REPORT TO THE STATE ELECTRICITY AUTHORITY

ICELAND

Concerning the Mývatn Diatomite Project

By John W. Kenney Jr.

June 30, 1964

During the week of June 15, Mr. Kenney reviewed the test reports and information available to Kaiser Engineers, concerning the development of a commercial diatomite filteraid operation based upon the deposit at Lake Mývatn in Northern Iceland.

From these reports and his experience, Mr. Kenney prepared flowsheets covering alternative methods of removing the non-diatomite impurities together with a complete flowsheet covering the conversion of the purified diatomite into several grades of commercial filteraids. Material balance studies for the several flowsheets were prepared. Design criteria were established and rough machinery and equipment sizing and specifications were prepared. A series of recommendations concerning testing and equipment selection were prepared.

Production of competitive flux calcined filteraids from crude ore containing 25% volcanic ash impurity is technically feasible.

This impurity can be removed by three methods :

1. Wet beneficiation of the ore prior to drying
2. Drying followed by three stages of air classification
3. Drying followed by two stages of mechanical separation

Fluxing can be accomplished using sodium chloride if the free chlorine and chlorine compounds formed during the reaction can be exhausted, and corrosion resistant equipment is provided. The gaseous reaction products sodium-carbonate or hydroxidefluxing are less corrosive and less noxious.

Wet beneficiationseems particularly adaptable to this project because of the high initial moisture content of the crude ore and the availability of dilution water. The chief objection would be the costs involved in transporting the dilution water (approx. 120,000 t/a in 1000 hours). The capital investment for equipment for this approach would eliminate alternate transport, and dry classification investments. Further advantages are evident :

1. A smaller drainage site is required.
2. Drying requirements are less.
3. Horsepower requirements are less than air classification and less than mechanical separation.
4. More efficient separation is probable.

1. Mr. Baldur Líndal took Mr. Lowell and Mr. Kenney to Lake Mývatn for the purposes of
   a) Observation of the location of the proposed mining area
   b) Observation of the mining conditions
   c) Inspection of the old slurry bed drained and exposed for several years
   d) Observation of the visual relationship of the mining area to the Town of Reykjahlíð
   e) The consideration of a possible plant site near the mining area in the lake.

2. The party observed additional plant and drainage sites, one enroute to the steam field and one in the steam field area.

3. The party proceeded to Húsavík to

   1) Inspect present road facilities
   2) Inspect the proposed warehouse site and the conditions to be encountered in transfering products from warehouse to ship.

ORE Quality.

The structural properties of the diatom fraction of the ore appear to be very good and this has been confirmed by laboratory tests. Neither the volcanic ash nor the organic impurities appear to be unamendable to removal by conventional methods as evidenced by laboratory testing.

When the Mývatn project is compared to commercial diatomite operations in the USA certain advantages and disadvantages can be noted. The ore is located closer to port facilities, the European market, and to excellent potential plant sites than the major USA producers. Drying fuel, in the form of geothermal steam, is quite reasonably priced. The ore has good quality ; it has not been displaced by shifting ; and the impurities can be removed by conventional methods. No overburden rests on the ore, and mining should recover the complete section.

The necessity for mining under water with no probable means of selective mining offers unique problems. Petroleum fuels for calcining are more expensive. It is believed that the advantages more than counter the disadvantages.

It is urged that American engineering and major equipment be used because of proven performance in the diatomite filteraid and similar fields.

Mining.

The actual digging of the crude Mývatn ore in place can be accomplished by suction dredging, by clamshell, shovel dredge or similar equipment. A drag line type operation seems applicable, also.

The best method at this time appears to be the suction dredge, perhaps if necessary in conjunction with a cutting head, or other suitable method to disturb the ore in place. USA experience on dry deposits has been that mining costs are high when small shovels are used to load conveyances. The suction dredge lends itself to advantageous means of transporting the ore to the plant site with an opportunity to beneficiate the ore with water and to transfer beneficiated ore to drainage areas, which become stock piles after suitable drain time.
These areas are near the plant site.

Ore Transport.

It is believed that the best method would be to convey the beneficiated ore to the plant site in slurry form through piping. In effect this would be a continuation of the suction dredge mining. USA experience indicates many economic problems would be eliminated ; although there is no good USA experience on diatomite using this method, and the economics must be established.

Plant Site.

Diatomaceous earth production facilities should not be located in close proximity to human habitation. Under normal operating conditions, the plant exhaust gases will consist of steam, dust, and various gaseous products formed during processing. The proposed fluxing agent is sodium chloride whose chlorine, a highly noxious gas, with herbicidal properties will be in the exhaust.

It is believed that Plant Site A and Plant Site B are sufficiently close to Reykjahlíð to be objectionable to the residents. Further it is believed that some local destruction of the beauty of the area would result from dust deposition and killing the flora. A plant, in either area, would probably drive the birds to other areas.

Plant Site C has fewer human and beauty objections but would require considerable proparation with no distinct advantages that are foreseeable at present.

Plant Site D appears most suitable because of its numerous advantages i.e. Corrosive and noxious gases are present from natural sources, and no vegetation can be hurt. The steam for heating is very close. Very little preparation for both drainage field and factory site is required. The area is now being used for commercial operations, which will undoubtedly multiply.

Volcanic Ash Removal.

Wet Method.

A limited laboratory observation, confirmed by observation of the old slurry bed formed several years ago, indicates that water classification is an effective means of removing ash. The combination of suction dredge mining, slurry transport and wet beneficiation of the ore appears to be extremely attractive for Lake Mývatn diatomite, and deserves testing to determine economic feasibility, and to provide separation efficiency data.

Mechanical Separation Method on Dried Ore.

USA experience has proven that this type equipment has been highly effective in removing volcanic ash and other solid impurities from diatomite. Such equipment has better operating and maintenance costs than air classification. It is believed that mechanical equipment will do the whole operation ; consequently, tests by a manufacturer along these lines would be highly desirable.

Drying.

