4.2 PRODUCTION TECHNOLOGY

4.2.1 Iron ore mines

(1) General

The full-scale development of Sierra Grande south deposit started in 1971. The mining method adopted from the beginning for the deposit was sub level stoping by truckless system suitable for the characteristics of this deposit. (deposit width : average 9 m, inclination :35～50° , length : 3000 m).

Main effort in the deposit development until the commencement of operations of the central shaft in 1980 was incline excavation. Mine trucks transported excavated ores to the crushing plant equipment at ground level via inclines during the 9 years development until 1980.

The Central shaft reached the 522 ML. No. 1 crusher (jaw crusher) installed at 410 ML and skip loading station installed at 480 ML. Excavated ores were placed into No.1 crusher and then hoisted by the skip to ground level where they were transported to the crushing plant at ground level (No.2 crusher) by belt conveyor.

(2) Underground structure

The development system of the south deposit is a composite development of inclined shaft and ordinary shaft.

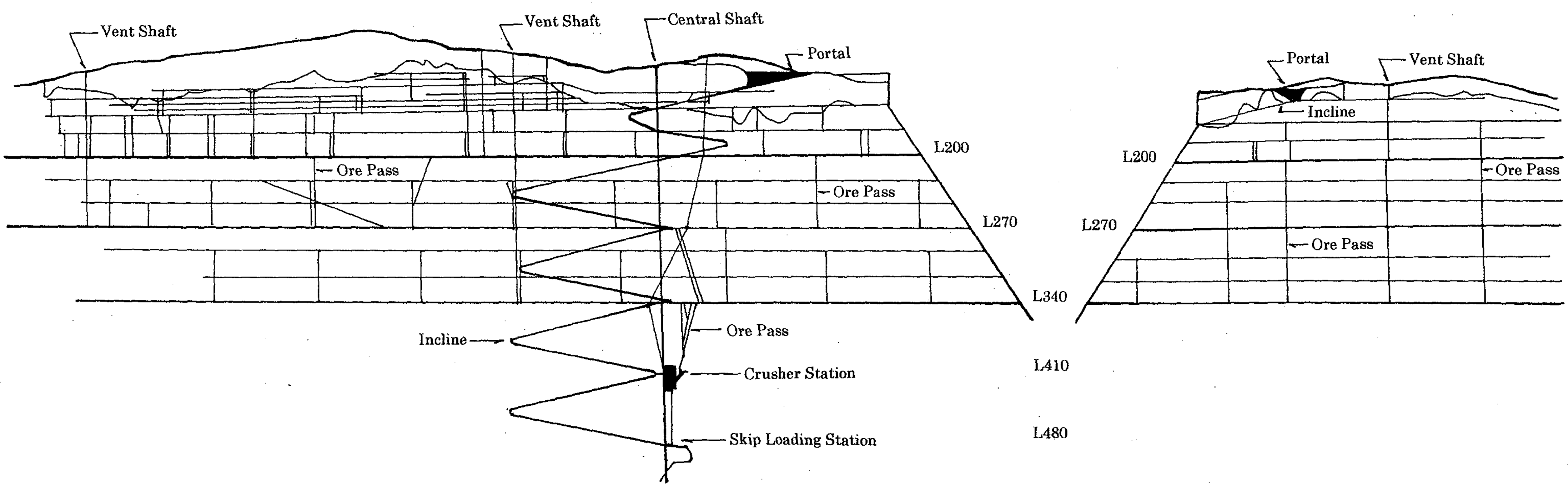
There is a central shaft in the middle of the south deposit. Inclines (section 5.5m × 5.0m) are extended to 522 ML from the central shaft.

Main level distance is 70m and a transportation drift (section 4.5m × 6.0m), a loading drift (section 4.5m × 6.0m) and a drilling drift (4.0m × 4.0m) are constructed and each of them are connected to the inclined spiral shaft.

Furthermore the main level is divided into a sub level each of 23 meters and each sub level has a transportation drift, loading drift and drilling drift.

The loading drifts are connected to ore loading gate at each main level by ore pass (section 2.4m × 2.4m). The underground map is attached hereto. (**Fig.-2**)

Fig.-2 Underground Map of South Deposit



(3) Mining method

A scale of one ore block at sub level stoping method is 70m in height, 9m in width and 200m in length.

A sub level in an ore block is set 23m in distance. Drilling drifts and loading drifts excavated from the incline are made at each sub level.

A pass which is the first free face of stoping is made at each end of the ore block. This pass connects to each sub level. Stoping starts from the expansion of the pass. When free face is completed, charging holes are drilled for full scale stoping.

The drilling method of charging holes is fan-shaped drilling by fan-drill jumbo.

Typical drilling pattern is spacing:1.8m, drilling length : 28.8～9.6m/hole, total drilling length : 231.6 m. A sub level of which fan-shaped drilling completed are blasted one after another. Excavated ores are transported by loader and dumped to the ore pass.

Pneumatic driven small loader (bucket capacity :0.5m^3) was used when HIPASAM started its operation, however, LHDs (bucket capacity :3.4～3.8 m^3) were successively introduced from 1979 which increased the transportation volume of excavated ore from the ore block. As a result, mining recovery increased from 83% to 85%.

(4) Transportation

As stated above, a transportation drift on the south deposit was made for a distance of 70 m. Excavated ores were dumped to the pass which connects each sub level.

Excavated ores collected in the pass were transported by the mine trucks to the ore pass which connects to the No. 1 crusher at 410 ML. The ore crushed by No.1 crusher were dumped to the skip at 480 ML and hoisted to ground level. The ore hoisted to ground level were further crushed by the crushing plant and stocked on the stock yard by the stacker.

(5) Ventilation and water discharge

As mentioned before, the underground structure of the south deposit is a composite structure. Ventilation is basically natural ventilation, however, mechanical ventilation by electric fan is also used due to truckless mining and deepening of stoping. 11 ventilation shafts were developed including the central shaft. Each ventilation shaft equipped with several electrical blowers of 20 kW～90 kW. Total power of the blowers being 620 kW and the total ventilation volume is 19,800 m^3/min.

Further auxiliary fans installed at the face or at locations where air flow is stagnant.

Natural mine water and operation drain water are collected by water drainage at each drift and water drain pipes (ϕ 80 mm) connecting each drift are then discharged to the outside of the drift by water pumps.

Total power requirement of the water discharging facilities is 731 kW and total water discharge volume is 665 m^3/h.

4.2.2 Iron ore concentration plant

(1) Underground primary crushing

Mineral processing of Sierra Grande iron ore mine started at the primary crushing station situated at 410m level of the mine. The ore was withdrawn from a 200t hopper and was fed to a 1800 by 1470 mm jaw crusher equipped with a 220 kW motor and rated at 800 t/h. The primary crusher reduced the size of the ore from up to 1 m^3 to less than 300mm.

(2) Secondary crushing

The ore hoisted by two 17 t capacity skips is dumped into 3,000 t bin in the hoist tower. And then it is fed to the secondary crushing.

The iorn ore is transported by two 800 mm belts to two 4800 by 1800 mm single-deck screens having 100 mm openings at secondary crushing. The plus 100 mm screen oversize is reduced to minus 100 mm by two 420 by 120mm hydroset secondary crushers each equipped with a 110 kW motors.

The minus 100 mm product of the secondary crushing is conveyed on a 1200 mm belt to a storage area where it is fed by a stacker to the pile of total capacity 90,000 t and 20,000 t live capacity.

(3) Preconcentration

Fig.-3 shows the outline of preconcentration plant. Beneath the stockpile the ore was withdrawn and fed with fourteen vibrating feeders (normally any four with a maximum six of which operate at one time) to a 1000 mm belt, from which it was transferred to a second belt feeding three 300 t bins in the preconcentrator for distribution to three parallel lines.

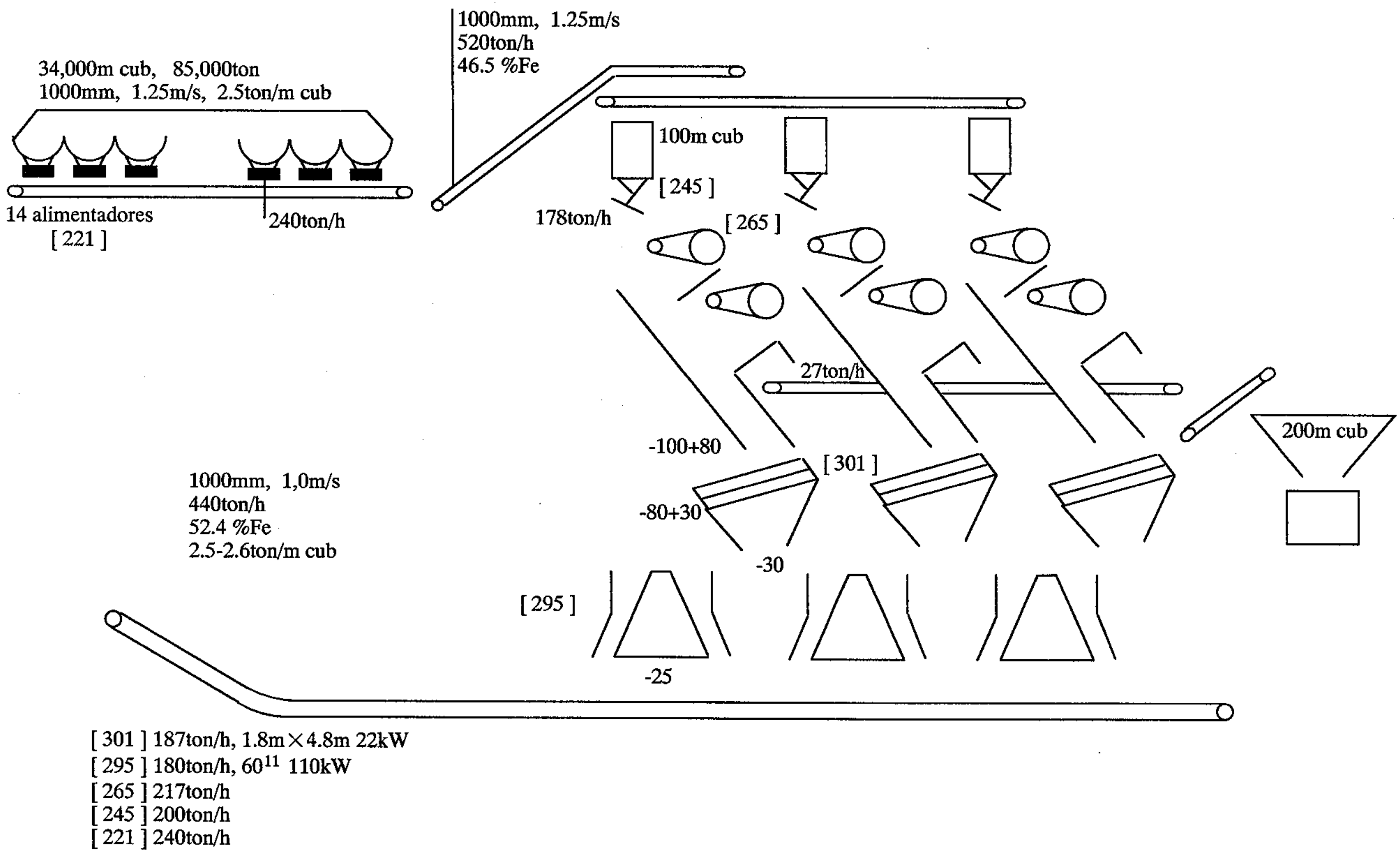
On each line the crude ore was fed to a 926 mm diameter and 2400-mm long dry primary magnetic separator of 700 gauss on which a concentrate was recovered and the rejects were fed to a secondary magnetic separator of the same dimensions. The rejects of the secondary separator were collected to a bin of $200m^3$ for loading into 40 t trucks and transported to the disposal area.

The pre-concentrate was collected and is conveyed to a 4800 by 1800 mm double-deck vibrating screen from which the plus 75mm was fed to the tertiary cone crusher driven by a 110 kW motor to reduce minus 25mm. The minus 75mm plus 25mm was fed either to the cone crusher or bypasses the crusher as grinding media for the pebble mills in the concentrator.

The minus 25mm preconcentrate was collected and fed onto a 1000mm belt equipped with a weightometer for conveying to three 3400 t capacity concrete silos, 9 m diameter by 27 m high at the concentrator. The plus 25mm pebble was conveyed on the same belt to a 2400 by 6000mm double-deck vibrating screen for separation, with the plus 25mm directed to one 9 by 27 m silo of 3,400 t .

The crude ore averaging 46.5% iron was upgraded to the preconcentrate of 53 to 54% iron by rejecting 29 to 30% weight of waste.

Fig.-3 Preconcentration Flow



(4) Concentration

1) Outline

It is reported that Swedish consulting company SWECO had done laboratory test, pilot plant test and basic design for the major part of concentration plant which are from the mill bin to process pre-concentrate to pellet feed. Construction of the concentration plant was done by Kurimoto of Japan and completed in 1977. Regular operation of the plant started in 1979 when pelletizing plant started the operation.

The flow sheet at the time of start of the concentration plant is shown in **Fig.-4**. There were 3 lines of grinding, magnetic separation and flotation of which equipment were same. It is reported that the flotation was not effectively done due to the reason of the accumulation of calcium ion in the recirculation water at the trial operation when the concentration plant started its operation. This trouble was eliminated by an addition of sodium carbonate. After the solution of the said trouble, it is reported that the concentration plant was operated rather smoothly.

The concentration plant had sufficient capacity and it may be said that a reason of not achieving the production plan was not caused by the plant capacity. Operation ratio of the concentration plant did not reach to 50% in average. All 3 lines were operated at the early stage of the production, however, 1 or 2 line operation was ordinally manner. Several modifications were made to the concentration plant and the process flow at the final stage when the concentration plant was in operation was shown in **Fig.-5**. Modifications were made to Line 1 and 2. Line 3 was used as a supply source of parts. The time, purpose and effect of the modification of process were not known as there is no engineers except maintenance engineers remain in the concentration plant.

Actual operation could not be informed by the same reason as stated above. Operation record such as balance sheet could not be found. Monthly report was found however, there is less information on actual operation. It can be said that the operation of concentration plant was unstable seeing from the data described in the operation logs. Power consumptions were unstable. Fluctuations of particle size after grinding were very large. Fluctuations of pulp density were also large. Analyzed quality for operation control purpose is shown in **Table-48** and analysis of particle size distribution is shown in **Table-49**, both of which are taken from November, 1986 as an example.

Major subject of the JICA study is the decrease of phosphorus content in the concentrate. Phosphorus content in the concentrate at the start of the concentration plant was specified to less than 0.18% and actual phosphorus content has never exceeded during the operation. Seeing from **Table-65**, the trend of annual average phosphorus content in the concentrate was stable around 0.137%. High phosphorus content in the concentrate as compared with other sources was the subject of discussion from the beginning of the operation and various measures to reduce the phosphorus content were tried between 1980 and 1983, such as selection of flotation reagents or cyclone classification, etc. No visible effect was found by such trials.

Research of quality of iron ore was also done. Quality of iron ore taken from south area of the south deposit was better than that of north area. It was confirmed that the concentrate made from the iron ore taken from south area has better quality. It also confirmed when size of concentrate became finer, phosphorus content could be decreased, however, it was believed that fine grinding caused difficulty of filtration of pellet feed. When checked at the site, it seemed that the filter itself had more problem for filtration.

Figure-4 Original Flowsheet Constructed by Kurimoto

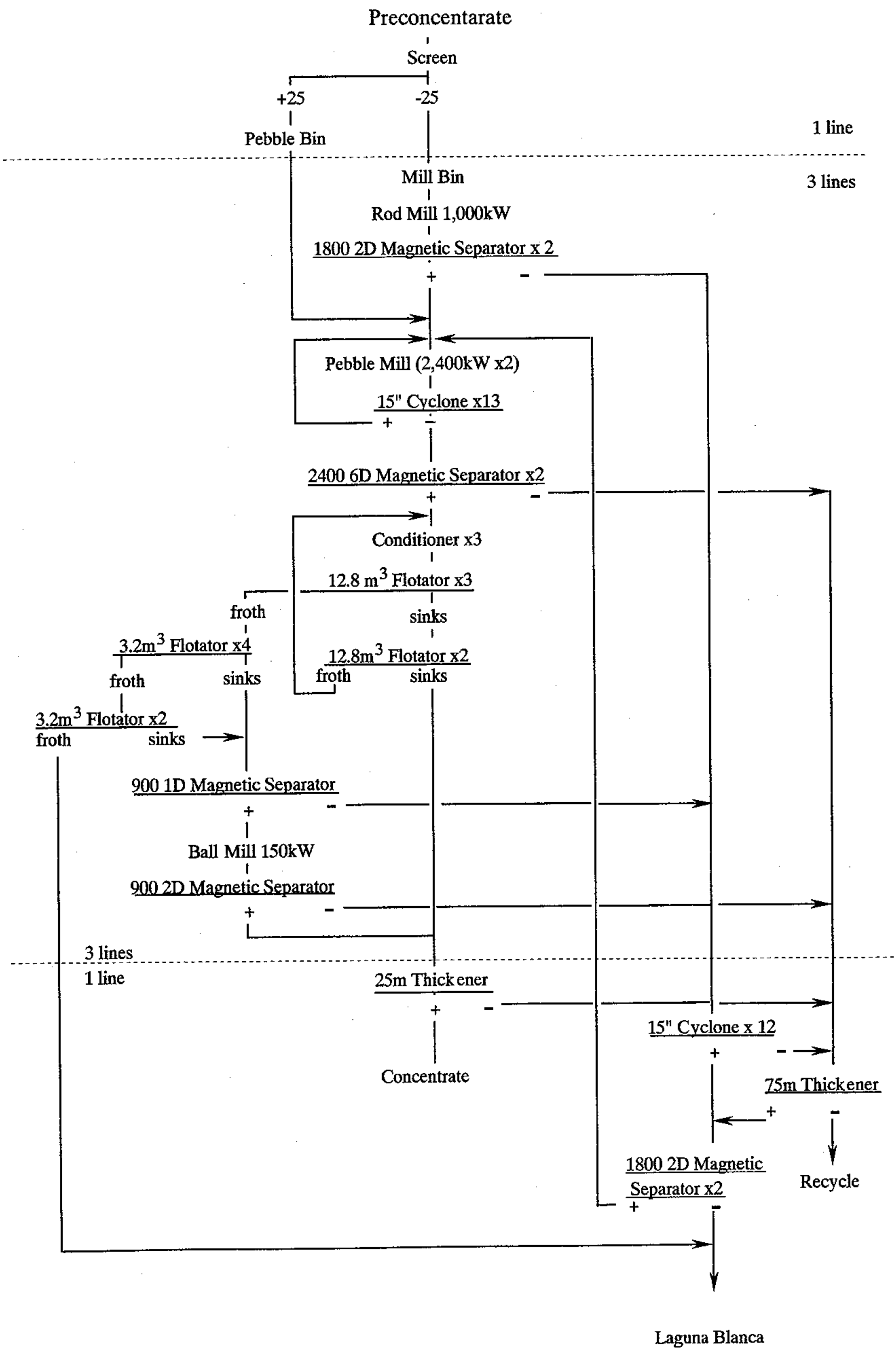


Figure-5 Flowsheet Operated by HIPASAM

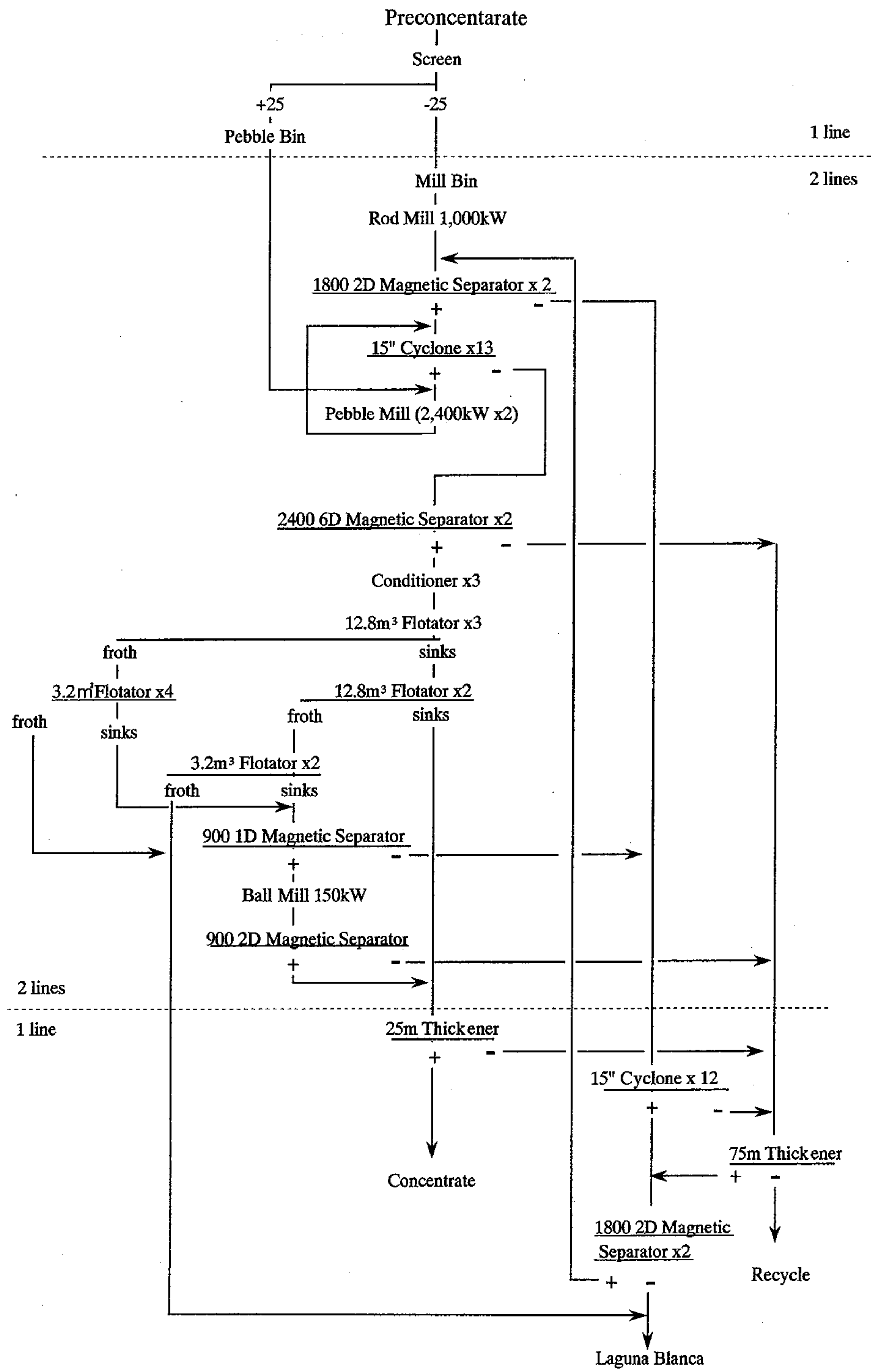


Table-48 Example of chemical analysis for operation control

Date	01 Nov. '86		02 Nov. '86		03 Nov. '86		04 Nov. '86		05 Nov. '86		10 Nov. '86		12 Nov. '86		13 Nov. '86		13 Nov. '86	
Line-shift	1-D		1-D		1-D		1-D		1-D		1-D		3-D		1-D		1-D	
Sample No. Description	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P
3 Pebble	58.10	1.305	56.87	1.341	56.56	1.422	56.65	1.449	57.66	1.449	56.24	1.357	58.06	1.428	58.06	1.301	58.37	1.373
4 Rod mill discharge	53.03	1.314	51.64	1.305	52.26	1.332	52.79	1.366	52.81	1.366	52.74	1.283	53.20	1.418	52.90	1.346	53.81	1.382
50 Primary mag. feed	53.95	1.305	53.18	1.386	51.63	1.368	54.63	1.320	50.92	1.477	51.98	1.445	53.50	1.355	53.20	1.310	55.33	1.355
6 Primary mag. tail	21.05	2.376	23.82	2.124	20.45	2.115	27.16	2.455	22.50	2.446	20.67	2.421	20.52	2.231	20.52	2.295	21.13	2.801
5 Primary mag. conc.	60.56	1.089	60.25	1.161	59.58	1.080	61.19	1.089	60.50	1.126	60.34	1.093	60.80	1.075	61.10	1.057	60.80	1.147
7 Cyclne overflow	59.48	1.179	61.63	1.098	60.61	1.035	61.15	1.071	60.80	1.098	60.19	1.129	62.47	0.976	62.02	1.057	60.34	1.175
9 Secondary mag. tail	33.35	3.501	36.12	3.240	33.83	3.483			33.44	3.526	33.44	3.460	32.07	3.551	32.53	3.569	30.25	3.966
8 Secondary mag. conc.	66.55	0.478	66.55	0.473	66.55	0.495	66.47	0.497	66.16	0.521	66.57	0.524	66.88	0.501	67.49	0.435	67.49	0.484
202 Rougher flot. froth	57.46	2.241	56.56	2.457	54.57	2.700	58.42	2.021	57.46	2.215	55.94	2.466	61.10	1.744	57.64	2.096	57.00	2.448
201 Rougher flot. conc.	68.24	0.134	68.40	0.153	67.67	0.148	68.29	0.160	68.70	0.145	68.40	0.177	68.86	0.165	68.86	0.181	68.25	0.180
130 Scovenger fl. froth	59.17	1.242	59.94	1.305	59.13	1.251	62.22	0.849	60.50	1.071	60.34	1.192	62.93	0.894	63.08	0.831	61.10	1.075
11 Flotation conc.	68.24	0.114	68.70	0.111	68.40	0.112	68.59	0.112	69.16	0.120	68.70	0.130	69.31	0.128	69.01	0.104	68.70	0.123
18 Non-magnetic tail	27.36	3.150	24.28	2.754	26.28	2.916	26.32	3.018	26.55	3.175	23.25	2.796	25.08	3.072	24.62	2.945	25.53	3.198
19 Total tail	31.82	3.024	29.51	3.024	31.05	2.889	30.78	2.963	31.87	3.009	30.70	2.926	30.40	3.126	30.25	2.972	30.55	3.298
20 Conc. thickner feed	68.55	0.125	68.40	0.117	68.40	0.116	68.40	0.131	68.29	0.132	68.70	0.143	68.86	0.154	68.86	0.133	68.55	0.145
21 Chips	55.79	1.557	56.10	1.431	54.10	1.575	56.95	1.431	56.15	1.486	56.39	1.338	57.30	1.581	56.09	1.590	57.76	1.545

Date	18 Nov. '86		20 Nov. '86		21 Nov. '86		22 Nov. '86		25 Nov. '86		26 Nov. '86		27 Nov. '86		28 Nov. '86		29 Nov. '86	
Line-shift	1-D		1-D		1-D		1-D		1-D		1-D		1-D		1-D		1-D	
Sample No. Description	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P	% Fe	% P
3 Pebble	58.67	1.409	57.91	1.440	59.13	1.267	58.06	1.404	57.71	1.404	58.02	1.213	59.25	1.265	56.78	1.503	56.63	1.503
4 Rod mill discharge	53.65	1.373	54.11	1.340	54.72	1.367	53.66	1.385	53.70	1.231	55.09	1.204	54.31	1.414	54.62	1.399	53.54	1.380
50 Primary mag. feed	52.74	1.485	55.48	1.394	54.72	1.376	53.66	1.404	54.16	1.231	57.71	1.132	55.08	1.389	54.93	1.295	52.92	1.446
6 Primary mag. tail	23.56	2.816	20.21	2.680	21.89	2.698	21.43	2.454	20.21	2.209	22.06	2.481	23.92	2.599	22.68		23.30	2.797
5 Primary mag. conc.	60.80	1.159	60.95	1.138	60.80	1.114	61.10	1.041	60.41	1.059	60.64	1.023	60.95	1.125	62.95	1.125	60.95	1.087
7 Cyclne overflow	61.10	1.105	61.56	1.068	61.10	1.087	61.26	1.096	60.79	1.132	62.18	0.969	60.79	1.049	62.49	0.907	61.72	1.049
9 Secondary mag. tail	31.46	3.830	30.40	3.957	31.16	3.848	33.14	3.613	35.33	3.314	32.09	3.604	31.17	3.742	31.17	3.931	33.09	3.884
8 Secondary mag. conc.	67.03	0.461	66.73	0.503	66.88	0.514	67.34	0.458	66.97	0.462	66.81	0.436	67.27	0.467	67.12	0.467	66.97	0.461
202 Rougher flot. froth	58.57	2.052	58.06	2.128	59.28	1.865	60.34	1.612	58.32	1.974	56.47	2.291	58.48	2.249	60.33	2.032	57.86	2.391
201 Rougher flot. conc.	68.25	0.166	68.40	0.184	68.86	0.142	68.70	0.167	68.57	0.156	68.82	0.145	68.35	0.169	68.20	0.144	69.74	0.133
130 Scovenger fl. froth	62.77	0.914	59.73	1.304	61.86	1.041	63.38	0.833	60.95	1.132	59.87	1.295	67.12	1.087	61.72	0.869	58.48	1.654
11 Flotation conc.	68.86	0.118	68.85	0.125	69.00	0.120	69.01	0.110	68.66	0.120	68.82	0.121	68.82	0.130	68.66	0.111	69.89	0.108
18 Non-magnetic tail	26.14	3.343	26.30	3.070	25.64	3.468	25.08	3.160	22.99	2.961	25.77	3.021	25.61	3.156	26.39	3.364	25.92	3.430
19 Total tail	31.16	3.171	32.07	3.079	31.92	3.368	30.86	3.006	30.24	3.124	31.79	3.088	30.55	3.374	30.24	3.251	30.24	3.478
20 Conc. thickner feed	68.70	0.146	68.70	0.139	68.86	0.141	69.01	0.142	68.05	0.141	68.05	0.142	68.66	0.156	68.51	0.142	68.66	0.125
21 Chips	57.15	1.391	56.24	1.440	57.76	1.458	57.76	1.250	57.86	1.440	57.40	1.322	55.86	1.540	54.62	1.625	55.86	1.588

Table-49 Example of size analysis for operation control

Date	01 Nov. '86		02 Nov. '86		03 Nov. '86		04 Nov. '86		05 Nov. '86		10 Nov. '86		12 Nov. '86		13 Nov. '86		15 Nov. '86	
Line-shift	1-D		1-D		1-D		1-D		1-D		1-D		3-D		1-D		1-D	
Sample	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
No. Description	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M
4 Rod mill discharge	61.0	31.0	61.8	33.0	57.4	30.4	57.8	32.2	53.7	27.7	59.1	33.4	60.7	36.9	62.3	34.3	56.0	28.4
5 Primary mag. conc.	58.2	28.8	59.7	31.3	55.5	29.8	56.4	30.7	58.9	31.2	60.8	34.1	59.0	34.5	59.6	33.6	54.1	26.1
8 Secondary mag. conc.		88.2		87.7		89.6		93.1		87.4		87.5		89.5		87.9		86.0
20 Conc. thickner feed		89.0		88.8		90.3		89.2		90.0		87.7		91.5		89.7		88.6

Date	18 Nov. '86		20 Nov. '86		21 Nov. '86		22 Nov. '86		25 Nov. '86		26 Nov. '86		27 Nov. '86		28 Nov. '86		29 Nov. '86	
Line-shift	1-D		1-D		1-D		1-D		1-D		1-D		1-D		1-D		1-D	
Sample	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
No. Description	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M	-100M	-325M
4 Rod mill discharge	60.5	33.8	57.9	31.2	57.6	33.0	60.3	32.7	50.7	28.6	51.4	25.0	56.8	31.7	59.9	34.7	62.7	35.0
5 Primary mag. conc.	57.0	21.3	59.1	31.9	59.9	36.6	58.0	30.5	49.6	24.9	48.0	23.3	53.9	27.3	57.6	29.9	60.9	34.3
8 Secondary mag. conc.		88.3		88.8		87.1		91.2		88.8		88.3		91.3		90.5		92.0
20 Conc. thickner feed		90.1		91.2		89.4		89.6		89.9		89.5		91.2		91.4		92.1

2) Primary grinding and magnetic separation

The preconcentrate was withdrawn from the silo and was transferred to a belt equipped with a weightometer feeding a 3.9m diameter by 5.2m long rod mill driven by a 1000 kW motor. Feed rate was normally 120 t/h. The rod mill ground the ore at 73～74% solids using 90mm diameter by 5.1m long rods to less than 1mm consuming 780 kW or 6.5 kW h/t of feed ore.

