(3) Results of 3rd Stage Evaluation

a. Adjustment with Power Development Plan (including Power Generation Plan)

The term of the 5-year Master Plan for power plant rehabilitation is set to be 1994 to 1998. The power development plan and power generation plan up to 2005 are shown in Tables 4-1 -- 4-5, Table 6-1-15 and Fig. 6-1-8. As is clearly indicated in these tables, it is estimated that the existing thermal power plants need to be operated at the annual capacity factor of 70% on an average.

b. Adjustment with Maintenance Plan

The implementation period for rehabilitation of Sucat No. 2 & No. 3 Units is scheduled as shown in Fig. 6-1-5. Therefore, in reference to the 2nd stage evaluation results, the rehabilitation schedule was arranged for the other power plant units.

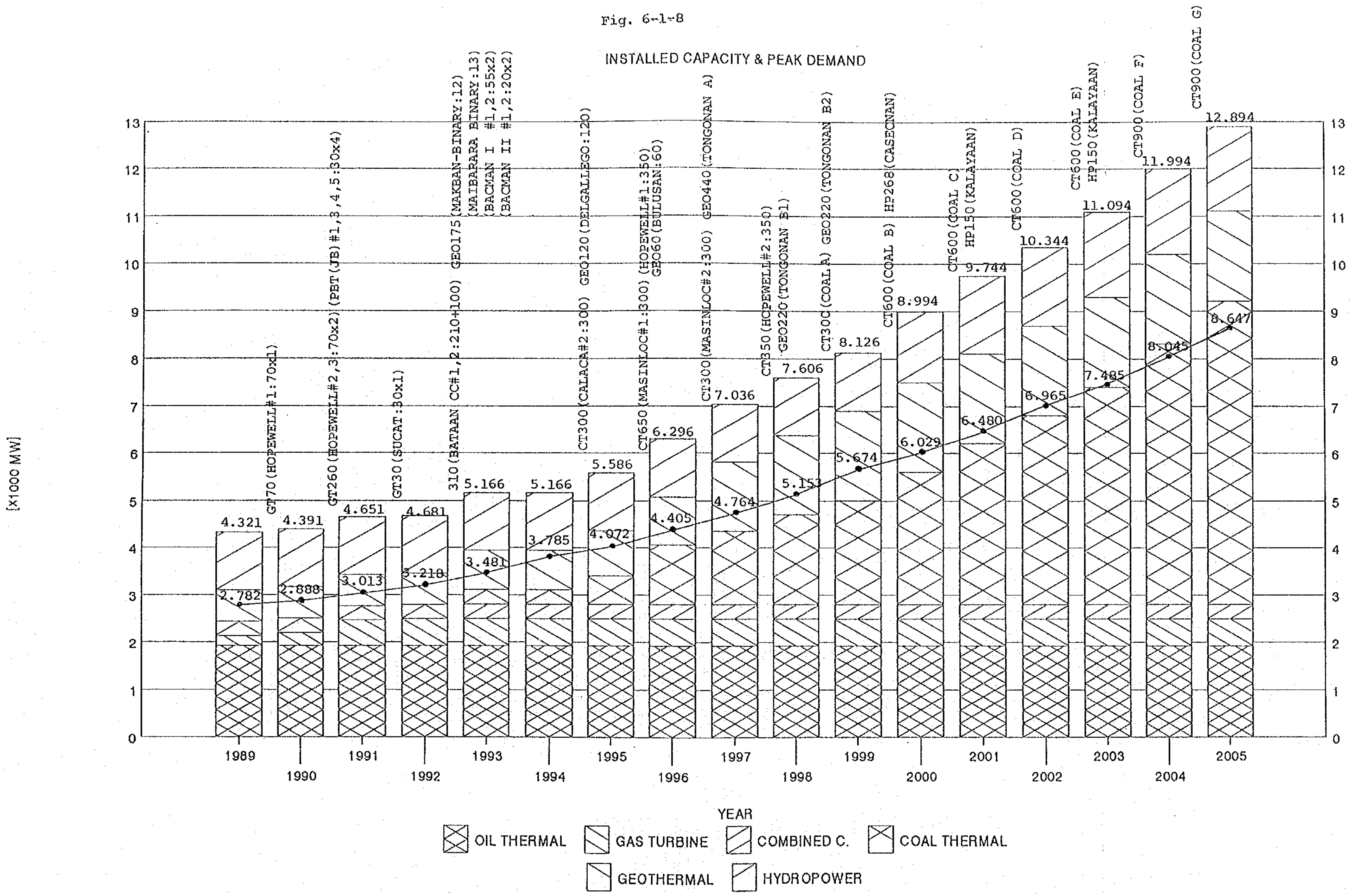
The periodic overhaul for each power plant should be scheduled, in principle, for once a year. Also, periodic overhaul should be coordinated to minimize the overlapping periods between the power plants and, in addition, not to increase shutdown capacity during the overlapping period. The final rehabilitation work schedule was drawn up as shown in Fig. 6-1-5 after discussions with NAPOCOR during the 2nd stage field investigation.

Table 6-1-15 POWER DEVELOPMENT AND PEAK LOAD IN LUZON GRID

	OIL THERMAL		COMBINED CYCLE		GAS TURBINE		COAL THERMAL		GEO THERMAL		HYDROPOWER		TOTAL		PEAK LOAD FORECAST (MW)
	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	
1989		1,925		0		210		300		660		1,226	0	4,321	2,782
1990		1,925		0	70 (HOPEWELL #1: 70 X 1)	280		300		660		1,226	70	4,391	2,888
1991		1,925		0	260 (HOPEWELL #2, 3: 70 x 2) (PBT(JB) #1, 3, 4, 5: 30 x 4)	540		300		660		1,226	260	4,651	3,013
1992		1,925		0	30 (SUCAT:30x1)	570		300		660		1,226	30	4,681	3,218
1993		1,925	310 (BATAAN CC #1, 2: 210 + 100)	310		570		300	175 (MAKBAN-BINARY: 12) (MAIBARARA BINARY: 13) (BACMAN I #1, 2: 55 x 2) (BACMAN II #1, 2: 20 x 2)	835		1,226	485	5,166	3,481
1994		1,925		310		570		300		835		1,226	0	5,166	3,785
1995		1,925		310		570	300 (CALACA #2:300)	600	120 (DEL GALLEGO GEO: 120)	955		1,226	420	5,586	4,072
1996		1,925		310		570	650 (MASINLOC #1: 300) (HOPEWELL #1: 350)	1,250	60 (BULUSAN GEO: 60)	1,015		1,226	710	6,296	4,405
1997	(LUZON - LEYTE INTERCONNECTION)	1,925		310		570	300 (MASINLOC #2: 300)	1,550	440 (TONGONAN A: 440)	1,455		1,226	740	7,036	4,764
1998		1,925		310		570	350 (HOPEWELL #2: 350)	1,900	220 (TONGONAN B1: 220)	1,675		1,226	570	7,606	5,153
1999		1,925		310		570	300 (COAL A: 300)	2,200	220 (TONGONAN B2: 220)	1,895		1,226	520	8,126	5,674
2000		1,925		310		570	600 (COAL B: 600)	2,800		1,895	268 (CASECNAN)	1,494	868	8,994	6,029
2001		1,925		310		570	600 (COAL C: 600)	3,400		1,895	150 (KALAYAAN)	1,644	750	9,744	6,480
2002		1,925		310		570	600 (COAL D: 600)	4,000		1,895		1,644	600	10,344	6,965
2003		1,925		310		570	600 (COAL E: 600)	4,600		1,895	150 (KALAYAAN)	1,794	750	11,094	7,485
2004		1,925		310		570	900 (COAL F: 900)	5,500		1,895		1,794	900	11,994	8,045
2005		1,925		310		570	900 (COAL G: 900)	6,400		1,895		1,794	900	12,894	8,647

Fig. 6-1-8

INSTALLED CAPACITY & PEAK DEMAND



ANNEX 1. PLANT OPERATIONAL DATA

Bataan Thermal Power Plant
Manila Thermal Power Plant
Sucat Thermal Power Plant
Malaya Thermal Power Plant
Batangas Coal Fired Thermal Power Plant
Bataan Gasturbine Power Plant
Malaya Gasturbine Power Plant

ANNEX 1. PLANT OPERATIONAL DATA

BATAAN THERMAL POWER PLANT UNIT No. 1

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	75	75	75	75	75
2.	DEPENDABLE CAPACITY	(MW)	69	68	69	68	64
3.	AVERAGE LOAD	(MW)	62.19	66.53	65.42	65.86	62.86
4.	GROSS GENERATION	(MWH)	417,898.18	475,291.6	429,782.9	521,140.8	454,038.3
5.	OPERATING HOURS	(Hr)	6,872.03	7,144.07	6,569.16	7,911.71	7,223.40
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	91,923.66	99,067.73	105,636.89	113,548.60	120,772.00
7.	TOTAL OUTAGE HOURS	(Hr)	1,887.97	1,615.93	2,214.84	848.29	1,536.60
	(1) FORCED OUTAGE	(Hr)	302.03	176.63	687.43	261.97	237.77
	(2) MAINTENANCE OUTAGE	(Hr)	689.18	537.00	543.84	247.18	111.40
	(3) PLANNED OUTAGE	(Hr)	799.60	882.47	966.03	305.63	1,120.30
	(4) ECONOMIC SHUTDOWN	(Hr)	88.71	0	0	0	41.00
	(5) OUTSIDE TROUBLE	(Hr)	8.45	19.83	17.54	33.51	26.13
8.	STATION USED POWER RATIO	(%)	6.40	6.27	5.84	5.66	6.18
9.	CAPACITY FACTOR	(%)	63.67	72.51	65.32	79.63	69.31
10.	AVAILABILITY FACTOR	(%)	79.40	81.74	74.89	91.09	83.18
11.	HEAT RATE (GROSS)	(BTU/KWH)	9,861	9,799	9,931	10,113	10,518
12.	THERMAL EFFICIENCY (GROSS)	(%)	34.61	34.83	34.37	33.73	32.45
13.	NUMBER OF STARTS (YEAR/TOTAL)		22/319	10/329	25/354	19/373	13/386

COMMISSIONING: MAY 1972

PLANT OPERATIONAL DATA

BATAAN THERMAL POWER PLANT UNIT No. 2

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	150	150	150	150	150
2.	DEPENDABLE CAPACITY	(MW)	141	145	146	142	131
3.	AVERAGE LOAD	(MW)	112.91	137.27	132.19	130.39	129.24
4.	GROSS GENERATION	(MWH)	766,139	966,899	811,229	983,933	588,618
5.	OPERATING HOURS	(Hr)	7,248.14	6,958.38	6,211.78	7,503.60	4,554.62
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	66,077.23	73,035.61	79,247.39	86,750.99	91,305.61
7.	TOTAL OUTAGE HOURS	(Hr)	1,511.86	1,801.62	2,572.22	1,256.40	4,205.38
	(1) FORCED OUTAGE	(Hr)	164.71	292.61	779.41	452.63	2,508.61
	(2) MAINTENANCE OUTAGE	(Hr)	169.86	447.13	730.21	268.45	84.22
	(3) PLANNED OUTAGE	(Hr)	730.35	986.73	1,062.60	300.85	1,552.83
	(4) ECONOMIC SHUTDOWN	(Hr)	405.16	61.06	0	209.20	59.72
	(5) OUTSIDE TROUBLE	(Hr)	41.78	14.09	0	25.27	0
8.	STATION USED POWER RATIO	(%)	6.8	5.83	6.20	6.47	6.67
9.	CAPACITY FACTOR	(%)	58.59	73.72	61.57	75.10	44.80
10.	AVAILABILITY FACTOR	(%)	82.91	80.28	70.52	88.79	52.68
11.	HEAT RATE (GROSS)	(BTU/KWH)	9,464	9,485	9,532	9,702	9,868
12.	THERMAL EFFICIENCY (GROSS)	(%)	36.06	35.98	35.81	35.18	34.20
13.	NUMBER OF STARTS (YEAR/TOTAL)		24/293	15/308	17/325	24/349	24/373