Most USA practice has been to dry the material in a process where drying, conveying, milling, beneficiating, and particle size classification occur simultaneously in the lines, blowers, classifiers and collectors used in moving the material in heated air. A USA Company, Combustion Engineering, has a package - The Raymond Flashdrier - where milling, drying and classification are accomplished simultaneously. This company also markets the Raymond Whizzer, a mechanical separator. Tests on both the package system, which includes the Whizzer, and on the mechanical separator alone are recommended.

One US diatomite producer uses a rotary dryer on non-filteraid diatomite. This dryer was tested sucessfully on filteraid crudes not regularly available. Tests on this type dryer are recommended.

Actually no testing is required to establish the mechanical separator's efficiency. It is known to be good. Quotations for properly sized equipment will result.

Either flash drying or rotary drying is good. Should, economic considerations be equal, the rotary system appears best at this time.

Port Facilities.

The Warehouse Site is very well located in terms of distance from the loading dock. The elevation above the dock may, while causing certain problems, turn out to be advantageous because of possible use of gravitational forces. For lift-truck operations, however, a plant site at or near the dock elevation would be better. Actually no US producer is so ideally located.

Transport of the finished products to Húsavik.

Equipment

Packages, placed on pallets of suitable size to conform with truck size, should be loaded on flat bed trailers by means of forklifts. US practice is mostly 20 ton (or 800 bag shipments), sometimes on two trailers pulled by a diesel tractor.

Most tractors and trucks for these purposes are diesel powered.

All US trucking experience, confirmed by specific diatomite experience on both ore and finished product, has demonstrated that the equipment should be as BIG as possible.

Roads.

Road restrictions on equipment weight, height and size dictate the choice of trucks, which dictate the size of pallets, which dictate the size of the bags which dictate the design of materials handling and packaging equipment. Decisions are required to establish these design criteria. It is urged that the decision makers think BIG.

Road Quality should be the best possible at all times. The road to Husavik, as presently designed and maintained, would be quite expensive in terms of equipment maintenance and operating costs. The latter would also be adversely affected by the narrow width. It is recommended that the highest quality of roads and road maintenance be provided over the shortest distance possible.

Health Hazards.

The inhalation of dust from calcined and fluxed diatomite products can result in a disabling, sometimes fatal lung ailment called " Diatomaceous Earth Pneumoconiosis ", similar to but less severe than Silicosis. The United States Department of Public Health has studied this problem and has published information with a fairly complete bibliography of previous publications. It is recommended that Kísilidjan become familiar with this information.

The above information means that adequate dust control should be provided in both equipment and in operating practices.

Recommended testing program.

1. Wet beneficiation tests by Denver Equipment or by Dorr-Oliver or by others on wet crude approximately 80% moisture, for :

   a. Equipment size and design and cost, and delivery and operating costs.
   b. Return of heads and tails for testing.

2. Dry beneficiation tests by Combustion Engineering or by Sturdivant or by Gayco on dried and wet crude, for :

   a. Equipment size and design and cost and delivery and operating costs.
      1. For beneficiating dry crude
      2. For drying and beneficiating wet crude
   b. Return of heads and tails for testing

3. Drying tests by Vulcan or Hardinge or others for

   a. Equipment design and cost and size and delivery and operating costs.

   b. For return of drying data and samples of heads and tails

4. Laboratory testing on returned samples for

   a. Fluxing properties with ground flux
   Vary % Flux, calcining temp. calcining time
   5, 6, 7, 8 % 1600°F 1700°F 1800°F 10, 20, 30, 40, 50, 60 min.
   Abandon approach which causes heavy sintering or dark colors.
   Suggested start 0 Timesamples can be taken in small amts. as desired on any condition.

   b. Air classification tests on dried crude at flowsheet dust loadings and velocities <5000 ft/min
   For equipment size, design

   c. Milling tests on fluxed product

      1. By rollers
      2. By centrifugal Blowers at flow sheet loadings & vel.

   d. Cooling tests on fluxed product

   e. Classification tests on fluxed products previously milled

5. Chemical testing on fluxed, milled, classified products

   a. H_20 solubility 5 minutes boiling 20 g/180 ml.
   b. Acid solubility 1, 3 Sp. G. H_2SO_4 1 hr. 98°C 2 g/100 ml.
   c. Acid soluble Fe_20_3 on above filtrate colorimetric KSCH
   d. Arsenic. Gutzeit or equivalent

6. Physical testing

   a. Color
   b. Filtercake density 50 g/250 ml. distilled H_20 pulled dry (liquid free)
   c. Permeability test

COSTS

Constant	Variable
Plant Payroll	Ore
Salary Payroll	Power
Leases	Fuel
Taxes	Flux
Insurance	Maintenance
Laboratory	Packages
Phone, Postage, etc.	Royalties
Office expense	Transport
Samples	
Depreciation and interest	

Plant and Warehouse Manning

	Day	Swing	Nite	Totals
Operator	1	1	1	3
Packer	1	1	1	3
Packer	1	1	1	3
Lab director	1			1
Lab technician	1	1	1	3
Lab technician	1			1
Manager	1			1
Maintenance	3			3
Plant ware house	3			3
Dock ware house	3			3
Office	2			2
Totals	18	4	4	26

Design Criteria.

Gas velocities in piping 3200–5000 ft/min 4000 ft/min desired

cyclones — d= outlet = inlet length = d

outlet $\frac{d}{4}$ below inlet — 2d= diameter

4,5d= length

discharge opening $\geq$ 14 "

ΔP = 10 " H_2O

outlet velocity for high collection 2500 ft/min

outlet velocity for classification 3000–3500 ft/min

outlet velocity for trapping 5000 ft/min

Seal valves rotary, double flapper } less maintenance

Dust loading $\geq$ .012 lbs/ft^3 or higher for collection

$\leq$ .012 lbs/ft^3 for trapping

= .012 lbs/ft^3 for classification

Densities	dryer exhaust product	2,0 lbs/ft^3
bagged 17.5 lbs/ft^3	trap waste	20,0 –
	dryer discharge	10,0 –
	cyclone discharge	8,0 –
	finished products bin	10,0 –

Warehousing approx. 14.6 ft^2/ton (bags 20x8x40) 26 bags high 2 pallets high

height > 13.4´

approx. 9.3 ft^2/ton (bags 20x6x40) 39 bags high 3 pallets high

height > 20,0´

Elevation – bucket elevators

Products transfer – screws $\geq$ 9" – not drag type conveyors

belts okay – pan feeders okay for crude

Storage. Feed 24 hr supply. Product 16 hrs.