The rod mill discharge was pumped with a 8 by 6-in. centrifugal pump to a distributor for distribution to the primary magnetic separators consisting of two two-drum separators having 916mm diameter by 1800mm long drums of 900 gauss. The preconcentrate of approximately 53% to 54% iron and 1.3% to 1.4% phosphorus was upgraded to 60 to 61% iron with 0.95 to 1% phsphorus.

3) Secondary grinding

The pebbles were withdrawn from the silo and conveyed to the 5.9m diameter by 10.5m long pebble mill equipped with two motors of 2400 kW each. The primary magnetic concentrate was pumped to a 12 by 10-in. pump which was in closed circuit with thirteen 15-in. cyclones, with the cyclone underflow recirculated to the pebble mill at 81 to 82% solids. Discharge of the pebble mill was of about 70% solids. Although feed rate of the pebble was not stable at all time depending on the quality of the ore, it was typically 18t/h. The product of secondary grinding was the cyclone overflow of 87～91% minus 44 microns.

4) Secondary magnetic separation

The cyclone overflow was distributed to two six-drum magnetic separators having 916mm diameter by 1800mm long drums of 900 gauss. In the secondary magnetic separation, the concentrate was improved from 60～61% iron with 0.95～1% phosphorus to 67% iron with 0.45% phosphorus. The secondary magnetic concentrate was directed to the flotation circuit.

Point to be noted at the secondary magnetic separation was that the feed supply method was modified not authodox style. Half of the feed was fed to the 1st drum, 1/4 to the 2nd and 3rd drum where the total number of the drum was 6. It is natural to supply full volume of the feed into the 1st drum. The performance of the 6 drum magnet separator was extraordinally dropped by this un-authodox supply method of the feed. It is estimated that the volume of the feed largely increased by the modification and the supply of the feed was changed to this un-authodox style. The density of cyclone overflow was 14% in 1991 where it was approximately 20% in 1986.

5) Floatation

To remove phosphorus, a flotation section was incorporated to float the apatite. The pulp flowed by gravity into a 3m diameter by 3m high conditioner, in which reagents were added consisiting of sodium carbonate, sodium hydroxide, and some additional water. The pulp was pumped to two conditioners of the same dimension in series. Waterglass was added in the second conditioner. The collector emulsion of tall oil and fuel oil was added in the third.

Flotation was conducted at 40% solid. From the third conditioner the pulp flowed to rougher stage consisting of three 12.8 m^3 Sala cells. The collector emulsion is also added between the cells.

The non-floated material went to two 12.8 m^3 Sala cells to scavenge the remaining apatite. The froth of the rougher and scavenger cells was pumped separately to four and two 3.2m^3 Sala cleaner cells respectively to free the manetite entrapped in the froth.

The froth of the cleaner cells reported to the tailing pond joining the non-magnetic tails.

6) Regrinding circuit

The non-floated middlings from the cleaner cells were thin in pulp density. They were pumped to a magnetic separator with a 916mm diameter by 900mm long drum of 900 gauss. The densified magnetic materials flowed at 60～70% solids to a 2.1m diameter by 2.8m long ball mill equipped with a 150kW motor using 20mm diameter steel balls. The reground material was pumped to a three drum magnetic separator comprising three 916mm diameter by 900mm long drums of 900 gauss. The concentrate recovered on this separator joined the concentrate from flotation.

7) Concentrate thickening

The final concentrate averaging 68.57% iron with 0.137% phosphorus was fed to a 25m diameter concentrate thickener. The thickend concentrate went to the slurry pipeline system.

8) Tailing disposal

The primary magnetic tailing was coarse material that was brought to eight 15-in. cyclones from which the overflow was fed to the 75m diameter tailing thickener. The underflow was pumped to three 910mm diameter by 2.4m long magnetic separators for control, removing part of the magnetite that was pumped back to the rod mill discharge.

The tailing from the three control magnetic separators and the tailing of the flotation circuit were the general tailing of the concentrator that was pumped to the Laguna Blanca natural tailing pond.

In the secondary magnetic circuit, the tailing flowed by gravity to the tailing thickener. Tailing thickner underflow at 50% solids was pumped to the same three control units to remove magnetite.

(5) Concentrate transportation system

The underflow from the concnetrate thickner passed through a demagnetizing coil and was fed to two agitated storage tanks having a capacity of 3000t. The concentrated slurry was transferred from the tanks to the 200mm inside diameter pipeline system in which it was pumped with three 6 by 6-in. 9V3 Ingersoll Rand pumps, two of which were normally operated at any time, a total distance of 32.4 km to Punta Colorada. The pressure was 70 kg/cm^2, with 5 kg/cm^2 at the discharging point.

Normally the concentrate slurry was pumped at the rate of 286 t/h, equivalent to $229m^3/h$, with a density of 62.8% solids. Sodium hydroxide was used for preparation of the concentrate slurry to maintain a pH of 10.3 to 10.5 to avoid pipeline corrosion. Sodium sulphate was used during the washing stage for oxygen removal to prevent corrosion.

There remains a supervisor of operation at concentrate transportation system from whom hearing of the actual operation could be made. Pipeline system was constructed by Bechtel Incorporated. 8 hours intermission and re-start test was cleared without any problem. There occured approximately 2 hours stoppage at actual operation, however, no problem for restart. Solids were withdrawn from the concentrate thickner with the density of 72～65% and diluted by water aiming 62% at the entrance of pump. Normal flow rate was 2.2 m/sec. but there was no problem of appying 1.2～2.5 m/sec..

4.2.3 Pelletizing plant

To establish the true reason for low annual production and low quality from the view point of pelletizing technology analysis is focused on past actual results because the plant has been closed for 8 years and it is very difficult to get accurate information other than from visual survey and verbal information.

Analysis of past records are summarized as follows.

- Main reason for low annual production is low availability not low hourly production rate.

- Low quality could be attributed to rapid heating pattern with bursting.

- Many problems remained for long periods without solution as the plant could not reach final development stage because the many problems caused people an impossible task to improve the plant.

In other words, problems made new more problems.

(1) General description of the pelletizing plant

1) History of the plant

This plant was constructed from 1973 to 1978 by Wright Engineering Ltd. with the subcontractor Midland Ross Ltd.. The contract between HIPASAM and Wright Engineering Ltd. was not satisfactorily completed due to non fulfillment of some items of the contract.

So, the guarantee test of the facilities and the performance test for capacity ware not carried out. The technical transfer was not done.

Accordingly equipment list, technical specification, operation manual, etc. do not exist as final documents. Final construction work was completed by HIPASAM itself and production was started at the end of 1978 and continued to 1991.

2) Plant layout

a) Main production equipment

Main production equipment (from disc filter to conveyors under cooler.) are installed in the pelletizing building size 48m width, 80m length and 40m height. The flow of material in the pelletizing plant is shown in **Fig.-6**. In the vicinity of the plant, there are screening and additive preparation house, thickener, pond etc. (Refer to **Fig.-7**, Plot plan in the vicinity of the pelletizing plant)

From the concentration plant on the mine site magnetite concentrate was transported through a slurry pipe line to the pelletizing plant at Punta Colorada.

After receiving slurry, it is to be sent to 6 disc filters to be dewatered to reduce moisture to 9 to 10 %. The filter cake after being blended with bentonite and hydrated lime is charged to 4 drum-type-pelletizers to be agglomerated to green pellets.

The pellets are charged into 4 shaft pelletizing furnaces after being screened. Each furnace has one pelletizer. Designed production capacity of the plant is 2.0 million-t product pellets per year (7,500 hours per year). After induration, pellets are screened for the removal of under size (under 5 mm) andthen sent to product yard.

Main facilities have following specification or dimension.

Disc filter (6 units, 10 filters/ unit)
- $100m^2$-total area

Drum pelletizer(4 units)
- 3.65m dia., 9.75m length,
- 5° inclination with 11.5 rpm rotating speed
- 67 t/h nominal capa./drum of dry green ball on size

Seed screen (4 units)
- with aperture of 9.2 mm and 19.5 mm

Shaft furnace (Refer to **Fig.-8**)(4 units,)
- Opening area at furnace top: 6.3m×2.4m
- Height of furnace (or chest part): 14m
- Height of cooler (or foot part): 12m
- Number of tuyeres: 48
  24 in one side of furnace
  20 on long side with blow hole of 75 mm dia
  2 on each 2 short side with apertures of 92 mm×
  195 mm

Product screen
(2 units existed originally and presently 1 unit exists)
- Sieving aperture: 5 mm

b) Other facilities

- There are a rotary dryer, Laymond mill and pneumatic transportation line for bentonite addition.

- Wet grinding system for silica and dolomite addition.

Figure-6 Plant flow from disc filter to product pile

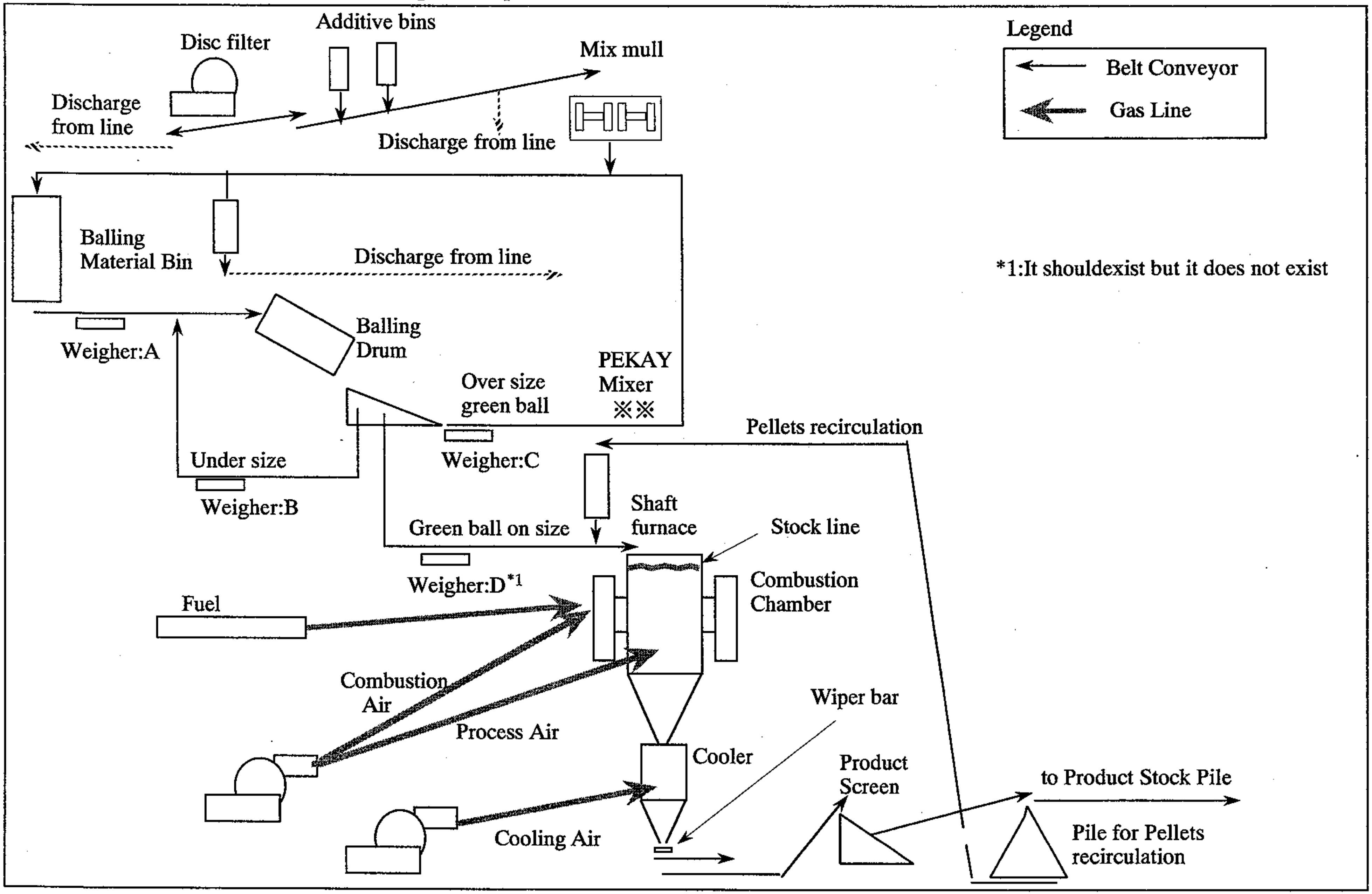
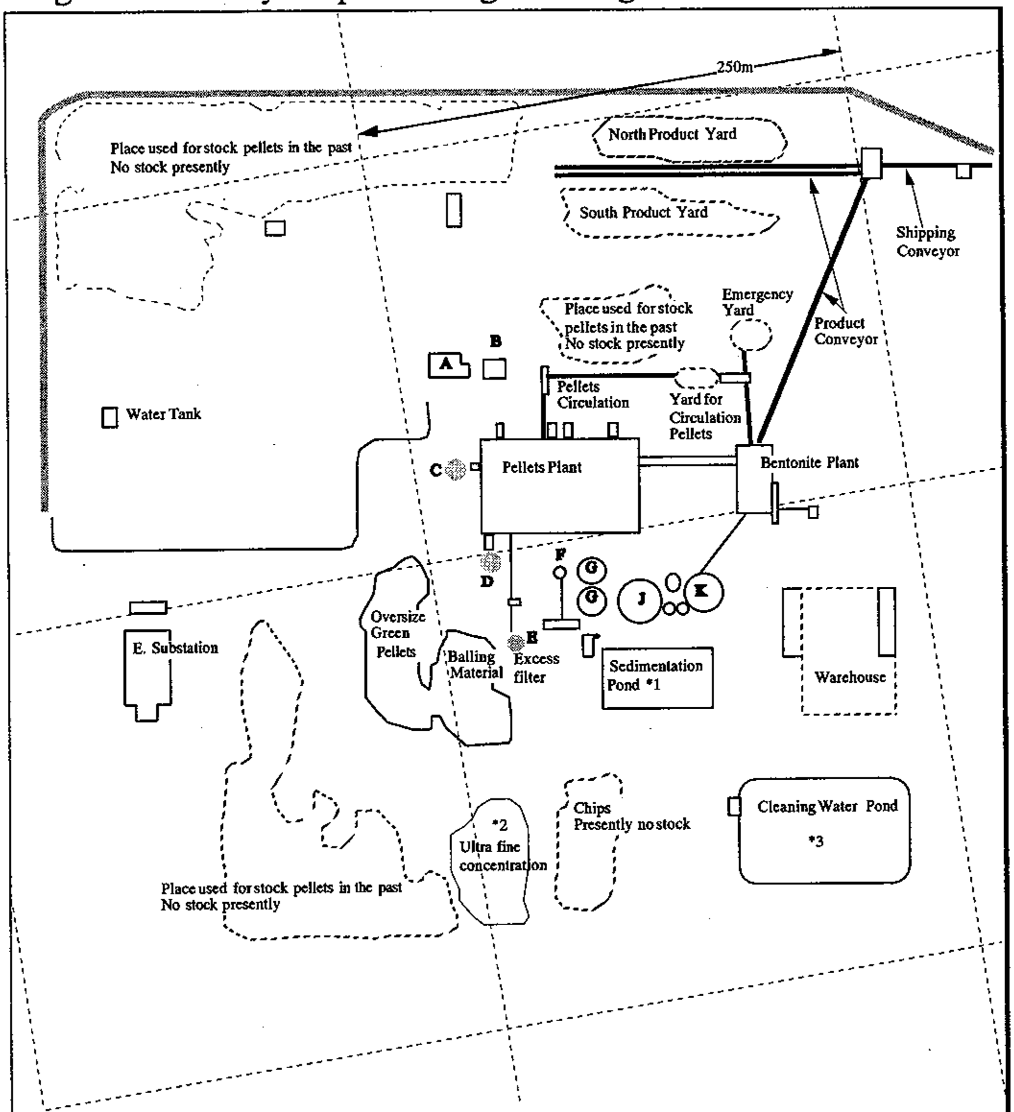


Fig.-7 Vicinity of pelletizing building

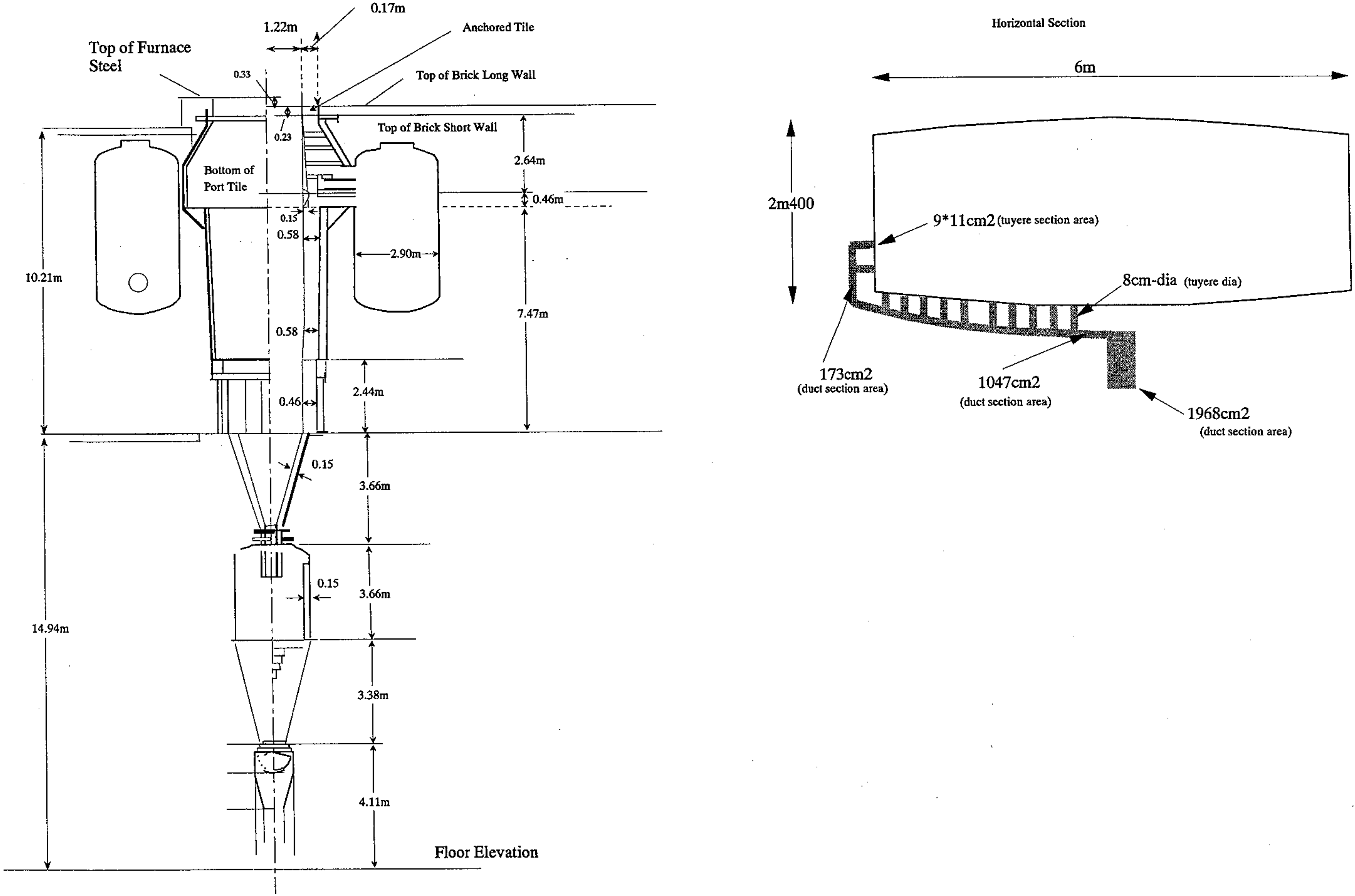


A:Emergency Generator
B:Cooling Tower
C:Emergency Discharge of Oversize Green Pellets
(from No 15)
D:Emergency Discharge of Balling Maternal
(from No 26)
E:Discharge of Excess Filter Cake
(from No 1)
F:Slurry Tank for recycling Excess Filter Cake

G:Slurry Receiving Tank
J:Concentration Thickener
K:Silica and Dolomite
Thickener

*1: Over flow from Concentration Thickener
*2:Stock of Dried Material from Sedimentation Pond and Cleaning Water Pond
*3:Pond for Cleaning Water of Slurry Duct from Mine to Pellet Plant
Partially used for Over Flow from Slurry Receiving Tank

Figure-8 Furnace dimension



(2) Availability

1) History of Furnaces

In **Graph-15**, monthly operating hours from 1979 to 1990 are shown.

Basically 2 furnaces were operated except for the period when a just repaired furnace was restarted.

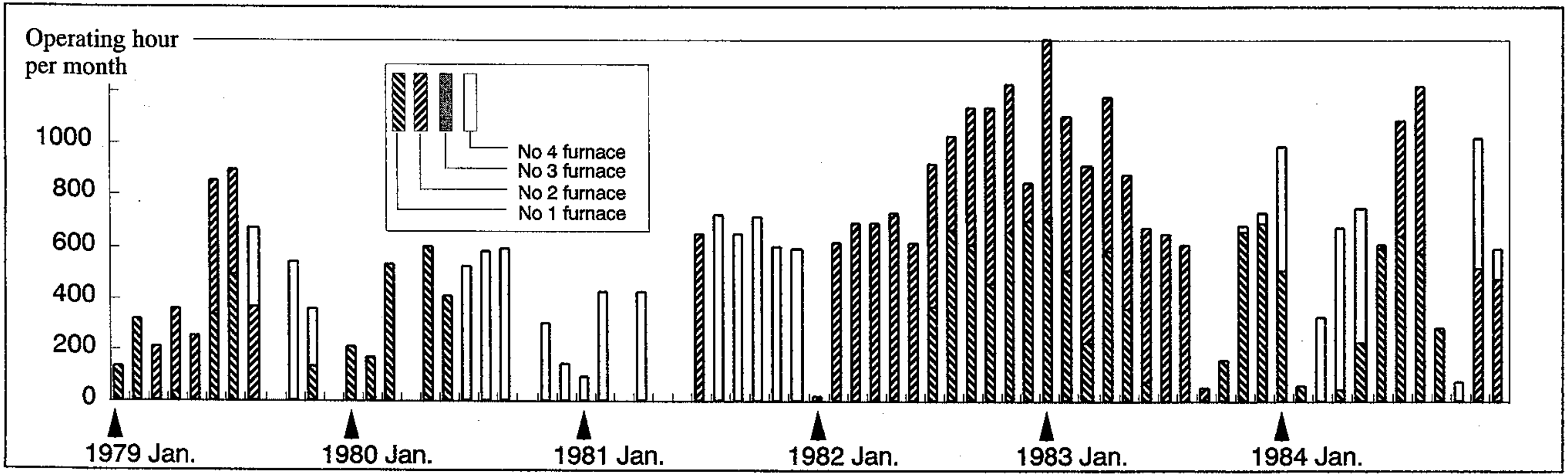
Two furnace operation continued to the end of project. No.3 furnace construction was completed in November, 1988. Longest operation was 18 month and average operation was about 10 months.

