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USE OF FINES AND SUBCOMMERCIAL (60 - 65 BPL) WET ROCK PHOSPHATE

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Indo Jordan Chemicals Company Ltd (IJC), profitant au maximum de la situation de ses usines à proximité des mines de phosphate, ont commencé à employer les fines de séchoir et le phosphate humide (60-65 PL) sous-commercial en mélange avec du minerai commercial (70-72 BPL) dans le but de réduire les coûts variables de production.

L'exposé s'étend sur l'expérience opérationelle avec les fines et le phosphate brut humide sous-commercial dans un atelier d'acide phosphorique à l'hémihydrate à un seul étage, en particulier sous les points suivants.

- Spécifications des différents phosphates traités
- Considérations théoriques sur l'impact du mélange de Programme C et Programme D
- Expérience opérationnelle avec mélange de programme (B + C)
- Expérience opérationnelle avec mélange de programme (B + C + D)
- Impact sur la performance de l'atelier : production, rendement en P_2O_5, consommation spécifique et facteur de marche

L'exposé conclut en indiquant que la performance globale de l'atelier s'est notablement améliorée en raison du prix attrayant des fines et du phosphate humide sous-commercial sans nuire au fonctionnement normal de l'atelier d'acide phosphorique.

Indo-Jordan Chemicals Co-Ltd (IJC) taking the fullest advantage of its plants being located very close to the rock phosphate mines, started using the dryer fines and subcommercial (60 - 65 *BPL*) wet rock as blend with commercial grade (70 - 72 *BPL*) wet rock phosphate, with the objective of minimising the variable cost of production.

This paper highlights the operating experience with fines and subcommercial wet rock in single stage Hemihydrate phosphoric acid plant, with special reference to the following topics.

- Specification of different Rock phosphates processed.
- Theoritical considerations on Impact of Blending of Schedule - C and Schedule - D.
- Operating experience with blend of Schedule (B + C).
- Operating experience with blend of Schedule (B + C + D).
- Impact on plant performance - Production, P2O5 recovery, specific consumption and Onstream factor.

The paper concludes by saying that the overall plant performance has improved substantially due to the attractive pricing of fines and subcommercial wet rock phosphate, without jeopardising the normal operation of phosphoric acid plant.

PREAMBLE

Indo Jordan Chemicals Company Ltd. (IJC), a joint venture company promoted by Southern Petrochemical Industries Corporation Ltd. (SPIC)- India, Jordan Phosphate Mines Co. Ltd. (JPMC), and The Arab Investment Company SAA (TAIC) - Saudi Arabia, has established a Phosphoric Acid Complex in the Special Industrial Free Zone in Eshidiya, Jordan.

The Phosphoric acid complex consists of a 2,000 MTPD sulphuric acid plant, based on Monsanto's Double Conversion and Double Absorption process, a 700 MTPD P2O5 phosphoric acid plant based on Hydro Agri's single stage hemihydrate process, and associated utilities and offsites.

IJC commissioned its plants early 1997 and crossed 100% capacity utilisation of its plants for the second year in succession during 1999.

Considering that IJC's phosphoric acid complex is located very close to the phosphate mines, phosphoric acid plant has been designed to accept wide range of phosphate rock feeds.

- Commercial 73 - 75 BPL Dry rock phosphate (Schedule - A).
- Commercial 70 - 72 BPL Wet rock phosphate containing 14 - 18% free moisture (Schedule - B).

- 70 - 72 BPL Dryer fines, as blend (Schedule - C).
- Subcommercial 60 - 65 BPL WeT Rock Phosphate containing 14 - 18 % free moisture, as blend (Schedule - D).

This paper describes the operating experience with use of Schedule 'C' and 'D' rocks as blend with Schedule 'B' rock with specific reference to the following.

- Specification of different rock phosphates processed.
- Operating experience with blend of Schedule (B + C).
- Operating experience with blend of Schedule (B + C + D).
- Impact on plant performance - production, P2O5 recovery, specific consumption and onstream factor.

SPECIFICATION OF DIFFERENT ROCK PHOSPHATES PROCESSED

❉ Commercial 70 - 72 BPL Wet Rock Phosphate (Schedule - B)

This is a wet beneficiated product, which is of commercial grade having 14 ~ 18% free moisture. Since commissioning, PA plant has been operating on this grade of rock phosphate from two different sources viz, Eshidiya and Abiad mines.

Dryer Fines (Schedule - C)

Dryer fines are essentially the fine fraction separated from the commercial 70 - 72 BPL dry rock phosphate before export. The fines from two different sources viz, Eshidiya and Abiad mines are being processed.

❉ **Subcommercial 60 - 65 BPL Wet Rock Phosphate (Schedule - D)**

1 - 2 mm size fraction, which is low in P2O5 and high in silica, is separated as byproduct in flotation line for upgrading the rock phosphate ore. The subcommercial rock phosphate from Eshidiya mines is being processed .

The specification and the typical analysis of Schedule B (two sources), Schedule C (two sources) and Schedule D , as received , are furnished in Exhibit – 1.

❉ **Comparison of Specification of Different Rock Phosphates**

From the typical analysis of the rock phosphates (refer Exhibit – 1) , the ratios for the three grades of rock phosphate are calculated and indicated below.