COMMISSIONING: FEB 1977

PLANT OPERATIONAL DATA

MANILA THERMAL POWER PLANT UNIT No. 1

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	100	100	100	100	100
2.	DEPENDABLE CAPACITY	(MW)	95	96	98	95	98
3.	AVERAGE LOAD	(MW)	58	80	71.16	71.45	86.45
4.	GROSS GENERATION	(MWH)	393,095	590,842	564,729	508,951	663,660
5.	OPERATING HOURS	(Hr)	6,739.85	7,266.46	8,092.44	7,122.75	7,676.89
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	170,346.75	177,613.21	185,705.65	192,828.40	200,505.29
7.	TOTAL OUTAGE HOURS	(Hr)	2,020.15	1,493.54	691.56	1,637.25	1,083.11
	(1) FORCED OUTAGE	(Hr)	447.43	298.31	30.47	146.98	114.94
	(2) MAINTENANCE OUTAGE	(Hr)	12.70	0	413.70	0	59.78
	(3) PLANNED OUTAGE	(Hr)	1,293.85	942.10	0	1,414.47	837.50
	(4) ECONOMIC SHUTDOWN	(Hr)	259.50	238.93	202.83	75.32	0
	(5) OUTSIDE TROUBLE	(Hr)	6.67	14.20	44.56	0.48	70.89
8.	STATION USED POWER RATIO	(%)	8.26	6.55	7.00	6.91	5.75
9.	CAPACITY FACTOR	(%)	44.91	67.45	64.29	58.10	75.76
10.	AVAILABILITY FACTOR	(%)	80.24	86.09	94.94	82.18	88.44
11.	HEAT RATE (GROSS)	(BTU/KWH)	10,361	9,196	10,101	10,212	9,964
12.	THERMAL EFFICIENCY (GROSS)	(%)	32.94	37.11	33.8	33.4	34.2
13.	NUMBER OF STARTS (YEAR/TOTAL)		14/260	8/268	12/280	11/291	8/299

COMMISSIONING: SEP 1965

PLANT OPERATIONAL DATA

MANILA THERMAL POWER PLANT UNIT No. 2

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	100	100	100	100	100
2.	DEPENDABLE CAPACITY	(MW)	89	91	99	97	97
3.	AVERAGE LOAD	(MW)	58	77	71.28	75.10	86.92
4.	GROSS GENERATION	(MWH)	366.265	592,334	569,693	483,076	714,216
5.	OPERATING HOURS	(Hr)	6,299.61	7,859.97	7,940.61	6,483.63	8,217.18
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	155,434.26	163,294.23	171,234.84	177,718.47	185,935.65
7.	TOTAL OUTAGE HOURS	(Hr)	2,460.39	900.03	843.39	2,276.37	542.82
	(1) FORCED OUTAGE	(Hr)	328.66	218.37	0	227.23	79.71
	(2) MAINTENANCE OUTAGE	(Hr)	0	385.49	607.95	157.95	232.35
	(3) PLANNED OUTAGE	(Hr)	1,298.30	288.00	0	1,757.25	0
	(4) ECONOMIC SHUTDOWN	(Hr)	833.43	0	224.19	112.33	59.27
	(5) OUTSIDE TROUBLE	(Hr)	0	8.17	11.25	21.61	171.49
8.	STATION USED POWER RATIO	(%)	7.74	6.25	6.54	6.26	5.88
9.	CAPACITY FACTOR	(%)	41.81	67.62	64.86	55.15	81.53
10.	AVAILABILITY FACTOR	(%)	83.07	88.04	93.08	75.54	96.44
11.	HEAT RATE (GROSS)	(BTU/KWH)	10,243	10,113	10,085	10,090	9,021
12.	THERMAL EFFICIENCY (GROSS)	(%)	33.32	33.75	33.8	33.8	34.4
13.	NUMBER OF STARTS (YEAR/TOTAL)		10/247	8/255	10/265	15/280	12/292

COMMISSIONING: OCT 1966

PLANT OPERATIONAL DATA

SUCAT THERMAL POWER PLANT UNIT No. 1

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	150	150	150	150	150
2.	DEPENDABLE CAPACITY	(MW)	100	99	98	130	150
3.	AVERAGE LOAD	(MW)	60.38	74.10	71	79	135
4.	GROSS GENERATION	(MWH)	504,960	624,540	395,290	356,690	1,044,680
5.	OPERATING HOURS	(Hr)	8,318.60	8,427.46	5,403.63	4,540.66	7,735.15
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	123,632.78	132,060.24	137,463.87	142,004.53	149,739.68
7.	TOTAL OUTAGE HOURS	(Hr)	441.40	332.54	3,380.37	4,219.34	1,024.85
	(1) FORCED OUTAGE	(Hr)	78.65	7.35	504.28	0	68.27
	(2) MAINTENANCE OUTAGE	(Hr)	0	215.92	717.34	0	677.93
	(3) PLANNED OUTAGE	(Hr)	0	0	2,002.95	4,018.83	266.05
	(4) ECONOMIC SHUTDOWN	(Hr)	241.26	109.27	92.50	200.51	0
	(5) OUTSIDE TROUBLE	(Hr)	121.49	0	63.30	0	12.60
8.	STATION USED POWER RATIO	(%)	10.02	8.38	10.13	8.95	5.28
9.	CAPACITY FACTOR	(%)	38.48	47.53	30.00	27.15	79.62
10.	AVAILABILITY FACTOR	(%)	99.36	97.45	64.98	54.12	88.43
11.	HEAT RATE (GROSS)	(BTU/KWH)	11,007	10,720	11,269	10,825	9,871
12.	THERMAL EFFICIENCY (GROSS)	(%)	31.01	31.84	30.29	31.53	34.58
13.	NUMBER OF STARTS (YEAR/TOTAL)		10/330	6/336	7/343	9/352	21/373

COMMISSIONING: JUL 1968 REHABILITATION: JUL 1989 - JAN 1990

PLANT OPERATIONAL DATA

SUCAT THERMAL POWER PLANT UNIT No. 2

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	200	200	200	200	200
2.	DEPENDABLE CAPACITY	(MW)	160	151	145	174	156
3.	AVERAGE LOAD	(MW)	125.07	134.59	123	139.0	146.0
4.	GROSS GENERATION	(MWH)	124,530	949,750	746,060	703,650	685,690
5.	OPERATING HOURS	(Hr)	995.71	7,086.50	6,032.84	5,048.25	4,709.74
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	99,069.22	106,155.72	112,188.56	117,236.81	121,946.55
7.	TOTAL OUTAGE HOURS	(Hr)	7,764.29	1,673.50	2,751.16	3,711.75	4,050.26
	(1) FORCED OUTAGE	(Hr)	55.64	383.34	712.60	9.50	628.78
	(2) MAINTENANCE OUTAGE	(Hr)	2,280.37	1,108.84	56.27	161.60	178.45
	(3) PLANNED OUTAGE	(Hr)	5,265.23	0	1,416.00	1,096.30	0
	(4) ECONOMIC SHUTDOWN	(Hr)	163.05	126.47	474.61	419.10	63.60
	(5) OUTSIDE TROUBLE	(Hr)	0	54.85	91.68	2,025.25	3,179.43
8.	STATION USED POWER RATIO	(%)	9.83	4.82	5.05	4.09	4.49
9.	CAPACITY FACTOR	(%)	7.14	54.21	42.47	51.06	61.44
10.	AVAILABILITY FACTOR	(%)	13.29	82.06	78.85	79.34	85.53
11.	HEAT RATE (GROSS)	(BTU/KWH)	10,899	11,136	11,446	10,975	11,095
12.	THERMAL EFFICIENCY (GROSS)	(%)	31.31	30.65	29.83	31.10	30.76
13.	NUMBER OF STARTS (YEAR/TOTAL)		6/330	12/342	8/350	13/363	11/374

COMMISSIONING: OCT 1970

PLANT OPERATIONAL DATA

SUCAT THERMAL POWER PLANT UNIT No. 3

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	200	200	200	200	200
2.	DEPENDABLE CAPACITY	(MW)	150	96	158	158	155
3.	AVERAGE LOAD	(MW)	124.25	93.63	126.66	125	132
4.	GROSS GENERATION	(MWH)	653,490	439,520	629,420	933,350	740,930
5.	OPERATING HOURS	(Hr)	5,415.42	4,538.09	5,125.54	7,427.72	5,629.39
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	95,706.42	100,244.51	105,370.05	112,797.77	118,427.16
7.	TOTAL OUTAGE HOURS	(Hr)	3,344.58	4,221.91	3,658.46	1,332.28	3,130.61
	(1) FORCED OUTAGE	(Hr)	420.70	1,143.33	273.00	202.00	1,697.26
	(2) MAINTENANCE OUTAGE	(Hr)	3.40	632.20	301.61	338.61	1,397.92
	(3) PLANNED OUTAGE	(Hr)	0	1,752.00	2,763.97	0	0
	(4) ECONOMIC SHUTDOWN	(Hr)	2,920.48	65.62	307.28	715.80	0
	(5) OUTSIDE TROUBLE	(Hr)	0	628.76	12.60	75.87	35.43
8.	STATION USED POWER RATIO	(%)	5.66	9.82	5.06	4.81	5.10
9.	CAPACITY FACTOR	(%)	37.30	25.09	35.83	53.74	42.46
10.	AVAILABILITY FACTOR	(%)	95.02	67.49	60.22	94.34	64.52
11.	HEAT RATE (GROSS)	(BTU/KWH)	11,936	12,670	11,920	12,210	12,487
12.	THERMAL EFFICIENCY (GROSS)	(%)	28.59	26.94	28.63	27.95	27.33
13.	NUMBER OF STARTS (YEAR/TOTAL)		14/302	9/311	15/326	14/340	15/355

COMMISSIONING: APR 1971

PLANT OPERATIONAL DATA

SUCAT THERMAL POWER PLANT UNIT No. 4

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	300	300	300	300	300
2.	DEPENDABLE CAPACITY	(MW)	228	240	221	240	272
3.	AVERAGE LOAD	(MW)	176.14	195.22	164.80	161	212
4.	GROSS GENERATION	(MWH)	815,090	1,181,120	629,770	581,210	300,920
5.	OPERATING HOURS	(Hr)	4,627.51	6,038.04	3,977.61	3,460.89	1,419.93
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	81,738.23	87,776.27	91,753.88	95,214.77	96,634.70
7.	TOTAL OUTAGE HOURS	(Hr)	4,132.49	2,721.96	4,806.39	5,299.11	7,340.07
	(1) FORCED OUTAGE	(Hr)	24.90	895.54	1,884.25	1,004.86	0
	(2) MAINTENANCE OUTAGE	(Hr)	271.25	728.23	128.33	0	0
	(3) PLANNED OUTAGE	(Hr)	2,322.25	948.83	2,160.00	1,332.00	7,340.07
	(4) ECONOMIC SHUTDOWN	(Hr)	1,514.09	60.48	478.58	849.92	0
	(5) OUTSIDE TROUBLE	(Hr)	0	88.88	155.23	2,112.33	0
8.	STATION USED POWER RATIO	(%)	4.75	4.32	6.04	5.65	7.11
9.	CAPACITY FACTOR	(%)	31.02	44.94	23.90	29.14	11.45
10.	AVAILABILITY FACTOR	(%)	71.75	70.77	51.77	67.19	16.21
11.	HEAT RATE (GROSS)	(BTU/KWH)	11,846	11,328	12,090	12,918	10,490
12.	THERMAL EFFICIENCY (GROSS)	(%)	28.81	30.13	28.23	26.42	32.54
13.	NUMBER OF STARTS (YEAR/TOTAL)		7/310	16/326	17/343	6/349	11/360

COMMISSIONING: JUN 1972 REHABILITATION: OCT 1989 - DEC 1990

PLANT OPERATIONAL DATA

MALAYA THERMAL POWER PLANT UNIT No. 1

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	300	300	300	300	300
2.	DEPENDABLE CAPACITY	(MW)	234	300	294	299	285
3.	AVERAGE LOAD	(MW)	187	245	251	250	268
4.	GROSS GENERATION	(MWH)	1,132,042	538,224	1,884,324	1,567,670	2,106,026
5.	OPERATING HOURS	(Hr)	5,947.53	2,332.80	7,510.51	6,249.25	7,862.42
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	72,999.54	75,332.34	82,842.85	89,092.10	96,954.52
7.	TOTAL OUTAGE HOURS	(Hr)	2,812.47	6,427.20	1,273.49	2,510.75	897.58
	(1) FORCED OUTAGE	(Hr)	242.95	14.85	166.76	2,003.70	655.56
	(2) MAINTENANCE OUTAGE	(Hr)	831.75	1,043.30	140.61	372.27	231.37
	(3) PLANNED OUTAGE	(Hr)	1,296.00	5,369.05	923.20	0	0
	(4) ECONOMIC SHUTDOWN	(Hr)	197.37	0	42.92	0	10.65
	(5) OUTSIDE TROUBLE	(Hr)	244.40	0	0	134.78	0
8.	STATION USED POWER RATIO	(%)	3.92	2.71	2.94	2.86	3.00
9.	CAPACITY FACTOR	(%)	43.90	20.48	71.51	60.58	80.14
10.	AVAILABILITY FACTOR	(%)	74.04	25.05	85.82	72.64	89.89
11.	HEAT RATE (GROSS)	(BTU/KWH)	10,658	9,669	9,910	10,132	10,556
12.	THERMAL EFFICIENCY (GROSS)	(%)	32.02	35.30	34.44	33.69	32.33
13.	NUMBER OF STARTS (YEAR/TOTAL)		17/240	13/253	15/268	22/290	19/309