Laboratory Facilities.

A) Process Control and Research

1. Drying - oven
2. Milling
   a. Flux
   b. Dried ore
3. Classification equipment
4. Calcination equipment - electric muffle furnace

B) Chemical Testing

1. Volumetric
2. Gravimetric
3. Colorimetric
4. Electrolytic - conductivity bridge, pH meter

D) Physical Testing

1. Density
   a. Wet centrifuge   b. Dry boxes   c. Cake filter tube
2. Flowrate
   Vacuum source
   Compressed air
   Filters

E) Desk Space

Packaging

Bag Size

Dicalite and Eagle-Picher use 4000-4800 in^3, for 50 lb. bags. The bags are approximately 20 inches wide, 40 inches long, and 5 and/or 6 inches thick. Johns-Manville bags are larger in volume, more narrow in width (18 inches) and thicker (8 inches) and longer.

The bag size and dimensions are governed by several factors.

1. Packaged density approx. 17.5 lbs/ft^3
2. Pallet size
3. Weight desired = 50 lbs. recommended

Bag Construction

A. USA Domestic

1. Natural Kraft - 3 plies - 150 lbs. paper
2. Extensible Paper - 2 plies - 120-130 lbs. paper

B. USA Export

1. Natural Kraft - 5 plies - 220 lbs. paper
2. Extensible - 4 plies - 190 lbs. paper (changing rapidly)

Bag Type

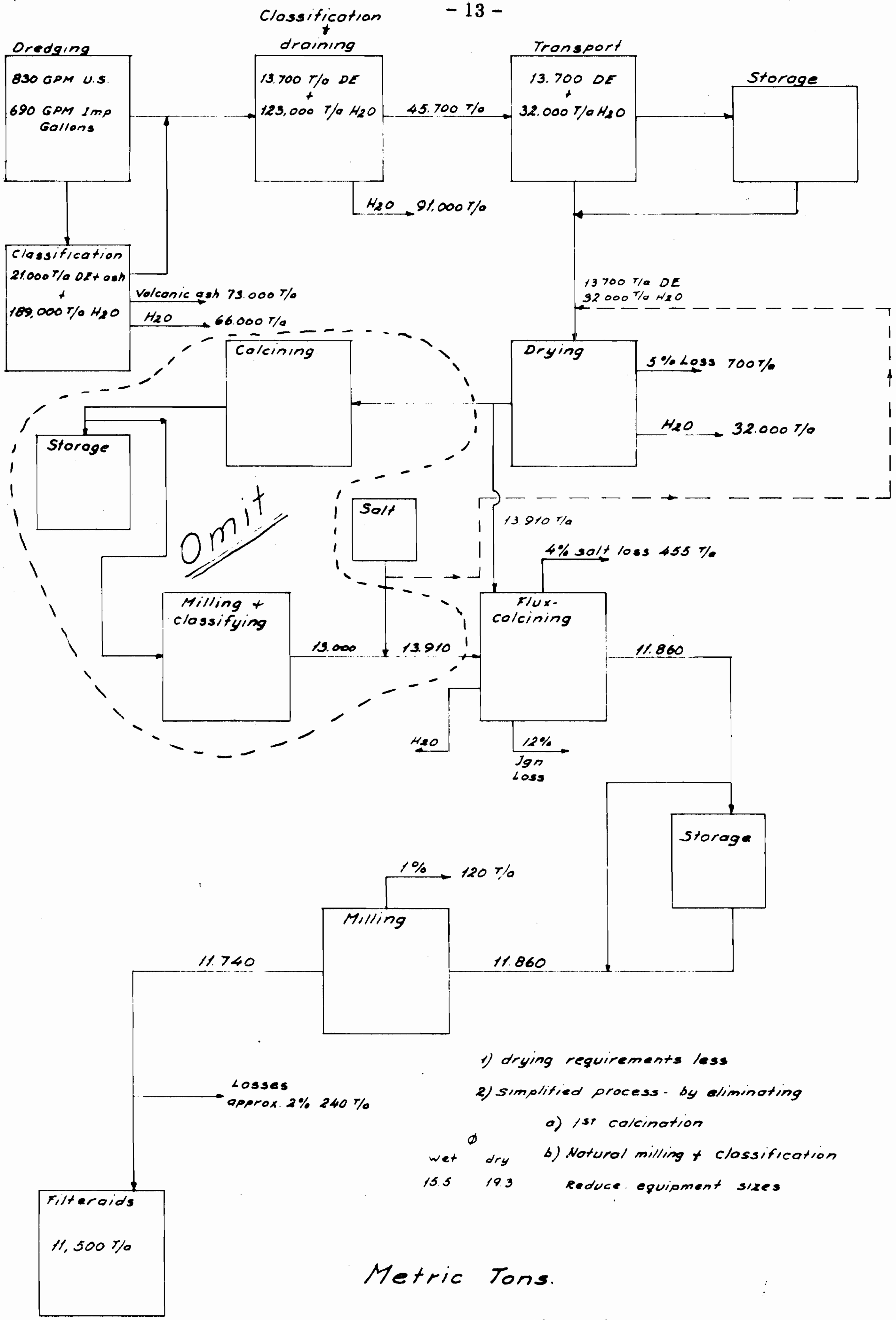
A. Tuck in sleeve chiefly

B. Self Sealing sleeve increasing

Packers

A. Fluo-Flow } These are the type recommended. Mechanical

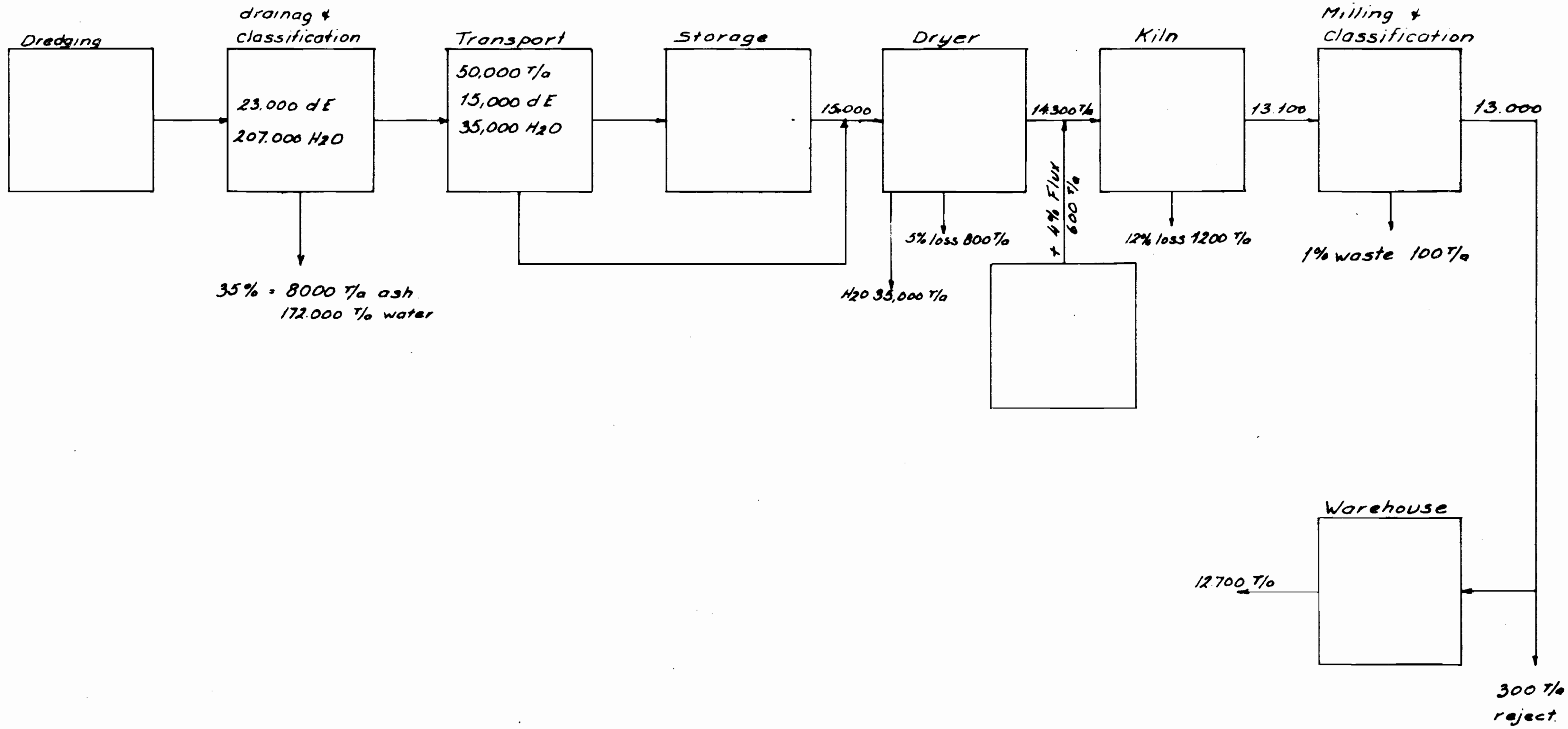
B. Force-Flow } filling is <u>not</u> recommended



Metric Tons.