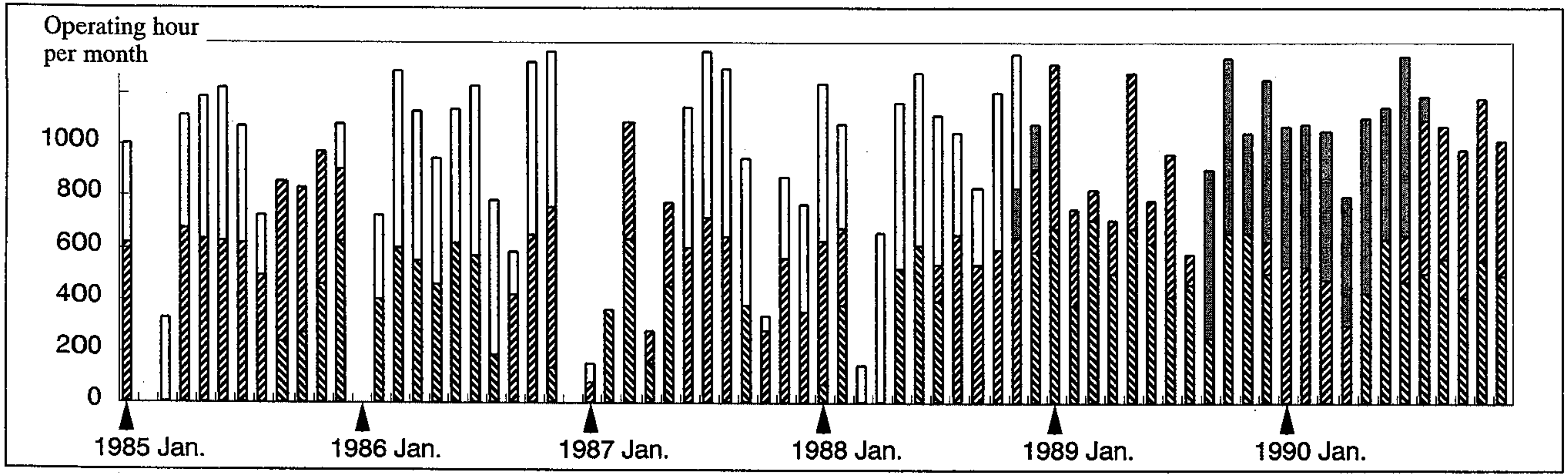
In **Table-50**, total operating hours and production for each year is shown.

Table-50 Production and furnace operating hours

	Production t/year	Shipping t/year	Furnace running hrs. h/year	t/h
1980	311,932	134,552	4,030	77
1981	326,303	303,184	4,842	67
1982	566,066	655,006	9,628	59
1983	520,822	596,090	9,008	58
1984	420,129	510,055	7,650	55
1985	509,429	513,749	10,369	49
1986	646,356	569,096	10,463	62
1987	464,660	438,858	9,360	50
1988	605,134	655,033	12,146	50
1989	591,899	659,117	11,722	50
1990	612,783	624,406	12,988	47

Graph-15 Monthly operating hours of furnaces





From 1988, 3 years before the project closure to 1990, annual production was about 600kilo-t per year and furnace operating hours reached about 12,000 (2 furnaces operating hour) hours per year. The ratio of furnace operating hours against calendar hours showed 70% more. Ratio (production-t/furnace operating hour) was decreasing year by year. (note: Generally, production rate is defined as [product/green pellets production hour]. The definition of it is the same in HIPASAM. Production rate is not [product/furnace operating hour]) This shows that stoping procedure after break down stoppage was more careful for the better restart of production. It is a requirement to continue hot gas blow with the re-charge of fired pellets into the furnace after break down stoppage in order to fire out green pellets layer charged just before a stoppage.

From the above mentioned it can be concluded that oneoperation period of a furnace was 10 to 18 month and availability of a furnace itself was about 70 % of this excluding major shut downs.

2) Analysis of stoppage

a) Cause of stoppage

As mentioned in (2)-1 of **4.2.3**, three years (1988 to 1990) just before the closure of the plant showed comparatively high and stable production and furnace availability. So data for the stoppage analysis has been extracted from this period. More precise data is extracted from the 1989 results because a full set of monthly reports exists for this one year only.

In **Table-51**, cause of stoppage from 1988 to 1990 is shown.

In **Table-52**, cause of stoppage by month wise in 1989 is shown.

From **Table-51** , causes of big stoppage are almost the same in each of the 3 years. The followings are the major causes of stoppage.

- Trouble with belt conveyor
- Balling drum and scraper
- Trouble with shaft furnace
- Trouble with index feeder buggy
- Trouble with wiper bar
- Lack of concentrate
- Shut down by labour union
- Trouble with utilities

In **Table-51** and **Table-52**, scheduled shutdown for maintenance is not listed. Items to be carried out in scheduled shut down might be conducted during long break down shutdown.

Major causes of stoppage in **Table-52**, for each month are almost the same as the annual results shown in **Table-51**. Stoppage due to trouble in blending of additive in August should be classified as a scheduled stoppage for the improvement of the system. The stoppage due to trouble in the shaft furnace body might be attributed to serious chunk formation. The stoppage due to Chunk Breaker would be attributed to serious chunk formation. The stoppage due to lack of concentrate and labour union occurred intermittently and lowered availability to a great extend.

Addition to these above-mentioned stoppages, trouble without utilities may be excluded from the cause of stoppage of plant itself if it is operated normal conditions.

Table-51 Cause of stoppage (1988 to 1990)

		1988		1989		1990		3 years total			
		Minutes	%	Minutes	%	Minutes	%	Minutes	%	Frequ -ency	Minutes/ one stoppage
1	Stock Tank for Concentrate	200	0.04	175	0.04	20	0.00	395	0.03	9	44
2	Thickner for Concentrate		0.00	20	0.00	40	0.01	60	0.00	2	30
3	Slurry Pump and Piping	1275	0.26	1435	0.33	3160	0.70	5870	0.43	105	56
4	Vaccum Pump	20	0.00	10	0.00	195	0.04	225	0.02	5	45
5	Compressor for Disc Filter		0.00	0	0.00	80	0.02	80	0.01	2	40
6	Disc Filter	1835	0.37	1053	0.24	7510	1.67	10398	0.75	153	68
7	Dozing of Additives	460	0.09	500	0.11	115	0.03	1075	0.08	9	119
8	Belt Conveyor	18474	3.77	13525	3.08	26068	5.80	58067	4.21	1373	42
9	Blendig of Additives	840	0.17	10235	2.33	4855	1.08	15930	1.16	60	266
10	Balling Bin and Feeder	3830	0.78	528	0.12	1434	0.32	5792	0.42	108	54
11	Balling Drum and Scraper	10383	2.12	6132	1.40	18941	4.21	35456	2.57	381	93
12	Green Pellets Screen	12338	2.52	16735	3.81	11640	2.59	40713	2.95	443	92
13	Furnace Body (Spout and grout)	44980	9.18	55018	12.53	210371	46.81	310369	22.51	1470	211
14	Chrge Conveyor Buggy	39554	8.07	23013	5.24	53761	11.96	116328	8.44	1514	77
15	Upper De-duster	2590	0.53	2465	0.56	1175	0.26	6230	0.45	80	78
16	Door for Dust Supression	11361	2.32	8974	2.04	3010	0.67	23345	1.69	242	96
17	Combustio Chanber	5975	1.22	2245	0.51	2330	0.52	10550	0.77	126	84
18	Chunk Breaker	6625	1.35	9435	2.15	4775	1.06	20835	1.51	103	202
19	Wiper bar in Cooler	16260	3.32	20997	4.78	12812	2.85	50069	3.63	10904	5
20	Compressor (cooling and process)	10210	2.08	2375	0.54	4145	0.92	16730	1.21	142	118
21	Plant Air Compressor	515	0.11	0	0.00	1305	0.29	1820	0.13	30	61
22	Water Punp for Process and Sealing	1870	0.38	0	0.00	205	0.05	2075	0.15	14	148
23	Cooling Tower	260	0.05	0	0.00	0	0.00	260	0.02	5	52
24	Furnace Charge System of Fired Pellets	1095	0.22	0	0.00	2370	0.53	3465	0.25	21	165
25	Electrical Substation and Control Room	203	0.04	0	0.00	1990	0.44	2193	0.16	14	157
26	Grindng System of Additives	0	0.00	0	0.00	0	0.00				
27	Product and Shipping Screen	795	0.16	0	0.00	1660	0.37	2455	0.18	73	34
28	Lack of Material	0	0.00	0	0.00	165	0.04	165	0.01	2	83
29	Lack of Concentrate	87062	17.76	186565	42.50	39965	8.89	313592	22.75	260	1206
30	Full of Product Yard		0.00	68	0.02	13	0.00	81	0.01	3	27
31	Labour Union	10465	2.14	68480	15.60	21625	4.81	100570	7.30	90	1117
32	Trobles in Utility	180848	36.90	8090	1.84	12625	2.81	201563	14.62	158	1276
33	Others	19820	4.04	915	0.21	1045	0.23	21780	1.58	34	641
	Total	490143	100.00	438988	100.00	449405	100.00	1378536	100.00	17935	77

Table-52 Cause of stoppage by month in1989

		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
		%	%	%	%	%	%	%	%	%	%	%	%
1	Stock Tank for Concentrate	0.00	0.00	0.21	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.24	0.21
2	Thickner for Concentrate	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Slurry Pump and Piping	1.61	0.00	0.00	0.00	0.66	0.00	1.14	0.02	0.00	0.76	0.32	0.73
4	Vaccum Pump	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
5	Compressor for Disc Filter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Disc Filter	0.63	0.00	0.13	0.29	0.42	0.00	0.05	0.00	0.29	1.34	0.32	0.55
7	Dosing of Additives	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.04	0.15	0.28	0.00	0.00
8	Belt Conveyor	8.28	1.52	1.77	0.80	7.65	1.59	2.74	2.06	1.23	4.52	4.19	4.14
9	Blendig of Additives	0.50	0.00	2.19	2.47	0.00	0.00	0.12	66.05	0.16	3.94	0.00	0.12
10	Balling Bin and Feeder	0.05	0.01	0.00	0.25	0.26	0.00	0.13	0.00	0.04	0.09	0.00	0.85
11	Pelletizer and it's Scraper	1.66	1.85	0.44	0.12	2.09	0.15	0.62	0.87	0.74	8.77	2.74	0.69
12	Green Pellets Screen	10.44	0.60	1.29	2.67	4.78	4.12	2.67	0.12	8.09	14.92	5.64	1.82
13	Shaft Furnace Body (Spout and grout)	8.57	2.12	2.24	3.28	13.97	2.07	3.62	11.15	22.49	17.69	52.22	2.27
14	Charge Conveyor Buggy	17.82	3.90	2.86	3.29	17.77	3.07	4.55	2.22	2.85	8.80	2.58	4.23
15	Upper De-duster	2.90	0.96	0.06	0.00	1.05	0.00	0.00	0.38	0.74	0.12	0.14	1.30
16	Door for Dust Supression	1.85	4.51	1.30	0.72	16.79	1.67	0.00	0.48	0.20	2.90	0.42	0.03
17	Combustion Chamber	1.00	0.16	0.28	0.02	0.16	0.40	0.02	0.27	0.40	0.00	1.75	1.78
18	Chunk Breaker	0.88	0.20	0.00	0.00	1.29	0.05	0.15	0.00	0.00	0.55	24.81	0.21
19	Wiper Bar	9.54	2.51	6.65	2.10	19.73	2.74	7.73	0.83	2.30	11.07	2.25	1.92
20	Compressor (cooling and process)	2.18	0.08	1.02	0.59	1.85	0.13	0.09	0.03	0.00	0.12	0.44	1.78
21	Plant Air Compressor	2.41	0.01	0.00	0.03	0.00	0.03	0.00	0.04	0.00	0.39	1.48	0.28
22	Water Punp for Process and Sealing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	Cooling Tower	0.00	0.00	0.04	0.09	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
24	Furnace Charge System of Fired Pellets	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.10	0.00	0.92	0.00	0.00
25	Electrical Substation and Control Room	0.54	0.09	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
26	Grindng System of Additives	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Product and Shipping Screen	0.01	0.50	0.00	0.04	0.05	0.03	0.16	0.00	0.05	0.15	0.13	0.48
28	Lack of Material	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	Lack of Concentrate	27.53	29.77	68.57	58.49	7.71	83.64	39.45	15.17	60.21	0.00	0.00	24.23
30	Full of Product Yard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
31	Labour Union	0.00	48.12	10.90	24.73	0.00	0.00	36.65	0.00	0.00	22.13	0.00	51.62
32	Troubles in Utility	1.61	3.09	0.00	0.00	3.49	0.21	0.00	0.08	0.00	0.52	0.33	0.76
33	Others	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.04	0.06	0.00	0.00	0.00
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

b) Classification of "cause of stoppage"

b-1) Troubles found frequently at the initial stage of newly constructed plant Initial stage stoppage)

Table-53 shows "cause wise and responsible group wise stoppage" with stoping minutes and frequency. **Table-54** shows it with percentage.

In **Table-54**, causes of stoppage of item 1, 2, 3, 4, 5, 6, 8, 9, 10, 11 and 12 form 11.4 % of stoppage. The total stoppage time is 49,848 minutes and number of stoppage is 775 times with average stoppage hour of 64.3 minutes per one stoppage. These items considered to be classified as initial stage stoppage as only mechanical and electrical maintenance group should be responsible. These problems could be solved after adjustment and small scale improvement.

For example, green pellets screen had trouble with roller bearings due to seizing as dust entered bearings. For this phenomenon, temporary counter measures were conducted by spraying lubricant oil from outside of bearing. Good rrresults was obtained but it was not a perfect solution. For this problem a selection of labyrinth type sealing and pressing of grease into the bearings may be the basic solution.

As for item 8, superficial reasons for stoppage are side travel of belt, slip between belt and pulley and choking in chute of belt conveyors from disc filter to pelletizer. The true reason for this may be high moisture of filter cake. If property of concentrate could be improved and dewatering carried out well, this problem would be solved.

Frequency of these stoppage may be reduced to about 10 times per month at a maximum if the plant is fully commisioned and operational. This means that stoppage would become less than 64.3×10×12=7716 min./year. Namely, these kinds of stoppage shall be decreased from 49,848 min./year to 7,716 min./year.

b-2) Stoppage due to the problems with control system

In **Table-54**, causes of stoppage of item 7, 17 and 20 form 1.2 % of stoppage. Total stoppage time is 5,120 minutes and number of stoppage is 63 times with average stoppage hour of 81.3 minutes per one stoppage. For these stoppages, the instrument maintenance group were mainly responsible. This would be solved by using a new controller (up-dated programmable logic controller in other words PLC) to reduce the number of relays.

Frequency of these stoppage would be reduced to one tenth. This means that stoppage would become less than 81.3× 10=813 min./year.

b-3) Cause of stoppage peculiar to this plant

In **Table-54**, causes of stoppage of item 13, 14, 15, 16, 22 and 23 form 27.3 % of stoppage. Total stoppage time is 119,902 minutes and number of stoppage is 1546 times with average stoppage hour of 77.6 minutes per one stoppage.

Item 13 contains 2 categories. One is spout and the other is grout.

Spout means that hot gas blow out from limited area of top surface in shaft furnace due to chunk formation. If chunk (which is formed with large scale by pellets adhering to each others) is formed in shaft furnace, it remains in the shaft for long time and disturbs homogeneous ascending flow of hot gas. Hot gas goes up through channel of high permeability formed by high descending speed of burden which goes down steering clear of the chunk.

Grout means the injection of mortar into the gap formed between steel shell of furnace and fire brick. Owing to frequent stoppage leading to cooling and heating of furnace and chamber, the fire brick is damaged to form the gap and hot gas penetrates the fire brick to the steel shell leading to the formation of a red spot of high temperature on the shell. The requirement for grouting was found frequently on the shell of the hot gas duct from the combustion chamber to the furnace.This was classified in same item 13 with spout because it occurred frequently after the stoppage due to spout and chunk formation.

If the problem of chunk formation should be solved, there would not be the stoppage due to spout, and stoppages due to the trouble of item 14, 15, 16,18 and 19 would be reduced. Pellets temperature was about 500℃ to 600℃ at transition from furnace to cooler which should be 300℃ on design. This could be considered to be the result of chunk formation it decreased the heat exchange. High temperature pellets might give damage to wiper bar.

Additional to the reduction of stoppage due to item 13 to 19, if the stoppage mentioned in **b-1)** and **b-2)** would be reduced, stoppage for grout would be reduced to a great degree.

By preventing chunk formation, it is hoped the stoppage mentioned in this **b-3)** would be reduced to one twentieth. This means the stoppage time would be 5,995 min./year.

b-4) Cause of stoppage out of control

In **Table-54**, causes of stoppage of item 29, 30, 31, 32 and 33 form 70% of stoppage. Total stoppage time is 264,118 minutes.

Social situation has been changed and new management will solve these kind of problems.

b-5) Problems which were not shown in tables

For example, originally there were two product screens in this plant. Screens had problems that they gave rise to abnormal vibration leading to sudden stop, breakage of parts and the shortage of spareparts. Finally one screen was removed and an emergency chute was installed at the place. This means that some product pellets were stacked in the product yard without screening. From the view point of quality control, this was a very serious problems.

There would be further more problems which were not recorded and forgotten and they will be found after re-start and will be rectified within short period.

Table-53 Cause wise and responsible groupwise stoppage in1989

No.	Cause	Maintenance								Production		Others in HIPASAM		Others outside HIPASAM		Total		
		Mechanical		Electrical		Instrument		Maintenance Total										
		min.	fre.	min.	fre.	min.	fre.	min.	fre.	min.	fre.	min.	fre.	min.	fre.	min.	%	fre
1	Stock Tank for Concentrate	90	3	85	1			175	4							175	0.04	4
2	Thickner for Concentrate	20	1					20	1							20	0.00	1
3	Slurry Pump and Piping	1205	20	230	9			1435	29							1435	0.33	29
4	Vaccum Pump			10	1			10	1							10	0.00	1
5	Compressor for Disc Filter							0	0							0	0.00	0
6	Disc Filter	408	12	205	3			613	15	440	14					1053	0.24	29
7	Dosing of Additives	45	1			455	4	500	5							500	0.11	5
8	Belt Conveyor	6690	212	2735	63	1535	30	10960	305	2565	107					13525	3.08	412
9	Blendig of Additives	9495	18	175	2	550	6	10220	26	15	1					10235	2.33	27
10	Balling Bin and Feeder	168	6	310	10			478	16	50	3					528	0.12	19
11	Pelletizer and it's Scraper	3815	16	827	29	845	12	5487	57	645	22					6132	1.40	79
12	Green Pellets Screen	15565	127	490	11	405	13	16460	151	275	23					16735	3.81	174
13	Shaft Furnace Body (Spout and grout)	14220	18	60	2	550	10	14830	30	39378	540	810	1			55018	12.53	571
14	Charge Conveyor Buggy	14981	223	6109	137	360	5	21450	365	1563	23					23013	5.24	388
15	Upper De-duster	1520	16	315	8	630	12	2465	36							2465	0.56	36
16	Door for Dust Supression	8974	103					8974	103							8974	2.04	103
17	Combustion Chamber	170	3	285	1	1600	21	2055	25	190	6					2245	0.51	31
18	Chunk Breaker	9270	16	165	5			9435	21							9435	2.15	21
19	Wiper Bar	1605	16	1620	52	265	3	3490	71	17497	355	10	1			20997	4.78	427
20	Compressor (cooling and process)	670	5	595	5	1110	17	2375	27							2375	0.54	27
21	Plant Air Compressor							0	0							0	0.00	0
22	Water Punp for Process and Sealing							0	0							0	0.00	0
23	Cooling Tower							0	0							0	0.00	0
24	Furnace Charge System of Fired Pellets							0	0							0	0.00	0
25	Electrical Substation and Control Room							0	0							0	0.00	0
26	Grindng System of Additives							0	0							0	0.00	0
27	Product and Shipping Screen							0	0							0	0.00	0
28	Lack of Material							0	0							0	0.00	0
29	Lack of Concentrate							0	0			175195	143	11370	9	186565	42.50	152
30	Full of Product Yard							0	0			68	2			68	0.02	2
31	Labour Union							0	0			700	1	67780	54	68480	15.60	55
32	Troubles in Utility							0	0			90	2	8000	31	8090	1.84	33
33	Others							0	0			870	7	45	3	915	0.21	10
	Total	88911	816	14216	339	8305	133	1E+05	1288	62618	1094	177743	157	87195	97	438988	100.00	2636
	% in Total	20.25	30.96	3.24	12.86	1.89	5.05	25.38	48.86	14.26	41.50	40.49	5.96	19.86	3.68	100.00		

Table-54 Cause wise and responsible groupwise stoppage(%) in1989

No.	Cause	Maintenance				Production	Others in HIPASAM	Others outside HIPASAM	Total			
		Mecha	Elect	Instru	M.Total							
		%	%	%	%	%	%	%	min.	%	fre	min/time
1	Stock Tank for Concentrate	0.021	0.019		0.040				175	0.040	4	44
2	Thickner for Concentrate	0.005			0.005				20	0.005	1	20
3	Slurry Pump and Piping	0.274	0.052		0.327				1435	0.327	29	49
4	Vaccum Pump		0.002		0.002				10	0.002	1	10
5	Compressor for Disc Filter											
6	Disc Filter	0.093	0.047		0.140	0.100			1053	0.240	29	36
7	Dosing of Additives	0.010		0.104	0.114				500	0.114	5	100
8	Belt Conveyor	1.524	0.623	0.350	2.497	0.584			13525	3.081	412	33
9	Blendig of Additives	2.163	0.040	0.125	2.328	0.003			10235	2.331	27	379
10	Balling Bin and Feeder	0.038	0.071		0.109	0.011			528	0.120	19	28
11	Pelletizer and it's Scraper	0.869	0.188	0.192	1.250	0.147			6132	1.397	79	78
12	Green Pellets Screen	3.546	0.112	0.092	3.750	0.063			16735	3.812	174	96
13	Shaft Furnace Body (Spout and grout)	3.239	0.014	0.125	3.378	8.970	0.185		55018	12.533	571	96
14	Charge Conveyor Buggy	3.413	1.392	0.082	4.886	0.356			23013	5.242	388	59
15	Upper De-duster	0.346	0.072	0.144	0.562				2465	0.562	36	68
16	Door for Dust Supression	2.044			2.044				8974	2.044	103	87
17	Combustion Chamber	0.039	0.065	0.364	0.468	0.043			2245	0.511	31	72
18	Chunk Breaker	2.112	0.038		2.149				9435	2.149	21	449
19	Wiper Bar	0.366	0.369	0.060	0.795	3.986	0.002		20997	4.783	427	49
20	Compressor (cooling and process)	0.153	0.136	0.253	0.541				2375	0.541	27	88
21	Plant Air Compressor											
22	Water Punp for Process and Sealing											
23	Cooling Tower											
24	Furnace Charge System of Fired Pellets											
25	Electrical Substation and Control Room											
26	Grindng System of Additives											
27	Product and Shipping Screen											
28	Lack of Material											
29	Lack of Concentrate						39.909	2.590	186565	42.499	152	1227
30	Full of Product Yard						0.015		68	0.015	2	34
31	Labour Union						0.159	15.440	68480	15.600	55	1245
32	Troubles in Utility						0.021	1.822	8090	1.843	33	245
33	Others						0.198	0.010	915	0.208	10	92
	Total	20.254	3.238	1.892	25.384	14.264	40.489	19.863	438988	100.00	2636	167

(3) Operation

1) Operation results

a) Selection of period for data

As mentioned in (2)-1 of 4.2.3, annual data (month wise data) for1989 is selected for the analysis. Monthly data (day wise data) for October is selected for the analysis because the most stable operation was carried out in this month. There was only one day with 24 hours operation in No.3 furnace in October and day data (hour wise) data is selected for the analysis.

Table-55 shows month wise operation data in 1989.

Table-56 shows day wise data of No.1 furnace in 1989, October.

Table-57 shows day wise data of No.3 furnace in 1989, October.

Table-58 shows hourly data of No.3 furnace on 17 th in 1989, October.

Table-55 Month wise operation data in1989

		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Average
Green Pellets	t/month	67698	37980	43858	37870	71132	45339	43767	48238	49432	77084	52741	57046	52682
Pellets Product	t/month	64773	35257	42170	33873	65752	38936	42325	43417	45125	72704	49507	58060	49325
Pellets re-used	t/month	4388	5011	5193	1613	5087	3534	(7620)	(5340)	4666	3795	6779	9176	5184
Pellets passing furnace	t/month	69161	40268	47363	35486	70839	42470	49945	(48757)	49791	76499	56286	67236	54508
Chips	t/month	654	356	426	345	669	393	423	434	451	727	495	581	496
Dust	t/month	654	356	426	345	664	393	423	434	451	727	495	581	496
Shipping	t/month	82504	44509	70493	19170	38293	66952	53764	39840	73130	58600	56039	55823	54926
Bentonite	kg/t-P	13.56	13.67	15.37	13.96	14.66	14.51	14.00	14.12	14.26	17.05	18.54	19.50	15.27
Quarzite	kg/t-P	6.53	6.22	6.11	6.48	6.67	6.05	6.28	5.37	6.25	5.96	5.92	6.77	6.22
Hydrated Lime	kg/t-P	0.85	0.91	0.38	0.60	0.57	0.77	0.43	0.44	0.49	0.55	0.58	0.51	0.59
Dolomite	kg/t-P	19.04	18.64	18.31	19.45	19.76	18.15	18.87	16.12	18.77	17.89	17.75	17.30	18.34
Electric power	kWh/t-P	74.29	77.11	77.76	82.44	74.79	89.11	79.96	85.78	84.68	69.81	77.84	76.35	79.16
Gas	m^3/t-P	28.89	26.39	25.38	23.71	30.35	26.91	25.65	28.96	21.77	26.07	24.67	17.30	25.50
Bentonite	t/month	878	482	648	473	964	565	593	613	644	1240	918	1132	763
Quarzite	t/month	423	212	258	220	438	236	2666	233	282	433	293	393	507
Hydrated Lime	t/month	55	32	16	20	38	30	18	19	22	40	29	30	29
Dolomite	t/month	1233	657	772	659	1299	707	799	700	847	1301	879	1180	919
Electric power	mega Wh/month	5138	3104	3584	3156	5298	3784	3994	4183	4217	5439	4382	5133	4284
Gas	km^3/month	1998	1058	1169	907	2150	1143	1281	1412	1084	2031	1389	1163	1399
Gas oil	litter/month	12076	9000	10126	7840	9000	11678	9689	13744	11382	12014	7977	9117	10304
G.media	kg/month	5000	2000		2000	4000			2000		9000		3000	2250
Filter cloth(out)	/month	125	125	125	50	100	75	100	25	50	185	125	75	97
Filter cloth(in)	/month	18	4	25	25	30	40				66	10		18
Availability	No.1	77.9	49.0	86.1	61.2	79.3	76.9	50.1	56.1	62.4	79.0	78.9	63.3	68.4
(%)	No.2	81.0	51.6	15.7	28.1	76.5	22.9	63.7	28.0				53.9	35.1
	No.3									56.0	87.3	49.2	87.9	23.4
	No.4													0.0
	Total	78.9	50.3	51.7	45.2	77.9	50.8	61.4	53.8	57.7	83.0	64.3	72.2	62.3
Product Rate	t/h	54.2	53.8	57.6	50.2	55.4	54.3	36.8	46.9	54.9	57.4	53.8	53.8	53.8