COMMISSIONING: DEC 1974 REHABILITATION: NOV 1986 - OCT 1987

PLANT OPERATIONAL DATA

MALAYA THERMAL POWER PLANT UNIT No. 2

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	350	350	350	350	350
2.	DEPENDABLE CAPACITY	(MW)	285	326	344	336	324
3.	AVERAGE LOAD	(MW)	205	260	288	280	292
4.	GROSS GENERATION	(MWH)	1,118,128	2,028,998	2,121,673	2,209,309	2,197,688
5.	OPERATING HOURS	(Hr)	5,464.71	7,654.61	7,368.85	8,039.75	7,352.16
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	52,809.63	60,464.24	67,833.09	75,872.84	83,405.00
7.	TOTAL OUTAGE HOURS	(Hr)	3,295.29	1,105.39	1,415.15	720.25	1,227.74
	(1) FORCED OUTAGE	(Hr)	80.28	18.70	68.28	30.65	269.74
	(2) MAINTENANCE OUTAGE	(Hr)	594.22	742.49	201.94	56.15	495.70
	(3) PLANNED OUTAGE	(Hr)	2,547.08	314.98	1,081.38	594.97	462.30
	(4) ECONOMIC SHUTDOWN	(Hr)	31.77	0	52.73	0	0
	(5) OUTSIDE TROUBLE	(Hr)	41.94	29.22	10.82	38.48	0
8.	STATION USED POWER RATIO	(%)	5.01	3.67	3.58	3.44	3.44
9.	CAPACITY FACTOR	(%)	36.64	66.18	69.01	72.38	71.68
10.	AVAILABILITY FACTOR	(%)	62.91	89.46	84.48	90.53	85.99
11.	HEAT RATE (GROSS)	(BTU/KWH)	10,212	9,604	9,413	9,568	9,676
12.	THERMAL EFFICIENCY (GROSS)	(%)	33.42	35.54	36.26	35.67	35.27
13.	NUMBER OF STARTS (YEAR/TOTAL)		17/149	11/160	12/172	7/179	10/189

COMMISSIONING: MAR 1979 REHABILITATION: JUL 1986 - JAN 1987

PLANT OPERATIONAL DATA

BATANGAS COAL FIRED THERMAL POWER PLANT UNIT No. 1

ITEMS		1986	1987	1988	1989	1990
1. RATED CAPACITY	(MW)	300	300	300	300	300
2. DEPENDABLE CAPACITY	(MW)	270	280	280	272	249
3. AVERAGE LOAD	(MW)	252.58	263.68	278.51	263.57	245.02
4. GROSS GENERATION	(MWH)	1,609,307	1,948,932	1,996,270	2,053,138	1,601,232
5. OPERATING HOURS	(Hr)	6,371.47	7,391.40	7,167.72	7,789.65	6,535.07
6. TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	14,417.04	21,808.44	28,976.16	36,765.81	43,300.88
7. TOTAL OUTAGE HOURS	(Hr)	2,388.53	1,368.6	1,616.28	970.35	2,212.93
(1) FORCED OUTAGE	(Hr)	158.78	154.54	241.86	577.08	420.08
(2) MAINTENANCE OUTAGE	(Hr)	210.72	186.77	336.38	170.05	311.58
(3) PLANNED OUTAGE	(Hr)	1,865.70	1,004.83	958.89	0	1,412.20
(4) ECONOMIC SHUTDOWN	(Hr)	126.36	0	54.24	147.12	47.41
(5) OUTSIDE TROUBLE	(Hr)	26.97	22.46	24.91	76.10	21.66
8. STATION USED POWER RATIO	(%)	5.16	5.17	5.07	5.34	5.56
9. CAPACITY FACTOR	(%)	61.24	74.16	75.75	78.12	61.01
10. AVAILABILITY FACTOR	(%)	74.41	84.59	82.45	91.40	75.43
11. HEAT RATE (GROSS)	(BTU/KWH)	9,704	9,732	9,306	9,592	9,652
12. THERMAL EFFICIENCY (GROSS)	(%)	35.17	35.07	36.67	35.58	35.36
13. NUMBER OF STARTS (YEAR/TOTAL)		28/115	25/140	21/161	46/207	28/235

COMMISSIONING: NOV 1984

PLANT OPERATIONAL DATA

BATAAN GASTURBINE POWER PLANT UNIT No. 1

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	-	-	-	31	31
2.	DEPENDABLE CAPACITY	(MW)	-	-	-	31	30
3.	AVERAGE LOAD	(MW)	-	-	-	32	28
4.	GROSS GENERATION	(MWH)	-	-	-	44,948	129,462
5.	OPERATING HOURS	(Hr)	-	-	-	1,395.22	4,548.05
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	-	-	-	1,395.22	5,943.27
7.	TOTAL OUTAGE HOURS	(Hr)	-	-	-	2,349.66	4,211.95
	(1) FORCED OUTAGE	(Hr)	-	-	-	2.21	435.04
	(2) MAINTENANCE OUTAGE	(Hr)	-	-	-	0	133.87
	(3) PLANNED OUTAGE	(Hr)	-	-	-	0	0.70
	(4) ECONOMIC SHUTDOWN	(Hr)	-	-	-	2,347.45	3,642.34
	(5) OUTSIDE TROUBLE	(Hr)	-	-	-	0	0
8.	STATION USED POWER RATIO	(%)	-	-	-	*1	*1
9.	CAPACITY FACTOR	(%)	-	-	-	38.72	47.67
10.	AVAILABILITY FACTOR	(%)	-	-	-	99.94	93.50
11.	HEAT RATE (GROSS)	(BTU/KWH)	-	-	-	11,407	12,113
12.	THERMAL EFFICIENCY (GROSS)	(%)	-	-	-	29.92	28.18
13.	NUMBER OF STARTS (YEAR/TOTAL)		-	-	-	*2	*2

COMMISSIONING: NOV 1989 *1: NO STATION SERVICE KWH METER *2: NO DATA AVAILABLE

PLANT OPERATIONAL DATA

BATAAN GASTURBINE POWER PLANT UNIT No. 2

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	-	-	-	31	31
2.	DEPENDABLE CAPACITY	(MW)	-	-	-	31	31
3.	AVERAGE LOAD	(MW)	-	-	-	31	29
4.	GROSS GENERATION	(MWH)	-	-	-	44,588	125,174
5.	OPERATING HOURS	(Hr)	-	-	-	1,422.43	4,278.88
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	-	-	-	1,422.43	5,701.31
7.	TOTAL OUTAGE HOURS	(Hr)	-	-	-	2,194.03	4,481.17
	(1) FORCED OUTAGE	(Hr)	-	-	-	473.30	1,014.54
	(2) MAINTENANCE OUTAGE	(Hr)	-	-	-	0	7.75
	(3) PLANNED OUTAGE	(Hr)	-	-	-	0	244.00
	(4) ECONOMIC SHUTDOWN	(Hr)	-	-	-	1,720.73	3,211.58
	(5) OUTSIDE TROUBLE	(Hr)	-	-	-	0	3.30
8.	STATION USED POWER RATIO	(%)	-	-	-	*1	*1
9.	CAPACITY FACTOR	(%)	-	-	-	39.77	46.11
10.	AVAILABILITY FACTOR	(%)	-	-	-	86.91	85.54
11.	HEAT RATE (GROSS)	(BTU/KWH)	-	-	-	11,326	12,073
12.	THERMAL EFFICIENCY (GROSS)	(%)	-	-	-	30.13	28.27
13.	NUMBER OF STARTS (YEAR/TOTAL)		-	-	-	*2	*2

COMMISSIONING: NOV 1989 *1: NO STATION SERVICE KWH METER *2: NO DATA AVAILABLE

PLANT OPERATIONAL DATA

BATAAN GASTURBINE POWER PLANT UNIT No. 3

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	-	-	-	31	31
2.	DEPENDABLE CAPACITY	(MW)	-	-	-	31	30
3.	AVERAGE LOAD	(MW)	-	-	-	29	27
4.	GROSS GENERATION	(MWH)	-	-	-	30,744	123,095
5.	OPERATING HOURS	(Hr)	-	-	-	1,050.88	4,482.63
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	-	-	-	1,050.88	5,533.51
7.	TOTAL OUTAGE HOURS	(Hr)	-	-	-	2,089.27	4,277.37
	(1) FORCED OUTAGE	(Hr)	-	-	-	0.50	1,344.03
	(2) MAINTENANCE OUTAGE	(Hr)	-	-	-	0	48.21
	(3) PLANNED OUTAGE	(Hr)	-	-	-	0	104.80
	(4) ECONOMIC SHUTDOWN	(Hr)	-	-	-	2,088.77	2,780.33
	(5) OUTSIDE TROUBLE	(Hr)	-	-	-	0	0
8.	STATION USED POWER RATIO	(%)	-	-	-	*1	*1
9.	CAPACITY FACTOR	(%)	-	-	-	31.58	45.33
10.	AVAILABILITY FACTOR	(%)	-	-	-	99.98	82.91
11.	HEAT RATE (GROSS)	(BTU/KWH)	-	-	-	11,414	12,233
12.	THERMAL EFFICIENCY (GROSS)	(%)	-	-	-	29.90	27.90
13.	NUMBER OF STARTS (YEAR/TOTAL)		-	-	-	*2	*2

COMMISSIONING: NOV 1989 *1: NO STATION SERVICE KWH METER *2: NO DATA AVAILABLE

PLANT OPERATIONAL DATA

BATAAN GASTURBINE POWER PLANT UNIT No. 4

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	-	-	-	31	31
2.	DEPENDABLE CAPACITY	(MW)	-	-	-	31	30
3.	AVERAGE LOAD	(MW)	-	-	-	33	28
4.	GROSS GENERATION	(MWH)	-	-	-	41,907	118,990
5.	OPERATING HOURS	(Hr)	-	-	-	1,289.20	4,294.87
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	-	-	-	1,289.20	5,584.07
7.	TOTAL OUTAGE HOURS	(Hr)	-	-	-	1,492.33	4,465.13
	(1) FORCED OUTAGE	(Hr)	-	-	-	53.86	995.45
	(2) MAINTENANCE OUTAGE	(Hr)	-	-	-	0	13.56
	(3) PLANNED OUTAGE	(Hr)	-	-	-	0	221.65
	(4) ECONOMIC SHUTDOWN	(Hr)	-	-	-	1,385.19	3,230.72
	(5) OUTSIDE TROUBLE	(Hr)	-	-	-	53.28	3.75
8.	STATION USED POWER RATIO	(%)	-	-	-	*1	*1
9.	CAPACITY FACTOR	(%)	-	-	-	49.55	43.84
10.	AVAILABILITY FACTOR	(%)	-	-	-	98.03	85.95
11.	HEAT RATE (GROSS)	(BTU/KWH)	-	-	-	11,517	12,181
12.	THERMAL EFFICIENCY (GROSS)	(%)	-	-	-	29.63	28.02
13.	NUMBER OF STARTS (YEAR/TOTAL)		-	-	-	*2	*2

COMMISSIONING: NOV 1989 *1: NO STATION SERVICE KWH METER *2: NO DATA AVAILABLE

PLANT OPERATIONAL DATA

MALAYA GASTURBINE POWER PLANT UNIT No. 1

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	-	-	-	31	31
2.	DEPENDABLE CAPACITY	(MW)	-	-	-	31	30
3.	AVERAGE LOAD	(MW)	-	-	-	30	26
4.	GROSS GENERATION	(MWH)	-	-	-	30,769	112,410
5.	OPERATING HOURS	(Hr)	-	-	-	1,025.23	4,269.84
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	-	-	-	1,025.23	5,295.07
7.	TOTAL OUTAGE HOURS	(Hr)	-	-	-	1,902.77	4,490.16
	(1) FORCED OUTAGE	(Hr)	-	-	-	383.07	2.79
	(2) MAINTENANCE OUTAGE	(Hr)	-	-	-	124.58	251.02
	(3) PLANNED OUTAGE	(Hr)	-	-	-	0	0
	(4) ECONOMIC SHUTDOWN	(Hr)	-	-	-	1,389.67	4,187.71
	(5) OUTSIDE TROUBLE	(Hr)	-	-	-	5.45	48.64
8.	STATION USED POWER RATIO	(%)	-	-	-	0.26	0.26
9.	CAPACITY FACTOR	(%)	-	-	-	33.96	41.63
10.	AVAILABILITY FACTOR	(%)	-	-	-	82.63	97.09
11.	HEAT RATE (GROSS)	(BTU/KWH)	-	-	-	11,469	12,033
12.	THERMAL EFFICIENCY (GROSS)	(%)	-	-	-	29.76	28.36
13.	NUMBER OF STARTS (YEAR/TOTAL)		-	-	-	*1	*1