Sl. No.	Description	Schedule – B		Schedule – C		Schedule -D
		Source 1	Source 2	Source 1	Source 2	
1.	P_2O_5 (%dry)	33.52	32.58	28.75	30.52	29.07
2.	CaO / P_2O_5	1.537	1.476	1.534	1.496	1.444
3.	F / SiO_2	2.437	0.541	0.335	0.389	0.197
4.	R_2O_3 / P_2O_5	0.008	0.010	0.030	0.057	0.030
5.	R_2O / P_2O_5	0.019	0.017	0.017	0.015	0.016
6.	F / P_2O_5	0.103	0.108	0.121	0.127	0.123
7.	CO_2 / F	0.149	0.122	0.223	0.117	0.111

Note : Source 1 – Abiad mines ; Source 2 – Eshidiya mines

The following table summarises the comparision on size distribution of the three grades of rock phosphate.

Sl. No.	Aperture (mm)	Schedule – B		Schedule – C		Schedule - D
		Source 1	Source 2	Source 1	Source 2	
1.	6.000	100.0	100.0	100.0	100.0	99.7
2.	4.000	99.7	99.2	100.0	100.0	97.8
3.	0.500	73.3	79.6	99.7	100.0	8.0
4.	0.212	46.8	30.5	98.4	99.6	1.4

Note : Percent passing .

THEORETICAL CONSIDERATIONS ON IMPACT OF BLENDING OF

SCHEDULE - C AND SCHEDULE - D

The theoretical impact of blending of dryer fines (Schedule - C) and subcommercial wet rock (Schedule - D) is reviewed by comparing the chemical characteristics, the particle size distribution and the physical characteristics of blended rocks with that of plant design basis as well as commercial wet rock phosphate (Schedule - B).

❉ Chemical Characteristics

The typical analyses of different combination of blends of Schedule - C and Schedule 'D', at maximum blending ratio with Schedule 'B' from two different sources, processed in IJC's PA Plant are tabulated in Exhibit - 2.

Based on the above analyses, the ratios for different blended rocks are calculated and brought out in Exhibit - 3 and the highlights are summarised below.

Sl No	Description	Plant Design Basis	Schedule (B)	Schedule (B + C)	Schedule (B + C + D)
1.	P_2O_5 (% dry)	32.00 - 33.00	32.58 - 33.52	31.78 – 32.89	31.41-32.42
2.	CaO / P_2O_5	1.580	1.476 - 1.537	1.480 – 1.536	1.477 - 1.528
3.	F / SiO_2	0.617	0.541 - 2.437	0.480 – 1.103	0.412 - 0.716
4.	R_2O_3 / P_2O_5	0.025	0.008 - 0.010	0.012 - 0.019	0.014 - 0.021
5.	R_2O / P_2O_5	0.017	0.017 - 0.019	0.017 - 0.019	0.017 - 0.019
6.	F / P_2O_5	0.114	0.103 - 0.108	0.106 - 0.112	0.108 - 0.114
7.	CO_2 / P_2O_5	0.169	0.122 - 0.149	0.121 - 0.163	0.12 - 0.16

From the above table, it is imperative that the blended rocks are chemically equivalent to commercial wet rock phosphate.

❉ Particle size distribution :

The size distribution diagram for different blended rocks is attached as Exhibit - 4.

The particle size distribution of the blended rocks is compared with that of plant design basis in the following table.

Sl. No	*Aperture (mm)*	*Plant Design Basis*	*Schedule (B)*	*Schedule (B + C)*	*Schedule (B + C + D)*
1.	***6.000***	***100***	***100***	***100***	***100***
2.	***4.000***	***100***	***99.2 - 99.7***	***99.4 - 99.8***	***99.2 - 99.6***
3.	***0.500***	***78***	***73.3 - 79.6***	***78.8 - 83.9***	***72.0 - 76.4***
4.	***0.212***	***32***	***30.5 - 46.8***	***44.8 - 57.9***	***41.7 - 53.1***

Note : Percent passing .

From the size distribution (refer Exhibit - 2),the Particle Mean Diameter for different blends of rock phosphate is calculated and summarised below.

Description	*Schedule (B)*	*Schedule (B + C)*	*Schedule (B + C + D)*
Particle Mean Diameter (mm)	***0.438-0.466***	***0.359-0.387***	***0.463-0.488***

It can be inferred from the above that the particle size distribution of the blended rocks is close to that of commercial wet rock phosphate Schedule.

❉ **Physical Characterstics / Reactivity Index :**

An attempt has been made to identify the physical characterstics viz, SSA, Permeability, Porosity of the rock phosphates processed (including loboratory prepared blended rocks) using the available in-house laboratory facilities.

Relative Reactivity index of the blended rocks (on 0 - 6 scale) has been arrived at, based on physical characterstics, mean particle diameter of the size distribution and common ratios – F/P_2O_5 and CO_2 / P_2O_5. The data is furnished in Exhibit - 5 and the highlights are :

Rock Phosphate	*Reactivity Index*
Schedule (B)	*4.0-4.7*
Schedule (B + C)	*4.3-4.5*
Schedule (B + C + D)	*4.2-4.6*

Since the Reactivity Indices for the blended rocks - Schedule (B+C) and Schedule (B+C+D) are within the range of the Reactivity Index for Schedule'B', the blended rocks are expected to behave similar to Schedule 'B' during reaction.