Table-56 Day wise data of No.1 furnace in October,1989

	Operation summarize							Balling																Furnace Condition														Tumbler	
	B.M.	O.H.	F.P.R.	P.	F	D.R.	P.R.	B.M.		G.B.Moist		D.N.		Comp.Strength (kg/P)				Heat Shock Test				Pre.Drop		Ex.Gas(T)		Temp. Entra.Cooler				A.R		A.S			
								wet-t/h		%		Times		wet		dry		500 ℃		700 ℃		mm H_2O		CAPERZA		N		S							
	t/day	hrs	t/day	t/day	t/day	t/h	t/h	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.
1	1431	19.4	125	1188	12	67.6	61.2	72.5	5.0	10.0	0.5	12.8	3.2	1.2	0.3	6.4	2.6	82.0	36.0	50.0	100.0	610	60	215	130	300	400	640	120	1.10	0.00	45.0	2.0	90.7	8.1
2	1052	14.4	274	874	9	79.9	60.8	72.5	5.0	9.8	0.3	12.6	1.2	1.0	0.2	6.0	2.2	100.0	0.0	82.0	36.0	520	240	190	140	425	290	640	120	1.10	0.00	46.0	0.0	88.2	14.5
3	448	5.9	265	372	4	107.6	62.8																												
4	1204	17.9	85	1003	10	60.5	55.8																												
5	1429	19.7	114	1187	12	66.1	60.3	72.5	5.0	10.0	0.3	11.8	2.2	1.0	0.3	7.4	4.1	100.0	0.0	97.0	6.0	590	80	250	100	400	40	630	140	1.10	0.10	46.0	4.0	90.4	9.7
6	1702	23.7	12	1413	14	60.2	59.7	75.0	0.0	9.9	0.3	10.2	1.8	1.0	0.2	6.7	0.5	100.0	0.0	83.0	34.0	605	50	235	70	475	250	625	150	1.08	0.15	48.0	0.0	89.1	11.6
7	1688	23.5	12	1404	14	60.1	59.6	72.5	5.0	10.1	0.8	11.2	3.7	1.1	0.2	7.0	4.3	100.0	0.0	96.0	8.0	590	20	245	30	380	200	565	270	1.10	0.00	48.0	0.0	89.4	8.9
8	1401	20.2	111	1165	12	63.2	57.7	70.0	10.0	10.2	0.6	19.1	0.9	1.0	0.2	7.2	2.0	87.0	26.0	50.0	100.0	590	20	220	120	290	200	650	100	1.13	0.05	47.0	2.0	90.4	8.5
9	1475	20.1	26	1225	12	62.3	61.0	70.0	10.0	10.3	0.2	17.5	2.5	1.1	0.3	6.3	1.9	65.0	70.0	39.0	78.0	600	40	265	50	330	280	650	100	1.15	0.00	47.0	2.0	87.0	10.3
10	1713	23.7	12	1422	14	60.6	60.1	75.0	0.0	10.0	0.4	17.4	2.3	0.9	0.6	7.5	3.0	92.0	16.0	56.0	88.0	640	80	240	80	365	370	575	250	1.15	0.00	48.0	0.0	89.9	5.1
11	1550	20.8	38	1286	13	63.6	61.7	75.0	0.0	9.6	0.4	8.8	2.4	1.3	0.8	6.4	1.7	84.5	31.0	52.0	96.0	620	40	205	110	380	320	660	80	1.15	0.00	47.0	2.0	91.9	5.5
12	1750	23.8	9	1453	15	61.5	61.2	75.0	0.0	9.9	0.4	15.4	2.8	1.0	0.3	7.7	4.0	100.0	0.0	60.0	76.0	630	20	250	60	375	350	675	50	1.13	0.05	47.0	2.0	88.4	9.9
13	902	11.6	169	749	8	79.2	64.7	75.0	0.0	10.4	0.1	16.5	3.6	1.2	0.2	7.3	2.8	87.0	26.0	43.0	70.0	590	140	180	120	275	250	670	60	1.10	0.00	46.0	0.0	93.0	3.4
14	1285	18.5	134	1069	11	64.9	57.7	72.5	5.0	10.2	0.2	15.8	2.6	1.2	0.3	6.3	1.0	86.0	28.0	42.0	84.0	530	180	250	80	255	270	660	80	1.10	0.00	46.0	0.0	90.3	7.7
15	1300	17.9	123	1080	11	67.1	60.2	75.0	0.0	10.2	1.1	16.6	3.2	1.0	0.4	7.8	2.0	90.0	20.0	56.0	88.0	600	40	220	40	295	290	660	80	1.10	0.00	46.0	0.0	85.7	8.8
16	1625	22.6	50	1350	14	61.9	59.7	75.0	0.0	10.1	0.5	14.8	3.3	1.0	0.4	6.0	1.0	71.0	58.0	65.0	70.0	530	140	240	40	395	290	640	100	1.10	0.00	47.0	2.0	89.9	10.7
17	1587	22.3	61	1319	13	61.9	59.2	75.0	0.0	10.6	0.8	17.1	2.9	1.2	0.2	8.1	2.6	64.0	72.0	50.0	100.0	610	60	245	50	345	110	650	100	1.10	0.00	48.0	0.0	90.9	8.5
18	1049	14.3	225	871	9	76.5	60.8	75.0	0.0	10.4	0.5	17.9	2.2	1.2	0.2	6.7	0.8	50.0	100.0	50.0	100.0	570	100	190	120	335	170	650	100	1.10	0.00	48.0	0.0	90.2	7.1
19																																			
20	1605	21.8	19	1333	13	61.9	61.0	72.5	5.0	10.1	0.8	14.5	2.7	1.2	0.2	6.7	2.2	100.0	0.0	50.0	100.0	490	180	220	40	290	220	410	480	1.10	0.00	42.0	0.0	88.3	13.3
21	1716	22.8	12	1424	14	62.9	62.4	75.0	0.0	10.1	0.4	13.9	2.8	1.1	0.2	7.6	2.5	100.0	0.0	50.0	100.0	590	20	235	30	315	130	610	180	1.10	0.00	42.0	0.0	86.0	10.0
22	1616	22.3	32	1342	14	61.7	60.3	75.0	0.0	10.2	0.3	15.3	2.4	1.2	0.3	6.6	1.3	80.0	40.0	59.0	70.0	605	50	245	30	325	250	530	340	1.10	0.00	42.0	0.0	87.0	6.0
23	915	13.3	114	761	7	65.5	57.0	72.5	5.0	10.4	0.4	16.0	4.1	1.1	0.1	6.6	1.0	100.0	0.0	99.5	1.0	540	160	220	80	275	210	590	220	1.10	0.00	45.0	6.0	84.8	15.2
24	1460	21.2	90	1215	12	61.5	57.2	72.5	5.0	10.3	0.7	14.2	4.1	1.0	0.3	6.1	1.8	100.0	0.0	54.0	72.0	535	170	235	70	360	360	700	0	1.10	0.00	48.0	0.0	87.9	1.2
25	1721	23.4	15	1430	15	61.6	61.0	75.0	0.0	10.1	0.8	13.6	2.5	1.2	0.2	6.5	0.6	100.0	0.0	62.0	76.0	590	20	235	30	465	190	700	0	1.10	0.00	48.0	0.0	92.2	5.2
26	1504	20.7	64	1249	13	63.5	60.4	75.0	0.0	9.9	0.6	14.2	5.8	1.0	0.4	6.4	4.0	100.0	0.0	77.0	46.0	580	40	220	60	375	250	550	300	1.10	0.00	46.0	4.0	91.1	8.0
27	438	5.6	166	363	4	94.7	65.0																												
28	630	9.5	90	525	5	64.4	55.0																												
29	1743	23.9	0	1448	15	60.5	60.5	72.5	5.0	10.1	0.8	8.9	2.6	0.9	0.2	6.2	1.1	100.0	0.0	92.0	16.0	570	20	225	50	470	180	700	0	1.10	0.00	48.0	0.0	82.6	11.3
30	1302	18.4	155	1082	11	67.1	58.7	75.0	0.0	10.0	1.0	10.0	3.0	1.0	0.3	6.5	2.2	55.0	90.0	76.0	48.0	540	120	225	30	390	480	585	230	1.10	0.00	48.0	0.0	89.5	5.6
31	1783	23.8	6	1478	15	62.4	62.1	75.0	0.0	10.1	0.6	12.2	1.7	1.1	0.2	5.8	2.5	100.0	0.0	45.0	90.0	560	40	225	50	435	270	600	200	1.10	0.00	46.0	4.0	89.1	5.3
	41297	571.3	2900	34308	345	65.1	60.0	73.8	2.5	10.1	0.5	14.1	2.8	1.1	0.3	6.8	2.1	88.2	23.6	62.9	67.4	578	82	228	69.6	358	255	624	148	1.11	0.01	46.3	1.2	89.0	8.4

Abreviation

B.M.=Balling material, O.H.=Operating hours, F.P.R.=Fired pellets re-charge, P.=Product pellets, D.R.=Discharge rate from furnace, P.R.=Production rate

D.N.=Drop number, Pre.Drop=Pressure drop in furnace, Ex.Gas(T)=Exhausted gas temperature, CAPERZA=Furnace top hood, Temp.Entra.Cooler=Temperature at the entarnce to cooler

Med.=(Maximum data+Minimum data), Wid.=Width=(Maximum data-Minimum data)

Table-57 Day wise data of No.3 furnace in October,1989

	Operation summarize							Balling													
	B.M.	O.H.	F.P.R.	P.	F	D.R.	P.R.	B.M. wet-t/h		G.B.Moist %		D.N. Times		Comp.Strength (kg/P) wet		Comp.Strength (kg/P) dry		Heat Shock Test 500 ℃		Heat Shock Test 700 ℃	
	t/day	hrs	t/day	t/day	t/day	t/h	t/h	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.
1	1430	18.8	82	1188	11	67.7	63.3	75.0	0.0	9.8	0.5	12.2	2.0	1.2	0.4	6.6	0.6	100.0	0.0	70.0	60.0
2	1030	14.3	193	856	8	73.5	60.0	75.0	0.0	9.1	1.2	11.2	0.9	1.1	0.4	6.0	1.3	100.0	0.0	57.0	86.0
3	1721	22.3	53	1427	14	66.3	63.9	75.0	0.0	9.8	1.2	16.8	3.0	1.5	0.9	7.6	2.7	66.0	68.0	50.0	100.0
4	1623	22.1	61	1352	14	63.7	61.0	75.0	0.0	9.4	1.2	10.6	2.6	1.0	0.3	6.4	2.5	100.0	0.0	70.0	60.0
5	1702	22.5	38	1414	14	64.5	62.8	75.0	0.0	10.0	0.3	14.2	2.2	1.1	0.3	5.9	2.0	83.0	34.0	50.0	100.0
6	1765	22.4	20	1465	15	66.2	65.3	75.0	0.0	9.7	0.6	11.4	0.7	1.0	0.5	5.9	1.4	100.0	0.0	60.0	80.0
7	1663	23.2	20	1384	14	60.4	59.6	75.0	0.0	9.7	0.6	11.4	0.7	1.1	0.1	6.4	1.3	100.0	0.0	67.0	66.0
8	1801	23.7	6	1497	15	63.4	63.1	75.0	0.0	10.2	0.4	14.9	1.8	1.1	0.3	8.1	3.9	100.0	0.0	50.0	100.0
9	1771	23.5	0	1471	15	62.6	62.6	75.0	0.0	10.1	0.5	17.3	2.1	1.1	0.2	6.4	1.0	100.0	0.0	81.0	34.0
10	1800	23.5	15	1495	15	64.2	63.6	75.0	0.0	9.8	0.7	16.3	3.4	1.1	0.2	6.1	1.4	100.0	0.0	51.0	46.0
11	1667	21.9	64	1384	14	66.0	63.1	75.0	0.0	10.2	1.3	10.0	3.4	1.0	0.3	5.4	2.2	100.0	0.0	57.0	86.0
12	1703	22.3	29	1414	14	64.6	63.3	75.0	0.0	9.9	0.4	16.4	4.0	1.2	0.4	6.8	1.1	100.0	0.0	48.0	96.0
13	1720	22.9	29	1427	14	63.6	62.3	75.0	0.0	10.1	0.6	12.9	1.3	1.2	0.3	6.8	2.2	64.0	72.0	44.0	88.0
14	1579	21.0	24	1313	13	63.6	62.4	75.0	0.0	10.1	0.8	16.4	3.6	1.1	0.2	6.1	1.3	82.0	36.0	62.0	76.0
15	1782	23.7	12	1481	15	63.0	62.5	75.0	0.0	10.1	0.4	16.2	2.6	1.2	0.3	6.4	1.8	100.0	0.0	91.0	18.0
16	1690	22.4	20	1405	14	63.5	62.6	75.0	0.0	10.1	0.3	16.6	2.9	1.1	0.4	6.2	1.3	87.0	26.0	67.0	66.0
17	1811	24.0	0	1505	15	62.6	62.6	75.0	0.0	10.6	0.2	20.0	0.0	6.8	1.4	6.9	2.0	52.0	96.0	12.8	25.5
18	1753	23.2	29	1456	14	64.0	62.8	75.0	0.0	10.3	0.6	14.0	6.0	1.3	0.4	7.9	1.7	67.0	66.0	46.0	92.0
19	1543	20.3	125	1283	13	69.4	63.2	75.0	0.0	10.3	0.4	17.2	2.9	1.1	0.2	6.9	1.7	67.0	66.0	54.0	92.0
20	1735	23.2	19	1441	15	63.0	62.2	75.0	0.0	10.2	0.3	12.3	1.5	1.2	0.2	6.5	1.3	100.0	0.0	55.0	90.0
21	1809	23.8	6	1501	15	63.5	63.2	75.0	0.0	9.9	0.6	12.9	3.1	1.0	0.1	6.6	0.8	100.0	0.0	89.0	22.0
22	1594	20.9	32	1324	13	64.8	63.2	75.0	0.0	10.1	0.2	14.9	1.8	1.1	0.2	8.0	2.0	55.0	90.0	50.0	100.0
23	1428	18.8	105	1188	12	68.5	62.9	75.0	0.0	10.3	0.4	18.5	1.5	1.1	0.2	6.5	2.6	100.0	0.0	85.0	30.0
24	1508	20.3	111	1255	13	67.0	61.6	75.0	0.0	10.2	0.7	15.7	3.3	1.1	0.2	5.6	1.1	100.0	0.0	66.0	64.0
25	1477	20.3	93	1228	12	65.1	60.5	75.0	0.0	10.1	0.4	12.5	3.5	1.1	0.1	6.8	1.1	100.0	0.0	82.0	36.0
26	25	0.3	385	21	0		62.9														
27	0	0.0	213	0	0																
28	1016	13.8	125	846	9	70.0	61.0														
29	1715	22.4	41	1424	14	65.3	63.5	75.0	0.0	9.9	0.5	9.3	3.3	1.0	0.3	6.8	4.5	100.0	0.0	50.0	100.0
30	1190	15.9	201	989	10	74.7	62.0	77.5	5.0	10.2	0.3	12.3	4.3	1.0	0.2	7.3	2.5	79.0	42.0	50.0	100.0
31	1163	14.6	160	964	9	77.2	66.2	77.5	5.0	10.4	1.2	12.6	2.3	1.1	0.1	7.0	1.2	55.0	90.0	56.0	88.0
	46214	612.2	2311	38397	385	66.4	62.7	75.2	0.4	10.0	0.6	14.2	2.5	1.3	0.3	6.6	1.8	87.8	24.5	59.7	71.5

	Furnace Condition												Tumbler	
	Pre.Drop mm H_2O		Ex.Gas(T) CAPERZA		Temp. Entra.Cooler N		Temp. Entra.Cooler S		A.R		A.S			
	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.	Med.	Wid.
1	630	60	200	160	283	141	309	152	1.03	0.05	40.0	0.0	87.8	11.8
2	580	120	185	170	384	267	429	337	1.00	0.00	40.0	0.0	87.7	13.7
3	670	20	225	90	358	205	401	295	1.05	0.00	40.0	0.0	94.1	6.3
4	703	85	215	70	345	261	361	160	1.05	0.00	40.0	0.0	88.0	10.1
5	620	40	220	40	259	261	421	260	1.05	0.00	42.0	0.0	94.3	1.5
6	645	10	220	40	333	287	357	302	1.05	0.00	41.5	3.0	92.2	8.9
7	620	40	200	40	263	124	377	249	1.00	0.00	38.0	0.0	90.3	11.2
8	600	0	210	40	364	190	350	143	1.03	0.05	41.0	2.0	88.2	12.4
9	670	140	220	60	427	276	403	305	1.05	0.00	42.0	0.0	93.3	4.1
10	630	100	210	20	363	298	300	173	1.05	0.00	40.0	0.0	93.3	3.2
11	590	20	220	40	339	142	308	200	1.05	0.00	41.5	3.0	89.1	8.7
12	610	60	225	30	292	210	271	218	1.05	0.00	42.0	0.0	93.3	1.3
13	620	40	220	40	310	250	326	322	1.05	0.00	42.0	0.0	94.1	2.5
14	590	180	200	20	439	303	401	90	1.05	0.00	42.0	0.0	93.4	3.9
15	630	20	210	40	465	153	450	279	1.05	0.00	42.0	0.0	91.2	5.1
16	660	40	220	40	495	258	436	214	1.05	0.01	45.0	6.0	91.7	6.1
17	640	0	220	40	445	126	389	214	1.05	0.00	42.0	0.0	91.9	2.5
18	700	0	215	30	395	278	418	132	1.05	0.00	42.0	0.0	94.3	2.0
19	710	60	225	50	422	303	438	276	1.05	0.00	42.0	0.0	93.5	1.2
20	625	10	210	20	422	263	374	363	1.05	0.00	42.0	0.0	94.0	1.1
21	630	20	210	40	385	181	398	233	1.05	0.00	42.0	0.0	94.7	1.2
22	650	100	200	20	412	319	307	127	1.05	0.00	42.0	0.0	94.5	1.6
23	595	190	205	90	370	412	271	219	1.05	0.00	42.0	0.0	92.1	1.6
24	580	160	225	50	430	231	307	357	1.05	0.00	42.0	0.0	92.3	6.1
25	650	60	225	50	397	237	409	334	1.05	0.00	42.0	0.0	94.2	2.5
26														
27														
28														
29	670	20	210	20	370	241	421	310	1.05	0.00	42.0	0.0	91.1	4.9
30	660	40	205	70	329	394	334	427	1.05	0.00	42.0	0.0	92.5	2.4
31	660	120	205	90	399	206	400	300	1.05	0.00	40.0	0.0	91.8	3.1
	637	63	213	53.9	375	243	370	250	1.04	0.00	41.5	0.5	92.1	5.0

Abreviation

B.M.=Balling material, O.H.=Operating hours, F.P.R.=Fired pellets re-charge, P.=Product pellets, D.R.=Discharge rate from furnace, P.R.=Production rate
D.N.=Drop number, Pre.Drop=Pressure drop in furnace, Ex.Gas(T)=Exhausted gas temperature, CAPERZA=Furnace top hood
Temp.Entra.Cooler=Temperature at the entarnce to cooler, Med.=(Maximum data+Minimum data), Wid.=Width=(Maximum data-Minimum data)

Table-58 Hourly Data, No.3 Furnace, 1989 October 17

	Balling							Furnace Condition						
	Balling Mate.	G.B. Moist	Drop Number	Comp.Strength		Heat Shock		Pre.Drop	Ex. Gas	Temp. Entra.Coo		A.R	A.S	Tumbler
	No.8			wet	dry	500 ℃	700 ℃			N	S			
Day	wet t/h	%	Times	kg/P	kg/P	%	%	mm H_2O	℃	℃	℃			%
06:30	75							640	200	389	417	1.05	42.0	
07:30	75							640	200	367	369			
08:30	75	10.4	+20	0.98	5.88	100.0	58.0	640	230	457	392	1.05	42.0	
09:30	75							640	230	478	533			90.7
10:30	75	10.5	+20	1.14	5.90	100.0	100.0	640	200	452	387	1.05	42.0	
11:30	75							640	200	435	501			91.3
12:30	75							640	200	463	471	1.05	42.0	
13:30	75							640	210	439	495			
14:30	75	10.7	+20	1.27	6.12			640	200	367	361	1.05	42.0	
15:30	75							640	210	391	399			90.7
16:30	75							640	230	420	418	1.05	42.0	
17:30	75							640	230	488	442			
18:30	75	10.4	+20	1.02	7.81	100.0	10.0	640	210	493	467	1.05	42.0	
19:30	75							640	200	507	486			92.0
20:30	75							640	220	432	490	1.05	42.0	
21:30	75							640	220	382	282			
22:30	75	10.4	+20	1.28	7.52	4.0	0.0	640	220	535	508	1.05	42.0	
23:30	75							640	230	400	400			93.2
00:30	75							640	240	450	403	1.05	42.0	
01:30	75							640	230	427	487			
02:30	75	10.3	+20	1.18	7.43	86.0	4.0	640	220	420	395	1.05	42.0	
03:30	75							640	220	398	458			95.1
04:30	75							640	230	508	395	1.05	42.0	
05:30	75							640	220	414	496			
Ave	75	10.5	20.0	1.15	6.78	78.0	34.4	640	216.67	438	435.5	1.05	42.0	92.2
St.Dev	0.000	0.120	0.000	0.125	0.900	41.809	43.483	0.000	13.077	46.524	59.922	0.000	0.000	1.715
Max	75	10.7	20.0	1.28	7.81	100.0	100.0	640	240	535	533	1.05	42.0	95.1
Min	75	10.3	20.0	0.98	5.88	4.0	0.0	640	200	367	282	1.05	42.0	90.7
Med	75.0	10.4	20.0	1.16	6.78	100.0	10.0	640	220	433.5	430	1.05	42.0	91.7
Width (Max-Min)	0.0	0.4	0.0	0.30	1.93	96.0	100.0	0	40	168	251	0.00	0.0	4.4

b) Month wise operation data (refer to **Table-55**)

Average availability in 1989 was 62.3%. In September No.3 furnace was re-started after repair and best availability (83.0%) was shown in October. Average monthly production was 50 kilo-t and production in October was 73 kilo-t. Fines (chips or undersize pellets from product screen) generation showed very low value ($496 \div 49{,}325 \times 100 = 1.01\%$).

It might be the result that sufficient fine was not removed sufficiently because only one screen was available and the generation is normally about 3 to 5 % in other plants. Quantity of pellets re-charged was 3,795t in October. Pellets re-charged means that already fired pellets were charged into the furnace again. It was charged when plant was stopped and re-started and when operation condition required the small quantity charge to keep good permeability in the furnace and to prevent big chunk formation.

Smaller quantity of pellets re-charged indicate that furnaces were operated under better conditions. Unit consumption of additives was constant throughout the year.

c) Day wise operation data (refer to **Table-56** and **Table-57**)

Material balance has small descrepancy between balling material and production of fired pellets.

In **Table-57.**

Balling material(B.M. et t/h)

75.2 wet-t/h=67.8 dry green ball t/h

=65.8 fired pellet t/h

Fired pellets production rate

62.7 t/h

There was the descrepancy of 3.1t/h (65.862.7) or of 4.9% (3.1/62.7×100). (For reference, charge rate including new balling material and balling return is estimated to be 280 t/h and new balling balling material charge rate is 66 t/h) The new balling material charge rate was kept constant basically and was reduced according to furnace conditions and the index of Tumbler Test. In No.3 furnace, this rate showed 75 t/h every day and it was increased near the end of the month. This means that furnace condition was very good through whole the month. Pellets production rate were 60 t/h in No.1 furnace and 62.5 t/h in No.3 furnace. Green pellets moisture showed the result of 10.6 % (median) with width 0.8% of moisture change on 17 th in No.1 furnace. This means moisture was 11% at maximum. This moisture content is too high compared with the other pelletizing plant results.

Fluctuation of moisture was very large. Drop number showed a very large fluctuation which might be generated by moisture fluctuation and fluctuation of dosing quantity of additives due to some problem with the additive dosing system.

A.R.(Air ratio) and A.S.(Air split) of No.1 furnace were higher than that of No.3. Pressure drop of No.1 was lower than that of No.3. Difference of north side temperature at entrance to cooler and south side was bigger in No.1 furnace than No.3 furnace. From A.R., A.S., pressure drop and temperature difference it can be concluded that chunk was formed in No.1 furnace.

Tumbler indexes of No.1 and No.3 were 89% and 92.1% respectively through the whole month.

Heat shock test result showed a big fluctuation. When it showed low level, deterioration of green pellets (bursting) near surface of burden in shaft might occur.

d) Hourly data (refer to **Table-58**)

On 17th October, there was no stoppage. From all the data, operation was considered to be vary stable and good.

2) Operation control

a) Green pellets production control

There is the moisture controll as one of operating control facors and it is possible to control the green pllets size and balling tield. Drum type pelletizers in this plant are equipped with water splaying facilities. Generally, balling with drum pelletizer is controlled only by changing moisture content in balling material. In this plant moisture content in filter cake was too high and the water splay was impossible. This means that yield control and size control were not done with normal method and they ware adjusted by the change of balling material feed rate and additive (like as bentonite and lime hydrate) feed rat.

According to the change of concentrate property, dewatering result of disc filter would change and balling conditions would change resulting in the change of green pellets production because convinient moisture control was not possible according to the change.

b) Induration control

The philosophy of induration control is as followings.

By setting A.R.(air ratio: kg-air/kg-dry green pellets production), A.S.(air split: combustion air÷{combustion air +process air}) and hot gas temperature, air volume to combustion chamber and to lower part of furnace and fuel injection was to be determined automatically in proportion of green pellets production.

According to tumbler index of fired pellets, small adjustment of A.R. and A.S. were done.

Base data for control was green pellets production but there was not weigher which measured green pellets production. Instead of green pellets production, balling material feed rate was used as base data for the control. (refer to **Fig.-9**) As mentioned in **a)**, green pellets production rate could change even if balling material feed rate was kept constant. In this plant, there was no control measure of water spray and the change of concentrate property affected directly green pellets production. As a result, stacking level of burden in the furnace changed and the operator was adjusting the discharge rate from the furnace by changing movement of wiper bar. This means that excess or insufficient air was blown into furnace leading to excess or insufficient heat supply which generated low tumbler index, spout or bursting.

Control flow should be as shown in **Fig.-10**.

c) Heat balance (in shaft excluding cooler)

Main items of heat pattern are listed in **Table-59** with comparison of other pant A.