COMMISSIONING: AUG 1989 *1: NO DATA AVAILABLE

PLANT OPERATIONAL DATA

MALAYA GASTURBINE POWER PLANT UNIT No. 2

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	-	-	-	31	31
2.	DEPENDABLE CAPACITY	(MW)	-	-	-	31	31
3.	AVERAGE LOAD	(MW)	-	-	-	29	27
4.	GROSS GENERATION	(MWH)	-	-	-	36,002	119,096
5.	OPERATING HOURS	(Hr)	-	-	-	1,233.59	4,376.29
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	-	-	-	1,233.59	5,609.88
7.	TOTAL OUTAGE HOURS	(Hr)	-	-	-	1,694.41	4,383.71
	(1) FORCED OUTAGE	(Hr)	-	-	-	171.60	1.47
	(2) MAINTENANCE OUTAGE	(Hr)	-	-	-	112.88	39.25
	(3) PLANNED OUTAGE	(Hr)	-	-	-	0	0
	(4) ECONOMIC SHUTDOWN	(Hr)	-	-	-	1,381.42	4,313.65
	(5) OUTSIDE TROUBLE	(Hr)	-	-	-	28.51	29.34
8.	STATION USED POWER RATIO	(%)	-	-	-	0.23	0.24
9.	CAPACITY FACTOR	(%)	-	-	-	40.05	44.00
10.	AVAILABILITY FACTOR	(%)	-	-	-	90.19	99.53
11.	HEAT RATE (GROSS)	(BTU/KWH)	-	-	-	11,459	11,824
12.	THERMAL EFFICIENCY (GROSS)	(%)	-	-	-	29.78	28.87
13.	NUMBER OF STARTS (YEAR/TOTAL)		-	-	-	*1	*1

COMMISSIONING: AUG 1989 *1: NO DATA AVAILABLE

PLANT OPERATIONAL DATA

MALAYA GASTURBINE POWER PLANT UNIT No. 3

	ITEMS		1986	1987	1988	1989	1990
1.	RATED CAPACITY	(MW)	-	-	-	31	31
2.	DEPENDABLE CAPACITY	(MW)	-	-	-	31	30
3.	AVERAGE LOAD	(MW)	-	-	-	31	28
4.	GROSS GENERATION	(MWH)	-	-	-	36,509	112,012
5.	OPERATING HOURS	(Hr)	-	-	-	1,175.14	4,041.90
6.	TOTAL OPERATING HOURS SINCE INITIAL SYNCHRO.	(Hr)	-	-	-	1,175.14	5,217.04
7.	TOTAL OUTAGE HOURS	(Hr)	-	-	-	1,752.86	4,718.10
	(1) FORCED OUTAGE	(Hr)	-	-	-	160.34	6.53
	(2) MAINTENANCE OUTAGE	(Hr)	-	-	-	45.80	187.50
	(3) PLANNED OUTAGE	(Hr)	-	-	-	0	245.67
	(4) ECONOMIC SHUTDOWN	(Hr)	-	-	-	1,465.19	4,250.24
	(5) OUTSIDE TROUBLE	(Hr)	-	-	-	81.53	28.16
8.	STATION USED POWER RATIO	(%)	-	-	-	0.23	0.25
9.	CAPACITY FACTOR	(%)	-	-	-	41.37	41.38
10.	AVAILABILITY FACTOR	(%)	-	-	-	92.76	94.96
11.	HEAT RATE (GROSS)	(BTU/KWH)	-	-	-	11,292	11,711
12.	THERMAL EFFICIENCY (GROSS)	(%)	-	-	-	30.22	29.14
13.	NUMBER OF STARTS (YEAR/TOTAL)		-	-	-	*1	*1

COMMISSIONING: AUG 1989 *1: NO DATA AVAILABLE

ANNEX 2. SUMMARY RECORD OF FORCED OUTAGE

Bataan Thermal Power Plant
Manila Thermal Power Plant
Sucat Thermal Power Plant
Malaya Thermal Power Plant
Batangas Coal Fired Thermal Power Plant
Bataan Gasturbine Power Plant
Malaya Gasturbine Power Plant

ANNEX 2.
SUMMARY RECORD OF FORCED OUTAGES

BATAAN THERMAL POWER PLANT UNIT No. 1

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER						
2) FUEL OIL SYSTEM	1				1	2
3) AIR HEATER			1	2	1	4
4) FORCED DRAFT FAN					2	2
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING		1			1	2
7) CONTROL SYSTEM		2	1		1	4
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE			2			2
2) CONDENSER				1		1
3) CIRCULATING WATER PUMP			1	1		2
4) CONTROL SYSTEM						
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM				1		1
2) MOTOR DRIVEN BFP	3	1		3		7
3) TURBINE DRIVEN BFP						
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM			1			1
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER		1	1			2
2) TRANSFORMER AND SUBSTATION			5	1		6
3) STATION SERVICE SYSTEM	3		2			5
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK	3		1	1		5
2) GENERATOR BACK-UP	2		2	1		5
3) OUTSIDE TROUBLE		1	1		2	4
TOTAL	12	6	18	11	8	55

SUMMARY RECORD OF FORCED OUTAGES

BATAAN THERMAL POWER PLANT UNIT No. 2

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER			3		2	5
2) FUEL OIL SYSTEM	1					1
3) AIR HEATER	1			2	3	6
4) FORCED DRAFT FAN				2	2	4
5) GAS RECIRCULATION FAN			1			1
6) VALVE AND PIPING	1		1	2	1	5
7) CONTROL SYSTEM		1	1	1	3	6
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE	1		1	1		3
2) CONDENSER	1	1				2
3) CIRCULATING WATER PUMP						
4) CONTROL SYSTEM					1	1
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM						
2) MOTOR DRIVEN BFP	1	1			2	4
3) TURBINE DRIVEN BFP						
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM						
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER	1			2	1	4
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM	1	1	2	3	2	9
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK		1	2		4	7
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE		1				1
TOTAL	8	6	11	13	21	59

SUMMARY RECORD OF FORCED OUTAGES

MANILA THERMAL POWER PLANT UNIT No. 1

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER		1			1	2
2) FUEL OIL SYSTEM	1			1		2
3) AIR HEATER				1		1
4) FORCED DRAFT FAN	4	2			1	7
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING	2					2
7) CONTROL SYSTEM						
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE						
2) CONDENSER	3			1		4
3) CIRCULATING WATER PUMP						
4) CONTROL SYSTEM						
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM						
2) MOTOR DRIVEN BFP						
3) TURBINE DRIVEN BFP						
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM						
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER						
2) TRANSFORMER AND SUBSTATION			3	3		6
3) STATION SERVICE SYSTEM				1	1	2
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK						
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE						
TOTAL	10	3	3	7	3	26

SUMMARY RECORD OF FORCED OUTAGES

MANILA THERMAL POWER PLANT UNIT No. 2

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER				1		1
2) FUEL OIL SYSTEM						
3) AIR HEATER						
4) FORCED DRAFT FAN	4			1		5
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING						
7) CONTROL SYSTEM						
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE				1		1
2) CONDENSER		1		1	1	3
3) CIRCULATING WATER PUMP						
4) CONTROL SYSTEM						
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM		1				1
2) MOTOR DRIVEN BFP						
3) TURBINE DRIVEN BFP						
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM		1			1	2
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER				1		1
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM					2	2
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK				1	1	2
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE						
TOTAL	4	3	0	6	5	18

SUMMARY RECORD OF FORCED OUTAGES

SUCAT THERMAL POWER PLANT UNIT No. 1

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER						
2) FUEL OIL SYSTEM						
3) AIR HEATER						
4) FORCED DRAFT FAN						
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING					1	1
7) CONTROL SYSTEM		1	1		1	3
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE			1		2	3
2) CONDENSER						
3) CIRCULATING WATER PUMP						
4) CONTROL SYSTEM						
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM						
2) MOTOR DRIVEN BFP						
3) TURBINE DRIVEN BFP						
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER					1	1
6) CONTROL SYSTEM						
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER	2					2
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM	1					1
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK		1			3	4
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE						
TOTAL	3	2	2	0	8	15

SUMMARY RECORD OF FORCED OUTAGES

SUCAT THERMAL POWER PLANT UNIT No. 2

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER		1			1	2
2) FUEL OIL SYSTEM						
3) AIR HEATER			1		2	3
4) FORCED DRAFT FAN						
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING						
7) CONTROL SYSTEM						
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE			1			1
2) CONDENSER		1	1		1	3
3) CIRCULATING WATER PUMP						
4) CONTROL SYSTEM						
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM					1	1
2) MOTOR DRIVEN BFP						
3) TURBINE DRIVEN BFP						
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM				1		1
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER						
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM						
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK	1			1	1	3
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE					1	1
TOTAL	1	2	3	2	7	15

SUMMARY RECORD OF FORCED OUTAGES

SUCAT THERMAL POWER PLANT UNIT No. 3

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER		2				2
2) FUEL OIL SYSTEM						
3) AIR HEATER	1			1	5	7
4) FORCED DRAFT FAN						
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING			1			1
7) CONTROL SYSTEM	1		1			2
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE	1				1	2
2) CONDENSER			1	1		2
3) CIRCULATING WATER PUMP					1	1
4) CONTROL SYSTEM			1	1		2
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM						
2) MOTOR DRIVEN BFP					1	1
3) TURBINE DRIVEN BFP				1		1
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER	1					1
6) CONTROL SYSTEM	1		2			3
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER						
2) TRANSFORMER AND SUBSTATION					2	2
3) STATION SERVICE SYSTEM				1		1
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK			1			1
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE						
TOTAL	5	2	7	5	10	29

SUMMARY RECORD OF FORCED OUTAGES

SUCAT THERMAL POWER PLANT UNIT No. 4

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER			3	1		4
2) FUEL OIL SYSTEM		1				1
3) AIR HEATER	1		4	2		7
4) FORCED DRAFT FAN		1				1
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING		1	1			2
7) CONTROL SYSTEM		1	1			2
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE		1	2			3
2) CONDENSER						
3) CIRCULATING WATER PUMP						
4) CONTROL SYSTEM						
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM						
2) MOTOR DRIVEN BFP						
3) TURBINE DRIVEN BFP			1			1
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM						
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER						
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM						
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK		1	1			2
2) GENERATOR BACK-UP		1				1
3) OUTSIDE TROUBLE						
TOTAL	1	7	13	3	0	24

SUMMARY RECORD OF FORCED OUTAGES

MALAYA THERMAL POWER PLANT UNIT No. 1

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER			1		1	2
2) FUEL OIL SYSTEM						
3) AIR HEATER	2					2
4) FORCED DRAFT FAN						
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING	1	1	1	1		4
7) CONTROL SYSTEM		1	4	3	3	11
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE			1	1	1	3
2) CONDENSER					1	1
3) CIRCULATING WATER PUMP	1					1
4) CONTROL SYSTEM			1	2		3
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM	1					1
2) MOTOR DRIVEN BFP	1					1
3) TURBINE DRIVEN BFP						
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM			2	1	2	5
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER				2	1	3
2) TRANSFORMER AND SUBSTATION					1	1
3) STATION SERVICE SYSTEM				2		2
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK			3	1	1	5
2) GENERATOR BACK-UP					5	5
3) OUTSIDE TROUBLE						
TOTAL	6	2	13	13	16	50

SUMMARY RECORD OF FORCED OUTAGES

MALAYA THERMAL POWER PLANT UNIT No. 2

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER					3	3
2) FUEL OIL SYSTEM					4	4
3) AIR HEATER						
4) FORCED DRAFT FAN						
5) GAS RECIRCULATION FAN	1					1
6) VALVE AND PIPING					1	1
7) CONTROL SYSTEM			1			1
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE		1				1
2) CONDENSER				1	1	2
3) CIRCULATING WATER PUMP						
4) CONTROL SYSTEM						
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM						
2) MOTOR DRIVEN BFP						
3) TURBINE DRIVEN BFP						
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM						
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER			1			1
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM		2				2
4) CONTROL SYSTEM			1			1
5. OTHERS						
1) B-T INTERLOCK		2			1	3
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE						
TOTAL	1	5	3	1	10	20