In summary, though it may not be recommended to process Schedule 'C' and 'D' rocks on independent basis (without blending) due to their narrow banded size distribution (eventhough chemical composition is acceptable), when these rocks are blended with commercial grade rock phosphate, the blended rock is suitable for processing in Hemi plant since the narrow banded size distribution of Schedule 'C' and 'D' rocks, up to

blending ratios of 25.0% and 15.0% respectively, gets favorably shifted towards normal size distribution.

OPERATING EXPERIENCE WITH BLEND OF SCHEDULE (B + C)

Schedule 'C' is being used since March 1998, with Schedule 'B' as blend at different blending ratios up to 21% at 120% plant load.

A comparative statement on the typical operating parameters of hemihydrate plant operation with Schedule 'B' alone and Schedule (B + C) is enclosed as Exhibit - 6.

The observations made during the plant operation with Schedule (B + C) are highlighted below .

- Fine rock got well mixed with commercial wet rock phosphate, which contains 14 - 18% free moisture, before being fed to the reactor, since it was introduced two belt conveyors and two transfer chutes ahead of reactors.

- No physical carry over / floating of fines along with slurry from the first reactor to second reactor was noticed due to underflow arrangement from first reactor to second reactor.

- Foaming in reactors was relatively high while processing Schedule B or Schedule (B+C) from source 1 (Abiad mines) compared to Schedule B or Schedule (B+C) from source 2 (Eshidiya mines).

- All plant parameters were maintained within the normal range of operation except reaction temperatures and recirculation slurry flow, which were reduced marginally.

- Rock phosphate was found sticking to the conveyor belt, which was minimised by installation of improved belt scappers.

- Dust evolution at the point of entry of Schedule 'C' to the conveyor belt was noticed.

- No appreciable change in scaling tendency was noticed and cycle time for the filter remained unchanged.

In summary, plant operation with a blend of commercial wet rock phosphate (Schedule -B) and dryer fines (Schedule -C) is as good as that of commercial wet rock phosphate (Schedule - B) alone.

OPERATING EXPERIENCE WITH BLEND OF SCHEDULE (B + C+ D)

Schedule 'D' is being used since November 1998 as blend (at different blending ratios up to 10.5% at 120% plant load) with Schedule 'C' (up to 21% blending ratio) and Schedule 'B' (balance).

A comparative statement on the typical operating parameters of hemihydrate plant operation with Schedule 'B' alone and Schedule (B + C + D) is also enclosed as Exhibit - 6.

The observations made during the plant operation with Schedule (B + C + D) are summarised below.

❉ **Rock Handling System**

- Thorough mixing of three rocks was noticed before entering the reaction system.
- No problems were experienced in respect of flowability and handling of rock phosphate.
- Dust evoluation at the point of feeding of Schedule 'C' to the conveyor belt was noted.

❉ **Reaction System**

- Reaction temperatures were marginally reduced.
- The solids content in the slurry was increased by 1% to handle additional quantity of solids generated on account of low grade rock blending.
- All other reaction parameters were maintained within normal range.
- No appreciable silica scaling was noticed inside the reactor walls and floor. Only coarse unreacted / partly reacted particles from rock feed got accumulated at the bottom of the reactor.

❉ **Filtration System**

- Wash flows were optimised to maintain 1% higher solid content in reactor slurry.
- Other filter parameters were maintained within normal range.
- No appreciable increase in scaling of the filter circuit was noticed.
- Filter cycle time was unaffected.

❉ **Flash Cooler System**

- Marginal increase in scaling inside the flash cooler and slurry inlet / outlet ducts was noticed.

❉ **Gas Scrubbing System**

- There was slight increase in whitish silica deposits in the scrubbers and vapour ducts.

❉ **Concentration System**

- No increase in scaling in heat exchanger was noticed.
- The cycle time remained unchanged.

❉ **Cooling water System**

- 1 - 2 mm silica deposits were observed in cooling water basins and trenches.

❉ **Quality of 54% P_2O_5 Acid**

- There is no apparent change in the quality of 54% product acid.

In summary, the plant operation with a blend of commercial wet rock phosphate (Schedule – B), dryer fines (Schedule - C) and subcommercial wet rock phosphate (Schedule – D) is as good as that of commercial wet rock phosphate (Schedule - B) alone.

IMPACT ON PLANT PERFORMANCE

The overall plant performance while blends of dryer fines as well as dryer fines + subcommercial wet rock are used, is as good as that while commercial (70 - 72) wet rock phosphate alone is used. The comparative figures on Production, P2O5 recovery, specific consumption of raw materials and onstream factor are indicated below.

