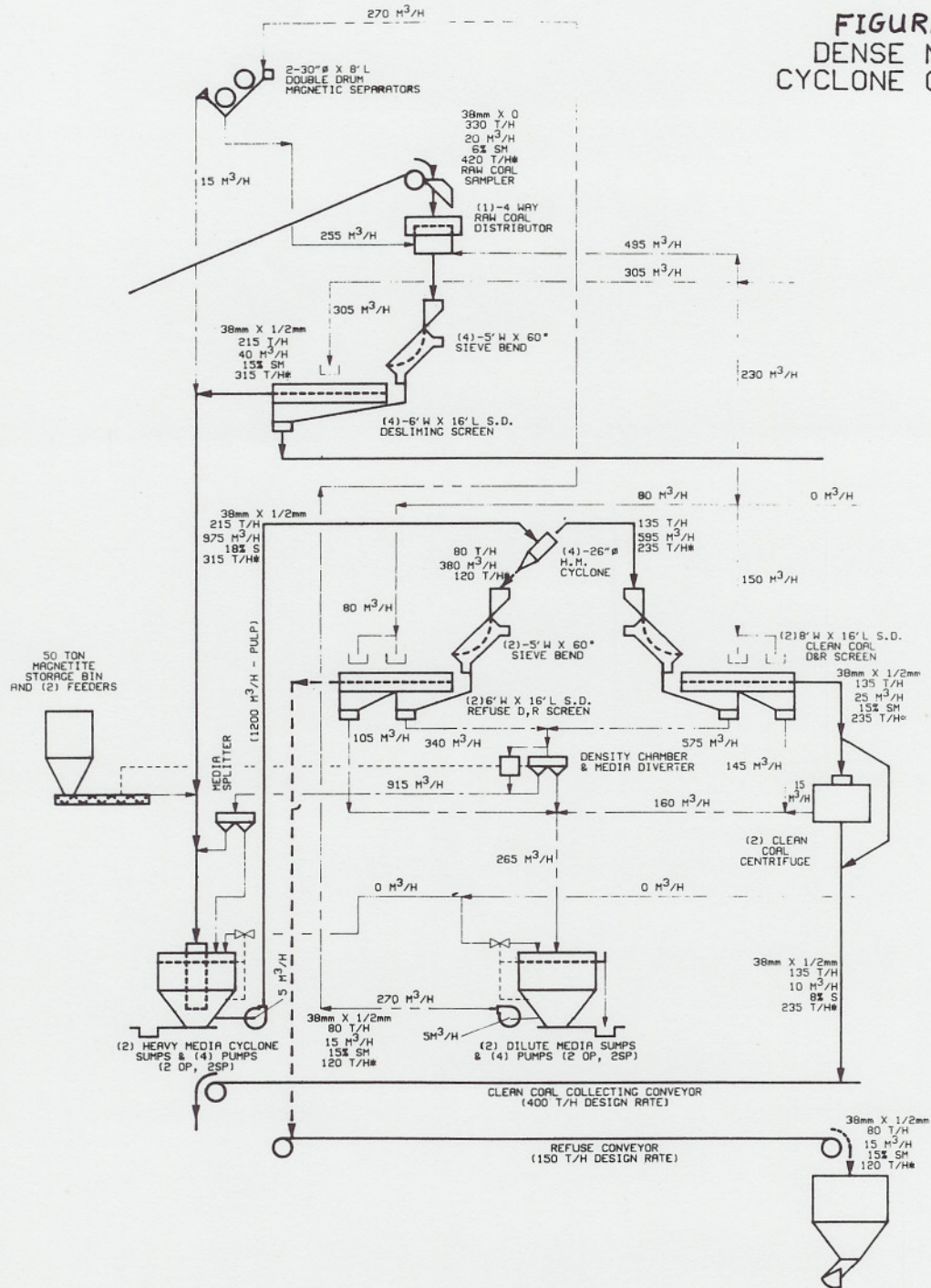


FIGURE 5
WATER-ONLY CYCLONE CIRCUIT

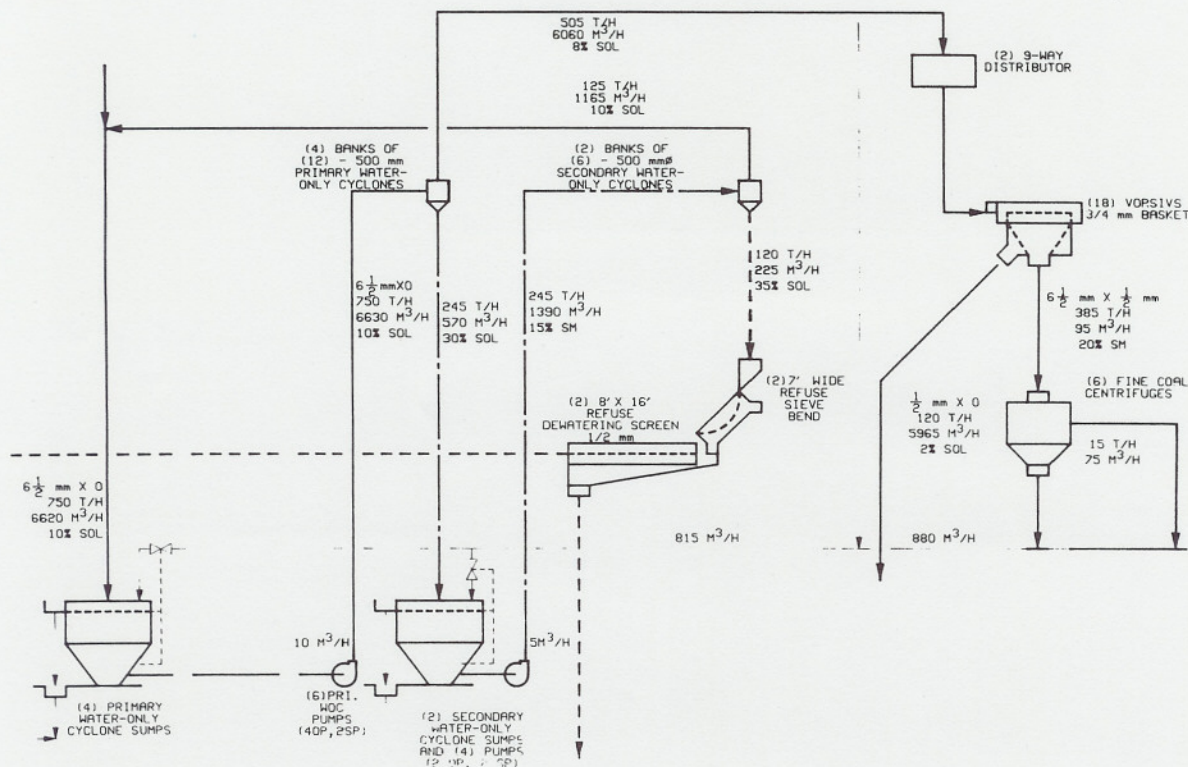
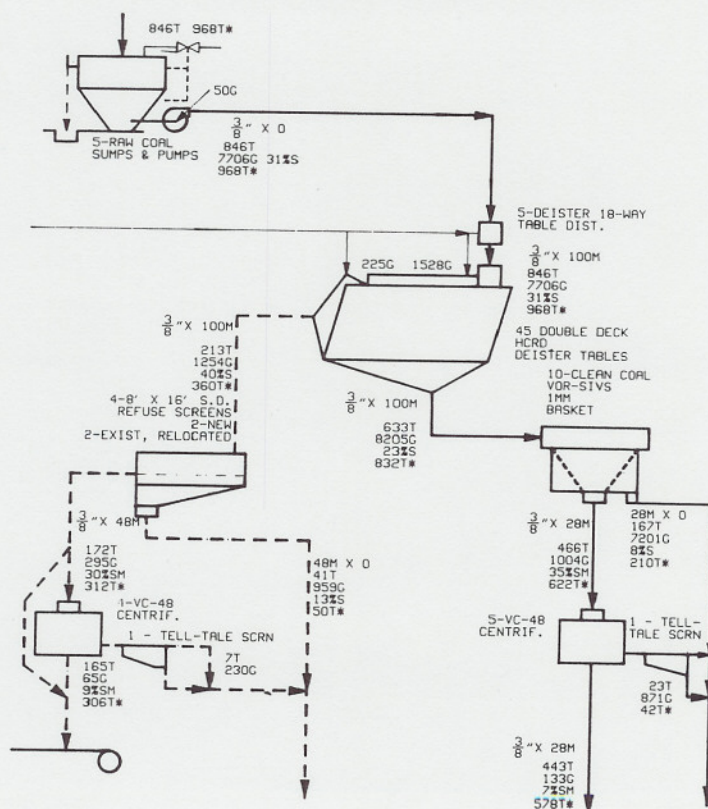