SUMMARY RECORD OF FORCED OUTAGES

BATANGAS THERMAL POWER PLANT UNIT No. 1

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. BOILER AND AUXILIARY						
1) BOILER	1	1	1	1	6	10
2) FUEL OIL & COAL SYSTEM	2	2	1			5
3) AIR HEATER				1		1
4) FORCED DRAFT FAN & IDF	5					5
5) GAS RECIRCULATION FAN						
6) VALVE AND PIPING	1	1		2		4
7) CONTROL SYSTEM	2	2	1	2	1	8
2. TURBINE AND AUXILIARY						
1) MAIN TURBINE		2		1	1	4
2) CONDENSER					1	1
3) CIRCULATING WATER PUMP						
4) CONTROL SYSTEM			1			1
3. CONDENSATE AND FEED WATER SYSTEM						
1) CONDENSATE AND MAKE-UP SYSTEM				1		1
2) MOTOR DRIVEN BFP			1			1
3) TURBINE DRIVEN BFP				1	1	2
4) LOW PRESS. HEATER						
5) HIGH PRESS. HEATER						
6) CONTROL SYSTEM			1	1		2
4. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER		1		2		3
2) TRANSFORMER AND SUBSTATION			1			1
3) STATION SERVICE SYSTEM				1		1
4) CONTROL SYSTEM						
5. OTHERS						
1) B-T INTERLOCK	3	10	5	23	12	53
2) GENERATOR BACK-UP	2					2
3) OUTSIDE TROUBLE						
TOTAL	16	19	12	36	22	105

SUMMARY RECORD OF FORCED OUTAGES

BATAAN GASTURBINE POWER PLANT UNIT No. 1

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. GAS TURBINE AND AUXILIARY						
1) GAS TURBINE					1	1
2) AIR COMPRESSOR					1	1
3) COMBUSTER						
4) LOAD GEAR						
5) STARTING EQUIPMENT					3	3
6) FUEL OIL SYSTEM				1	2	3
7) CONTROL SYSTEM					2	2
2. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER						
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM					2	2
4) CONTROL SYSTEM						
3. OTHERS						
1) GT INTERLOCK						
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE					1	1
TOTAL				1	12	13

SUMMARY RECORD OF FORCED OUTAGES

BATAAN GASTURBINE POWER PLANT UNIT No. 2

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. GAS TURBINE AND AUXILIARY						
1) GAS TURBINE				1	1	2
2) AIR COMPRESSOR					1	1
3) COMBUSTER					1	1
4) LOAD GEAR						
5) STARTING EQUIPMENT						
6) FUEL OIL SYSTEM					1	1
7) CONTROL SYSTEM						
2. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER				1	2	3
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM					1	1
4) CONTROL SYSTEM						
3. OTHERS						
1) GT INTERLOCK						
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE						
TOTAL				2	7	9

SUMMARY RECORD OF FORCED OUTAGES

BATAAN GASTURBINE POWER PLANT UNIT No. 3

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. GAS TURBINE AND AUXILIARY						
1) GAS TURBINE					1	1
2) AIR COMPRESSOR					1	1
3) COMBUSTER					2	2
4) LOAD GEAR					1	1
5) STARTING EQUIPMENT						
6) FUEL OIL SYSTEM				1	3	4
7) CONTROL SYSTEM						
2. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER					2	2
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM						
4) CONTROL SYSTEM						
3. OTHERS						
1) GT INTERLOCK						
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE						
TOTAL				1	10	11

SUMMARY RECORD OF FORCED OUTAGES

BATAAN GASTURBINE POWER PLANT UNIT No. 4

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. GAS TURBINE AND AUXILIARY						
1) GAS TURBINE				1	1	2
2) AIR COMPRESSOR					3	3
3) COMBUSTER						
4) LOAD GEAR					1	1
5) STARTING EQUIPMENT						
6) FUEL OIL SYSTEM					1	1
7) CONTROL SYSTEM						
2. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER						
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM					1	1
4) CONTROL SYSTEM						
3. OTHERS						
1) GT INTERLOCK						
2) GENERATOR BACK-UP						
3) OUTSIDE TROUBLE					1	1
TOTAL				1	8	9

SUMMARY RECORD OF FORCED OUTAGES

MALAYA GASTURBINE POWER PLANT UNIT No. 1

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. GAS TURBINE AND AUXILIARY						
1) GAS TURBINE				2	1	3
2) AIR COMPRESSOR				1	1	2
3) COMBUSTER						
4) LOAD GEAR						
5) STARTING EQUIPMENT						
6) FUEL OIL SYSTEM				3		3
7) CONTROL SYSTEM						
2. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER					1	1
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM						
4) CONTROL SYSTEM						
3. OTHERS						
1) GT INTERLOCK						
2) GENERATOR BACK-UP				1	1	2
3) OUTSIDE TROUBLE						
TOTAL				7	4	11

SUMMARY RECORD OF FORCED OUTAGES

MALAYA GASTURBINE POWER PLANT UNIT No. 2

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. GAS TURBINE AND AUXILIARY						
1) GAS TURBINE				2	2	4
2) AIR COMPRESSOR						
3) COMBUSTER						
4) LOAD GEAR						
5) STARTING EQUIPMENT						
6) FUEL OIL SYSTEM				1		1
7) CONTROL SYSTEM						
2. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER						
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM						
4) CONTROL SYSTEM						
3. OTHERS						
1) GT INTERLOCK						
2) GENERATOR BACK-UP				2		2
3) OUTSIDE TROUBLE				1		1
TOTAL				6	2	8

SUMMARY RECORD OF FORCED OUTAGES

MALAYA GASTURBINE POWER PLANT UNIT No. 3

ITEMS	1986	1987	1988	1989	1990	TOTAL
1. GAS TURBINE AND AUXILIARY						
1) GAS TURBINE				1	5	6
2) AIR COMPRESSOR					1	1
3) COMBUSTER				1		1
4) LOAD GEAR						
5) STARTING EQUIPMENT						
6) FUEL OIL SYSTEM						
7) CONTROL SYSTEM				2		2
2. ELECTRICAL EQUIPMENT						
1) GENERATOR & EXCITER						
2) TRANSFORMER AND SUBSTATION						
3) STATION SERVICE SYSTEM						
4) CONTROL SYSTEM						
3. OTHERS						
1) GT INTERLOCK						
2) GENERATOR BACK-UP				2	1	3
3) OUTSIDE TROUBLE				1		1
TOTAL				7	7	14

ANNEX 3. SUMMARY OF MAJOR REHABILITATION WORKS

ANNEX 3.

SUMMARY OF MAJOR REHABILITATION WORKS

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Boiler a. Superheater	Detailed inspection of SH tubes	◉	◉	◉	◐	◎	◎	◎	◎	◎	◎	☆ 1992	
	Replacement of SSH tube	◉ ☆ Partial, 1992	◉ ☆ Partial, 1992	◉ Partial	◐	◎	◎	◎	◎	◎	◎		
	Replacement of roof SH tube	◉ Partial			◐							* ☆ 1992	*Primary SH
	Replacement of deteriorated/ thinning tube	◉	◉	◉	◐	◎	◎	◎	◎	◎	◎	☆ 1992	
b. Reheater	Detailed inspection of RH tubes	◉	◉	◉	◐	◎	◎	◎	◎	◎	◎	☆ 1992	
	Replacement of RH tube	◉ Partial	☆ 1992	◉ Partial	◐	◎	◎	◎ Partial	◎ Partial	◎	◎	☆ 1992	
	Replacement of deteriorated/ thinning tube	◉	◉	◉	◐	◎	◎	◎	◎	◎	◎	☆ 1992	
c. Water Wall	Detailed inspection of W/W tube	◉	◉	◉	◐	◎	◎	◎	◎	◎	◎		
	Replacement of W/W tube	◉ Partial	◉ ☆ Partial, 1992	◉	◉ ☆ 1992	◎	◎						
d. Boiler Casing & Gas, Air Duct	Repair of leaking boiler casing and gas, air duct	◉ ☆ 1993	◉	◉	◐	◎	◎	◎	◎	◎		☆ 1992	
e. Attemperator	Replacement of SH and RH attemperator spray nozzle	◉		◉	◐	◎	◎	◎	◎	◎	◎		
f. Burner	Modification of steam atomizing burner system	◉	◉	◉	◐	◎	◎					* ☆ 1992	*Coal Burner
g. Bottom Hopper	Repair of bottom ash hopper					◎	◎						
h. Safety valve	Replacement/repair of safety valve			◉ SH-3						☆	☆		
Boiler Auxiliaries a. Forced Draft Fan /Gas Recircu- lation Fan	Replacement/repair of FDF/GRF	◉ FDF	◉ FDF					* ◎ FDF	* ◎ FDF		☆ GRF		*Transfer of FDF
b. Air Heater	Replacement of heating elements and parts	◉ ☆ 1992	◉ ☆ 1992	◉	◐	◎	◎	◎	◎	◎	◎	☆ 1992	

LEGEND: ◉-Implemented ◎-1st Priority ○-2nd Priority ☆-To be implemented in overhaul

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
c. Steam Coil Air Heater	Replacement of heating elements	◉		◉	◉	◎	◎	* ◎	* ◎	◎	◉		*Additional of SCAH
	Modification of SCAH drain system	◉	◉	◉	◉	◎	◎	◎	◎	◎	◉		
d. Fuel Oil Firing System	Replacement/repair of fuel oil heater	◉	◉	☆ 1993	◉	◎	◎	◎	◎	◎	◎		
	Modification of light oil firing system	◉	◉	◉	◉	◎	◎						
e. Ash Handling System	Replacement of ash handling system	◉	◉	◉	◉	◎	◎	◎	◎			☆ 1992	
	Replacement/repair of dust collector	◉	◉	◉	◉	◎	◎	◎	◎			* ☆ 1992	*EP
f. Auxiliary Steam System	Repair/modification of auxiliary steam line and auxiliary boiler	◉ Aux. B		◉	◉	◎	◎	◎	◎				
g. Soot Blower	Replacement/repair of soot blower	◉ ☆ 1992	◉	◉	◉	◎	◎	◎	◎	◎	◎	☆ 1992	
h. Piping System	Inspection and repair of pipe line	◉	◉	◉	* ◉	* ◎	* ◎	◎	◎	◎	◎		*Inspection of main steam pipe
i. Smoke stack	Guniting for smoke stack	☆ 1993	☆ 1992		◉	◎		○	○	☆			
j. Stacker and Reclaimer	Realignment of the rail											☆ 1992	
k. Cool Yard	Cement all stockpile flooring											☆	
l. Conveyor	Replacement/repair of conveyor											☆ 1992	
m. Transfer Tower	Rehabilitation of transfer tower											☆ 1993	
n. Mill	Replacement/repair of mill											☆ 1992	

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Turbine a. HP Turbine	Major inspection	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of inner casing				◉	◎	◎	◎	◎				
	Replacement of turbine rotor		☆ Blade 1992	◉ Blade	◉	◎	◎	◎	◎	* ◎	* ◎		* Diagnosis of remaining life
b. IP Turbine	Major inspection	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of inner casing	◉			◉	◎	◎	◎	◎				
	Replacement of turbine rotor	☆ 1993		◉ Blade	◉ Blade	◎	◎	◎	◎	* ◎	* ◎		* Diagnosis of remaining life
c. LP Turbine	Major inspection	◉	◉	◉	◉	* ◎	* ◎	◎	◎	◎	◎		
	Replacement of turbine rotor	◉ ☆ Blade 1993	☆ Blade 1992	◉	◉	◉ Blade 1990	◎ Blade			* ◎	* ◎		* Diagnosis of remaining life
	Replacement of casing				☆ 1994								
d. Main Stop Valve	Replacement of turbine main valve							◎ MSV	◎ MSV		◎ Parts		
e. BFP Turbine	Reblading of BFP turbine	☆ 1993											
Turbine Auxiliaries a. Condenser	Replacement of tubes	◉ ☆ Aux 1992	◉ 1983	◉ Partial	◉	◉ 1991	◎ Partial	◉ * ◎ 1986	◉ 1991	☆ 1993	☆ 1993	☆ 1992	* Air cooling zone only
	Installation of on-line cleaning and Debris filter system							☆ 1993	☆ 1993	◉ 1992	☆ 1993		
b. Low Pressure Feed Water Heater	Replacement of LP heater	◉ #3 ☆ #3 1993	☆ #2,3 1992				◎ #3		◎ #3				
c. High Pressure Feed Water Heater	Replacement of HP heater	◉ #5A, #5B ☆ #5A #5B 1993		☆ #6 1992	◉ #5A, 5B #6A, 6B	◎ #5A, 5B	◉ ◎ #6A, #6B 1991	◉ #5, 1983 #6, 1981	◉ ◎ #5, #6 1983	◎ ☆ HP#1, #2	◉ HP#1, 2		
	Installation of HP heaters by-pass line	◉				◉	◉						