Production **:**

Schedule B	***Schedule (B + C)***	***Schedule (B + C + D)***
820 - 840 MT P2O5/day	*820 - 840 MT P2O5 / day*	*820 - 840 MT P2O5/day*

P2O5 Recovery (based on filter cake) **:**

Schedule B	***Schedule (B + C)***	***Schedule (B + C + D)***
92 - 93 %	*92 - 93 %*	*91.5 - 92.5 %*

Specific Consumption of Rock Phosphate **:**

Schedule B	***Schedule (B + C)***	***Schedule (B + C + D)***
3.40 - 3.45 MT/MT P2O5	*3.46 - 3.50 MT/MT P2O5*	*3.50 - 3.55 MT/MT P2O5*

Specific Consumption of Sulphuric Acid (as 100 % H2SO4) **:**

Schedule B	***Schedule (B + C)***	***Schedule (B + C + D)***
2.80 – 3.05 MT/MTP2O5	*2.90 - 3.05 MT/MTP2O5*	*2.90 - 3.00 MT/MTP2O5*

The specific consumption of rock phosphate is marginally higher when blended rocks are used due to low P2O5 content in rock, however, interms of input cost, there is substantial advantage to process the blended rocks, since the cost of dryer fines is approximately half the cost of commercial wet rock, while the cost of subcommercial wet rock is one third the cost of commercial wet rock.

Onsteam Factor

The onstream factor for PA plant during 1998, 1999 & 2000 (Jan - March) is enclosed as Exhibit 7. From this, it is clear that the onstream factor has not been affected by the use of blended rocks, though the blending ratios were not constant throughout the above period.

CONCLUSION

As envisaged at the conceptal stage of the project, IJC has been successfully operating its PA plant using dryer fines (Schedule - C) and 60 - 65 BPL subcommercial wet rock phosphate (Schedule - D), up to 21 % and 10.5 % blending ratios respectively, as blend with 70 - 72 BPL wet rock phosphate (Schedule – B), considering the attractive pricing of these two grades of rock phosphate as well as the proximity of its plant to the operating phosphate mines.

IJC's experience indicates that processing of byproducts from phosphate mines, which are otherwise nonsaleable, in hemi phosphoric acid plant by suitable blending with conventional rock phosphate and fine tuning of the operating parameters as required, is not only technically feasible but also results in substantial reduction in variable cost of production, without jeopardising the normal operation of the plant in terms of scaling tendency, washing cycles and onstream factor etc.

REFERENCES

1. Pierre Becker, Phosphates and Phosphoric Acid, Second Edition 1989, Marcel Dekker Inc., New York.

2. B. K. Verghese and V. Ganesh, " Policies and Concepts for improving Plant Performance at Indo Jordan Chemicals Company Ltd. (IJC)", 1998 IFA Technical Conference, Morocco.

EXHIBIT - 1

SPECIFICATION OF DIFFERENT GRADES OF ROCK PHOSPHATE PROCESSED

Description	70-72 BPL WET ROCK (SCHEDULE B)			DRYER FINES (SCHEDULE C)			60-65 BPL SUBCOMMERCIAL WET ROCK (SCHEDULE D)	
	Specification	Typical analysis (source1)	Typical analysis (source2)	Specification	Typical analysis (source1)	Typical analysis (source2)	Specification	Typical analysis
Chemical Analysis (dry basis -% w/w)								
P2O5	32.00-33.00	33,52	32,58	32.00 - 33.00	28,75	30,52	27.50 - 29.80	29,07
CaO	50.60-52.10	51,52	48,08	50.60 - 52.10	44,11	45,67	42.00 - 45.00	41,97
SiO2	4.00-8.00	1,42	6,53	4.00 - 8.00	10,36	9,98	14.00 - 20.00	18,10
CO2	5.00-6.00	5,01	3,97	5.00 - 6.00	6,40	3,58	3.00 - 6.00	3,24
Fluorine	3.60-3.80	3,46	3,53	3.50 - 3.80	3,47	3,88	3.60 - 6.00	3,57
Chlorine	0.04 - 0.06	0,03	0,04	0.04 - 0.06	0,06	0,04	0.04 - 0.06	0,03
Fe2O3	0.20 - 0.50	0,13	0,16	0.20 - 0.50	0,37	0,60	0.20 - 0.50	0,46
Al2O3	0.30 - 0.60	0,15	0,17	0.30 - 0.60	0,49	1,14	0.30 - 0.60	0,40
Organic matter as C	0.10 - 0.20	0,20	0,30	0.10 - 0.20	0,28	0,17	0.10 - 0.20	0,21
SO3	1.00 - 1.50	0,92	1,22	1.00 - 1.50	1,61	1,03	1.00 - 1.50	0,81
Na2O	0.40 - 0.60	0,61	0,54	0.40 - 0.60	0,47	0,45	0.40 - 0.60	0,45
K2O	0.04 - 0.06	0,03	0,02	0.04 - 0.06	0,04	0,02	0.04 - 0.06	0,02
MgO	0.20 - 0.25	0,24	0,20	0.04 - 0.06	0,25	0,48	0.20 - 0.25	0,38
SrO	0.20 - 0.25	0,10	0,08	0.20 - 0.25	0,09	0,03	0.20 - 0.25	0,07
Free moisture	14.00 - 18.00	18,31	15,84	1.00 - 3.00	0,80	2,64	14.00 - 18.00	14,73
Screen Analysis (% w/w)								
+ 6.3 mm	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30
+ 4.0 mm	0,00	0,30	0,80	0,00	0,00	0,00	2.00 - 5.00	1,90
+ 2.0 mm	0,00	1,60	0,80	0,00	0,00	0,00	2.00 - 5.00	7,40
+ 1.0 mm	0.50 - 1.00	7,20	1,00	0,00	0,00	0,00	85.00 - 90.00	57,40
+ 0.5 mm	19.00 - 21.00	17,60	17,80	0,00	0,30	0,00	5.00 - 15.00	25,00
+ 0.212 mm	42.00 - 46.00	26,50	49,10	0,00	1,30	0,40		6,60
+ 0.15 mm	17.00 - 19.00	19,70	17,50	0,00	8,70	2,70		0,90
+ 0.106 mm	9.00 - 11.00	20,40	7,60	0.00 - 2.00	25,10	7,10		0,30
+ 0.075 mm	5.00 - 7.00	3,80	2,60	10.00 - 30.00	15,50	24,50		0,10
+ 0.053 mm	1.00 - 2.00	2,10	1,80	20.00 - 35.00	20,70	22,90		0,10
- 0.053 mm	0.50 - 1.50	0,80	1,00	40.00 - 60.00	28,40	42,40		0,00