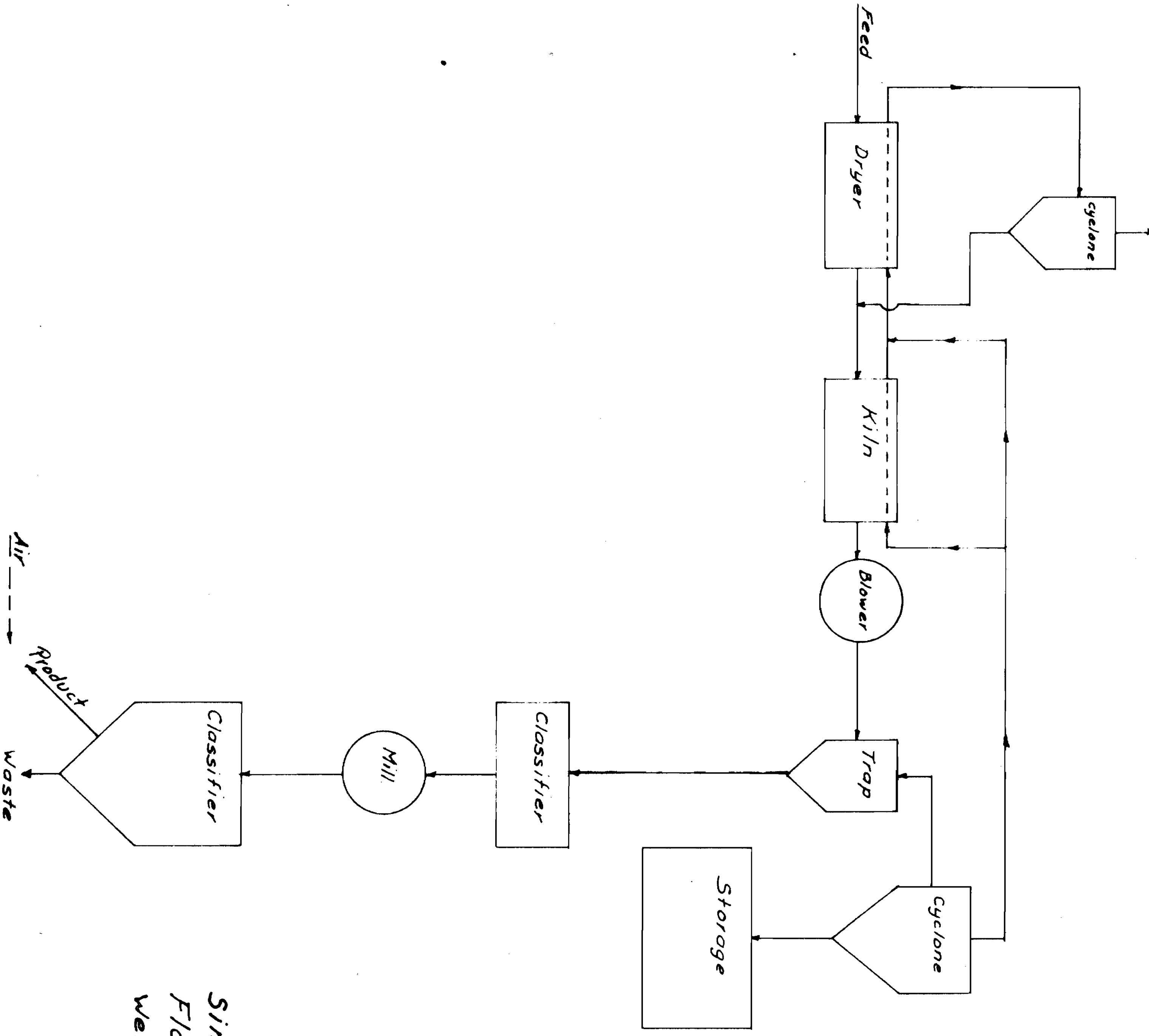
Modified TNO Flowsheet

JWK



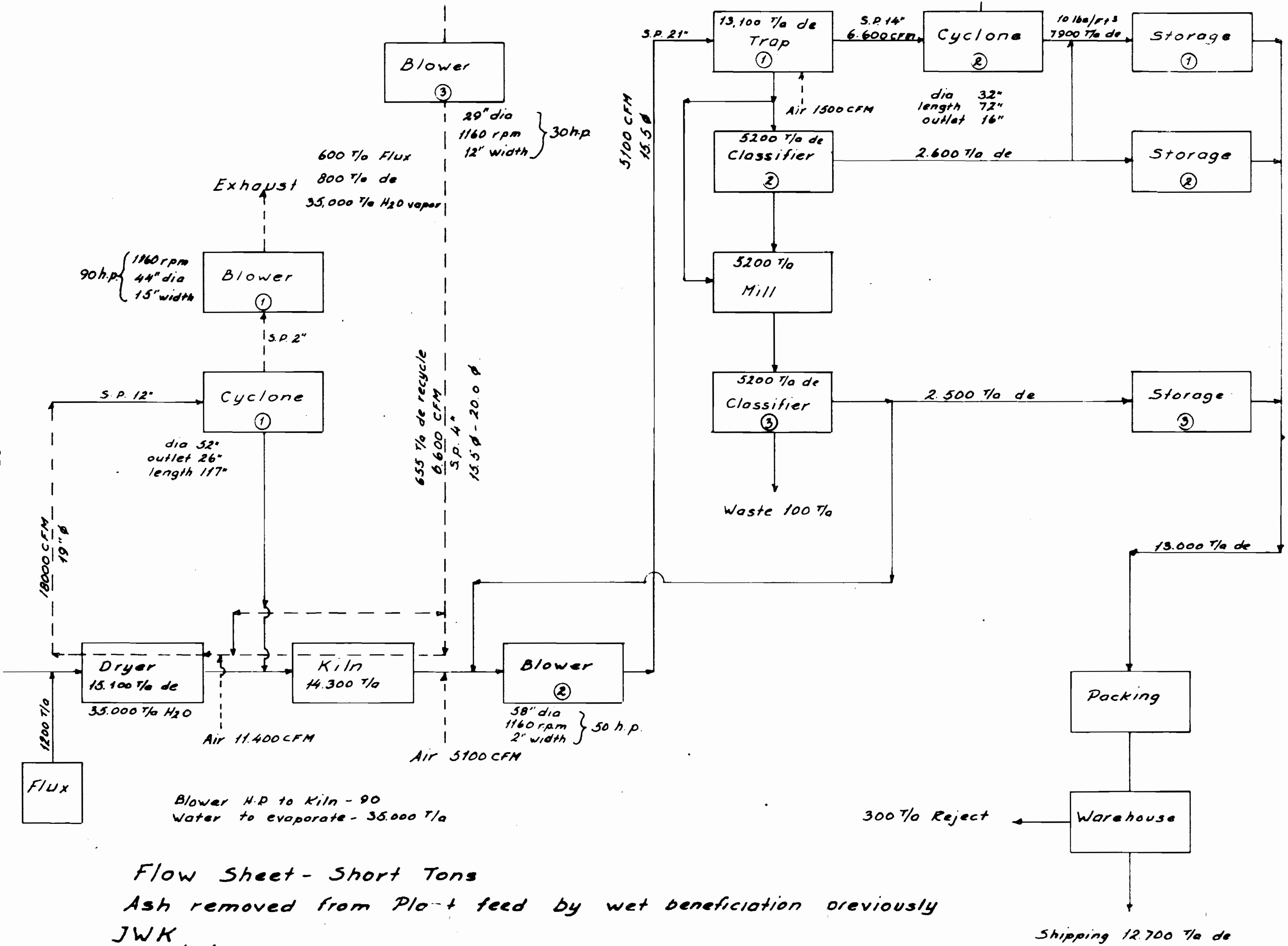
Wet Beneficiaton Method

Short Tons.