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
d. Deaerator	Modification of deaerator		◉		☆ 1994					☆ 1993			
e. Turbine Oil Pump	Replacement/repair of oil pump	◉ JOP		◉	◉								
f. Turbine Lube Oil System	Modification of lube. oil purifying system	◉											
g. Air ejector	Replacement of air ejector					◎	◎						
h. Extraction Steam line	Additional non-return valve at the extraction steam to deaerator	◉			◉								
i. House Service Closed Cycle Heat Exchanger	Replacement of HSCC heat exchanger			☆ 1993	◉	◎	◉	○	○	◎ Tube			
	Additional installation of heat exchanger	◉ ☆ 1993								◉ 1991			
j. Boiler Feed Water Pump	Replacement/repair of BFP	◉		◉	◉					◎	* ◎	☆ 1992	* BFP Outlet valve
k. Circulating Water Pump	Replacement/repair of CWP				◉			☆ 1993	☆ 1993	◎ Parts	◎ Parts		
l. Condensate Water Pump	Replacement/repair of CP							☆	☆		☆ Parts 1992		
m. Piping System	Repair of damaged pipe insulation	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
n. Others	Installation of travelling crane			◉									
	Replacement of passenger elevator				* ◉					☆	☆		* Additional installation
	Repair/replacement of power house ventilation fans	◉ ☆ 1993	◉	◉	◉	◉	◉	◎	◎				
o. Cooperation with manufacturer	Invitation of Manufacturers supervisor for the above checking/improvement/replacement	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	◎	

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Electrical Equipment a. Generator	Replacement/repair of generator stator	* ☆ 1992	☆ Bushing 1992		◉			* ◎	* ◎	◎	◎		*Diagnosis of remaining life
	Replacement/repair of generator rotor	◉	* ◉	◉	◉			◎	◎	◎	◉ ◎ 1991		*Diagnosis of remaining life
b. Exciter	Replacement/repair of exciter	◉ ☆ 1992			◉	◎	◎						
	Replacement/repair of AVR				◉	◎	◎			◎	◎		
c. Gas and Seal oil	Replacement/repair of generator gas and seal oil equipment									◎	◎		
d. Batteries and CVCF/UPS	Additional/replacement of batteries	* ◉	* ◉					☆	☆				*Additional silicon dropper
	Additional of CVCF/UPS set				◉	◎	◎			☆			
e. Emergency Diesel Generator	Automatic start and cabling of emergency diesel generator	◉ ☆ 1993	◉										
f. Motor	Replacement of 4,160V/480V motor		☆ CWP 1992	◉ RWP	◉ ☆ RWP CWP			○ CP,BFP CWP	○ CP,BFP CWP		◎ AOP		
g. Switchgear	Replacement of 4,160V switch-gear							○ P/C,Tr	○ P/C,Tr	☆ VCB			
	Additional/replacement of MCC	◉ E				◎ B,T,SS	◎ B,T,SS, VF			☆ P/C			
h. Power Cable	Replacement of power cable			◉	◉	◎ 4.16kV 480V	◎ 4.16kV 480V	○ 4.16kV	○ 4.16kV	◎ 15kV			
i. Switchyard	Replacement/repair of switch-yard equipment				☆ GCB	◎ GCB,DS	◎ GCB,DS			◎ GCB,LA	◎ GCB,LA		
j Communication Facilities	Additional communication facilities	☆	◉			☆		☆		☆		☆	
k. Others	Replacement of fire protection system	◉											
	Replacement of sootblower electrical control system					◎	◎	○	○	◎		☆ 1992	

ITEM			MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Instrument and Control	Additional recorder for condensate flow, turbine speed/cam position, condenser vacuum & generator output		◉	◉	◉	◉	◎	◎						
	Replacement of local gauge and meter		◉	◉	◉	◉	◎	◎						
	Replacement of control board recorder and indicator		☆ 1993	☆ 1993	◉	◉	◎	◎	○	○	◎	◎		
	Replacement/modification of ABC and start-up system		◉ N-90	☆ N-90	◉ N-90	◉ N-90	◎ N-90	◎ N-90	◎ N-90	◎ N-90	◎ N-90	◎ N-90		
	Spare parts		◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement/modification of fuel oil control system			◉ Burner			◎	◎						
	Installation of furnace/smoke monitoring TV		◉	◉	◉	◉	◎	◎	◎ Smoke	◎ Smoke	☆	☆		
	Replacement of boiler metal temperature measurement		◉ ☆ 1992	☆ 1993	◉	◉	◎	◎						
	ABC and start up control overhaul/calibration and fine tuning		◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement/ repair of local control	Deaerator, Heater & condensate drain control	◉		◉	◉	◎	◎	○	○	◎			
		Aux. steam and AH temp. control	◉	◉ ☆ 1992	◉	◉	◎	◎	○	○	◎			
		Others	◉ ☆ 1992	◉ ☆ 1992	◉	◉	◎	◎	○	○	◎			
	Replacement/repair of EHG		◉			◉	◎	◎				◎		
	Replacement of relay for plant interlock		◉	◉		◉	◎	◎	○	○				
	Inprovement of central control room air conditioner		◉ ☆ 1992								* ☆ 1992			* Repair
	Additional control/station service air compressor and modification of piping		◉ CONT ☆ CONT 1992		◉	◉					☆ SWYD		☆ SS 1992	

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Instrument and Control	Additional first out indicator	◉	◉										
	Modification of alarm system	◉	◉										
	Additional alarm and annunciator	◉	◉	◉	◉	◎	◎				◎		
	Modification for load run-back	◉ FDF,CWP	◉ FDF,CWP	◉ FDF,CWP	◉ FDF,CWP	◎ FDF,CWP	◎ FDF,CWP						
	Additional/replacement of protective relay	◉ GEN				◎ GEN							
	Replacement of fuel oil flow meter	◉	◉	◉	◉	◎	◎	○	○	○	☆		
	Replacement of drum level transmitter/indicator		◉	◉				☆	☆	☆	☆		
	Replacement of mercury type float, temp. & press. switches	☆ 1992				◎	◎	○	○				
	Replacement of BFP minimum flow and control valve			◉		◎	◎	☆	☆				
	Additional sequence of event recorder			◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of flue gas O_2 measurement			◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of turbine supervisory instruments	◉ ☆ 1993			◉	◎	◎			◎	◎		
	Additional generator H_2 purity meter	◉		◉	◉	◎	◎	○	○	☆	☆		
	Replacement of turbine wall stress evaluator					◎	◎						

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Demineralizer	Additional demineralizing plant	◉ 1986			◐ 1984	◎ 1993				* ◎			* Replacement of HCl tank
	Additonal pre-water treatment plant	◉ 1986			◐ 1991								
	Overhauling and resin make-up	☆				◎ 1992		☆		☆		☆	
	Using of Laguna Lake Water	◉			◉			—		—		—	
	Neutralizing equipment	☆ 1992			◉			☆		◉		◉	
	Replacement of demineralizer instruments							☆ PH, Conductivity		☆ PH, Conductivity Silica		☆ Silica	
Condensate Polishing Plant	Replacement of control panel including instruments	◉	—	—	◐	◎	◎	—	—	—	—	—	
	Repair/replacement of control system for automatic operation	◉	—	—	◐	◎	◎	—	—	—	—	—	
	Using of higher quality caustic soda of rayon grade	◉	—	—	◐	◉	◉	—	—	—	—	—	
	Overhauling, and resin make-up	☆	—	—	☆	◎	◎	—	—	—	—	—	
	Adjustment of resin level	—	—	—	—	◎	◎	—	—	—	—	—	
	Installation of condensate magnetic filter	—	—	—	◐	◎	◎	—	—	—	—	—	
Oil Water Separator	Installation of oil water separator									☆ 1992			

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Secondary Water Treatment a. Chemical Feed System b. Chemical Feed Control	Replacement of chemical feed system	◉	☆ 1992	◉	◉	◎	◎	◎	◎			◉	
	Determination of NH3 injection by the measurement of conductivity	◉	☆	◉	◉	◎	◎					◉	
	Automatic pH control	◉	☆	◉	◉	◎	◎					◉	
Sampling Rack	Replacement of sampling rack	◉	◉	◉	◉	◎	◎	◎	◎	☆ 1992	☆ 1992	☆	
Monitoring Instrument	Additional of chemical monitoring instruments	◉	◉	◉	◉	◎	◎	○	○	☆	☆	☆	
Cooling Water a. House Service Closed Cycle Heat Exchanger	Change of water quality analysis item	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	◉	
	Injection of chemicals	◉	◉	◉	◉	◉	◉	◎	◎	◎	◎	◉	
	Check of sacrifical zinc plate	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	◉	
b. Condenser Cooling Water	Replacement/repair of cathodic protection equipment	◉	◉		◉	◎	◎	○	○	○	○	◉	
	Replacement of travelling water screen				◉			◎ Wash P	◎ Wash P	○	○		
	Replacement of raw water pump		☆ 1992		☆ 1992								
	Reinstallation of gantry crane											☆ 1992	
	Replacement/repair of circulating water pipe line									* ◎	* ◎	* ☆ 1992	* Including marine pipe

6.2 Geothermal Power Plant

For the Philippines, not rich in energy resources, the geothermal power is an important indigenous energy source and the potential in the country is said to be 200,000 MW-century. Should one tenth of the potential be effectively developed, the available energy would be as large as 20,000 MW for a century operation.

The Philippines has been suffering from the extreme shortage of foreign exchange since her economic crisis in 1983. In such economic situation, the geothermal power generation, which can produce electric energy from the indigenous energy resource and does not require precious foreign exchange like the thermal power, has come to play an important role year by year. In the Power Expansion Program formulated by National Power Corporation (NAPOCOR) in 1991, the development of the geothermal power makes the center with a high priority together with the coal-fired thermal power plants.

There are two geothermal power plants in the Luzon Grid, Tiwi in Albay Province and Mak-Ban at Bay and Calawan in Laguna Province. The installed capacity of each power plant is 330 MW, or 55 MW x 6 Units (660 MW in total). The installed capacity of these power plants has the share of 15% of the system total and the annual generation 24% in 1990. The capacity factor in 1990 recorded 68% in Tiwi and 88% in Mak-Ban, while 85% is generally used in the installation planning in Japan. Since the average capacity factor of the 10 best power plants in the Luzon Grid was 55.8% (in the same year), both Tiwi and Mak-Ban were operated at more than the average.

The reason why the capacity factor of Tiwi was conspicuously lower than that of Mak-Ban is the insufficient steam supply in the Tiwi geothermal area. If the necessary quantity of steam supply is available, Tiwi may be operated with a capacity factor higher than 85%.

For reliable operation of the geothermal power plants at the rated output, the following essential conditions should be satisfied.

1) The necessary quantity of geothermal steam supply is always secured.

2) The steam purity at the turbine inlet is sufficiently high.

3) The equipment and facilities are properly operated and periodically maintained and there is no factor to hamper the operation.

4) The spare parts are readied in the store.

Items 1) and 2) above are excluded from the discussion in this report since these are the matters to be handled by PGI (Philippine Geothermal Incorporated), the steam supplier, and not by Tiwi and Mak-Ban Power Plants. Only the review of the steam supply plan of the steam supplier is made in this report.

Table 6-2-1

SUMMARY OF GEOTHERMAL POWER PLANT FACILITIES

POWER PLANT	PLANT OUTPUT kW	GEOTHERMAL WELL: PRODUCTION WELL: NUMBER	GEOTHERMAL WELL: PRODUCTION WELL: TOTAL DEPTH m	GEOTHERMAL WELL: PRODUCTION WELL: MAX.MIN DEPTHS m	GEOTHERMAL WELL: REINJ. WELL NUMBER	GEOTHERMAL WELL: TOTAL STEAM FLOW t/h	GEOTHERMAL WELL: TOAL HOT-WATER FLOW t/h	PLANT CYCLE	COOLING TOWER	TURBINE: UNIT No.	TURBINE: TYPE	TURBINE: RATED OUTPUT kW	TURBINE: STEAM PRESSURE kg/cm2	TURBINE: STEAM TEMPERA-TURE C	TURBINE: EXHAUST PRESSURE mmHg.abs	TURBINE: SPEED rpm	TURBINE: MANUFAC-TURER	GENERATOR: RATED CAPACITY kVA	GENERATOR: VOL-TAGE kV	GENERATOR: FREQU-ENCY Hz	GENERATOR: MANUFAC-TURER	COMMISS-IONING
MAK-BAN	330,000	58		MAX. 3,141 MIN. 655	21	3,249		SINGLE FLASH	CROSS FLOW INDUCED DRAFT	1	DOUBLE FLOW	55,000	5.68	162.3	101.6	3,600	M.H.I.	68,750	13.8	60	MITSU-BISHI ELECTRIC	SEP 1979
								DO	DO	2	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	NOV 1979
								DO	DO	3	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	AUG 1980
								DO	DO	4	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	OCT 1980
								DO	DO	5	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	SEP 1984
		(SEP) (1991)						DO	DO	6	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	DEC 1984
TIWI	330,000	77		MAX. 2,970 MIN. 457	7	2,360		SINGLE FLASH	CROSS FLOW INDUCED DRAFT	1	DOUBLE FLOW	55,000	6.10	160.6	101.6	3,600	TOSHIBA	69,000	13.8	60	TOSHIBA	JAN 1979
								DO	DO	2	DO	55,000	6.10	160.6	101.6	3,600	DO	69,000	13.8	60	DO	MAY 1979
								DO	DO	3	DO	55,000	6.10	160.6	101.6	3,600	DO	69,000	13.8	60	DO	JAN 1980
								DO	DO	4	DO	55,000	6.10	160.6	101.6	3,600	DO	69,000	13.8	60	DO	APR 1980
								DO	DO	5	DO	55,000	6.00	164.4	101.6	3,600	DO	69,000	13.8	60	DO	DEC 1981
								DO	DO	6	DO	55,000	6.00	164.4	101.6	3,600	DO	69,000	13.8	60	DO	MAR 1982

6.2.1 Present Situation and Problems in Tiwi Geothermal Power Plant

1. Outline of Tiwi Geothermal Power Plant

The Tiwi Geothermal Power Plant is located in Albay Province at the southernmost part of Luzon Island. The area is famous as the hot spring resorts since old times. The rated output of the 6 units is 55 MW each, and the commissioning dates are as tabulated below:

Plant	Unit	Commissioned in
A	Unit-1	January 1979
A	Unit-2	May 1979
B	Unit-3	January 1980
B	Unit-4	April 1980
C	Unit-5	December 1981
C	Unit-6	March 1982

Units 1 to 4 were originally designed as the double flash system, but converted later to the single flash system. Units 5 and 6 were designed as the single flash system from the beginning.