NOTE : SOURCE 1 - ABIAD MINES ; SOURCE 2 - ESHIDIYA MINES

** -1.0 mm*

EXHIBIT - 2

SPECIFICATION OF VARIOUS BLENDS OF ROCK PROCESSED

DESCRIPTION	SPECIFICATION	SCHEDULE B		SCHEDULE (B+C)				SCHEDULE (B+C+D)			
		SOURCE 1	SOURCE 2	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8
Chemical Analysis (dry basis -% w/w)											
P2O5	*32.00-33.00*	*33,52*	*32,58*	*32,52*	*32,89*	*31,78*	*32,15*	*32,05*	*32,42*	*31,41*	*31,78*
CaO	*50.60-52.10*	*51,52*	*48,08*	*49,96*	*50,29*	*47,25*	*47,57*	*48,96*	*49,29*	*46,60*	*46,93*
SiO2	*4.00-8.00*	*1,42*	*6,53*	*3,30*	*3,22*	*7,33*	*7,25*	*5,05*	*4,97*	*8,55*	*8,47*
CO2	*5.00-6.00*	*5,01*	*3,97*	*5,30*	*4,71*	*4,48*	*3,89*	*5,12*	*4,52*	*4,40*	*3,81*
Flourine	*3.60-3.80*	*3,46*	*3,53*	*3,46*	*3,55*	*3,52*	*3,60*	*3,47*	*3,56*	*3,52*	*3,61*
Chlorine	*0.04 - 0.06*	*0,03*	*0,04*	*0,04*	*0,03*	*0,04*	*0,04*	*0,04*	*0,03*	*0,04*	*0,04*
Fe2O3	*0.20 - 0.50*	*0,13*	*0,16*	*0,18*	*0,23*	*0,20*	*0,25*	*0,22*	*0,26*	*0,24*	*0,28*
Al2O3	*0.30 - 0.60*	*0,15*	*0,17*	*0,22*	*0,36*	*0,24*	*0,37*	*0,25*	*0,38*	*0,26*	*0,40*
Organic matter as'c'	*0.10 - 0.20*	*0,20*	*0,30*	*0,22*	*0,19*	*0,30*	*0,27*	*0,22*	*0,19*	*0,29*	*0,26*
SO3	*1.00 - 1.50*	*0,92*	*1,22*	*1,06*	*0,94*	*1,30*	*1,18*	*1,05*	*0,93*	*1,26*	*1,14*
Na2O	*0.40 - 0.60*	*0,61*	*0,54*	*0,58*	*0,58*	*0,53*	*0,52*	*0,56*	*0,56*	*0,52*	*0,51*
K2O	*0.04 - 0.06*	*0,03*	*0,02*	*0,03*	*0,03*	*0,02*	*0,02*	*0,03*	*0,03*	*0,02*	*0,02*
MgO	*0.20 - 0.25*	*0,24*	*0,20*	*0,24*	*0,29*	*0,21*	*0,26*	*0,26*	*0,31*	*0,23*	*0,28*
SrO	*0.20 - 0.25*	*0,10*	*0,08*	*0,10*	*0,09*	*0,08*	*0,07*	*0,09*	*0,08*	*0,08*	*0,07*
Free moisture	*14.00 - 18.00*	*18,31*	*15,84*	*14,63*	*15,02*	*12,68*	*13,07*	*14,26*	*14,64*	*12,57*	*12,95*
Screen Analysis (% w/w)											
+ 6.3 mm	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,03*	*0,03*	*0,03*	*0,03*
+ 4.0 mm	*0,00*	*0,30*	*0,80*	*0,24*	*0,24*	*0,63*	*0,63*	*0,41*	*0,41*	*0,75*	*0,75*
+ 2.0 mm	*0,00*	*1,60*	*0,80*	*1,26*	*1,26*	*0,63*	*0,63*	*1,87*	*1,87*	*1,33*	*1,33*
+ 1.0 mm	*0.50 - 1.00*	*7,20*	*1,00*	*5,69*	*5,69*	*0,79*	*0,79*	*10,96*	*10,96*	*6,71*	*6,71*
+ 0.5 mm	*19.00 - 21.00*	*17,60*	*17,80*	*13,97*	*13,90*	*14,13*	*14,06*	*14,74*	*14,68*	*14,88*	*14,82*
+ 0.212 mm	*42.00 - 46.00*	*26,50*	*49,10*	*21,21*	*21,02*	*39,06*	*38,87*	*19,12*	*18,93*	*34,60*	*34,41*
+ 0.150 mm	*17.00 - 19.00*	*19,70*	*17,50*	*17,39*	*16,13*	*15,65*	*14,39*	*15,42*	*14,16*	*13,91*	*12,65*
+ 0.106 mm	*9.00 - 11.00*	*20,40*	*7,60*	*21,39*	*17,61*	*11,28*	*7,50*	*19,28*	*15,50*	*10,51*	*6,73*
+ 0.075 mm	*5.00 - 7.00*	*3,80*	*2,60*	*6,26*	*8,15*	*5,31*	*7,20*	*5,87*	*7,76*	*5,05*	*6,94*
+ 0.053 mm	*1.00 - 2.00*	*2,10*	*1,80*	*6,01*	*6,47*	*5,77*	*6,23*	*5,80*	*6,26*	*5,59*	*6,05*
- 0.053 mm	*0.50 - 1.50*	*0,80*	*1,00*	*6,60*	*9,54*	*6,75*	*9,69*	*6,51*	*9,45*	*6,65*	*9,59*