Figure-9 Control flow in HIPASAM

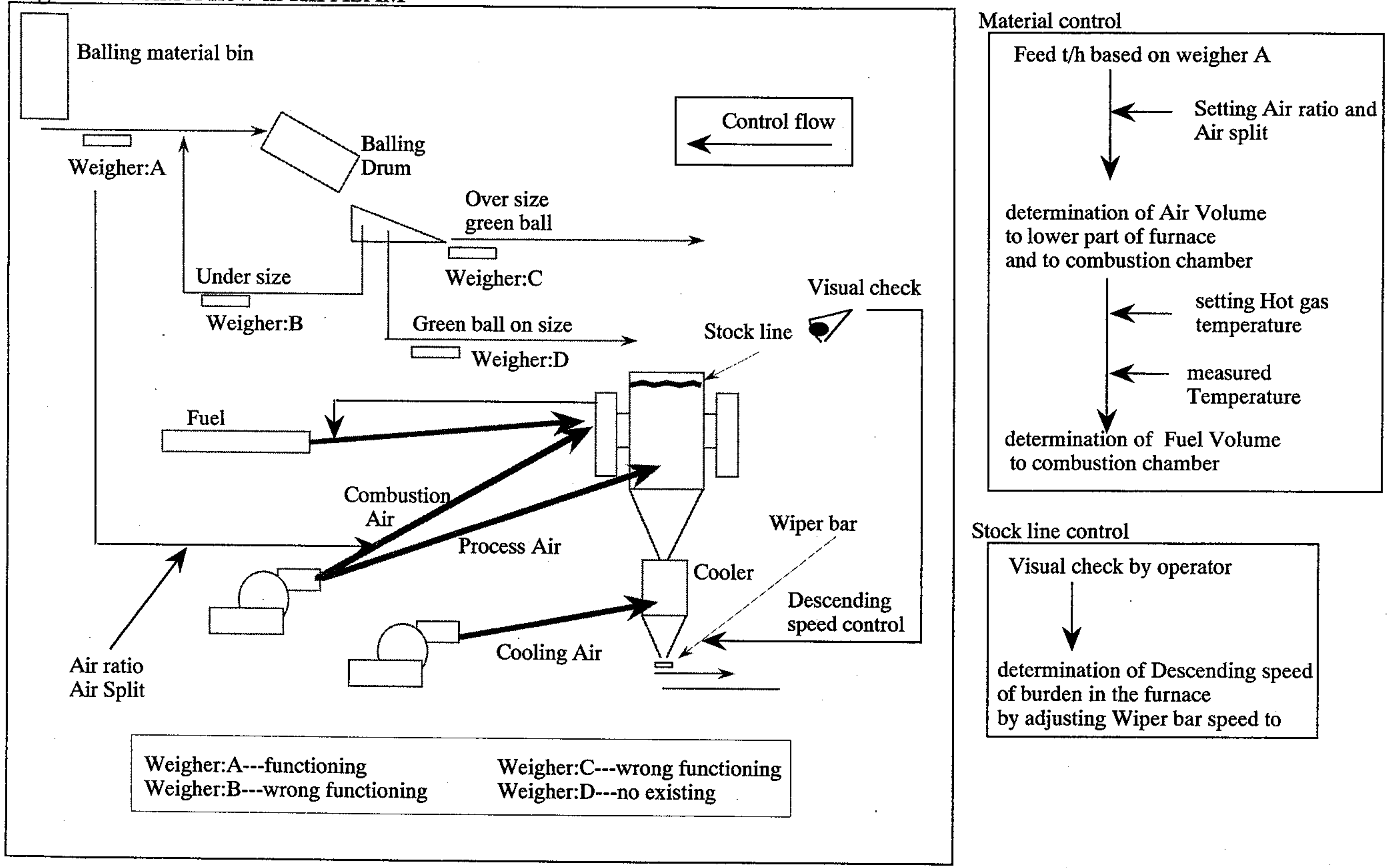


Fig.-10 Required control flow

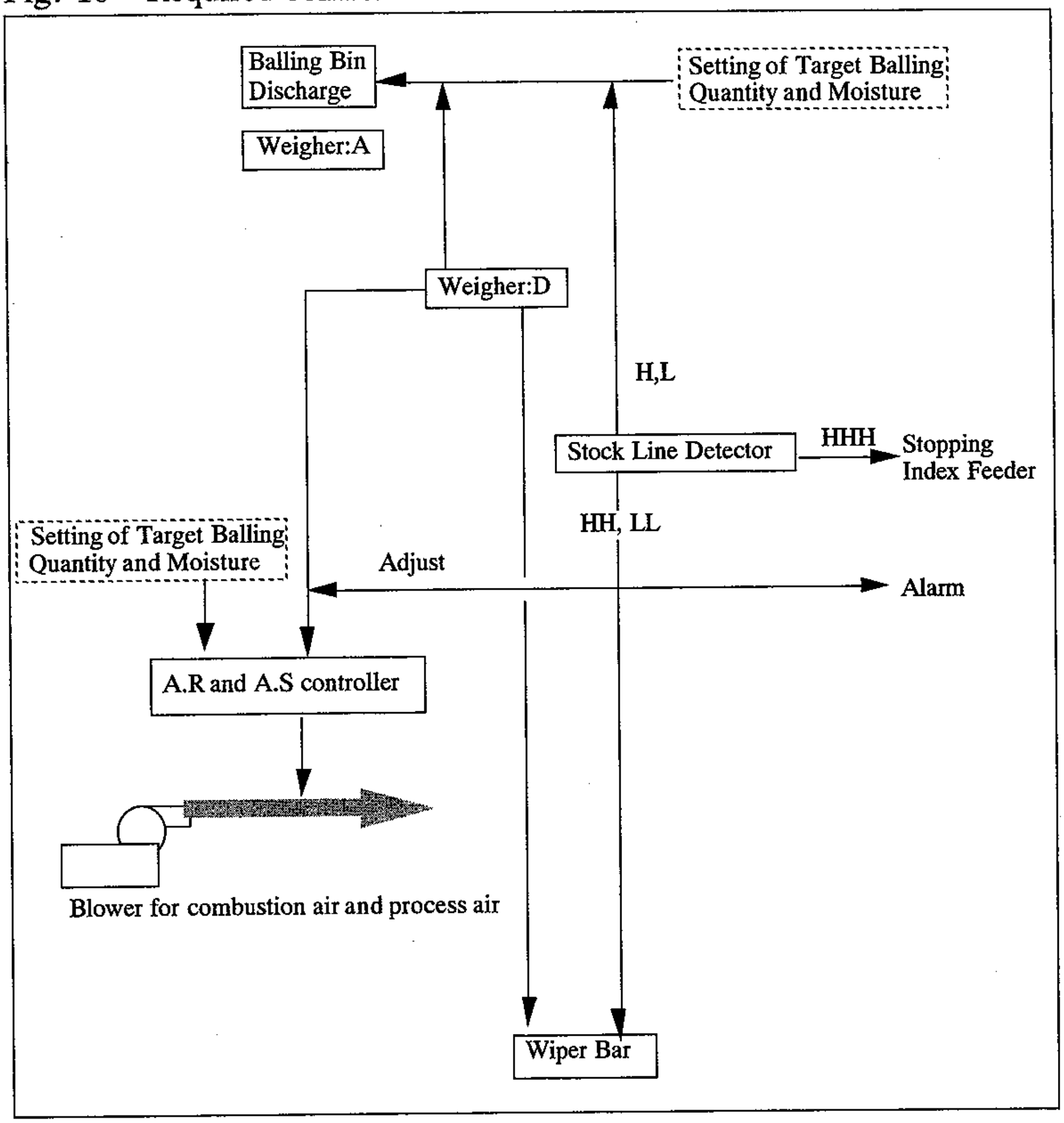


Table-59 Main index of furnace operation

Table- 59-1 Material (kg/kg-PP)

	HIPASAM	A
Concentrate	0.988	1.067
Bentonite(kg/kg-PP)	0.016	0.008
H.Lime	0.001	0.000
Dolomite	0.018	0.000
Silica	0.007	0.000
Total Material	1.029	1.075
Product Pellets	1.000	1.000
Fines	0.021	0.050
Dust	0.010	0.030
Others	0.017	0.017

Table- 59-2 Green pellets moisture

	HIPASAM	A
Moiture	11.0	9.4

Table- 59-3 Dimension of Furance

	HIPASAM	A
Width-Max(m)	2.4	2.1
Width-Min(m)	2.1	1.8
Length(m)	6.3	5.4
Area (m^2)	14.2	10.6

Table- 59-4 Heat source (kg/t-P.P.)

	HIPASAM	A
Fe3O4	865.98	933.87
N.Gas	19.29	0.00
Coal	0.00	6.00
Heavy oil	0.00	10.80

Table- 59-5 Operating condition

	HIPASAM	A
Product rate(t/h)	57.000	78.100
Air (kg-air / kg-PP)		
A.R. (kg-air / kg-PP)	1.080	0.850
A.S. (%)	41.000	30.000
A.R. (kg-air / kg-GP)	1.050	0.914

Table- 59-6 Base data for heat balance

	HIPASAM	A
Fe3O4(% in conc)	87.65	87.50
Fe3O4(%) in P.Pellets	5.10	1.66

Table- 59-7 Temp (℃)

	HIPASAM	A
Exhaust gas	280	180
Furnace out pellets	600	600
Firing temp	1370	1340?
Firing temperature level	200±50	400

Firing temp; ?=Estimation
Firing temperature level=(mm) from stacking level

Table- 59-8 Number of tuyers

	HIPASAM	A
Short side	4×2	10×2
long side	20×2	18×2

Table- 59-9 Gas balance (m^3/h)

	HIPASAM	A
Wsated(1) gas total	49152	50834
O2 partial pr in waste	13.20	14.58
Wsated(2) gas total	58170	61676
O2 partial pr in waste	11.16	12.01

Waste gas (1): excluding H2O from green pellets
Waste gas (2): inluding H2O from green pellets

Table- 59-10Heat balance (kcal /t-PP)

	HIPASAM	A
Input		
Hot gas	238761	107353
Fe3O4	102792	110850
Carbon	0	50634
Input Total	341553	268837
Out put		
Waste gas	106101	48976
Pellets	117355	113570
Cooling Water	702	702
De-composition	6291	545
Water evapolation	74491	65364
Output Total	304940	229158

Table- 54-11 Dscending of burden and ascending of waste gas(1)

	HIPASAM	A
Dscending (cm/min)	4.7	9.0*1
Ascending (cm/sec)	96.3	132.8*1
A/D	20.54	14.83*1

*1: Calcurated based the results of dscending speed, horizontal area and feed rate of furnace of HIPARSAM and feed rate and hrizontal area of furnace of A plant.

3) Quality control

a) Quality design

In the first two years after starting production fine was generated in great degree, compressive strength was low, tumbler index showed low value and Index of LTD showed low value with the blend of bentonite 7 kg/t-product pellets.

At the end of 1981, hydrated lime addition tests were done with the blending ratio 0.2 to 1.0 %.

By blending hydrated lime, compressive strength of green pellets and resistance against heat shock was increased but the requirement of increasing bentonite to 15 kg/t-product pellets occurred for keeping drop strength. But still the LTD index was low and finally the addition of quartzite and dolomite was done to improve LTD index. Pellets with blending of hydrated lime, quartzite, dolomite and bentonite was named No.219 and this pellets was produced to the end of the project.

b) Quality measurement for process

As for green pellets, moisture, drop number, compressive strength and heat resistance were measured 2 times per shift. As shown in **Table-56** and **Table-57**, tumbler indexes lower than 90 % were shown frequently.

As for concentrate and product pellets, items for measurement and it's results are known from **Table-60** to **Table-62**.

c) Control method of tumbler strength

When low tumbler strength was shown, A.R. was increased for first step. When low tumbler strength was shown after the increase of A.R., then A.S. was increased.

Table-60 Quality measurement (concentrate sampled) for process

	Conc. Consump.	T.Fe	Fe++	Fe_3O_4	P	S	SiO_2	Al_2O_3	CaO	MgO	V_2O_5	TiO_2	Cr	Ni	Zn	Na_2O	K_2O
	t/month	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1988-Ave	50,656	68.69	22.86	91.88	0.125	0.090	1.68	1.49	0.347	0.091	0.142	0.137	0.027	0.037	0.011	0.064	0.034
1989-01.	66,548	68.68	23.08	94.41	0.142	N.A	1.72	1.51	0.340	0.095	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1989-02.	33,851	68.56	23.00	94.08	0.137	N.A	1.84	1.56	0.356	0.118	0.158	N.A	0.038	0.026	0.011	0.052	0.026
1989-03.	41,774	68.59	22.86	94.00	0.134	N.A	1.83	1.54	0.345	0.109	N.A	N.A	N.A	N.A	N.A	0.066	0.041
1989-04.	35,907	68.80	22.95	94.10	0.142	N.A	1.83	1.55	0.354	0.106	N.A	N.A	N.A	N.A	N.A	0.057	0.039
1989-05.	66,943	68.50	23.16	94.68	0.145	N.A	1.72	1.57	0.336	0.098	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1989-06.	40,825	68.61	23.06	94.45	0.164	N.A	1.77	1.62	0.375	0.133	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1989-07.	42,743	68.69	23.17	95.26	0.139	N.A	1.80	1.61	0.340	0.114	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1989-08.	46,462	68.66	23.43	93.43	0.137	N.A	1.75	1.61	0.328	0.112	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1989-09.	44,306	68.62	23.19	93.19	0.128	N.A	1.75	1.63	0.337	0.1	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1989-10.	72,844	68.94	22.94	92.11	0.121	N.A	1.56	1.55	0.277	0.082	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1989-11.	48,385	68.57	22.94	91.70	0.117	N.A	1.57	1.49	0.298	0.118	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1989-12.	54,549	68.70	23.03	93.32	0.111	0.074	1.71	1.48	0.278	0.094	N.A	N.A	N.A	N.A	N.A	0.054	0.030
1989-Ave	49,595	68.67	23.07	93.67	0.134	N.A	1.72	1.56	0.326	0.104	N.A	N.A	N.A	N.A	N.A	N.A	N.A
1990-Ave	48,160	68.88	22.70	92.72	0.131	N.A	1.59	1.55	0.314	0.096	N.A	N.A	N.A	N.A	N.A	N.A	N.A

Table-61 Quality measurement (physical property of product pellets) for process control

	Produc-tion	Tumbler Test			Comp.Streng.		Size Distribution				RDI (JIS)				LTD (ISO)			Reduction Test(JIS)			RUL (ISO)		Swelling		Porosity
	t/month	T.Ind.	A.Ind.	-6.35 mm	Ave	-80 kg	+19 mm	19-8 mm	-4.75 mm	Ave	+9.5 mm	+6.3 mm	+3.15 mm	-0.5 mm	+6.3 mm	+3.15 mm	-0.5 mm	Red. 180	CSAR	dR / dt	Red. 80	dR / dt	Swell	Red.	
		%	%	%	kg/P	%	%	%	%	mm	%	%	%	%	%	%	%	%	kg/P	%/min	%	%/min	%	%	%
1988-Ave	49,761	92.1	5.4	6.8	280	2.1	3.3	85.8	4.2	12.2	72.3	81.1	87.8	8.6	59.6	69.1	19.1	59.5	65.0	0.299	65.9	0.830	20.9	64.7	20.5
1989-01.	64,777	91.1	5.8	8.9	267	3.4	4.8	81.1	5.9	11.9	71.2	81.2	88.1	8.2	50.0	62.3	22.1	58.2	58.7	0.286	N.A	N.A	20.8	68.6	22.0
1989-02.	35,257	91.0	6.1	7.3	257	6.9	3.9	84.7	4.1	12.0	69.5	78.9	86.0	9.5	53.8	66.8	19.4	60.9	64.7	0.302	N.A	N.A	23.7	60.4	21.7
1989-03.	42,157	92.2	5.6	5.9	295	3.2	3.7	87.1	3.8	12.4	75.7	82.6	87.5	9.3	67.6	75.6	16.0	59.9	67.1	0.305	N.A	N.A	19.2	68.3	21.6
1989-04.	33,866	91.7	6.0	6.4	306	2.5	4.3	86.3	4.1	12.6	76.2	83.3	88.6	8.8	46.2	57.8	27.0	58.5	61.0	0.293	N.A	N.A	21.4	63.9	21.1
1989-05.	65,751	91.6	5.7	7.4	282	3.1	4.4	84.6	4.7	12.5	71.0	80.4	87.6	8.3	54.7	63.7	22.4	58.0	61.1	0.287	N.A	N.A	24.3	62.9	20.8
1989-06.	38,936	91.3	6.1	6.6	280	3.1	3.8	87.1	4.3	12.9	75.8	82.2	88.4	7.9	53.4	64.8	22.5	59.1	53.7	0.307	N.A	N.A	21.0	60.7	20.6
1989-07.	42,325	91.6	5.9	5.9	271	2.5	2.9	87.8	3.6	12.4	72.9	82.3	88.3	8.0	60.5	68.3	20.6	59.0	50.7	0.290	N.A	N.A	22.7	70.9	21.6
1989-08.	43,418	92.0	5.7	7.0	253	3.8	2.0	87.4	4.1	11.6	76.5	83.8	88.7	8.2	72.5	78.7	13.9	60.8	71.6	0.296	N.A	N.A	19.4	65.8	22.0
1989-09.	45,124	91.8	6.0	6.1	244	3.6	1.9	86.8	3.5	11.5	79.2	86.1	90.0	7.3	72.7	78.5	13.6	59.7	46.1	0.279	N.A	N.A	20.1	64.0	21.6
1989-10.	72,704	91.5	6.2	8.1	265	5.7	3.3	85.4	4.9	11.9	81.0	86.7	90.3	7.7	63.2	73.8	16.1	60.0	52.9	0.301	N.A	N.A	20.6	62.9	20.8
1989-11.	49,507	90.3	7.3	9.9	298	5.1	4.6	81.2	6.9	12.6	79.7	85.2	88.9	8.7	65.4	73.8	18.0	61.3	52.9	0.297	N.A	N.A	17.3	65.5	21.1
1989-12.	57,960	90.3	6.9	8.5	277	6.0	3.8	85.5	5.0	12.5	79.4	85.8	89.4	7.7	61.9	72.2	16.1	66.3	50.3	0.351	N.A	N.A	21.7	58.1	21.4
1989-Ave	49,329	91.3	6.1	7.5	274	4.1	3.0	85.2	4.7	12.2	75.8	83.4	88.6	8.2	60.2	69.8	18.8	60.2	57.1	0.300	N.A	N.A	21.0	64.3	21.3
1990-Ave	51,050	90.2	6.8	6.5	275	4.1	7.2	83.9	4.0	13.5	68.0	77.8	85.1	10.7	44.5	55.8	29.0	66.5	54.9	0.346	N.A	N.A	23.2	69.0	21.6

Table-62 Quality measurement (chemistry of product pellets) for process control

	Produc -tion	T.Fe	Fe++	P	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	S	V_2O_5	TiO_2	Cr	Ni	Zn	Basicity	
	t/month	%	%	%	kg/P	%	%	%	%	mm	%	%	%	%	%	%	Bin.	Quat.
1988-Ave	49,761	65.19	1.28	0.104	3.17	1.77	0.85	0.36	0.077	0.051	0.0054	0.155	0.121	0.031	0.040	0.010	0.268	0.245
1989-01.	64,777	65.07	1.18	0.104	3.34	1.83	0.94	0.45	0.075	0.051	0.0054	0.189					0.281	0.269
1989-02.	35,257	64.97	1.33	0.120	3.27	1.88	0.99	0.47	0.066	0.044	0.0050	0.136					0.303	0.283
1989-03.	42,157	65.14	1.21	0.116	3.24	1.81	0.87	0.44	0.075	0.057							0.269	0.259
1989-04.	33,866	65.06	1.17	0.110	3.22	1.85	0.86	0.44	0.072	0.060							0.267	0.256
1989-05.	65,751	65.08	1.13	0.115	3.15	1.82	0.87	0.40			0.0043						0.276	0.256
1989-06.	38,936	65.05	1.12	0.127	3.33	1.79	1.00	0.43			0.0029						0.300	0.279
1989-07.	42,325	65.04	1.14	0.113	3.35	1.84	0.96	0.46			0.0032						0.287	0.274
1989-08.	43,418	65.15	1.11	0.113	3.20	1.85	0.89	0.46									0.278	0.267
1989-09.	45,124	65.04	1.06	0.113	3.23	1.80	0.86	0.48			0.0040						0.266	0.266
1989-10.	72,704	65.27	1.06	0.104	3.11	1.76	0.83	0.47									0.267	0.267
1989-11.	49,507	65.20	1.21	0.104	3.17	1.69	0.84	0.51			0.0040						0.265	0.278
1989-12.	57,960	65.22	1.22	0.104	3.20	1.67	0.82	0.46	0.068	0.057	0.0080						0.256	0.263
1989-Ave	49,329	65.12	1.16	0.111	3.23	1.79	0.89	0.45	0.071	0.054	0.0046	0.163		0.035	0.029	0.011	0.276	0.267
1990-Ave	51,050	65.14	1.25	0.114	3.15	1.77	0.86	0.49	0.064	0.050	0.0043						0.273	0.274

4.3 PRODUCTION MANAGEMENT

4.3.1 Iron ore mines

Mining Division consisted of 6 departments of Production, Preparation, Services, Geology, Planning and Maintenance. Each department is further divided into 2～3 sections in accordance with contents of work. Production and Preparation department which are the major part of the operation allocated a responsible person for each shift to carry out the site management properly.

Annual and monthly production plan was prepared by the responsible person of each department. Weekly and monthly meeting was held to review the result. Standard operation of fan-drilling, drifting or drilling pattern were prepared.

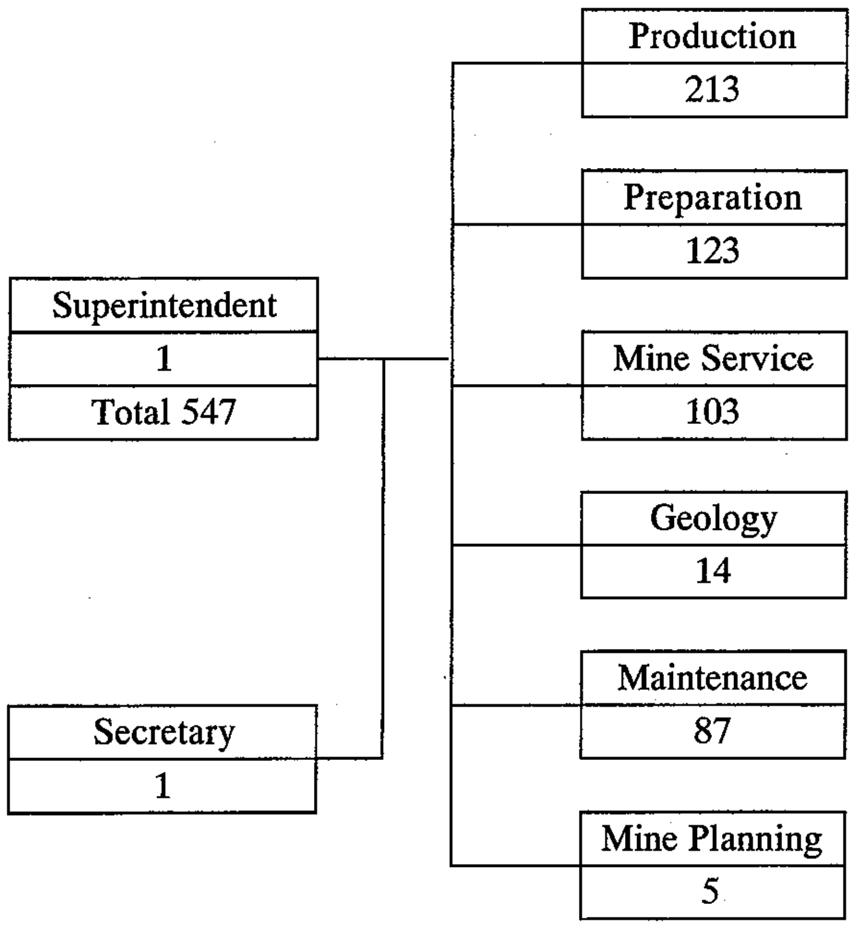
Mining work was carried out on 3 shift basis including maintenance. The time spent at work was 8 hours per day (actual working hours; 5.8 hours) and average working days per month was 22.2 days.

Crew system at each shift employed a full time expert worker at each operation and equipment. Further apprentices were allocated for training and education according to the contents of work such as fan-shaped drilling or blasting.

Fig.-11 shows the organization and number of employees in 1989.

Safety manual included all HIPASAM work as well as mining work was prepared and the safety management was executed in accordance with this safety manual.

Fig.-11 Organization and Number of Employees in 1989



4.3.2 Iron ore concentration plant

(1) Production control

Production was controlled by annual production plan. Monthly production report was issued. Monthly and annual production record was described in it.

Actual production was unstable. Concentration plant stopped its operation by the trouble of pellitizing plant. Monthly production volume fluctuated month by month.

Chemical analysis and size distribution analysis were executed at each shift day by day. Data taken too much and seemed not effectively used. There found not less contradictions in each data. It seemed insufficient to analyse the operation detail in half an year or in one year.

(2) Standardization

Operation manual existed, however, actual operation seemed not to coincide with the instruction described in it. It was not confirmed as there is no operation engineers remaining in HIPARSA.

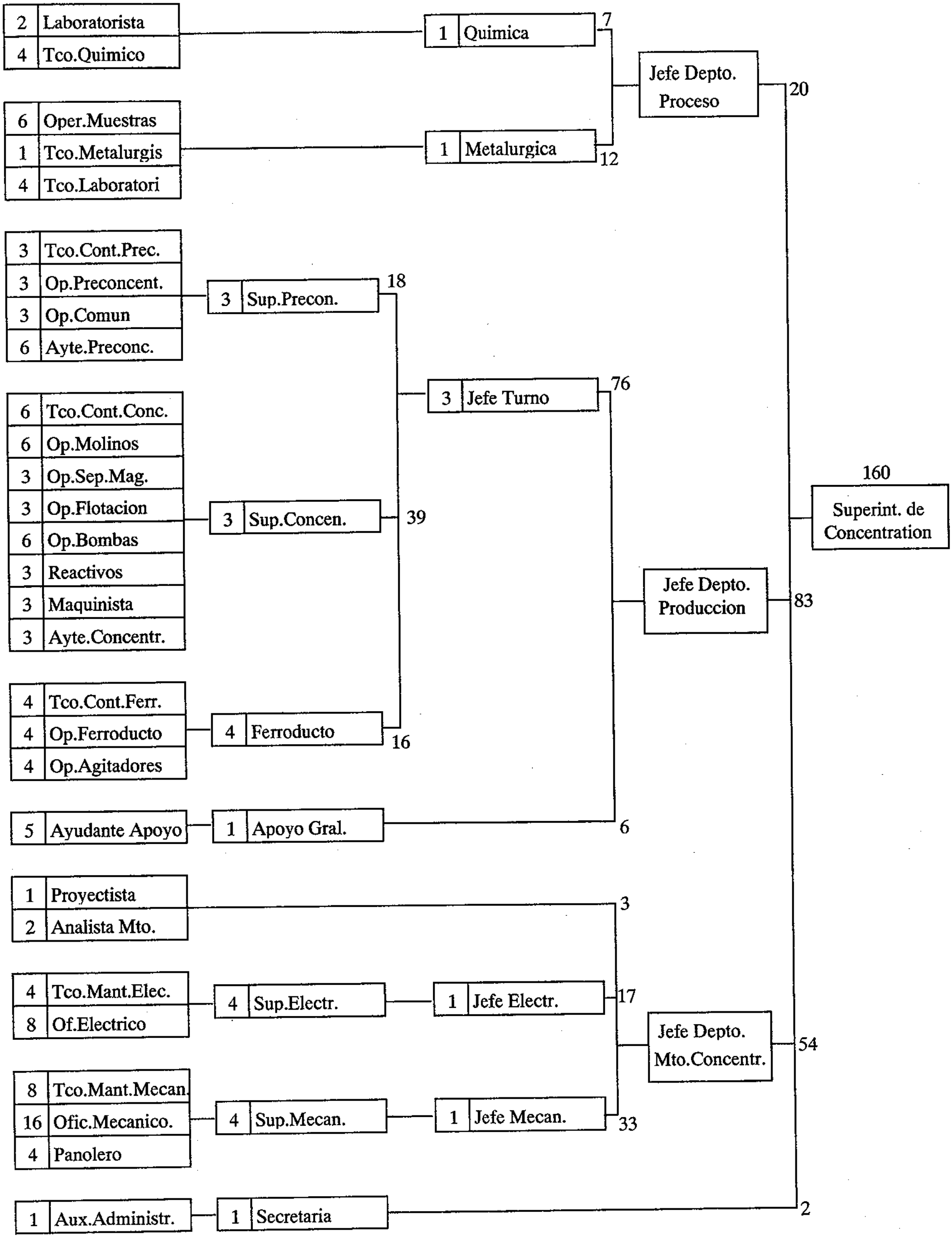
It is confirmed that the operation of concentration transportation pipeline was operated in accordance with the instruction described in the operation manual.

(3) Organization

Concentration plant was divided to 3 sectors, i.e., process, operation and maintenance. Operation further divided to pre-concentration,

concentration and concentrate transportation pipeline. Pre-concentrate and concentrate sections were operated in 3 crew 3 shift basis, where concentrate transportation pipeline section was operated in 4 crew 3 shift basis. Organization and man-power allocation is shown in **Fig.-12**.

Fig.-12 Organization and manpower list of ex-HIPASAM



4.3.3 Pelletizing plant

(1) Production control

Production plan was made due to the annual consumption fore cast of ex-SOMISA, only one customer for HIPASAM.

One significant cause of stoppage was the lack of concentrate which might include no demand by ex-SOMISA and it was countered as lack of concentrate because mine and concentration were stopped and concentrate was not transported to plant site.

The production budget was prepared but it can not be the reference data for this study and the explanation about it was eliminated in this report.

(2) Standardization

As mentioned in (1) of 4.2.3, there are no final documents of the plant and no operational manual for the plant. From what we are told it is understood that operation standard (or norma) and technical standard were not prepared by persons in HIPASAM. Chiefs from each group held morning meeting, judged pant conditions after analyzing plant conditions and made workin order in the form of documents if there was abnormal conditions to rectify it. In other words, technical status of this plant is the initial stage to step up to the next stage with standards (or normas).

(3) Organization in the plant

Table-63 shows the organization of pellet plant of HIPASAM. Total persons number was 221. (209 of HIPASAM employee + 12 of contractor) From this table, it can be recognized that;

- there were too many supervisors (38 persons).

- maintenance and laboratory which could have common work with mine and concentration were independent from mine and concentration.

- in the organization of HIPASAM, all the jobs concerned with the pelletizing plant were done by HIPASAM employees except the repair of refractory and cleaning of plant.

- usual repair work (excluding large scale fabrication) was done within the organization.

Functions of the organization were as follows.