For extraction of the non-condensable gas (NCG), the steam ejector system was adopted and no gas compressor was installed for all the 6 units.

It is essential to increase the emission height for better dispersion into the air and decreased ground concentration of the non-condensable gas (NCG) . For this purpose, the utilization of the heat of the secondary steam of the steam ejector was intended, and the after-condenser was omitted. As a result, the steam from the ejector is discharged directly into the air, and the condensed water wets the surrounding and causes accelerated corrosion of outdoor equipment, piping, structures, measuring instruments, etc.

2. Geothermal Steam Supply

(1) Steam Requirement

The steam supply necessary for operation at the installed capacity of 330 MW (55 MW x 6 Units) is 3,125 t/hr, and the steam consumption is 9.47 kg/kWh. (Refer to Table 6-2-2)

(2) Steam Supply

The geothermal steam available from PGI, the steam supplier, is 2,360 t/hr as of the end of July 1991. Thus, it is short of the steam requirement by 765 t/hr, or 80 MW equivalent. According to the plant operation log on July 29, 1991, the peak load was 251 MW and the capacity factor was 70% as shown in Table 6-2-3.

As for the steam production, the past records show that the production declines by 7% or more per year as shown in Fig. 6-2-1.

(3) Geothermal Reservoir Capacity

a. Geothermal Reservoir and Production Wells

(a) The volume of the geothermal reservoir is estimated at 15 km^3 (16.5 km^2 x 0.9 km). The mass of geothermal fluid is estimated to be 6.5×10^{11} kg with a heating value of 2.75×10^{18} J, or 6.75×10^{17} kcal. Assuming that the plant operation life of 35 years, the area was assessed to have the possibility of development of a 500 to 800 MW power plant. Based on the assessment, the well drilling was started in 1971 and a total of 134 wells have been drilled to date. The largest depth of drilling was 2,970 m and the shallowest 457 m, and the highest temperature was recorded at 300°C and the average output per production well was 7 MW.

(b) The number of the wells currently used for power generation is 77 of production wells and 7 of reinjection wells. The remaining 50 wells have been discarded. The main reason of the desertion is the intrusion of cold water into the reservoir, and about 40% of the reservoir was deteriorated by the cold water as shown in Fig. 6-2-2.

(c) Steam is now extracted from the west side area of the reservoir, and 75% of the total steam consumption is extracted from the area equivalent to 30% of the total reservoir. The remaining 25% of the steam is extracted from the reservoir deteriorated by the cold water intrusion and the average output per production well in this area has decreased to 3.3 MW. Because of the transfer of the steam extraction area to the west, the pipelines of the gathering system became longer, and the longest gathering system is 9 km and the shortest 4 km, and the total piping length is 56 km.

b. Reassessment of Geothermal Reservoir

Recently, Electroconsult of Italy (ELC), carried out the study and investigation of the potential of the reservoir and power development scale in Tiwi Area, and presented the final report with the title of "Reservoir Assessment of Tiwi Geothermal Field". According to the report, the stored heat in Tiwi Geothermal Reservoir is estimated at 46,000 GWh in electrical energy and 250 MW x 25 years in plant capacity.

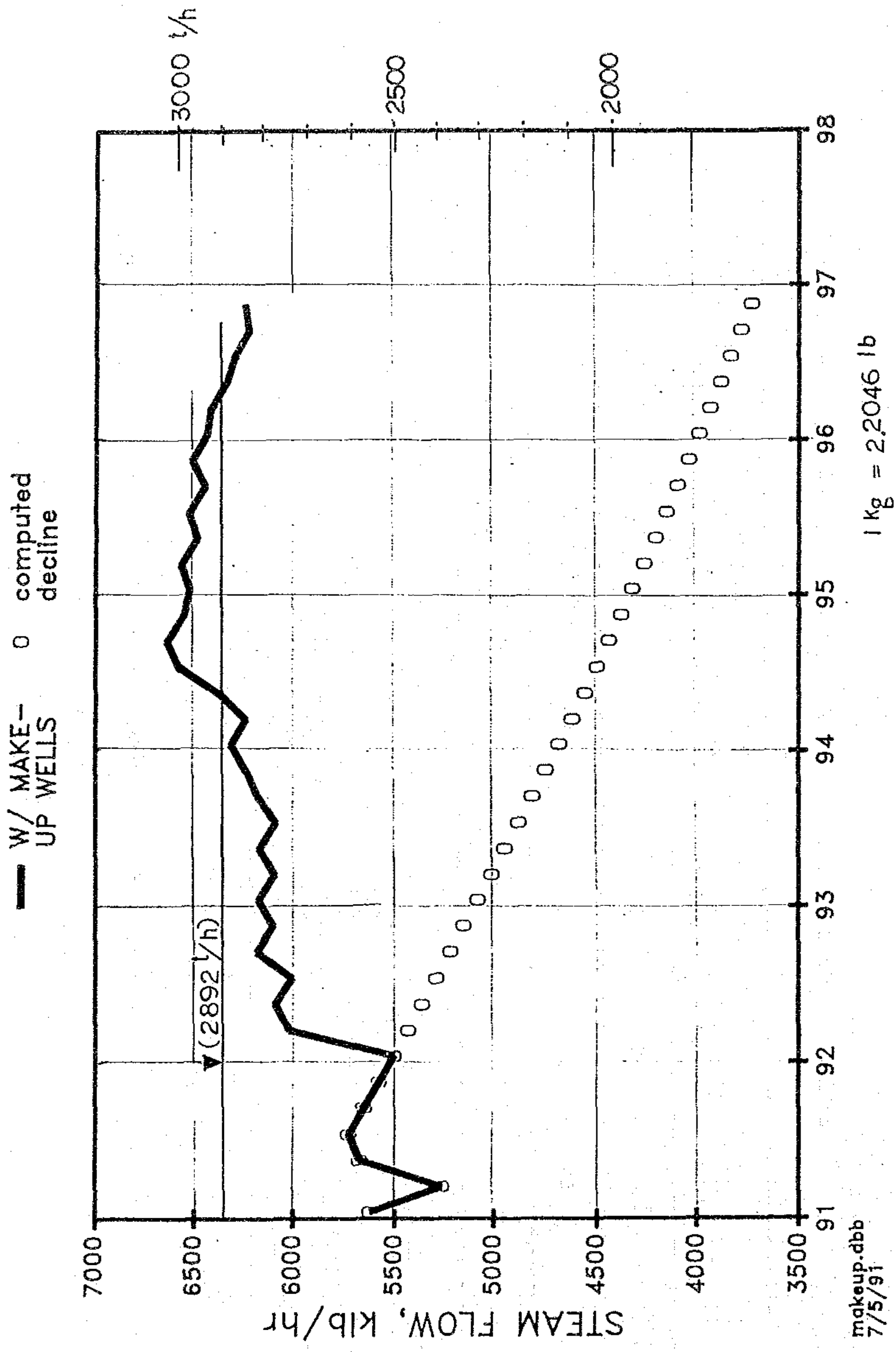
Table 6-2-2 Steam Requirement of Tiwi Geothermal Power Plant

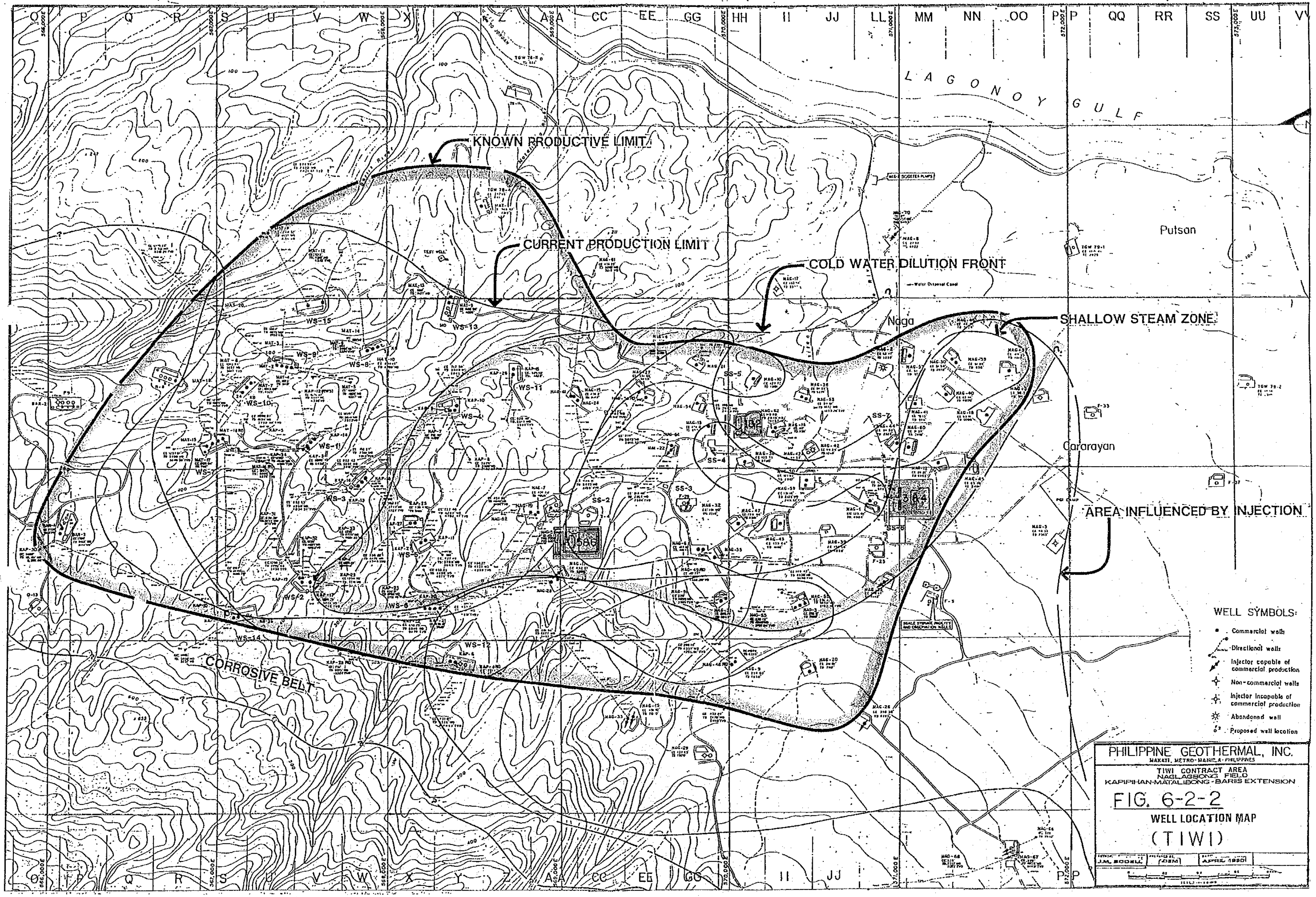
Unit No.	Turbine (t/hr)	Steam Ejector (t/hr)		Gland Steam (t/hr)	Total (t/hr)
		1st Stage	2nd Stage		
1	447.93	32.64	38.36	1.12	520.05
2	447.93	32.64	38.36	1.12	520.05
3	447.93	32.64	38.36	1.12	520.05
4	447.93	32.64	38.36	1.12	520.05
5	432.47	36.42	52.39	1.12	522.4
6	432.47	36.42	52.39	1.12	522.4
Total	2,656.66	203.4	258.22	6.72	3,125.0