Legend:

Source 1 - Abiad mines
Case 1 - 79%Schedule B (Abiad)+21%Schedule C (Abiad)
Case 2 - 79%Schedule B (Abiad)+21%Schedule C (Eshidiya)
Case 3 - 79%Schedule B (Eshidiya)+21%Schedule C (Abiad)
Case 4 -79%Schedule B (Eshidiya)+21%Schedule C (Eshidiya)

Source 2 -Eshidiya mines
Case 5 -68.5%Schedule B (Abiad)+21%Schedule C (Abiad)+10.5%Schedule D
Case 6 -68.5%Schedule B (Abiad)+21%Schedule C (Eshidiya)+10.5%Schedule D
Case 7 -68.5%Schedule B (Eshidiya)+21%Schedule C (Abiad)+10.5%Schedule D
Case 8 -68.5%Schedule B (Eshidiya)+21%Schedule C (Eshidiya)+10.5%Schedule D

EXHIBIT 3

COMPARISION OF DIFFERENT BLENDED ROCKS PROCESSED

DESCRIPTION	SCHEDULE B		SCHEDULE (B+C)				SCHEDULE (B+C+D)			
	SOURCE 1	SOURCE 2	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8
Chemical Characterstics										
P2O5 (% DRY)	***33,52***	***32,58***	***32,52***	***32,89***	***31,78***	***32,15***	***32,05***	***32,42***	***31,41***	***31,78***
CAO/P2O5	**1,537**	**1,476**	**1,536**	**1,529**	**1,487**	**1,480**	**1,528**	**1,520**	**1,484**	**1,477**
F/SIO2	**2,437**	**0,541**	**1,050**	**1,103**	**0,480**	**0,497**	**0,688**	**0,716**	**0,412**	**0,426**
R2O3/P2O5	**0,008**	**0,010**	**0,012**	**0,018**	**0,014**	**0,019**	**0,014**	**0,020**	**0,016**	**0,021**
R2O/P2O5	**0,019**	**0,017**	**0,019**	**0,018**	**0,017**	**0,017**	**0,019**	**0,018**	**0,017**	**0,017**
F/P2O5	**0,103**	**0,108**	**0,106**	**0,108**	**0,111**	**0,112**	**0,108**	**0,110**	**0,112**	**0,114**
CO2/P2O5	**0,149**	**0,122**	**0,163**	**0,143**	**0,141**	**0,121**	**0,160**	**0,140**	**0,140**	**0,120**
Screen Analysis (% w/w)										
6.3 mm	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**
4.0 mm	**99,7**	**99,2**	**99,8**	**99,8**	**99,4**	**99,4**	**99,6**	**99,6**	**99,2**	**99,2**
0.5 mm	**73,3**	**79,6**	**78,8**	**78,9**	**83,8**	**83,9**	**72,0**	**72,1**	**76,3**	**76,4**
0.212 mm	**46,8**	**30,5**	**57,6**	**57,9**	**44,8**	**45,0**	**52,9**	**53,1**	**41,7**	**42,0**
Particle Mean Diameter (mm)										
Mean diameter	**0,466**	**0,438**	**0,387**	**0,382**	**0,365**	**0,359**	**0,488**	**0,482**	**0,468**	**0,463**