- Port shipping
- Mechanical, electrical and instrumentation maintenance
- Workshop
- Laboratory
- Production

Table-63 Organization of HIPASAM in Pelletizing plant

Position and Job	No in shift	Shift	Total number
Superintendent	1	1	1
Secretary	1	1	1
Administration	1	1	1
Sub total			3
Port			
Port Captain	1	1	1
Shipping,Port service	1	1	1
Shipping	1	1	1
Supervisor in electric,mechanic and shi	1	1	1
Mechanic Operator	7	1	7
Electric Operator	3	1	3
Inspection services of port	2	1	2
Sub total			16
Maintenance	1	1	1
Technical	1	1	1
Technical Oficer	1	1	1
Project	1	1	1
Drawer	2	1	2
Analist	1	1	1
Instrumentation	1	1	1
Chief	1	1	1
Instrument(day)	1	4	4
Instrument(shift)	4	1	4
Electric	1	1	1
Chief of Electric, Maintenanceshop	1	1	1
Skilled Electrician	3	1	3
Electrician	4	1	4
Supervisor of shift	1	4	4
Skilled Electrician(shift)	1	4	4
Electrician(shift)	1	4	4
Preventive Maintenance	1	1	1
Preventive mechanical maintenance	2	1	2
Mechanical maintenance	4	1	4
Lublication	4	1	4
Planning	1	1	1
Inspection	2	1	2
Techinician of Electromech	2	1	2
Techinician of Electric and	1	1	1
			0
Clening Chief	2	1	2
Helper (contractor)	6	1	6
Plant mechanical			0
Refractory			0
Chief	1	1	1
Out side contractor	6	1	6
Mechanic in workshop			0
Chief	2	1	2
Tech.Mechanic in worksho	4	1	4
Mechanic	12	1	12
Shift superviser (Tech.Mechanic)	1	4	4
Mechanic	2	4	8
Tool(ware house)	1	4	4
Sub total			104

Position and Job	No in shift	Shift	Total number
Production	1	1	1
Technician	1	1	1
Assistant	1	1	1
Shift			0
Chief of shift	1	4	4
Super visor	1	4	4
Control room	1	4	4
Control room auxiliary	1	4	4
Furnace(skilled)	1	4	4
Furnace	2	4	8
Wiper bar	1	4	4
Assistant	1	4	4
Slurry accept	1	4	4
Disc filter	1	4	4
Assist. Disc filter	1	4	4
Drum pelletizer	1	4	4
Belt conveyor	1	4	4
Loading	1	4	4
Stacker	1	4	4
Additives	1	4	4
Sub total			71
Processing	1	1	1
Chief of laboratory	1	1	1
Supervisor for chemistry	1	1	1
Skilled chemist	3	1	3
Instrument analysis	1	4	4
Sampler	1	4	4
Super visor for physist	1	1	1
Skilled physist	2	1	2
Plant measurement	2	4	8
Metallurgical	1	1	1
Skilled operator	1	1	1
Sub total			27
Grand Total			221

4.4 RECORDS OF AMOUNT

4.4.1 Iron ore mines

(1) Production amounts

Graph-16 shows a trend of production when HIPASAM started operation.

Production started in 1972. However the production amount stayed at rather a low level until 1979 because the work during this period was mainly preparation of shaft and drift development.

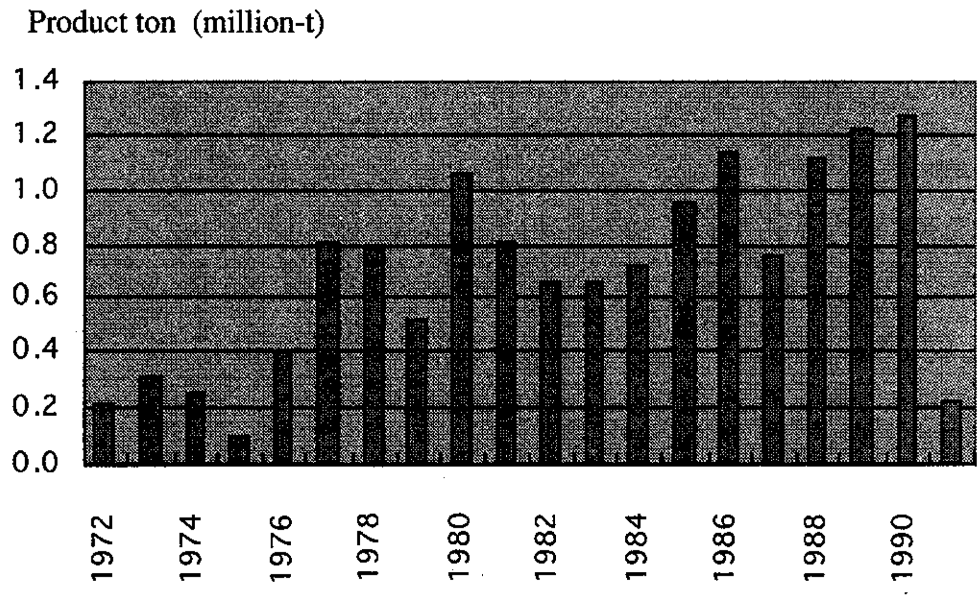
Center shaft started operation in 1980 and production volume increased in this year. However production volume of mining was adjusted to a low level from 1981 due to quality problems of concentrates and pellets. Then, production volume of iron ores increased year by year from 1985 except 1987 in which year labour problems and power supply problems occurred.

(2) Drifting

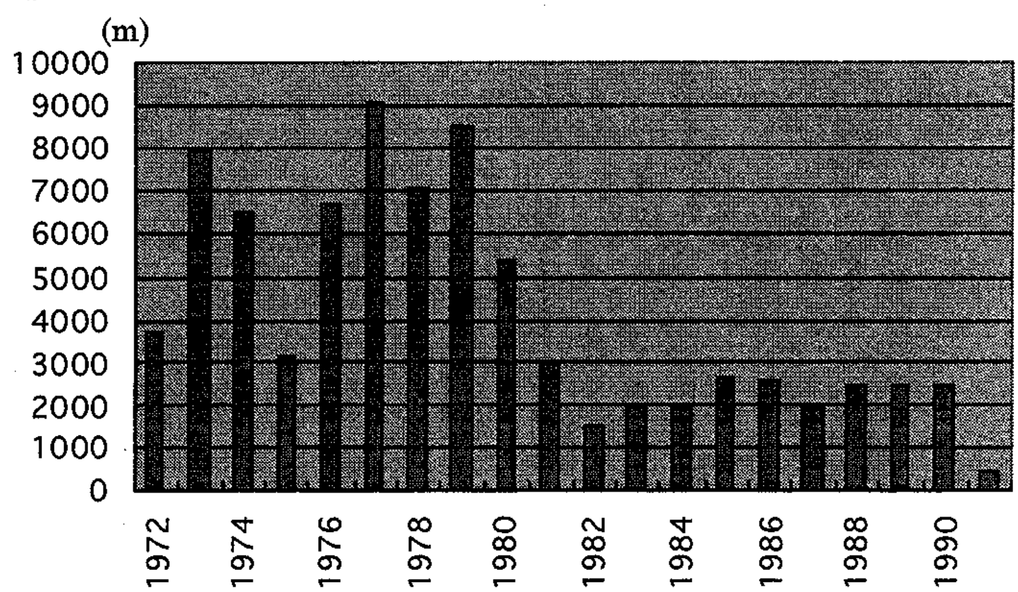
Graph-17 shows the trend of drifting length when HIPASAM started operation.

Drifting started in 1971 and the total length of drifting until the operation start of center shaft in 1980 was 58,575.6 m. Afterwards the main work moved from drifting to production and drifting length per year remained between 2,000 m to 2,500 m.

Graph-16 Trend of Production



Graph-17 Trend of Drifting



(Source:HIPARSA)

4.4.2 Iron ore concentration plant

Records on amount and quality of products of ex-HIPASM are shown in **Table-64, 65** and **66**.

Table-64 Transition of yearly production in Preconcentration Plant

Year	Crude Ore	Preconcentrate		Waste
	t	t	Wt.%	t
1980	742,944	518,349	69.77	224,595
1981	656,574	481,900	73.4	174,674
1982	1,160,180	832,883	71.79	327,297
1983	1,138,024	776,734	68.25	361,290
1984	909,206	615,542	67.7	293,664
1985	1,041,807	732,337	70.29	309,470
1986	1,481,960	1,085,361	73.24	396,599
1987	1,061,893	759,271	71.5	302,622
1988	1,345,994	987,243	73.35	358,751
1989	1,274,420	941,266	73.86	333,154
1990	1,292,531	885,773	68.53	406,758
Total	12,105,533	8,616,659	71.18	3,488,874

(Source: HIPARSA)

Table-65 Transition of yearly production in Concentration Plant

Year	Preconcentrated Feed			Concentrate			Tails		
	t	% Fe	% P	t	% Fe	% P	t	% Fe	% P
1980	506,719	54.31	1.332	337,519	68.43	0.145	169,200	26.13	3.700
1981	478,690	53.75	1.361	296,884	68.41	0.143	181,806	29.82	3.350
1982	867,743	53.97	1.396	523,644	68.73	0.139	344,099	31.52	3.308
1983	790,941	54.16	1.355	496,652	68.52	0.136	294,289	29.93	3.411
1984	630,107	53.10	1.328	394,720	68.42	0.134	235,387	27.41	3.329
1985	740,711	53.23	1.330	463,821	68.28	0.149	276,890	28.01	3.309
1986	1,069,074	53.29	1.293	650,794	68.43	0.140	418,280	29.73	3.086
1987	772,597	53.08	1.306	450,476	68.66	0.138	322,121	31.29	2.939
1988	963,878	52.66	1.304	585,177	68.66	0.126	378,701	27.93	3.124
1989	954,082	52.62	1.342	567,539	68.65	0.135	386,543	29.09	3.115
1990	927,096	53.54	1.298	568,488	68.87	0.133	358,608	29.24	3.146
Total	8,701,638	53.37	1.329	5,335,714	68.57	0.137	3,365,924	29.27	3.218

(Source: HIPARSA)

Table-66 Chemical Analysis of Concentrate

(%)

Year	Fe	Fe++	Fe_3O_4	P	S	SiO_2	Al_2O_3	CaO	MgO	V_2O_5	TiO_2	Cr	Ni	Zn	Na_2O	K_2O
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1988	68.69	22.86	91.88	0.125	0.0900	1.68	1.49	0.347	0.091	0.142	0.137	0.027	0.037	0.011	0.064	0.034
1989	68.67	23.07	93.67	0.134	ND	1.72	1.56	0.326	0.104	ND	ND	ND	ND	ND	ND	ND
1990	68.88	22.70	92.72	0.131	ND	1.59	1.55	0.314	0.096	ND	ND	ND	ND	ND	ND	ND

(Source: HIPARSA)

4.4.3 Pelletizing Plant

Table-67 and **Table-68** show the annual shipping results 1988-1990 and monthly shipping results in 1989.

Table-67 Physical Property of pellets (for Shipping)

	Shipping	Tumbler Test		Comp.Streng.		Size Distribution						Reduction Test(JIS)			Swelling	Porosity	Moist.
		T.Ind.	A.Ind.	Ave	-80 kg	+19 mm	19-8 mm	-4.75 mm	Ave	+6.3 mm	-0.5 mm	Red.	CSAR	dR / dt	Swell		
	t/month	%	%	kg/P	%	%	%	%	mm	%	%	%	kg/P	%/min	%	%	%
1988-Ave	54586	92.4	5.4	281	2.0	3.5	86.3	5.0	12.6	81.4	9.0	59.1	68.0	0.294	19.9	20.3	2.38
1989-01.	82509	91.4	6.0	270	2.5	4.3	84.7	5.8	12.6	82.0	10.2	59.6	57.8	0.301	20.6	21.6	2.46
1989-02.	44509	92.2	5.9	270	1.3	4.5	82.6	7.0	12.2	77.2	11.7	60.6	61.9	0.299	23.0	21.6	2.29
1989-03.	70494	92.4	5.6	269	5.6	4.0	86.8	4.9	12.6	82.6	6.8	61.9	57.1	0.310	22.9	21.5	2.48
1989-04.	19170	92.5	5.5	315	3.0	6.7	84.5	6.6	13.4	84.0	10.1	59.7	55.9	0.285	21.5	19.9	2.45
1989-05.	38293	92.3	5.6	286	1.6	3.8	85.4	5.7	12.7	77.6	10.4	57.1	55.2	0.277	19.8	21.0	2.57
1989-06.	66952	92.1	5.7	282	2.6	4.4	86.8	4.7	13.1	84.6	8.0	58.5	56.1	0.287	22.9	20.9	2.38
1989-07.	53764	91.9	6.0	280	2.0	4.0	89.0	4.3	12.9	81.3	8.9	54.5	54.6	0.245	21.0	21.2	2.55
1989-08.	39840	92.9	5.0	260	3.0	3.2	88.1	4.5	12.5	87.5	5.9	61.3	50.5	0.303	21.7	20.5	2.66
1989-09.	73130	92.4	5.4	259	3.0	3.6	85.1	4.8	11.8	91.4	6.0	59.9	50.5	0.287	21.5	21.7	2.88
1989-10.	58600	92.8	5.4	270	3.4	4.0	84.4	5.9	12.0	88.6	7.4	59.7	52.5	0.300	21.8	20.7	2.58
1989-11.	56039	91.7	6.4	284	4.3	4.6	84.4	6.3	12.4	89.7	7.2	61.8	47.6	0.300	22.2	21.7	2.58
1989-12.	55823	91.7	6.2	302	2.1	3.7	83.0	7.6	12.2	83.0	8.7	64.2	52.0	0.310	21.7	20.6	2.06
1989-Ave	54927	92.1	5.8	276	3.0	4.1	85.4	5.6	12.5	84.5	8.3	60.0	54.3	0.293	21.8	21.2	2.50
1990-Ave	52034	91.2	6.4	269	2.9	5.6	83.0	6.2	13.1	76.0	11.4	65.9	53.5	0.333	22.5	21.2	2.17

Table-68 Chemistry of pellets (shipping analysis)

	Production	T.Fe	P	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	S	Basicity	
	t/month	%	%	kg/P	%	%	%	%	mm	%	Bin.	Quat.
1988-Ave	54586	65.28	0.103	3.22	1.77	0.835	0.34	0.071	0.057	0.0044	0.259	0.236
1989-01.	82509	65.08	0.107	3.20	1.89	0.874	0.44	0.068	0.044	0.0039	0.273	0.258
1989-02.	44509	65.17	0.119	3.33	1.86	0.942	0.44	0.075	0.051	0.0046	0.283	0.266
1989-03.	70494	64.91	0.116	3.28	1.82	0.903	0.44	0.074	0.055	0.0043	0.275	0.262
1989-04.	19170	64.82	0.128	3.26	1.69	0.970	0.47	0.080	0.070	0.0046	0.298	0.290
1989-05.	38293	64.91	0.112	3.20	1.78	0.865	0.38	0.073	0.057	0.0059	0.270	0.250
1989-06.	66952	65.00	0.122	3.36	1.77	0.956	0.41	0.067	0.055	0.0042	0.285	0.266
1989-07.	53764	65.00	0.124	3.25	1.83	0.943	0.46	0.071	0.047	0.0026	0.290	0.276
1989-08.	39840	65.07	0.121	3.07	1.78	0.934	0.48	0.071	0.050	0.0036	0.304	0.291
1989-09.	73130	65.01	0.116	3.17	1.86	0.888	0.46	0.074	0.049	0.0043	0.280	0.269
1989-10.	58600	65.22	0.106	3.17	1.72	0.812	0.47	0.070	0.048	0.0040	0.256	0.262
1989-11.	56039	65.18	0.109	3.09	1.74	0.818	0.48	0.068	0.047	0.0044	0.265	0.269
1989-12.	55823	65.19	0.100	3.21	1.68	0.827	0.48	0.061	0.050	0.0052	0.258	0.268
1989-Ave	54927	65.06	0.114	3.22	1.80	0.889	0.45	0.070	0.051	0.0043	0.276	0.267
1990-Ave	52034	65.13	0.114	3.11	1.75	0.861	0.48	0.067	0.048	0.0047	0.277	0.276

Table-69 shows present general quality requirement for BF pellets. Pellets of HIPASAM showed lower quality than general requirement about chemical component of P, Na_2O+K_2O and physical property of particle content of 4.75 mm under, Swelling and Abrasion.

From these results, pellets made by HIPASAM are not competitive in the market compared with other pellets.

Table-69 General quality requirement for BF pellets

	Minimum requirement	HIPASAM
T.Fe	64.00 %-Min	65.1
S	0.03%-Max	0.0047
P	0.04%-Max	0.11
Al_2O_3	1.0%-Max	1.78
SiO_2	3.50%-Max	3.2
Na_2O+K_2O	0.05%-Max	0.12
fraction of particle size between 1.75-19 mm	90%-Min	91
fraction of particle size under 4.75 mm	5%-Max	5.6
Compressive strength before reduction	200 dan Min	270
Fraction of pellets with strength weaker than 78 dan	5%-Max	3.0
Compressive strength after reduction	44 dan Min	54
JIS Reducibility	60%-Min	60
Swelling Index	16%-Max	22
Abrasion index(-0.5 mm%)	4.9%-Max	5.8

Chapter 5

RECENT SITUATION OF HIPARSA

Since May 1991, mine has been operating intermittently to supply iron ore to domestic cement manufacturers and iron ore dressing plant and iron ore pelletizing plant have never been operated.

However, all the equipment and facilities of the mine, iron ore dressing plant and iron ore pelletizing plant have been keeping under careful maintenance of HIPARSA maintenance people.

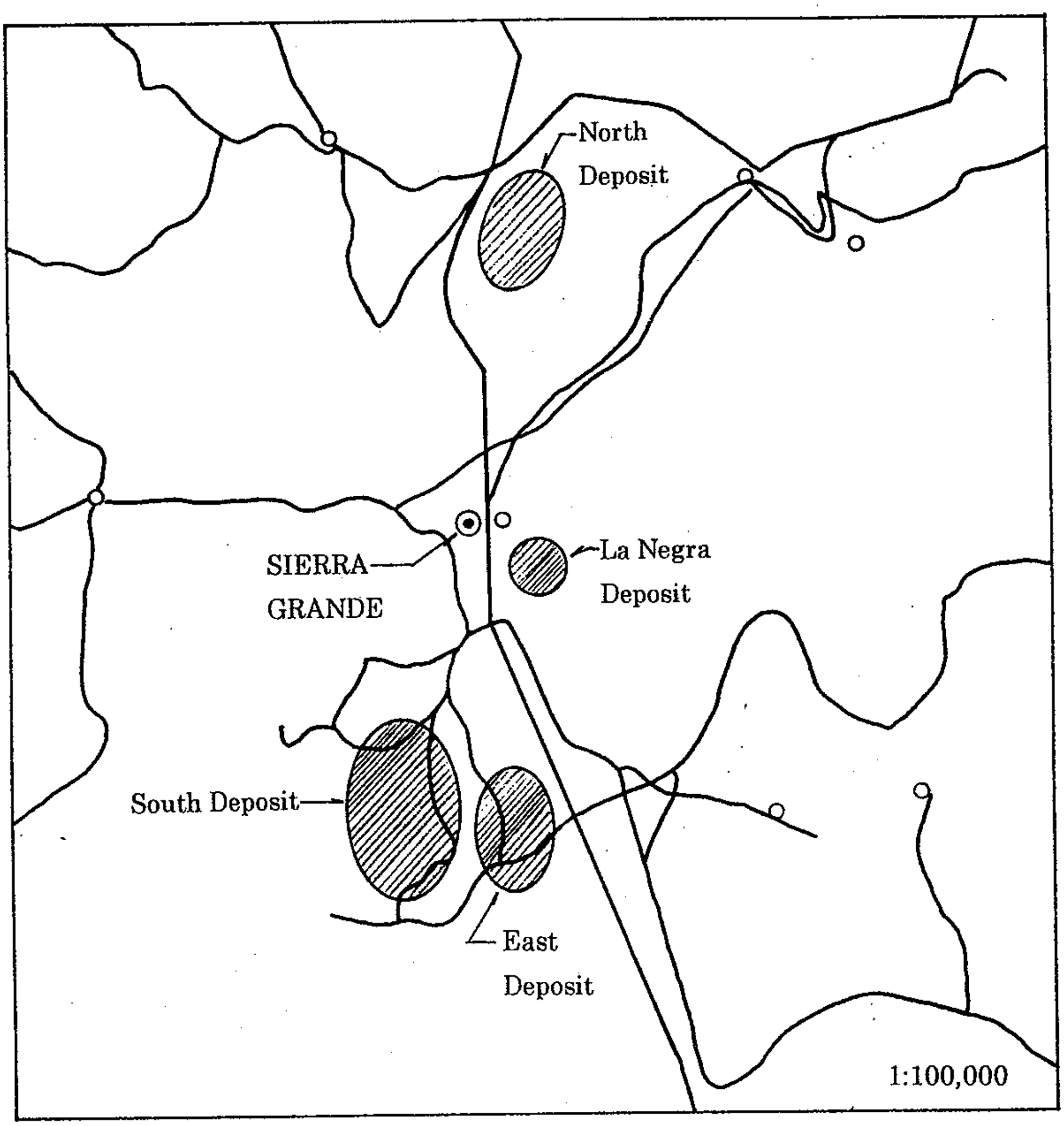
In this chapter, equipment and facilities condition of HIPARSA at the time of 1998 is explained.

5.1 FACILITIES AND PLANTS

5.1.1 Ore deposit

Sierra Grande iron ore deposit consists of four deposits of the south, the east, the north and the La Negra, which are shown in **Fig.-13**. HIPARSA has the mining right of the south and the east deposit in 1998.

Fig.-13 Sierra Grande Iron Ore Deposit



Ore reserves of the south deposit are the largest among the four deposits so far surveyed. Magnetic prospecting and/or drilling survey was carried out in the past for another three deposits but there is no precise information such as geological plans and profiles, columnar section of drilling holes and calculation sheets to estimate existence of ore body or scale of deposit. There exists only figures of possible ore reserves prepared at the time of HIPASAM.

Ore reserves of all four deposits are shown in **Table-70** and the ore reserve of the south deposit by depth is shown in **Table-71**.

Table-70 Ore Reserves of Deposits

(Unit : kilo-t)

Item		South	East	North	La Negra
Proved Reserves		90,535	----------	----------	N/A
Probable Reserves		38,348	----------	11,300	N/A
Possible Reserves		72,260	30,000～40,000	20,000	N/A
Total		201,143	30,000～40,000	31,300	N/A
Grade	Fe(%)	54.80	56.03	54.60	N/A
	P(%)	1.43	1.15	----------	N/A

Table-71 Ore Reserves of South Deposit

(Unit : kilo-t)

Item	Proved Reserves	Probable Reserves	Possible Reserves	Total
Surface～410ML	41,809	781	346	42,936
410ML～620ML	42,563	3,445	5,438	51,446
620ML～830ML	6,163	21,156	33,171	60,490
830ML～920ML	--------	12,966	33,305	46,271
Total	90,535	38,348	72,260	201,143

5.1.2 Iron ore mines and facilities

(1) Iron ore mines

Since stopping operation of the mines in 1991 periodical inspection by patrol has been executed until today. Rock fall or loose rock of roof or wall is properly eliminated so that drifts are well maintained. Remarkably rock falls are not observed on both the hanging and foot wall of the ore block already developed. Drifting was partially carried out to the level of 340ML and the situation of development at the time when operation of HIPARSA ceased is as follows.

200ML～270ML

When HIPARSA decided to stop operation work on this ore block was in progress. Estimated reserves of minable ore is 3,180 kilo-t. Fan-shaped drilling is completed with 2,560 kilo-t and remaining reserves of minable ore is 620 kilo-t.

270ML～340ML

When HIPARSA decided to stop operation about 82% of the preparation work was already executed. Estimated reserves of minable ore of this ore block is approximately 12,000 kilo-t. No fan-shaped drilling is carried out so far.

340ML under

Below this 340ML level there exists only incline and central shaft. Future development will be carried out from this drift.

Presently one ore block already developed close to the surface and a part of drift to this ore block is opened to the public for a sightseeing business named “Tour to the center of the earth”. HIPARSA contracted with a private tour company for this sightseeing business and this tour company collects tour guests.

The tour consists of two courses. One course is named “ordinary tour” and the other is named “adventure tour”. The charge for the ordinary tour for adults is $10.00 and for child under 12 years is $5.00. The adventure tour is only for adults and the charge is $20.00. Visitors are conducted by a tour guide of the private tour company. In the case of the ordinary tour a guide conducts a tourist group by foot from the ground entrance of the drift to the end of an already developed face of the ore block located about 100 from the ground to see the mine. In the case of the adventure tour a guide conducts a tour group to a deeper level ore block by bus to see the mine and to take a walk at the face of the developing ore block.

Presently the mine has stopped operation so that no serious effect is observed to the maintenance work of the mine. Safety of tourists is always kept by careful sounding and scaling of loose parts of the block by periodical safety patrol of HIPARSA employees and the mandatory wearing of safety helmets,cap light and mine shoes. However, there always exists the possibility of a rock fall from the roof or wall of the ore block used for an adventure tour so that safety of the tourists cannot always be assured. It is strongly recommended to stop the adventure tour even now to avoid occurrence of any damage to tourists by a rock fall.

This sightseeing business can be guaranteed only by reason of stoping operation of the mine and careful safety check patrol by the maintenance employees. When HIPARSA will be reactivated entry of non-employees to inside of HIPARSA’s premises shall be limited to only those who are related to the mining activity to ensure the proper production and avoid hindrance of the safety management.

(2) Facilities and equipment

1) Underground mobile equipment

Underground mobile equipment and their conditions presently possessed by HIPARSA are shown in **Table-72**.

All jumbo which is the main equipment for drifting and stoping, is equipped with pneumatic-driven drifter however cylinders and pistons for drifter or cylinder and engine and other movable parts of oil-hydraulic systems have not been maintaining since stoping operation of HIPARSA. It means that the re-use of the jumbos would be very difficult.

Furthermore these jumbos were bought in the 1970's and procurement of necessary spare parts from the manufacturer seems difficult as modern jumbos are driven by an hydraulic oil system.

Loading and transporting equipment are properly maintained by HIPARSA's maintenance shop even now and they are ready to use. Climbers used for raising of ore pass are placed at the face developed at the time of stoping operation of HIPARSA. These jumbos seemed to re-start by proper tuning up of air motor and other parts.

Table-72 Underground Mobile Equipment in 1998

Item	Manufacture	Model	Quantity	Installation year	Condition
Jumbo	Tamrock	Paramatic, 2 Booms	2	1972, 1978	Kept under the roof
	Tamrock	Minimatic, 2 Booms	2	1978	No maintaining
	Atlas Copco	565 2Booms	1	1972	
Fan Drill Jumbo	Garader-Demler	Mark II	5	1975	Kept under the roof
	Tamrock	Twinring A605 RR	1	1988	No maintaining
	Tamrock	Duo A605 RS	1	1988	
	Atlas Copco	Promec	1	1975	
Climber	Alimak	STH-5L	3	1975	Place at the face
Front-end Loader	Caterpillar	980B, 3.4m³	2	1975	On use
	Caterpillar	980C, 3.4m³	2	1986	
	Caterpillar	950 , 3.4m³	1	1975	
LHD	GHH	LF-7.1 3.8m³	1	1979	On use
	Toro	350 BD 3.8m³	2	1985	
	Wagner	ST-6C 4.1m³	2	1970	
Truck	kiruna	K 500 40t	2	1975	On use(kiruna)
	GHH	MK V40.1 42t	4	1978	Kept under the roof No maintaining (GHH)

2) Stationary equipment

Stationary equipment of the mine is periodically maintained by the maintenance employees of HIPARSA. Trial operation of all the stationary equipment was carried out in 1995 and there seems no serious problems for re-starting except replacement of certain worn parts.

Major stationary equipment is shown in **Table-73**.

Table-73 Stationary equipment in 1998

Item	Specification	Quantity	Remarks
No.1 cr	Jaw Crusher, 800t/h, 300kW,	2	Crushing Plant:1 410ML:1
Skip	800t/h, 220kW Hoisting speed: 6m/sec.	1	Cycle time: 90sec.
Cage	60persons, 220kW Hoisting speed: 6m/sec.	1	
No.2 cr	Cone Crusher, 400t/h, 300kW	2	
Stacker	800t/h,	1	Stockpile capacity 90,000t

5.1.3 Iron ore concentration plant

HIPARASA stopped its operation in 1991. 7 years has passed since then and equipment and facilities of the iron ore concentration plant are maintained in good condition. Although equipment and facilities are well maintained it is not sufficient to reactivate the iron ore concentration plant in Sierra Grande. There is a need for hardware for the iron ore concentration plant and software to operate the iron ore concentration plant. At present there are no experienced operational staff except maintenance personel in HIPARSA and precious experiences of operational techniques and skills of the past 10 years operation are lost.

If a new company after reactivation commences operations in the same way as the past there will be no serious problems to operate with non-experienced people. But high phosphorus content in the iron ore is the problem. Pellet feed produced in the past contained average 0.137% phosphorus and it is not competitive in the modern market. Requirement for phosphorus content in the pellet of HBI in the present market is less than 0.05%.

Obviously there is a necessity for modification of the hardware and process flow of the existing iron ore concentration plant although the verification of improved mineral dressing tests are now being undertaken at the laboratory of HIPARSA.