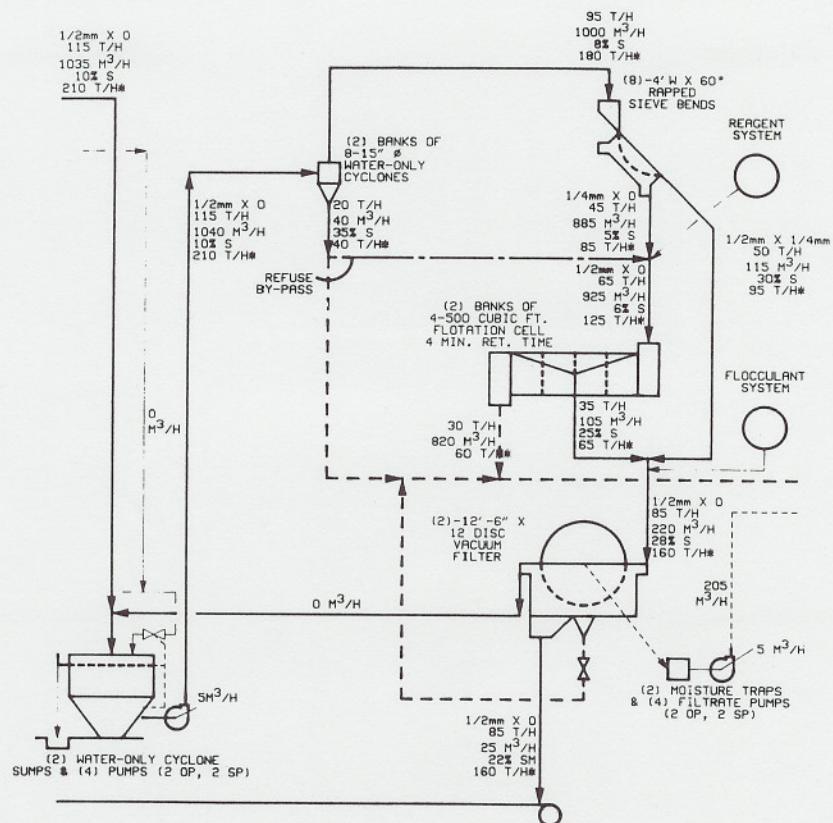


FIGURE 6
TABLE CIRCUIT



**FIGURE 7
FINE COAL
CIRCUIT**



**FIGURE 8
REFUSE CIRCUIT**