Legend: Refer Exhibit - 2

EXHIBIT -4
SIZE DISTRIBUTION OF BLENDED ROCKS

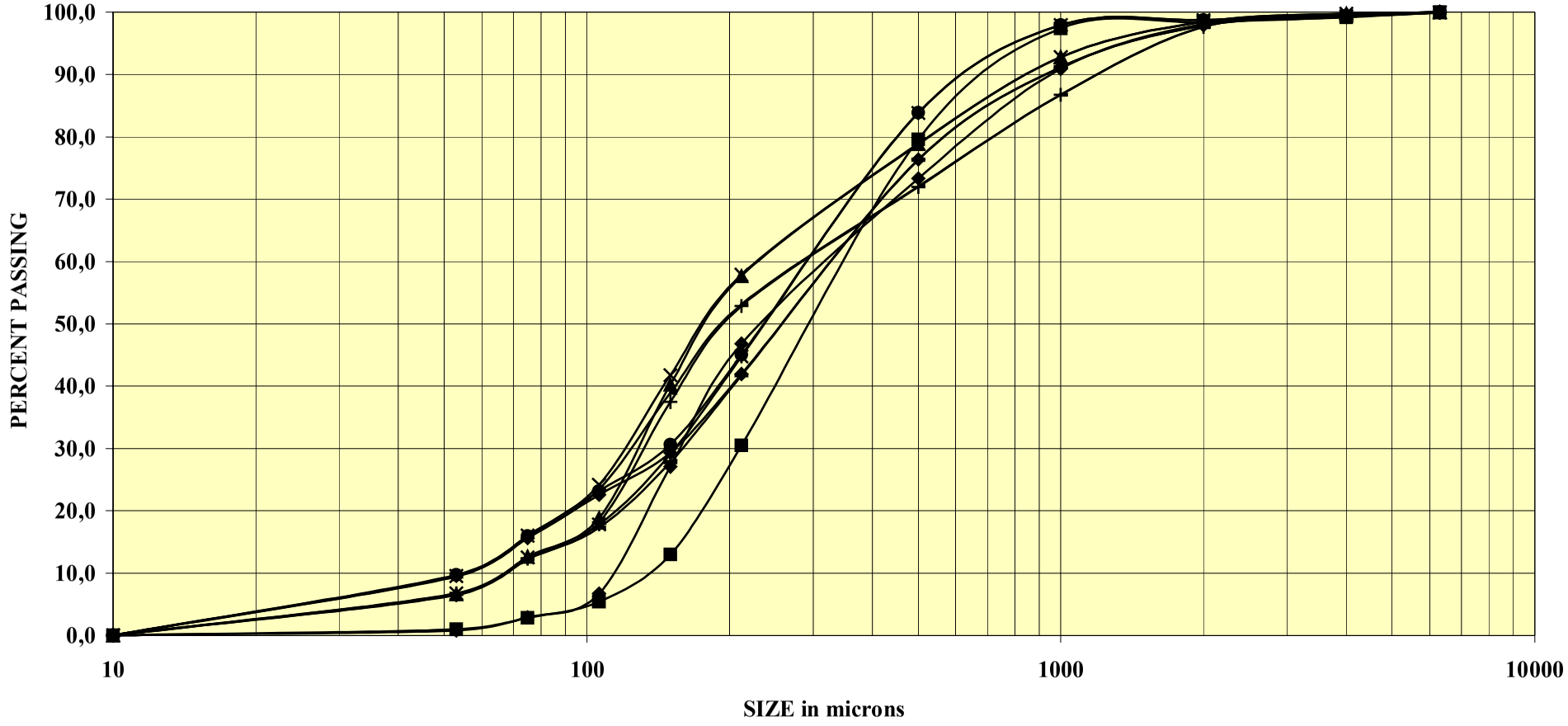


EXHIBIT - 5
REACTIVITY INDEX FOR DIFFERENT BLENDS OF ROCK

A: PARAMETERS CONSIDERED FOR CALCULATION OF REACTIVITY INDEX

S NO	DESCRIPTION	SCHEDULE B		SCHEDULE (B+C)				SCHEDULE (B+C+D)			
		SOURCE 1	SOURCE 2	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8
1	SSA	268	209	529	853	406	972	654	1031	532	668
2	PERMEABILITY	124	360	37	10	65	10	33	12	54	30
3	POROSITY	0,42	0,52	0,49	0,44	0,49	0,47	0,56	0,53	0,55	0,52
4	PARTICLE MEAN DIAMETER	0,466	0,438	0,387	0,382	0,365	0,359	0,488	0,482	0,468	0,463
5	F/P2O5	0,103	0,108	0,106	0,108	0,111	0,112	0,108	0,11	0,112	0,114
6	CO2/P2O5	0,149	0,122	0,163	0,143	0,141	0,121	0,16	0,14	0,14	0,12

B: CALCULATION OF RELATIVE REACTIVITY

S NO	DESCRIPTION	SCHEDULE B		SCHEDULE (B+C)				SCHEDULE (B+C+D)			
		SOURCE 1	SOURCE 2	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8
1	SSA	0,26	0,20	0,51	0,83	0,39	0,94	0,63	1,00	0,52	0,65
2	PERMEABILITY	0,34	1,00	0,10	0,03	0,18	0,03	0,09	0,03	0,15	0,08
3	POROSITY	0,75	0,93	0,88	0,79	0,88	0,84	1,00	0,95	0,98	0,93
4	PARTICLE MEAN DIAMETER	0,83	0,88	0,96	0,97	0,99	1,00	0,80	0,81	0,83	0,84
5	F/P2O5	0,90	0,95	0,93	0,95	0,97	0,98	0,95	0,96	0,98	1,00
6	CO2/P2O5	0,91	0,75	1,00	0,88	0,87	0,74	0,98	0,86	0,86	0,74
	REACTIVITY INDEX	**4,0**	**4,7**	**4,4**	**4,4**	**4,3**	**4,5**	**4,5**	**4,6**	**4,3**	**4,2**