Simplified
Flow Sheet for
Wet Classified Feed

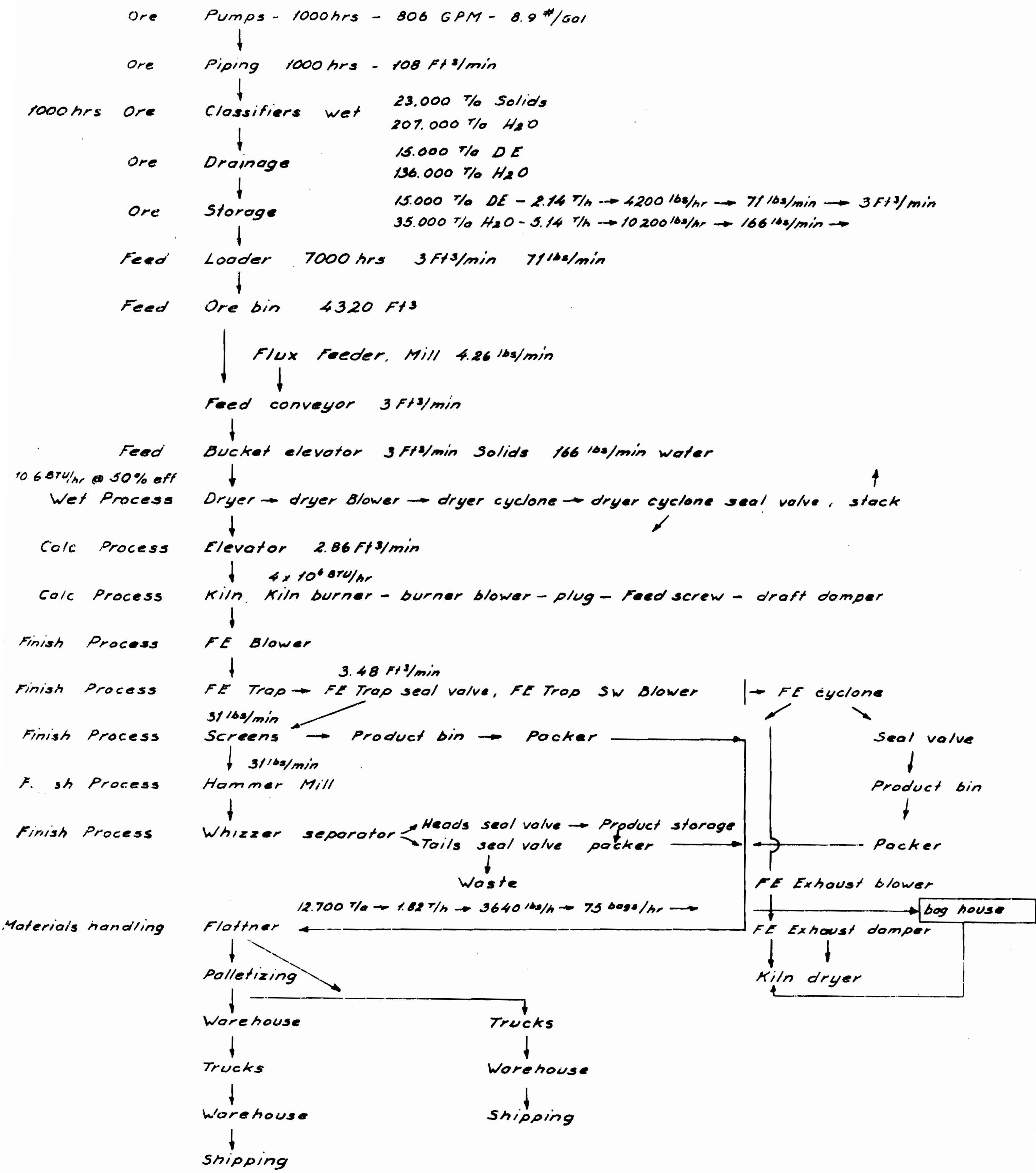
JWK
6/16/64



Flow Sheet - Short Tons

Ash removed from Pla-t feed by wet beneficiation previously

JWK
6/17/64



Ore Pumps - 1000 hrs - 806 GPM - 8.9 #/Gal
Ore Piping 1000 hrs - 108 Ft³/min
1000 hrs Ore Classifiers wet
23.000 T/a Solids
207.000 T/a H₂O
Ore Drainage
15.000 T/a DE
136.000 T/a H₂O
Ore Storage
15.000 T/a DE - 2.14 T/h → 4200 lbs/hr → 71 lbs/min → 3 Ft³/min
35.000 T/a H₂O - 5.14 T/h → 10 200 lbs/hr → 166 lbs/min →
Feed Loader 7000 hrs 3 Ft³/min 71 lbs/min
Feed Ore bin 4320 Ft³
Flux Feeder, Mill 4.26 lbs/min
Feed conveyor 3 Ft³/min
Feed Bucket elevator 3 Ft³/min Solids 166 lbs/min water
10.6 BTU/hr @ 50% eff
Wet Process Dryer → dryer Blower → dryer cyclone → dryer cyclone seal valve, stack
Calc Process Elevator 2.86 Ft³/min
4 x 10⁶ BTU/hr