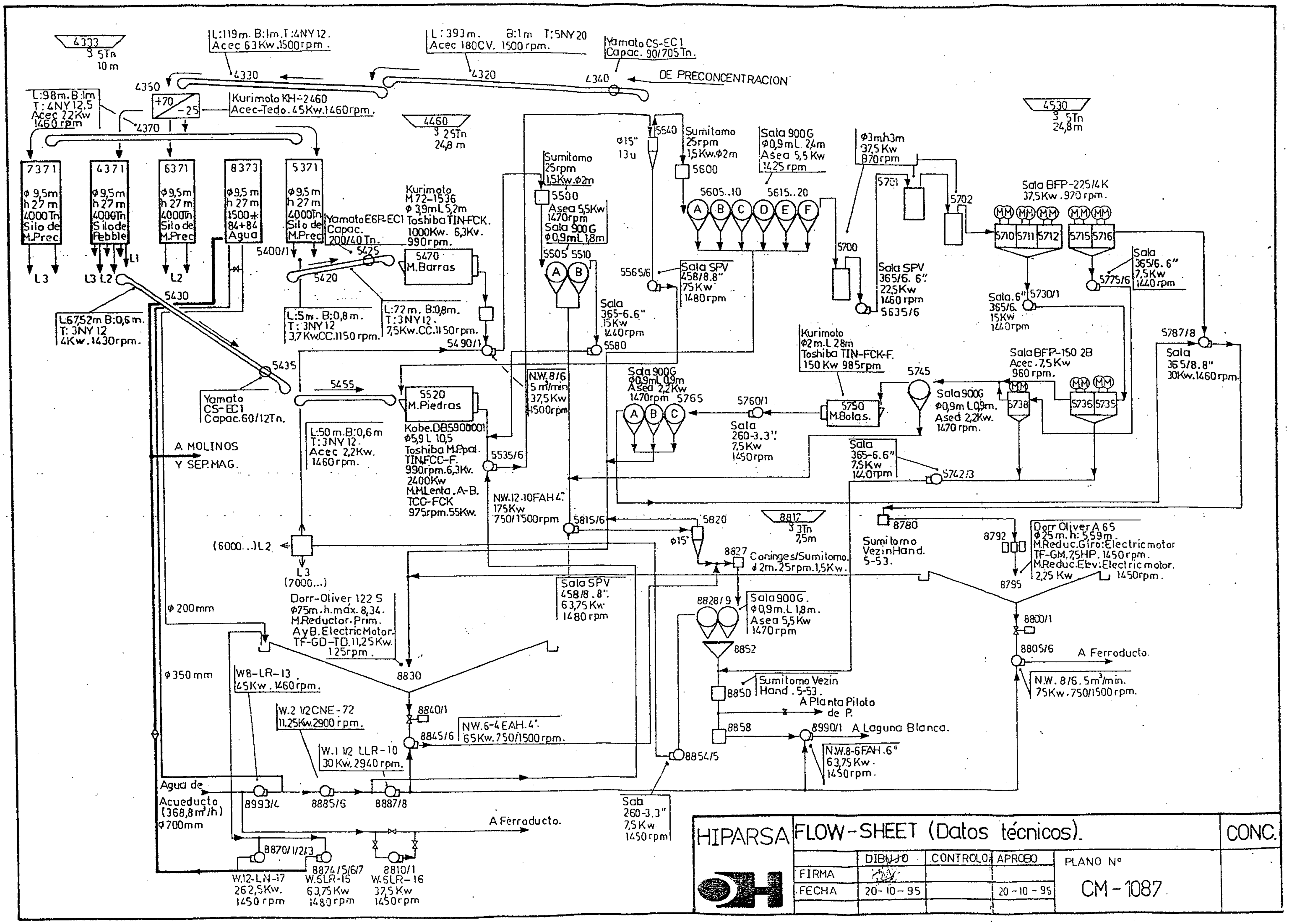
Information on past operations especially past operational data for each of the facilities are definitely necessary to study required modifications. However sufficient information was not obtained at the site survey except general operation data of the iron ore concentration plant. It is important to grasp the actual operation results for grinding in the past operation to study countermeasures for high phosphorus content however records of the relation between grinding power and particle size could not be provided.

There is definitely a need for an explanation of the operational procedures by persons who have past operation experience of the plant in order to study the required countermeasures however there are only maintenance people available. It is not now possible to discuss how to improve and modify the present hardware and software. This nonavailability of operational experienced people represents the biggest difficulty to study the required countermeasures to the existing iron ore concentration plant.

Flow sheet with dimensions of facilities dated October 20, 1995 (**Fig.-14**) and sheet with assay data (**Fig.-15**) were obtained at the first site survey. But the latter was incomplete as a balance sheet and actual operation could not be realized.

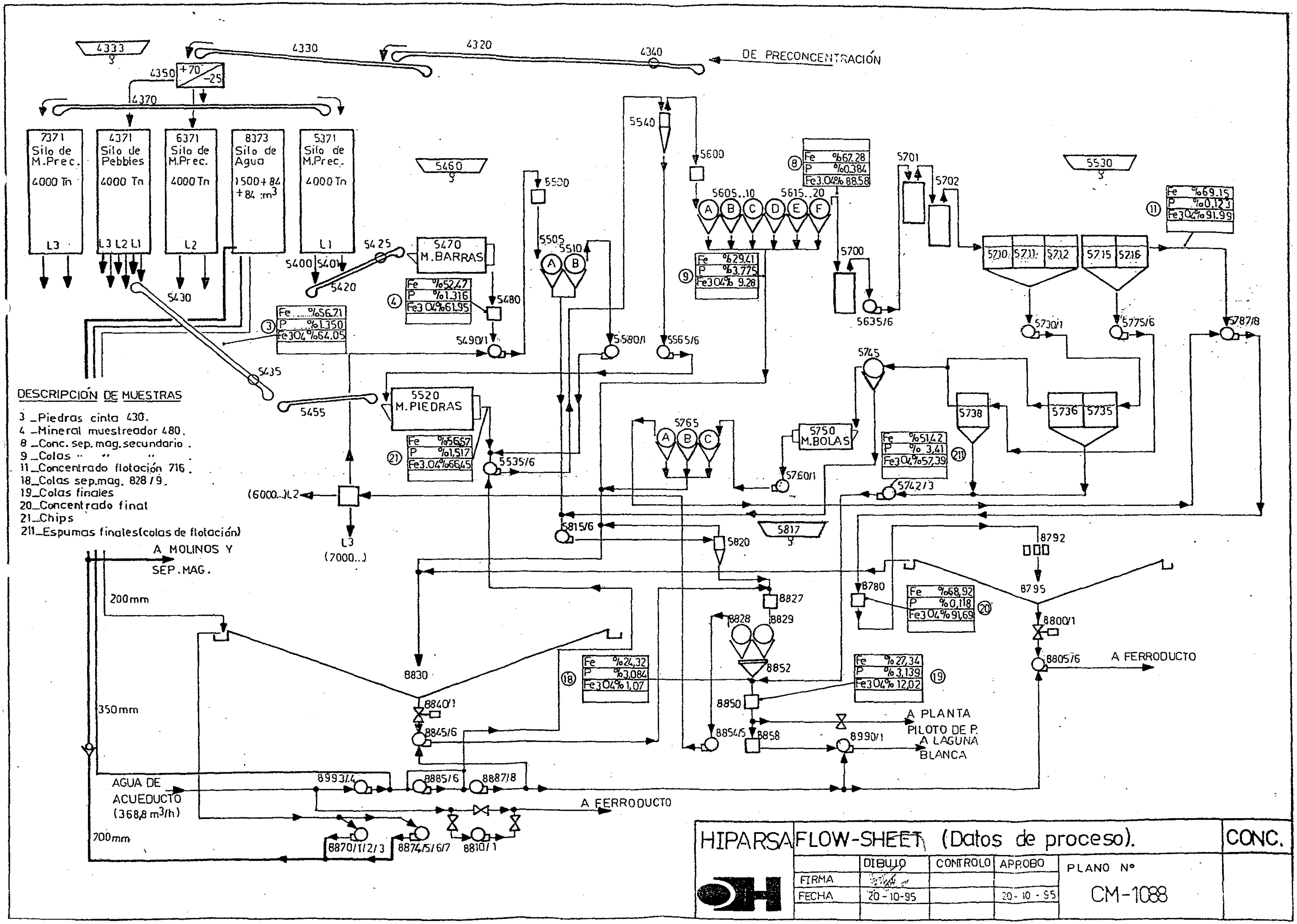
It was reported at the first site survey that some facilities had been removed and it is not possible to re-start the iron ore concentration plant immediately although the existing iron ore concentration plant has been well maintaining by the maintenance people. Machine lists with present conditions are shown in **Table-74**.

Figure-14



4333
5Tn
10 m
L:119m. B:1m. T:4NY 12.
Acec 63Kw. 1500rpm.
L: 393m. B:1m T:5NY 20
Acec 180CV. 1500 rpm.
Yamato CS-EC1
Capac. 90/705Tn.
4330
4320
4340
DE PRECONCENTRACION
4350
L:98m. B:1m
T: 4NY 12,5
Acec 22Kw
1460 rpm
+70
-25
Kurimoto KH-2460
Acec-Tedo. 45Kw. 1460rpm.
4370
4460
25Tn
24,8 m
4530
5Tn
24,8m
7371
φ 9,5m
h 27 m
4000Tn
Silo de
M.Prec
4371
φ 9,5m
h 27 m
4000Tn
Silo de
Pebble
6371
φ 9,5m
h 27 m
4000Tn
Silo de
M.Prec
8373
φ 9,5 m
h 27 m
1500+
84+84
Agua
5371
φ 9,5m
h 27 m
4000Tn
Silo de
M.Prec
L3
L3 L2
L1
L2
Kurimoto
M 72-1536
φ 3,9mL 5,2m
Toshiba TIN-FCK.
1000Kw. 6,3Kv.
990rpm.
Yamato E6P-EC1
Capac.
200/40 Tn.
5400/1
5425
5420
5470
M.Barras
5430
L:67,52m B:0,6m.
T: 3NY 12
4Kw. 1430rpm.
L:5m. B:0,8 m.
T: 3NY 12
3,7 Kw.CC. 1150 rpm.
L:72 m. B:0,8m.
T: 3NY 12.
7,5Kw.CC. 1150rpm.
5490/1
5435
Yamato
CS-EC1
Capac. 60/12Tn.
5455
5520
M.Piedras
Kobe. DB5900001
φ5,9 L 10,5
Toshiba M.P.pal.
TINFCC-F.
990rpm. 6,3Kv.
2400Kw
M.M.Lenta. A-B.
TCC-FCK
975rpm. 55Kw.
L:50 m. B:0,6 m
T: 3NY 12.
Acec 2,2Kw.
1460rpm.
A MOLINOS
Y SEP.MAG.
5535/6
N.W. 8/6
5 m³/min
37,5Kw
1500rpm
Sumitomo
25rpm
1,5Kw. φ2m
5500
Asea 5,5Kw
1470rpm
Sala 900G
φ 0,9mL 1,8m
5505 5510
Sala
365-6.6"
15Kw
1440rpm
5580
φ15"
13u
5540
Sumitomo
25rpm
1,5Kw. φ2m
5600
Sala 900G
φ0,9mL. 2,4m
Asea 5,5 Kw
1425 rpm
5605..10
5615..20
5565/6
Sala SPV
458/8.8"
75Kw
1480rpm
φ3m.h3m
37,5 Kw
870 rpm
5701
5702
5700
Sala SPV
365/6. 6"
22,5Kw
1460 rpm
5635/6
Sala BFP-225/4K
37,5Kw. 970 rpm.
5710 5711 5712
5715 5716
Sala
365/6. 6"
7,5Kw
1440 rpm
5775/6
Sala. 6"
365/6.
15Kw
1440rpm
5730/1
5787/8
Sala
365/8.8"
30Kw. 1460 rpm.
Kurimoto
φ2 m. L 2,8m
Toshiba TIN-FCK-F.
150 Kw 985rpm
5745
Sala BFP-150 2B
Acec. 7,5 Kw
960 rpm.
Sala 900G
φ0,9m L0,9m.
Ased 2,2Kw.
1470 rpm.
5738
5736 5735
5750
M.Bolas.
5760/1
Sala
260-3.3"
7,5Kw
1450rpm
Sala 900G
φ0,9mL 0,9m
Ased 2,2Kw
1470rpm
5765
Sala
365-6.6"
7,5Kw
1440rpm
5742/3
NW.12-10FAH 4"
175Kw
750/1500rpm
5815/6
5820
φ15"
8817
3Tn
7,5m
8827
Coninges/Sumitomo.
φ 2m. 25rpm. 1,5Kw.
8780
Sumitomo
Vezin Hand.
5-53.
8792
Dorr Oliver A 65
φ 25 m. h: 5,59m.
M.Reduc.Giro: Electric motor
TF-GM. 75HP. 1450rpm.
M.Reduc.Elev: Electric motor.
2,25 Kw 1450rpm.
8795
(6000...) L2
L3
(7000...)
Sala SPV
458/8.8"
63,75Kw
1480 rpm
Dorr-Oliver 122 S
φ75m. h.máx. 8,34.
M.Reductor. Prim.
A y B. Electric Motor.
TF-GD-TD. 11,25Kw.
125rpm.
φ 200mm
8830
8828/9
Sala 900G.
φ0,9m.L 1,8m.
Asea 5,5Kw
1470rpm
8852
8800/1
8805/6
A Ferroducto.
N.W. 8/6. 5m³/min.
75Kw. 750/1500 rpm.
φ350 mm
WB-LR-13
45Kw. 1460rpm.
8840/1
W.2 1/2CNE-72
11,25Kw. 2900 rpm.
NW.6-4 EAH. 4"
65Kw. 750/1500 rpm.
8845/6
W.1 1/2 LLR-10
30 Kw. 2940 rpm.
Sumitomo Vezin
Hand. 5-53.
8850
A Planta Piloto
de P.
8858
8990/1
A Laguna Blanca.
N.W.8-6FAH. 6"
63,75Kw.
1450rpm.
8854/5
Agua de
Acueducto
(368,8m³/h)
φ700mm
8993/4
8885/6
8887/8
Sala
260-3.3"
7,5Kw
1450rpm
A Ferroducto.
8870/1/2/3
8874/5/6/7
8810/1
W.12-LN-17
262,5Kw.
1450 rpm
W.6LR-15
63,75Kw
1480rpm
W.6LR-16
37,5Kw
1450rpm
HIPARSA
FLOW-SHEET (Datos técnicos).
CONC.
DIBUJO
CONTROLO
APROBO
PLANO Nº
FIRMA
FECHA
20-10-95
20-10-95
CM-1087

Figure-15



DE PRECONCENTRACIÓN
4333
4330
4320
4340
4350
+70
-25
4370
7371 Silo de M.Prec. 4000 Tn L3
4371 Silo de Pebbles 4000 Tn L3 L2 L1
6371 Silo de M.Prec. 4000 Tn L2
8373 Silo de Agua 1500+84 +84 m3
5371 Silo de M.Prec. 4000 Tn L1
5460
5425
5400
5401
5420
5430
5435
5455
5470 M.BARRAS
5480
5490/1
5520 M.PIEDRAS
5535/6
5500
5505
5510
5580/1
5540
5565/6
5600
5605..10
5615..20
A B C D E F
5700
5635/6
5701
5702
5530
5710 5711 5712
5715 5716
5730/1
5775/6
5787/8
5745
5738
5736 5735
5750 M.BOLAS
5760/1
5742/3
5765
5815/6
5817
5820
(6000...)L2
L3 (7000...)
8792
8795
8780
8800/1
8805/6
A FERRODUCTO
8827
8828
8829
8852
8850
8854/5
8858
8990/1
A PLANTA PILOTO DE P.
A LAGUNA BLANCA
8830
8840/1
8845/6
8993/4
8885/6
8887/8
8870/1/2/3
8874/5/6/7
8810/1
A FERRODUCTO
A MOLINOS Y SEP.MAG.
200mm
350mm
700mm
AGUA DE ACUEDUCTO (368,8 m3/h)
③ Fe %56.71 P %1.350 Fe3O4 %64.05
④ Fe %52.47 P %1.316 Fe3O4 %61.95
⑧ Fe %67.28 P %0.384 Fe3O4% 88.58
⑨ Fe %29.41 P %3.775 Fe3O4% 9.28
⑪ Fe %69.15 P %0.123 Fe3O4 %91.99
㉑ Fe %56.57 P %1.517 Fe3.O4 %66.45
211 Fe %51.42 P % 3,41 Fe3O4 %57,39
⑳ Fe %68,92 P %0,118 Fe3O4 %91,69
⑱ Fe %24,32 P %3,084 Fe3O4% 1,07
⑲ Fe %27,34 P %3,139 Fe3O4% 12,02
DESCRIPCIÓN DE MUESTRAS
3 _Piedras cinta 430.
4 _Mineral muestreador 480.
8 _Conc. sep. mag. secundario.
9 _Colas " " " .
11_Concentrado flotación 716.
18_Colas sep.mag. 828 / 9.
19_Colas finales
20_Concentrado final
21_Chips
211_Espumas finales (colas de flotación)
HIPARSA
FLOW-SHEET (Datos de proceso).
CONC.
DIBUJO
CONTROLO
APROBO
PLANO Nº
FIRMA
FECHA
20-10-95
20-10-95
CM-1088

Table-74-1 Equipment List (Preconcentration Plant)

Eq.No.	Equipment	Supplyer	Specification	Qn'ty	Condition
221	Vibrating feeder	UDHE	111-240 t/h	14	Operative
226	Dust collector	Aerofolax		1	Operative
227	Dust collector	Aerofolax		1	Operative
228	Dust collector	Aerofolax		1	Operative
229	Belt weigher	Fairbanks	430-590 t/h	1	Operative
230A/B	Belt conveyor	Famia		2	Minor mainte.
233					
235	Reversible conveyor	Famia		1	Operative
275A/B	Belt conveyor	Famia		2	Operative
276	Hopper		$100m^3$	1	Operative
285	Dust collector	Ciarrapico	$53000m^3/h$ x 355mmAq	1	Major mainte.
290	Hoist crane	Serma	15 ton	1	Operative
S1/S2/S3	Ore bin		$100m^3$	3	Operative
245/246/247	Vibrating feeder	AEG Telefunken	1.8mW x 2.0mL, 200 t/h	3	2 Operative, 1 Minor mainte.
250/251/252	Dry mag-sepa	Sala	916mm ϕ x 2400mmL, 700 gauss,96-240 t/h	3	2 Operative, 1 Minor mainte.
265/266/267	Dry mag-sepa	Sala	916mm ϕ x 2400mmL, 700 gauss,96-240 t/h	3	1 Minor, 2 Major mainte.
295/296/297	Hydrocone crusher	Svedala	200-340 t/h	3	2 Operative, 1 Major mainte.
301/302/303	Secondary screen	Svedala	1800mmW x 4800mmL,75, 25mm Double deck	3	2 Minor, 2 Major mainte.
	Preconcentrate silo		9m ϕ x 27mH, 3400ton	3	3 Operative
	Pebble bin		9m ϕ x 27mH, 3400ton	1	Operative

Table-74-2 Equipment List (Concentration Plant-1)

Eq.No.	Equipment	Supplyer	Specification	Qn'ty	Condition
320	Belt conveyor	Franceschini	1mW x 393mL, 441 t/h, kW	1	Minor mainte.
330	Belt conveyor	Franceschini	1mW x 119mL, 441 t/h, 63kW	1	Minor mainte.
340	Belt weigher	Yamoto	90-705 t/h	1	Major mainte.
350	Vibrating screen	Kurimoto		1	Operative
361	Dust collector			1	Operative
370	Reversible conveyor	Franceschini	1mW x 98mL, 440 t/h, 22kW	1	Operative
780	Automatic sampler	Sumitomo		1	Operative
795	Concentrate thickener	Dorr Oliver	25m ϕ x 5.59mH	1	Operative
805/806	Slurry pump	Nisso-Warman	8/6 SC, 4.6m³/min, Head 25.5m, 75kW	2	1 Minor, 1 Major mainte.
810/811	Water pump	Worthington	180m³/h, Head 10m, 37.5kW	2	Operative
827	Pulp distributor	Coninges	2m ϕ, 1.25mH	1	Minor mainte.
828/829	Magnet separator	Sala	916mm ϕ x1800mmL, 900 gauss	2	Operative
830	Tailing thickner	Dorr Oliver	75m ϕ	1	Major mainte.
845/846	Slurry pump	Nisso-Warman	6/4 EAH, 2.3m³/min, Head 29m	2	2 Major mainte.
850	Automatic sampler	Sumitomo		1	Operative
854/855	Slurry pump	Sala	SPV 365/6, 1.3m³/min, 7.5kW	2	2 Minor mainte.
1870/2870/3870	Water pump	Worthington	1800m³/h, Head 40m, 262.5kW	4	1 Operative, 3 Major mainte.
871					
1874/2874/3874	Water pump	Worthington	360m³/h, Head 40m, 63.75kW	4	4 Operative
875					
885/886	Water pump	Worthington	60m³/h, Head 35m, 11.25kW	2	2 Operative
887/888	Water pump	Worthington	36m³/h, Head m, 30kW	2	2 Operative
893/894/895	Water pump	Sala	48m³/h, Head 8m, 45kW	3	2 Operative, 1 Major mainte.
990A/990B	Tailing pump	Nisso-Warman	8/6 FAH, 3.9m³/min, Head 33m,63.75kW	2	1 Operative, 1 Major mainte.
993/994	Water pump	Worthington	600m³/h, Head 22m, 45kW	2	2 Operative

Table-74-3 Equipment List (Concentration Plant-2)

Eq.No.	Equipment	Supplyer	Specification	Qn'ty	Condition
650	Sodium carbonate mixer			1	Operative
651	Sodium hydrooxide mixer			1	Operative
654	Sodium carbonate mixer			1	Operative
655	Sodium hydrooxide pump	Hashimoto	8 l/min	1	Operative
657	Sodium hydrooxide mixer			1	Operative
658	Pan feeder	Kushida		1	Operative
660	Tall/gas oil mixer			1	Operative
661	NaOH & hot water mixer			1	Operative
666/670	Pump	Hashimoto		2	2 Operative
668/672	Pan feeder	Kushida		2	2 Operative
675	Emulsion tank		21.2m³	1	Operative
678	Emulsion pump			1	Operative
680/681	Emulsion mixer			2	2 Operative
685/686	Sodium silicate mixer			2	2 Operative
688	Floculant mixer			1	Operative
689	Floculant tank			1	Operative
690	Floculant mixer			1	Operative

Table-74-4 Equipment List (Concentration Plant-3) 4/7

Eq.No.	Equipment	Supplyer	Specification	Qn'ty	Condition
1400/2400/3400	Belt feeder	Franceschini	200 t/h	3	3 Operative
1401/2401/3401	Belt feeder	Franceschini	200 t/h	3	2 Operative, 1 Minor mainte.
1410/2410/3410	Vibrating feeder	Shinko-electric	25 t/h	3	3 Operative
1411/2411/3411	Vibrating feeder	Shinko-electric	25 t/h	3	3 Operative
1420/2420/3420	Belt conveyor	Franceschini	0.8mW x 72mL, 120 t/h, 7.5kW	3	1 Operative, 1 Minor, 1 Major mainte.
1425/2425/3425	Belt weigher	Yamato	40-200 t/h	3	2 Operative, 1 Minor mainte.
1430/2430/3430	Belt conveyor	Franceschini	0.6mW x 67.52mL, 25 t/h, 4kW	3	2 Operative, 1 Major mainte.
1435/2435/3435	Belt weigher	Yamato	12-60 t/h	3	3 Operative
1455/2455/3455	Belt conveyor	Franceschini	0.6mW x 50mL, 25 t/h, 2.2kW	3	1 Operative, 1 Minor mainte.
1470/2470/3470	Rod mill	Kurimoto	3900mm ϕ x 5200mmL, 1000kW	3	2 Minor mainte., 1 Major mainte.
1472/2472/3472	Rod charger			3	3 Operative
1490/2490/3490	Slurry pump	Nisso-Warman	8/6 SC, 5.1m³/min, Head 15.5m, 37.5kW	6	2 Operative, 2 Minor, 2 Major mainte.
1491/2491/3491					
1500/2500/3500	Pulp distributor	Sumitomo	2m ϕ	3	2 Operative, 1 Major mainte.
1505/2505/3505	Magnetic separator	Sala	916mm ϕ x1800mmL, 900 gauss, 2 drums	6	3 Operative, 1 Minor, 2 Major mainte.
A/B					
1510/2510/3510	Magnetic separator	Sala	916mm ϕ x1800mmL, 900 gauss, 2 drums	6	3 Operative, 1 Minor, 2 Major mainte.
A/B					
1520/2520/3520	Pebble mill	Kobelco	5900mm ϕ x 10500mmL, 2400kW x 2	3	2 Minor, 1 Major mainte.
1535/2535/3535	Slurry pump	Nisso-Warman	12/10 FAM, m³/min, Head 27.5m, 75kW	6	6 Major mainte.
1536/2536/3536					
1540/2540/3540	Hydrocyclone	Krebs	15" ϕ	13x3	13x2 Operative, 13 Major mainte.
1565/2565/3565	Slurry pump	Sala	SPV 458/8 8" x 6", 75kW	6	3 Minor, 3 Major mainte.
1566/2566/3566					
1580/2580/3580	Slurry pump	Sala	SPV 365/6 6", 15kW	6	2 Operative, 2 Minor, 2 Major mainte.
1581/2581/3581					

Table-74-5 Equipment List (Concentration Plant-4)

Eq.No.	Equipment	Supplyer	Specification	Qn'ty	Condition
1600/2600/3600	Pulp distributor	Sumitomo	2m ϕ	3	1 Operative, 1 Minor, 1 Major mainte.
1605/2605/3605	Magnetic separator	Sala	916mm ϕ x 2400mmL, 900 Gauss, 6 Drums	18	12 Minor, 6 Major mainte.
A/B/C/D/E/F					
1615/2615/3615	Magnetic separator	Sala	916mm ϕ x 2400mmL, 900 Gauss, 6 Drums	18	12 Minor, 6 Major mainte.
A/B/C/D/E/F					
1635/2635/3635	Slurry pump	Sala	SPV 365/6, 22.5kW	6	3 Minor.3 Major mainte.
1636/2636/3636					
1700/2700/3700	Pulp conditioner		3m ϕ x 3mH, 22.3m^3	9	9 Operative
1701/2701/3701					
1702/2702/3702					
1710/2710/3710	Flotator	Sala	BFP-225/4 K, 11.5m^3	15	7 Operative, 5 Minor, 3 Major mainte.
1711/2711/3711					
1712/2712/3712					
1715/2715/3715					
1716/2716/3716					
A-B					
1710/2710/3710	Froth paddle		37.5kW	6	2 Operative, 2 Minor, 2 Major mainte
P1/P2					
1730/2730/3730	Froth pump	Sala	SPV 365/6, 4.85 m^3/min, Head 6m, 15kW	6	1 Operative, 5 major mainte.
1731/2731/3731					
1735/2735/3735	Flotator	Sala	BFP-150/2B, 6 m^3	9	9 Operative
1736/2736/3736					
1738/2738/3738					
1735/2735/3735	Froth paddle		7.5kW	6	6 Operative
P1/P2					

Table-74-6 Equipment List (Concentration Plant-5)

Eq.No.	Equipment	Supplyer	Specification	Qn'ty	Condition
1742/2742/3742	Froth pump	Sala	SPV 365/6, 1.3 m^3/min, Head 6m, 7.5kW	6	2 Minor, 4 Major mainte.
1743/2743/3743					
1745/2745/3745	Magnetic separator	Sala	916mm ϕ x 900mmL,1 Drum, 2.2kW	3	2 Operative, 1Major mainte.
1750/2750/3750	Ball mill	Kurimoto	2100mm ϕ x2800mmL, 150kW	3	3 Operative
1760/2760/3760	Slurry pump	Sala	SPVF 260-3, 3", 0.79 m^3/min, 7.5kW	6	2 Minor, 4 Major mainte.
1761/2761/3761					
1765A/2765A/3765A	Magnetic separator	Sala	916mm ϕ x 900mmL, 3 Drums, 2.2kW	9	6 Operative, 3 Major mainte
1765B/2765B/3765B					
1765C/2765C/3765C					
1775/2775/3775	Slurry pump	Sala	SPV 365/6, 0.45m^3/min, Head 11.5m, 7.5kW	6	2 Operative, 3 Minor, 1 Major mainte.
1776/2776/3776					
1787/2787/3787	Slurry pump	Sala	SPV 365/6, 2.64m^3/min, Head 8m, 30kW	6	1 Operative, 3 Minor, 2 Major mainte.
1788/2788/3788					
1815/2815/3815	Slurry pump	Sala	SPV 458/8, 5.94m3/min, Head 14m, 63.75kW	6	4 Minor, 2 Major mainte.
1816/2816/3816					
1820/2820/3820	Hydrocyclone	Krebs	D15-15B, 15"	12	4 Minor, 8 Major mainte.
1821/2821/3821					
1890/2890/3890	Water pump	Sala	48m^3/h, Head 8m	6	2 Operative, 4 major mainte.
1892/2892/3892					
1910A/2910A/3910A	Air blower	Ciarrapico	80m^3/min x 2200mmAg, 30kW	6	3 Operative, 3 Minor mainte.
1910B/2910B/3910B					

Table-74-7 Equipment List (Slurry Pipe Line) 7/7

Eq.No.	Equipment	Supplyer	Specification	Qn'ty	Condition
	Pipe line	Bechtel (design)	219mmOD ϕ x 31.25 kmL, thickness 9.5mm	1	Operative
TK1/TK2	Slurry tank	Denver	15000mm ϕ x 14000mmH, 3000ton	2	2 Operative
112	Valve		Clarkson 8"	1	Operative
			Fisher 4"	1	Operative
134	Valve		Merex 8"	1	Operative
Booster 1/2	Slurry pump	Allen Sherman	10" x 8", 17.5 kg/cm², 202.5kW	2	2 Operative
195/196	Recuperation pump	Allen Sherman	6", 9 kg/cm2	2	2 Operative
197/198	Instrment water pump?	Allen Sherman	2", 9 kg/cm2	2	2 Operative
213	Valve		Merex 8"	1	Operative
218	Valve		Merex 6"	1	Operative
	NaOH tank		160 m³	2	2 Operative
371/372	NaOH pump	Stork	SP4560, 5.92 l/stroke	2	2 Operative
	Sulfide pump	Pascal	DRP-18D, 0-18l/min, 18 kg/cm²	2	2 Minor mainte.
	Inhibitor mixing tank	Denver	20m³	2	2 Operative
	Water dilution pump	Worthington	136 m³/h, Head 35m	2	2 Operative
	sello ? pump	Worthington	17 m3/h, Head 63m	2	2 Operative
	Cleaning pump		55 m³/h, 5 kg/cm²	3	3 Operative
BP1/BP2/BP3	Slurry pump	Ingersoll	130 m³/h, 100.85 kg/cm², 450kW	3	3 Minor mainte.