Legend: Refer Exhibit - 2

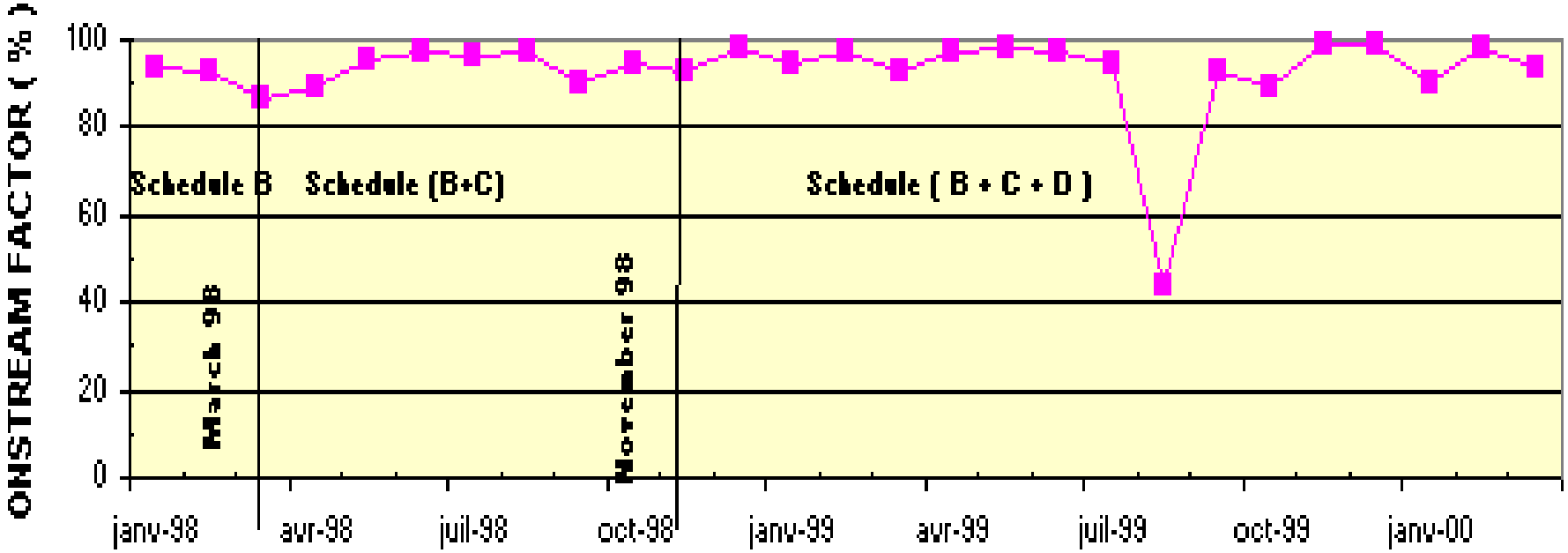
EXHIBIT - 6

COMPARISION OF TYPICAL OPERATING PARAMETERS

SL. NO.	DESCRIPTION	70 - 72 BPL WET ROCK SCHEDULE B	BLEND OF 70-72 BPL WET ROCK & FINES SCHEDULE (B+C)	BLEND OF 70-72 BPL WET ROCK & FINES & SUBCOMMERCIAL WET ROCK SCHEDULE (B+C+D)
1	Rock feed (dry)			
	70 - 72 wet rock (MT/hr)	118	109 - 91	100 - 80
	Dryer fines (MT / hr)	-	10 - 30	10 -30
	Subcommercial wet rock	-	-	10-12
	Total (MT/hr)	118	119 - 121	120 - 122
2	Reactor Temperature			
	R 1A (^{o}C)	97 - 98	96 - 97	96 - 97
	R 1B (^{o}C)	98 - 99	97 - 98	97 - 98
	R 2 (^{o}C)	95 - 96	95 - 96	95 - 96
3	Reactor Slurry			
	P2O5 (%)	41.0 - 41.5	40.0 - 41.0	40.0 - 41.0
	SO4 (%)	1.8 - 2.0	1.8 - 2.0	1.8 - 2.0
	Solids (% w/w)	29 - 30	29 -30	30 - 31
4	Filtration			
	Speed (m /min)	14 - 18	14 - 18	14 - 18
	Cake thickness (mm)	25 - 35	25 - 35	25 - 40
5	Cake Characterstics			
	SSA (cm2/gm)	1050 - 1200	1100 - 1200	1000 - 1100
	Permeability(cm2)	40 - 50	35 - 45	35 - 40
	Porosity	0.65 - 0.67	0.65 - 0.67	0.65 - 0.67
6	Cake Losses			
	WS losess (%)	0.4 - 0.8	0.4 - 0.8	0.4 - 0.8
	Unreacted losess (%)	0.8 - 1.0	0.8 - 1.0	1.0 - 1.2
	Cocrystallised losses(%)	0.5 - 0.7	0.6 - 0.8	0.6 - 0.8

EXHIBIT -7

ONSTREAM FACTOR FOR PA PLANT



	janv-98	févr-98	mars-98	avr-98	mai-98	juin-98	juil-98	août-98	sept-98	oct-98	nov-98	déc-98	janv-99	févr-99	mars-99	avr-99	mai-99	juin-99	juil-99	août-99	sept-99	oct-99	nov-99	déc-99	janv-00	févr-00	mars-00
ONSTREAM FACTOR (%)	94	93	86	89	95	97	97	97	91	95	95	98	95	97	99	98	98	98	95	44	93	89	95	95	98	98	94