Calc Process Kiln, Kiln burner - burner blower - plug - Feed screw - draft damper
Finish Process FE Blower
3.48 Ft³/min
Finish Process FE Trap → FE Trap seal valve, FE Trap Sw Blower
→ FE cyclone
31 lbs/min
Finish Process Screens → Product bin → Packer
Seal valve
31 lbs/min
F. sh Process Hammer Mill
Product bin
Finish Process Whizzer separator
Heads seal valve → Product storage
Tails seal valve packer
Packer
Waste
FE Exhaust blower
12.700 T/a → 1.82 T/h → 3640 lbs/h → 75 bags/hr →
bag house
Materials handling Flattner
FE Exhaust damper
Palletizing
Kiln dryer
Warehouse
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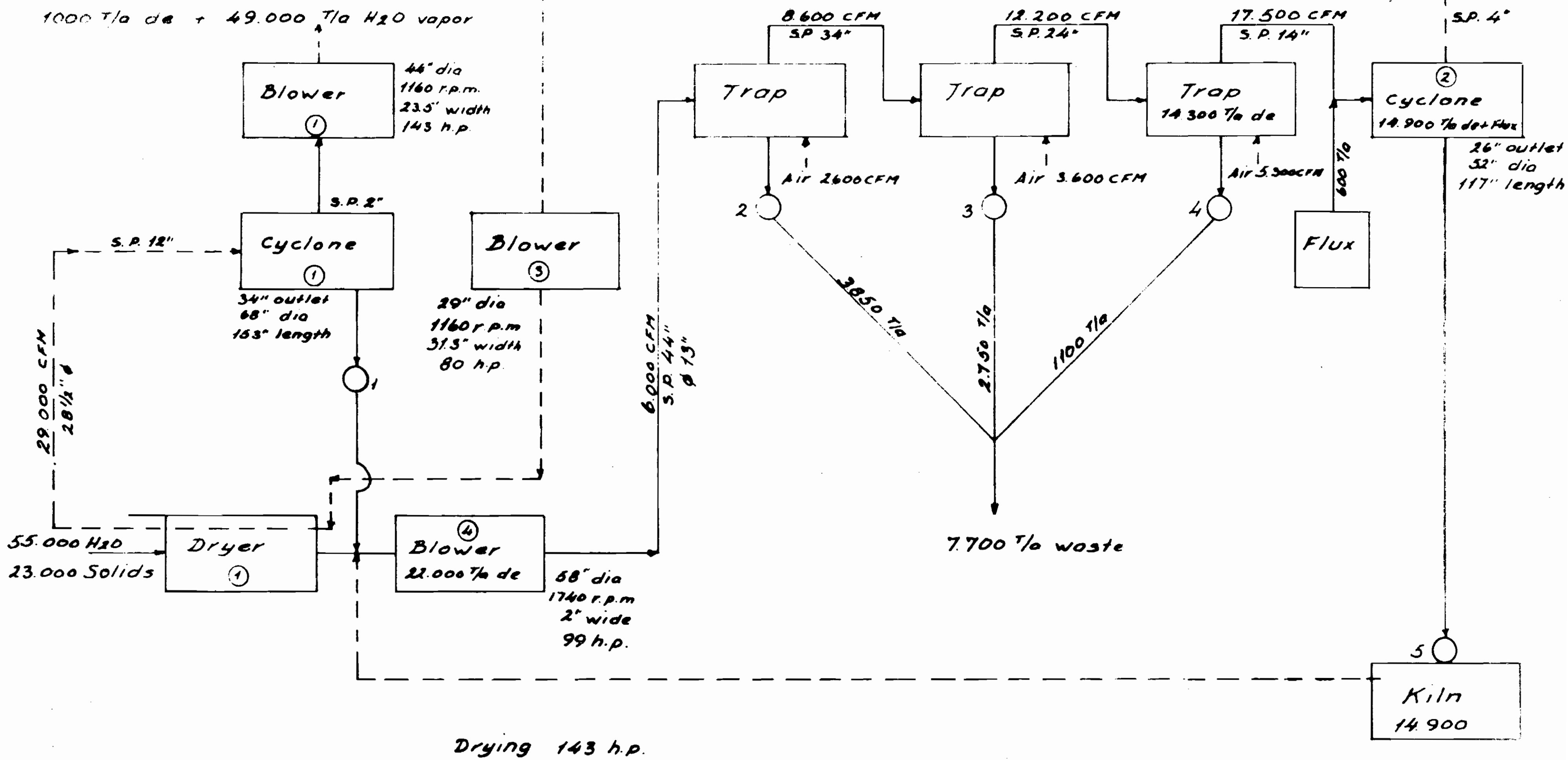
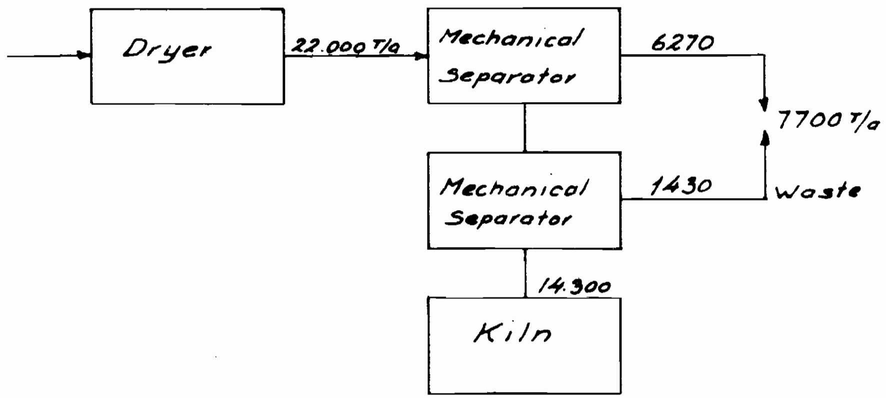


Blower h.p. to Kiln 322 Drying 143 h.p.
Classifying 179 h.p.

Water 55 000 T/a

Flow Sheet to Kiln - Short Tons
Ash removal by air Classification.

J W K.
6/17/64.