(1) Preconcentration plant

The preconcentration plant is operating intermittently for supply of iron ore preconcentrate to the cement factory. There exists operational data from February 1996. 2 lines out of 3 lines are well maintained and immediate operation could be possible.

Operated hours per day of the pre-concentration plant was rather short and were thought that there should be sufficient capacity, however, 2 line only operation seems insufficient if 2,600,000t per year crude ore shall be treated and 3 line operation deems necessary. Secondary magnetic separeator, screen and cone crusher are needed maintenance at No. 1 line. Although No.2 and No.3 lines, are available for operation now, there is no stock of spare parts.

(2) Concentration plant

There are 3 lines of almost the same equipment in the concentration plant. It appears that No.1 and No.2 line are well maintained except slurry pump. No.3 line is deteriorated as this line was used for supply source of parts for other two lines. Problem of these 2 lines are same to the pre-concentration plant as there is no stock of spare parts and consumables. Repair of No.3 line seems not necessary as 2 line operation is sufficient to produce 1,100,000 t per year of concentrate.

(3) Facilities for tailing disposal

Mechanism of tailing thickener was disassembled and maintained as it is now. There is a need of repair, maintenance and assemble work. 15 inch cyclones for primary magnetic separation tailing installed prior to the tailing thickener were removed. These shall be re-installed.

(4) Facilities for thickening and transportation pipeline of concentrate

It seemed that there will be no serious problems regarding the facilities for concentrate transportation as the maintenance condition of those facilities appears good. but there are no spare parts and consumables.

(5) Laboratory

Mineral dressing test using the existing iron ore concentration plant was planned at the first site survey. Check work as to whether or not it is possible to carry out the mineral dressing test using the actual plant showed a negative result.

From this result a series of laboratory level mineral dressing test were planned. There were problems at HIPARSA laboratory, such as;

① balls for grinding ball mill are in shortage.

② connecting hose to supply iron ore to the magnetic separator is too big and clogging occurred frequently.

③ no stop watch therefore flotation time was not recorded.

④ bats for recovery and drying of flotation froth are in shortage,

⑤ electronic balance which requires to be frequently used was out of order.

⑥ a bulb in the spectrophotometer for analyzing phosphorus could not be used.

⑦ a series of standard sieves necessary for measurement of particle size distribution are partly lacking. Especially the most important 325 mesh and 200 mesh sieves which have deteriorated and their reliability is doubtful.

⑧ no microscope for mineral dressing therefore there was no observation of mineral dressing results immediately after the magnetic separation and flotation.

A more difficult problem was the non-existence of qualified laboratory engineers and technicians. The only person who can carry out the laboratory mineral dressing test was the chief laboratory worker who had experience of laboratory tests when HIPARSA was in operation. There was also a shortage of assistant workers at laboratory and it took a long time to prepare and carry out even a preliminary mineral dressing test. During the stay of JICA first site survey team merely preliminary mineral dressing test could be executed.

In order to carry out the planned mineral dressing test, there is a need to dispatch a concentration specialist in advance to the JICA second site survey team to properly supervise the laboratory level mineral dressing test with the necessary preparation of laboratory test machines, tools and materials.

A series of laboratory test was carried out during the second site survey by the join work with INTEMIN, JICA and HIPARSA with the necessary tools and equipment brought by JICA. INTEMIN has fully cooperated to the laboratory tests and good results were obtained as a laboratory test. Results of the laboratory tests are described in Chapter 6.

5.1.4 Pelletizing plant

(1) Equipment

Presently, equipments shown in **Table-75** and **Table-76** exists.

The followings are the results of the inquiry.

- All equipment was run 3 years ago, and there is no lost equipment.
- Some motors have been removed from the place where they should be installed but these motors still exist in the workshop.
- Some conveyor belts are missing.

All facilities or equipment can be operated with usual maintenance work (such as cleaning, lubrication and centering) and do not require large repairs with the exception of the refractory in the furnace, index conveyor and product screen but there is much equipment which requires modification which should be done at the initial stage of commercial production after construction and guarantee test as mentioned in (2)-2 of 4.2.3.

Table-75 Belt conveyor list

	Trough Angle	Capacity	Belt width	Belt speed	Inclination (Max)	Horizontal length	Lift	Motor	
	°	t/h	mm	m/min	°	m	m	kW	rpm
B.C.No.01(Disc filter to No.2 or No.28)	20	82	610	60	0	19.8	0.0	1.5	1450
B.C.No.02 (To No.26 or No.3)	20	249	914	60	0	57.9	0.0	11.2	1450
B.C.No.03 (To No. 16 through mix mull mixer)	0	680	1219	77	0	10.4	0.0	7.5	1450
B.C.No.04 (from reverse bin to No. 16)	20	340	610	105	0	14.9	0.0	1.5	1450
B.C.No.05 (to No. 06)	20	340	762	105	13	75.6	18.3	29.8	1450
B.C.No.06 (to No. 07)	20	340	762	105	16	14.3	4.0	11.2	1450
B.C.No.07 (to Balling Bin)	0	340	1219	60	0	61.0	0.0	11.2	1450
B.C.No.08 (to No. 09) A,B,C,D	20	249	762	90	16	14.3	4.3	7.5	1450
B.C.No.09 (to Balling Drum) A,B,C,D	20	249	762	90	13	10.1	2.4	5.6	1450
B.C.No.10 (to No.11) A,B,C,D	20	68	762	Variable	0	14.9	2.4	3.7	1450
B.C.No.11 (to Furnace) A,B,C,D	0	68	914	90	13	10.1	2.4	5.6	1450
B.C.No.12 (for under size g.pellets from seed screen) A,B,C,D	0	166	2438	Variable	0	6.9	0.0	3.7	1800
B.C.No.13 (return to No. 09) A,B,C,D	20	166	762	90	8	18.3	2.7	5.6	1450
B.C.No.14 (for over size g.pellets from seed screen) A,B,C,D	20	100	610	40	0	3.4	0.0	1.1	1450
B.C.No.15 (from No. 15 and mix mull to No. 16)	20	340	762	105	0	54.9	0.0	11.2	1450
B.C.No.16 (to No. 05)	20	340	762	105	0	22.6	0.0	5.6	1450
B.C.No.17 (Under cooler) A,B,C,D	10	200	610	90	20	3.1	0.0	2.2	1450
B.C.No.18 (to product screen) A,B	20	300	914	60	12	126.0	9.5	18.7	1450
B.C.No.19 (P.screen to No. 20 and to B.C.Tr No. 01) A,B	20	300	914	60	0	7.9	0.0	3.7	1450
B.C.No.20 (to Special and Re-charge yard)	20	300	914	60	16	74.7	9.1	18.7	1450
B.C.No.21 (under size of P.screen to Mill)	20	50	610	35	0	10.4	0.0	0.7	1450
B.C.No.22 (to re-pulping tank)	20	50	762	35	16	8.8	2.7	11.2	1450
B.C.No.23 (Re-charge Y. to No. 24)	N.A								
B.C.No.24 (No. 23 to No. 25) Pocket type conveyor	20	100	610	60	0			29.8	1450
B.C.No.25 (to Re-charge Hopper)	0	100	610	60	0	30.5	0.0	2.2	1450
B.C.No.26 (Discharge of excess filter from No. 02)	20	340	762	105	0	57.3	0.0	7.5	1450
B.C.No.27 (From hopper to No. 22 for re-pulping)	20	50	914	16	15	7.9	2.1	11.2	1450
B.C.No.28 (From No. 01 to No.29)	20	82	610	35	0	2.7	0.0	2.2	1450
B.C.No.29 (No. 28 to No. 30)	20	82	610	35	14	43.3	9.1	5.6	1450
B.C.No.30 (from No. 29 to Balling Bin)	20	82	610	35	15	31.7	9.4	5.6	1450
B.C.No.32 (Bentonite breaker to Dryer)	20	277	610	30	16	20.1	6.1	1.5	1440
B.C.No.33 (From B.Elevator of Silica to Mill)	20	27	610	15	13	16.2	3.7	0.7	970
B.C.Tr No.01 (to product Yard)	35	454	800	120	0	186.0	7.0	37.3	1470
B.C.Tr No.02 (to Stacker)	35	454	800	120	0	160.0	7.0	37.3	1470
B.C.Tr No.03 (to Stacker)	35	1814	1200	144	0	150.0	7.0	74.6	1480
B.C.Tr No.04 (to Stacker)	35	1814	1000	180	0	1490.0	16.0	253.6	1488

Table-76-1 Equipment list(Main line)

Conc thickener		81001	Structure	Reinforced concrete	
			Dia	25	m
			Side wall height	2.6	m
			Manufacturer	Dorr Oliver Long	
	Rake		Main drive motor	5.595	kW
				1500	rpm
			Lifting motor	2.238	kW
				1500	rpm
	Slurry pump	81121	Type	Centrifuge 8*6*18" Model SRL-CHD	
		81131	Capacity	660-1100	usgpm
			Head	28.956	m
			Number	2	units
			Motor	74.6	kW-DC
				1500	rpm
			Manufacturer	Allis Chalmers	
	Over flow tank		Structure	Basin constructed on the ground	
			Capacity	8000	m^3
	Water pump		Type	Axial 3 etapas Model 16G-DWT	
			Capacity	480	m^3/h
			Head	71	m
			Number	2	units
			Motor	134.28	kW
				1485	rpm
			Manufacturer	Byron Jackson	
Tank for Repulping		82331	Stock capacity	92	m^3
			Dia.	4.9	m
	Agitator	82641	Agitating	0.097	rpm
			Motor	29.8	kW
				1500	rpm
	Slurry pump		Capacity	250	m^3/h
			Head	23.6	m
Stock tank(for pulp)		81020	Stock capacity	2014	m^3
		81040	Number	2	units
			Dia	15	m
			Height	11.4	m
			Steel structure	93.23	t
			Manufacturer	Kirchheimer Hnos S.A	
	Agitator	81021	Type	screw with vertical shaft	
		81041	Number	2	units
			Manufucturer	Denver Hamilton	
			Speed	23.41	rpm
			Paddle dia.	3.657	m
				6	blades
			Motor	149.2	kW
				960	rpm
	Slurry pump primary and Slurry pump secondary	81151	Number	8	units
		81141	Type	Centrifuge 8*6*18" Model SRL-CHD	
		81191	Capacity	660-1100	usgpm
		81181	Head	28.956	m
		81171	Motor	74.6	kW
		81161		AC for primary and DC for secondary	
		81201		1500	rpm
		81211	Manufacturer	Allis Chalmers	

Table-76-2 Equipment list(Main line)

Silica thickener		87040	Stock capacity	610	m^3
			Dia	18	m
			Height		m
	Rake	87041	Speed	1500	rpm
			Power	1.49	kW
	Slurry pump	87050	Power	3.73	kW
		87051	Capacity	22.7	liter/cycle
				15	cycle/min
			Solid		t/h
			Head	8.8	m
Silica stock tank		87600	Stock capacity	2014	m^3
		87620	Dia	6.3	m
	Agitator	87601	Speed	1500	rpm
		87621	Power	29.8	kW
	Slurry pump	87052	Power	5.6	kW
		87053	Solid(50%)	8.5	t/h
Regrind thickener		86000	Stock capacity	125	m^3
			Dia	7.6	m
			Solid	50	%
	Rake	86001	Speed	0.27	rpm
			Power	1.1	kW
	Slurry pump	86111	Type	3x3x10	
			Power	7.5	kW
			Solid	60	%
Day bin for Hydrated lime		82410	Capacity	30	t
			Number	1	
			Structure	steel	
			Level detector	Capacitance	
	Screw weigher	82411	Capacity(max)	4.4	t/h
			Accuracy	1.1	%
Day bin for bentonite		82430	Capacity	50	t
		82450	Number	2	
			Structure	steel	
			Level detector	Capacitance	
	Compressor fluidization for HL	87131-64 87131-65	Capacity		m^3/h
	Screw weigher	82431	Capacity(max)	4.4	t/h
		82451	Accuracy	1.1	%
Tank of high vaucum for disc filter 82001, 82021, 82041, 82061, 82081, 82101			Volume	4.8	m^3
Tank of low vacuum for disc filter 82005, 82025, 82045, 82065, 82085, 82105			Volume	1.42	m^3
	Vacuum pump 82141, 82161, 82181, 82201, 82221, 82241		Capacity	311.5	m^3/h
			Pressure	24	mm-Aq
Tank of snap air for disc filter		82291	Volume	5.8	m^3

Table-76-3 Equipment list(Main line)

Disc filter		82000			
	Filter	82001	Capacity	20-70	t/h/unit
		82021	Cake moisture	8.0-10.0	%
		82041	Type	Disc type	
		82061	Number of unit	6	units
		82081	Number of discs/unit	10	discs
		82101	Filtering area	106	m²/unit
			Rotating speed	0.24-0.72	rpm
			Driving motor	5.595	kW
				1500	rpm
			Agitating motor	7.46	kW
				1500	rpm
			Steel weight	12.0204	t/unit
			Manufacturer	Dorr Oliver Long	
	Vacuum Pump				
			Type	Double stage root	
			Lowest pressure	24	mm-Hg
			Suction Volume	11000	CFM at 24mm
			Number of units	6	units
			Main motor	373	kW
				1483	rpm
			Manufacturer	Dresser Roots	
	Snap Blow Compressor				
			Type	Alternative Simple stage	Model VL-50
			Number of units	2	units
			Capacity	1000	CFM
			Pressure	40	PSIG
			Main motor	111.9	kW
				1500	rpm
			Manufacturer	Bellis Morcon	
Mixer mix-mull (80t/h)		82341	Capacity	80	t/h
			Power	74.6	kW
				1000	rpm
Mixer mix-mull (340t/h)		82361	Type	Double room wheels mixer	
				Simpson Multi Mull 26 GP/350	
			Capacity	350	t/h
			Wheel Diameter	1.2192	m
			Wheel Separation	1.8288	m
			Chamber Diameter	3.048	m
			Chamber Separation	2.7432	m
			Motor	261.1	kW
				1000	rpm
			Steel weight	22.68	t
			Manufacturer	National Engineering Company	
Pekay mixer		82401	Type	3 row 2 line of wheel	
			Capacity	390	t/h
			Cutting wheel speed	150	rpm
			Motor	37.3	kW
				1500	rpm

Table-76-4 Equipment list(Main line)

Pekay mixer	82441	Type	3 row 2 line of wheel	
		Capacity	375	t/h
		Cutting wheel speed	375	rpm
		Length of unit	4.89	m
		Motor	37.3	kW
			1500	rpm
		Steel weight	3.61	t
		Manufacturer	Pekay Machine & Engineering CO.	
Pelletizer				
Drum pelletizer-A,B,C,D	83001	Length	9.7536	m
	83021	Dia	3.6576	m
	83041	Rotating speed	10	rpm
	83061	Capacity	67.5	dry t/h
		Recirculating ratio	200-300	%
		Cutter bar speed	65	rpm
		Manufacturer	Allis Chalmer	
Balling material bin	83160	Capacity	100	t
	83190	Number	4	
	83200	Structure	steel	
	83220	Level detector	Conductive	
Balling material bin-reverse	83240	Capacity	50	t
		Number	1	
		Structure	steel	
		Level detector	Conductive	
Table feeder of balling material	83161	Type	SKM 27	
	83181	Capacity	100	t/h
	83201	Table dia.	2700	mm
	83221	Number of tables	4	
Table feeder of balling material-re	83241	Capacity	100	t/h
		Number	1	
Seed screen-A,B,C,D	83081			
	83101	Type	Single deck rod screen TY-Rock F-900	
	83121	Holding structure	Rubber suspension	
	83141	Width	2.1336	m
		Length	4.8768	m
		Inclination	18	°
		Width of vibration	9.525	mm
		Frequency	879	Cycles/min
		aperture(big)	9.2	mm
		aperture(small)	19.5	mm
		Main motor	22.38	kW
			1500	rpm
		Steel weight	8.6184	
		Manufacturer	The W.S. Tyler Company	

Table-76-5 Equipment list(Main line)

Pellet reciculation				
Hopper	84081	Capacity	50	t
84081,84101,84121, 84141	84101	Number	4	
	84121	Structure	steel	
	84141	Level detector	weighing	
Vibrating feeder		Manufacturer	Syntron Canadian LTD	
84080,84100,84120, 84140		Model	F-330-B	kW
		Size	457x1371	mm
Buggy for No 10-A,B,C,D		Speed(long)	9.6	m/min
		Speed(short)	26.3	m/min
		Power	7.5	kW
Buggy for No 11-A,B,C,D(B.C.)		Speed(long)	6.4	m/min
		Speed(short)	23.5	
		Power	11.2	kW
Furnace-A,B,C,D				
Furnace		Type	Shaft Pelletizing Furnace	
		Width at furnace top	2.4384	m
		Length	6.4008	m
		Height	14.3256	m
		Capacity	67.5	t/h
		Number of units	4	units
		Manufacturer	Midrex division(Midland Ross Corp.)	
Chunk breaker-A,B,C,D				
		Number of units	7	units/furnace
		Hydraulic unit motor	14.92	kW
			1500	rpm
		Manufacturer	Midrex division(Midland Ross Corp.)	
Wiper bar-A,B,C,D				
		Number of units	2	units/furnace
		Hydraulic unit motor	3.73	kW
			1750	rpm
		Manufacturer	Midrex division(Midland Ross Corp.)	
Combustion Chamber				
		Dia.	2.8702	m
		Height	6.6548	m
		Burner	254.88	m^3/min-hot gas
			800	m^3/h-N gas
		Manufacturer	Midrex division(Midland Ross Corp.)	
Cooler				
		Capacity	67.5	t/h
		Dia.	2.5146	m
		Height	7.3914	m
		Inlet Temp.of Pellets	500-600	℃
		Outlet Temp.	60-70	℃
		Manufacturer	Midrex division(Midland Ross Corp.)	
Process Air Compressor	206			
		Type	Centrifuge, single stage SL 10a	
		Capacity	85320	Nm^3/h
		Static pressure	9500	mm-Aq
		Driving motor	2611	kW
			1500	rpm
		Manufacturer	KKK(Kuhnle, Kopp & Kausch)	

Table-76-6 Equipment list(Main line)

	Cooling Air Compressor	217			
			Type	Centrifuge, single stage KL 10a	
			Capacity	72720	Nm^3/h
			Static pressure	3200	mm-Aq
			Driving motor	932.5	kW
				1500	rpm
			Manufacturer	KKK(Kuhnle, Kopp & Kausch)	
	Upper Cyclone	207	Type	Model 700/150 Type VM Tamano 4-730	
			Gas Volume	112000	PCM
			Gas Temp.	422.2222222	℃
			In/Outlet tube dia.	1.8288	m
			Number of cyclone	4	
			Steel weight	17.2368	t
			Manufacturer	The Ducon CO, Inc.	
	Bottom Cyclone	216	Type	Model 700/150 Type VM Tamano 4-730	
			Gas Volume	115600	PCM
			Gas Temp.	371-537	℃
			In/Outlet tube dia.	1.8288	m
			Number of cyclone	4	
			Steel weight	17.2368	t
			Manufacturer	The Ducon CO, Inc.	
	Top Gas Fan	208	Type	Centrifuge, Model 73/IV	
			Capacity	112000	PCM
			Static pressure	8	inch at 70℃
			Driving motor	186.5	kW
				1000	rpm
			Manufacturer	AIRCARE	
	Exhaust fan lower				
Product Screen		85001	Type	Double Deck Screen TY-LEVEL	
		85021	Holding structure	Spring suspension	
			Width	2.4384	m
			Length	4.8768	m
			Inclination	4	°
			Width of vibration	12.7	mm
			Frequency	820	Cycles/min.
			aperture(big)	7/16.	mm
			aperture(small)	3/16.	mm
			Main motor(double)	11.19	kW/motor
				1450	rpm
			Capacity	300	t/h
			Steel weight	8.6184	t
			Manufacturer	The W.S. Tyler Company	

Table-76-7 Equipment list(Main line)

Stacker				
Stacker		Capacity	500	t/h
		Boom length	29	m
		Derricking height	4.0-13.0	m
Boom belt		Width	800	mm
		Speed	2	m/sec.
		Manufacturer	Fried. Krupp GMbH	
Reclaimer		Type	Bucket wheel type Ldr 220.1200/13+20	
		Capacity	1000	t/h
		Steel weight	143	t
		Manufacturer	Fried. Krupp GMbH	
Ship Loader		Type	Telescopico Desplazable 173	
		Capacity	2000	t/h
		Length of boom	75-106	m
		Derricking height	-9.63 to +2.21	m-from axis point
Boom belt		Width	1200	mm
		Speed	3.1	m/sec.
		Receiving vessels	20000	t- design base
		Manufacturer	Fried. Krupp GMbH	
Crane(Bridge type)-82121(5t)		Type	Munck228-12,28	
		Capacity	5	t
		Bridge speed	27.4	m/min.
		Trolley speed	16.8	m/min.
		Hoisting speed	11.9	m/min.
		Span	15.9	m
		Manufacturer	Munck	
Crane(Bridge type)-82321(5t)		Type	Manual apparel	
Crane(Bridge type)-80181(5t)		Type	Manual apparel	
Crane(Bridge type)-84001(5 & 30 t)		Type	Munck228-12,28	
		Capacity	5&30	t
		Bridge speed	30.2	m/min.
		Trolley speed	24.1	m/min.
		Hoisting speed	5.5/0.5	m/min.
		Aux. Hoist speed	11.9/1.2	m/min.
		Span	22.9	m
		Manufacturer	Munck	
Weigher (for No. 02 BC)		Material to be weighed	Filter cake	
		Type	VEY-R-WEIGH SCALES	
		Capacity	400	t/h
		Belt width	914	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Weigher (for No. 08 BC) A,B,C,D		Material to be weighed	Balling material discharged from Hopper	
		Type	VEY-R-WEIGH SCALES	
		Capacity	100	t/h
		Belt width	762	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Weigher (for No. 13 BC) A,B,C,D		Material to be weighed	Under size green pellets	
		Type	VEY-R-WEIGH SCALES	
		Capacity	400	t/h
		Belt width	762	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	

Table-76-8 Equipment list(Main line)

Weigher (for No. 16 BC)		Material to be weighed	Over size green pellets	
		Type	VEY-R-WEIGH SCALES	
		Capacity	100	t/h
		Belt width	762	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Weigher (for No. 20 BC)		Material to be weighed	Fired pellets to re-charge yard	
		Type	VEY-R-WEIGH SCALES	
		Capacity	300	t/h
		Belt width	914	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Weigher (for No. 21 BC)		Material to be weighed	Chips	
		Type	VEY-R-WEIGH SCALES	
		Capacity	10	t/h
		Belt width	610	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Weigher (for No. 23 BC)		Material to be weighed	Pellets to be re-charged	
		Type	VEY-R-WEIGH SCALES	
		Capacity	100	t/h
		Belt width	610	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Weigher (for No. 33 BC)		Material to be weighed	Dolomite to grinding mill	
		Type	VEY-R-WEIGH SCALES	
		Capacity	12	t/h
		Belt width	610	mm
		Manufacyurer	RAMSEY ENGINEERING COMPANY	
Weigher (for B.C.Tr No.01)		Material to be weighed	Pellets for Product yard	
		Type	VEY-R-WEIGH SCALES	
		Capacity	400	t/h
		Belt width	800	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Weigher (in Reclaimer)		Material to be weighed	Pellets reclaimed for shipping	
		Type	VEY-R-WEIGH SCALES	
		Capacity	1000	t/h
		Belt width	1000	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Weigher (for B.C.Tr No.01)		Material to be weighed	Pellets for shipping	
		Type	VEY-R-WEIGH SCALES	
		Capacity	4000	t/h
		Belt width	1000	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Dosing Weigher (for Day bin of Bentonite)		Material to be weighed	Bentonite to be dosed	
		Type	Gravimetric Feeder	
		Capacity	4	t/h
		W×L×H(mm)	559×838×508	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	
Dosing Weigher (for Auxiliary Day bin of Bentonite)		Material to be weighed	Bentonite to be dosed	
		Type	Gravimetric Feeder	
		Capacity	2	t/h
		W×L×H(mm)	457×610×406	mm
		Manufacturer	RAMSEY ENGINEERING COMPANY	

Table-76-9 Equipment list(Silica line)

Stock silo	87660	Capacity	300	t
		Number	1	
		Structure	steel	
Grinding Mill	87001	Type	Ball mill	
		Dia.	2.3	m
		Length	3.04	m
		Capacity	8.5	t/h
		Rotating speed	21.65	rpm
		Grinding Media	18.5	t
		Main motor	261.1	kW
			985	rpm
		Manufacturer	Allis Chalmer	

Table-76-10 Equipment list(Bentonite line)

Crusher for bentonite	87082			
Feeder for bentonite	87121			
Dryer	87091	Type	Rotary kiln	
		Shell inside dia.	1.372	m
		Shell length	10.944	m
		Slope	12	°
		Rotating speed	9	rpm
		Capacity	6	t/h
		Input moisture	28	%
		Output moisture	10	%
		Main motor	7.46	kW
			1440	rpm
		Manufacturer	Lochehead Haggerty	
Raymond Mill		Capacity	5	t/h
		Product size	85-90	% of 74micron under
		Product moisture	5.0-6.0	%
		Main motor	74.6	kW
			980	rpm
		Steel weight	8.75	t
		Manufucturer	Combustion Engineering INC.	
			Raymond Bartlett -Snow Division	
Silo for ground bento.	87680	Capacity	300	t
		Number	1	
		Structure	steel	
		Level detector	Conductive	

(2) Estimation of the time to re-start (without modification work)

It is reported that the required man-month total is estimated to be 300 man-month which includes work by employees of HIPARSA and excludes brickwork and the purchase time for bricks. Work related to the furnace maintenance by HIPARSA personel is estimated to be only 28 man-month. From item wise consideration, electrical and instrumental work is longest one and it is estimated to be 78 man-month excluding modification and fabrication.

(3) Manpower

Only 3 engineers are working at present and almost manpower must be hired before the re-start and technical assistance, training and organization will be required.