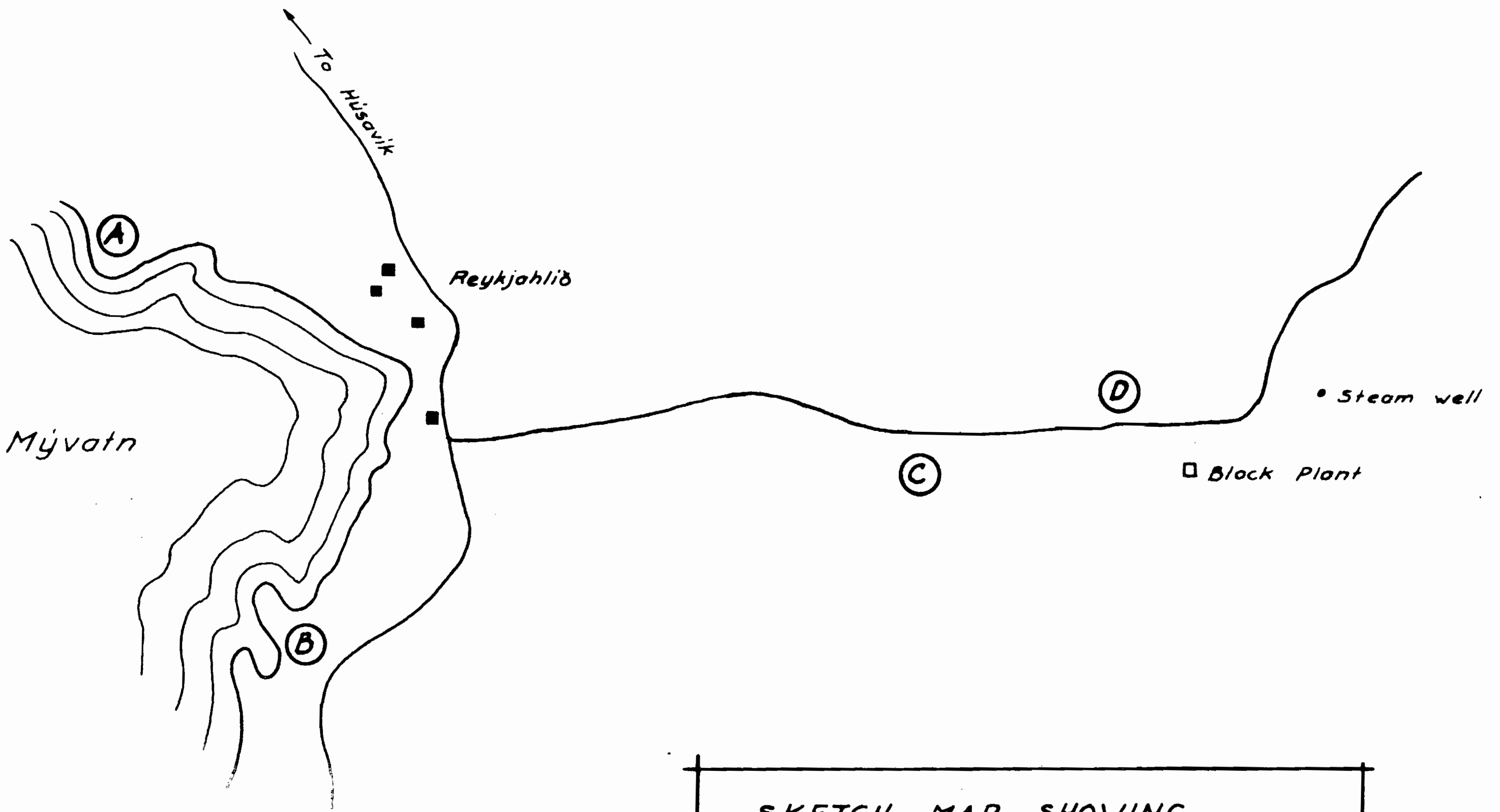


Assuming 25% ash
93% efficiency.

Drying 143 h.p.
Classific 60 h.p. } 203 h.p.

Flow Sheet to Kiln Short Tons
Ash removal by Mechanical Separation

JWK.
6/17/64



SKETCH MAP SHOWING
POTENTIAL PLANT- SITE AREAS

No scale

RAL 30/6/64

TYPICAL LETTER TO DORR OLIVER AND DENVER EQUIPMENT.

Gentlemen,

We are considering constructing a diatomite plant in Iceland. The ore, which is under water, contains coarse volcanic ash impurities which must be removed. We are considering mining by use of a suction dredge and pumping the slurry to a drainage area near the plant site.

Because the ore will be in slurry form and ample dilution water is available, we would like to investigate the possibility of removing the volcanic ash impurity by means of water classification prior to transfer to the drainage area.

We understand that you maintain testing facilities for analyzing problems of this nature. We further understand that you supply industrial equipment which is engineered by utilizing the laboratory data.

Will you please advise if you are in a position to test our material. Also please advise the amount of sample required together with all pertinent information that you need to provide quotations, operating cost estimates and delivery time on industrial equipment to accomplish our objectives.

We are also interested in dewatering the slurry. If the scope of your organization includes this activity, this should also be included.

TYPICAL LETTER TO VULCAN AND HARDINGE.

Gentlemen,

We are considering constructing a diatomite plant in Iceland. The ore contains considerable moisture which must be removed.

We understand that you maintain testing facilities for analyzing problems of this nature. We further understand that you can supply industrial equipment which is engineered by utilizing the laboratory data.

Will you please advise the amount of testing material you require, together with all pertinent information you need, to submit quotations, operating cost estimates, and anticipated delivery schedules on industrial equipment to accomplish our objectives ?

We are also interested in dewatering a slurry. If the scope of your organization covers this activity, this should also be included.

TYPICAL LETTER TO BIRD AND DE LAVAL.

Gentlemen,

We are considering constructing a diatomite plant in Iceland. We are considering mining by use of a suction dredge and then pumping a slurry to a drainage area near the plant site. We wish to dewater the slurry prior to transfer to the drainage area.

We understand that you maintain testing facilities for analyzing problems of this nature. We further understand you can supply industrial equipment which is engineered by utilizing the laboratory data.

Will you please advise the amount of testing material you need, plus all additional information needed, for you to submit quotations, operating cost estimates, and anticipated delivery schedules on industrial equipment to accomplish our objectives.

We are also interested in separating a coarse volcanic ash impurity from the diatomite portion of the slurry. If the scope of your organization covers such activity, this, also, should be included.

TYPICAL LETTER TO COMBUSTION ENGINEERING

Gentlemen,

We are considering constructing a diatomite plant in Iceland. The ore contains considerable water along with coarse volcanic ash both of which must be removed.

We understand that you maintain testing facilities for analyzing problems of this nature. We further understand that you can supply industrial equipment which is engineered by utilizing the laboratory data.

Will you please advise the amount of sample required, together with all pertinent information that you need to provide quotations, operating cost estimates and anticipated delivery schedules on industrial equipment to accomplish our objectives ?

We are also interested in dewatering a slurry. If the scope of your organization includes this activity this should also be included.