Table 6-2-3 The Generation Record of Tiwi Geothermal Power Plant on July 29, 1991

Unit No.	Capability (MW)	Peak load (MW)	Condenser Vacuum (mmHg)	Bowl Press. (kg/cm2g)	Daily Gross Generation (MWh)	Daily Net Generation (MWh)	Remarks
1	50.92	52	665	5.95	1,221.9	1,182.7	
2	49.83	51	654	5.95	1,221.5	1,182.5	
3	48.47	48	647	5.95	1,178.5	1,078.1	
4	Stop	-	-	-	-	-	
5	52.66	55	654	5.65	1,300.3	1,250.9	
6	43.70	45	663	5.65	553.6	521.3	
Total		251			5,475.8	5,216.5	

FIG. 6-2-1 TIWI STEAM SUPPLY PROJECTION




KNOWN PRODUCTIVE LIMIT
CURRENT PRODUCTION LIMIT
COLD WATER DILUTION FRONT
SHALLOW STEAM ZONE
AREA INFLUENCED BY INJECTION
CORROSIVE BELT
LAGONOY GULF
Putsan
Naga
Cararayan
WELL SYMBOLS:
Commercial wells
Directional wells
Injector capable of commercial production
Non-commercial wells
Injector incapable of commercial production
Abandoned well
Proposed well location
PHILIPPINE GEOTHERMAL, INC.
MAKATI, METRO-MANILA-PHILIPPINES
TIWI CONTRACT AREA
NAGLAGBONG FIELD
KAPIPIHAN-MATALIBONG-BARIIS EXTENSION
FIG. 6-2-2
WELL LOCATION MAP
(TIWI)

3. Present Status of Steam Supply and Power Plant Facilities

(1) General

The total number of shutdowns of Units 1 to 6 in Tiwi Geothermal Power Plant in 5 years from 1986 to 1990 was 325 and the total shutdown period was 1,476 days, which is equivalent to 13.5% of the total operating days as shown in Table 6-2-4. (A plant shutdown of shorter duration than one day is counted as one day.)

The causes of shutdown are classified in the following: (Ratio is shown in the percentage of shutdown days.)

Cause of the Plant Shutdown	Ratio
Plant overhaul/maintenance	57.4%
Power System faults	12.4%
Troubles of PGI steam supply system	10.2%
Cleaning of steam strainers	7.1%
Sticking of MSV and CV, and governor troubles	4.4%
Hotwater pump troubles	3.0%
Troubles of exhaust stack	1.8%
Plant electrical system faults	1.6%
Condenser vacuum low	0.7%
Instrument air supply system troubles	0.7%
Cooling water pipeline troubles	0.5%
Spark of generator slip ring carbon brushes	0.2%

(2) Mechanical Facilities

a. Shutdown for Plant Overhaul and Maintenance

The number of plant shutdown days for the plant overhaul/maintenance accounts for 57.4% of the total shutdown days. The frequency of overhauls varies depending on the units, and the period of overhaul also varies greatly from 2 to 13 weeks depending on the units. The frequency of overhauls in Japan is generally standardized to be once in two years and the period required for the overhaul is 16 days for a plant with a spare rotor and 22 days for one without a spare rotor as shown in Fig. 6-2-3.

The period of overhaul depends on the restoration of the turbine rotor/diaphragms, and even in the worst case of rubbing of the rotor due to the accumulation of scale, the unit could be put back into operation by replacing the rotor with the spare rotor, if one is available in stock. Then the damaged rotor can be repaired later, and the damage by the trouble could be minimized.

Therefore, if PGI can guarantee the supply of sufficient steam for the operation of all the 6 units of Tiwi Power Plant into the future, it is advisable to purchase one spare rotor and one set of spare diaphragms in this rehabilitation project.

It is said that at the power plant where the total silica (SiO_2) and chloride (Cl) content in the steam is 1 to 2 ppm, satisfactory operation of the plant can be maintained with an overhaul per 2 years. Thus, further improvement of steam quality and securing of the necessary steam is imperative for decreasing the frequency of overhauls by half and increasing the capacity factor.

In 1990, the steam scrubber system was installed in the 1st stage drain scrubber steam outlet pipes of Units 1, 2, 4, 5 and 6, and the test of removal of scaling elements in the steam has been continued. The effect of the steam scrubber system is not known definitely, since the test period is not long enough. It is expected, however, that the plant derating rate due to scaling, which was about 25% to 27% per year before the installation, is likely to decrease by half.

b. Troubles on PGI Steam Supply System

In case where the rupture disc installed as the safety device on the pressure vessel of the steam gathering system was burst, it was necessary to shutdown the unit for the replacement. Now, however, the device has been improved and the replacement of burst rupture discs can be made without unit shutdown.

c. Steam Quality

The clogging of the steam strainer at the turbine inlet and mal-functioning of MSV and CV would be eliminated if the steam quality is improved. And also the sticking of the sliding parts of MSV and CV would be prevented by adding the oiling device.

d. Condenser Vacuum Low and Cooling Water Pipeline Troubles

Carbon steel (SM-41A) is used for U-seal pipes and cooling water pipes. It was judged that the carbon steel material could be used without troubles for the cooling water system, if the pH control of the cooling water was made satisfactorily. Occasionally, however, for lack of chemicals for pH control, the pH of the cooling water dropped to less than 3. As a result, the cooling water pipe was corroded and punctured, entailing vacuum low and water leakage.

Corrosion of the cooling water pipes and hot water pipes is so serious that more than 40% of the pipe wall thickness has been lost, and in the extreme case the corrosion has reached more than 74% of the original thickness as shown in Fig. 6-2-4.

(3) Electrical facilities

The plant electrical facilities can be grouped into those within the powerhouse and those in the switchyard. Problems common to both facilities in this power plant are corrosion of conductors, terminals, insulations, supports, overhead ground wires, etc., due to H_2S gas contained in NCG, which cause mis-operation of relays, mal-operation of the equipment, broken cables, insulation breakdown of insulators, etc.

Tiwi Power Plant is located at the southernmost part of Luzon Island, and it is connected to the major power demand area of Metropolitan Manila by quite long transmission lines of 341 km. The longer transmission lines involve higher probability of troubles in the power system, and the power plant experiences an annual average of 4 to 5 plant trips due to the power system faults.

The problems with electrical facilities and countermeasures are discussed in Section 4.

The frequency and number of days of the plant trips by causes are shown in Table 6-2-4 "Summary of Plant Shutdowns".

Table 6-2-4 Summary of Plant Shutdowns

(1/5)

Cause of Shutdown	Year	Tiwi Power Plant													
		Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Unit 6		Total	
		Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days
Troubles of PGI Steam Supply System	1986	2	2	2	2	0	0	0	0	1	1	1	1		
	1987	3	4	2	4	3	17	5	59	2	14	0	0		
	1988	1	1	1	1	1	5	3	3	3	6	2	2		
	1989	2	11	3	3	0	0	0	0	0	0	0	0		
	1990	0	0	3	4	4	10	0	0	0	0	1	1		
	Sub-total	8	18	11	14	8	32	8	62	6	21	4	4	45 (13.8%)	151 (10.2%)
Plant Overhaul/ Maintenance	1986	0	0	0	0	2	9	1	25	0	0	0	0		
	1987	3	4	3	97	1	26	1	31	1	61	0	0		
	1988	1	1	2	46	1	88	1	35	2	39	0	0		
	1989	2	11	2	27	1	0	1	15	0	0	1	6		
	1990	0	0	1	74	1	54	1	4	0	0	2	48		
	Sub-total	8	18	8	244	4	177	5	110	3	100	3	54	28 (8.7%)	846 (57.4%)
Power System Faults	1986														
	1987	1	1	1	1	1	1	5	19	1	31	1	1		
	1988	13	13	13	13	7	7	12	12	16	16	15	15		
	1989	3	3	6	8	7	9	2	2	3	7	2	7		
	1990	2	5	1	2	2	3	2	3	1	2	1	2		
	Sub-total	19	22	21	24	17	20	21	36	21	56	19	25	118 (36.4%)	183 (12.4%)

Table 6-2-4 Summary of Plant Shutdowns

(2/5)

Cause of Shutdown	Year	Tiwi Power Plant													
		Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Unit 6		Total	
		Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days
Cleaning of Steam Strainers	1986	2	34	1	2	0	0	0	0	0	0	0	0		
	1987	4	9	1	1	0	0	1	3	0	0	0	0		
	1988	4	4	5	8	1	4	2	2	1	1	1	1		
	1989	13	19	3	4	1	1	0	0	0	0	1	2		
	1990	1	2	4	5	0	0	0	0	1	3	0	0		
	Sub-total	24	68	14	20	2	5	3	5	2	4	2	3	47 (14.4%)	105 (7.1%)
Sticking of MSV & CV	1986														
	1987	0	0	1	3	0	0	0	0	0	0	0	0		
	1988	0	0	1	3	0	0	0	0	1	1	0	0		
	1989	1	1	0	0	1	2	0	0	0	0	1	7		
	1990	1	1	0	0	0	0	0	0	0	0	1	6		
	Sub-total	2	2	2	6	2	2	0	0	1	1	2	13	8 (2.5%)	24 (1.6%)
Governor Troubles	1986	0	0	0	0	1	1	0	0	0	0	0	0		
	1987	0	0	0	0	0	0	0	0	0	0	0	0		
	1988	6	9	0	0	1	1	1	1	1	0	0	0		
	1989	6	11	2	2	3	4	1	2	0	10	0	0		
	1990	0	0	0	0	0	0	0	0	0	0	0	0		
	Sub-total	12	20	2	2	5	6	2	3	1	10	0	0	22 (6.8%)	41 (2.8%)

Table 6-2-4 Summary of Plant Shutdowns

(3/5)

Cause of Shutdown	Year	Tiwi Power Plant													
		Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Unit 6		Total	
		Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days
Hot Water Pump Troubles	1986	0	0	0	0	0	0	0	0	1	1	0	0		
	1987	0	0	1	1	1	2	0	0	0	0	0	0		
	1988	0	0	1	1	1	2	1	4	1	1	0	0		
	1989	0	0	0	0	1	17	1	1	0	0	0	0		
	1990	0	0	1	1	0	0	1	14	0	0	0	0		
	Sub-total	0	0	3	3	3	21	3	19	2	2	0	0	11 (3.4%)	45 (3.0%)
Condenser Vacuum Low	1986														
	1987	0	0	1	2	0	0	0	0	1	1	0	0		
	1988	0	0	0	0	0	0	1	1	1	1	0	0		
	1989	1	3	0	0	0	0	0	0	0	0	0	0		
	1990	0	0	1	1	1	2	0	0	0	0	0	0		
	Sub-total	1	3	2	3	1	2	1	1	2	2	0	0	7 (2.2%)	11 (0.7%)
Plant Electrical System Faults	1986	0	0	1	1	0	0	0	0	0	0	0	0		
	1987	0	0	1	1	1	1	0	0	2	2	2	2		
	1988	1	1	2	3	0	0	1	1	1	3	2	2		
	1989	0	0	0	0	0	0	2	2	0	0	0	0		
	1990	1	1	0	0	1	1	0	0	0	0	1	2		
	Sub-total	2	2	4	5	2	2	3	3	3	5	5	6	19 (5.8%)	23 (1.6%)

Table 6-2-4 Summary of Plant Shutdowns

(4/5)

Cause of Shutdown	Year	Tiwi Power Plant													
		Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Unit 6		Total	
		Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days
Instrument Air Supply System Troubles	1986	0	0	1	1	1	1	0	0	0	0	0	0		
	1987	0	0	0	0	0	0	0	0	1	1	1	1		
	1988	0	0	0	0	0	0	0	0	0	0	0	0		
	1989	0	0	0	0	0	0	0	0	2	4	1	2		
	1990	0	0	0	0	0	0	0	0	0	0	0	0		
	Sub-total	0	0	1	1	1	1	0	0	3	5	2	3	7 (2.1%)	10 (0.7%)
Cooling Water Pipeline Troubles	1986	0	0	0	0	0	0	0	0	0	0	0	0		
	1987	0	0	0	0	2	4	0	0	0	0	0	0		
	1988	0	0	0	0	0	0	0	0	1	1	0	0		
	1989	1	3	0	0	0	0	0	0	0	0	0	0		
	1990	0	0	0	0	0	0	0	0	0	0	0	0		
	Sub-total	1	3	0	0	2	4	0	0	1	1	0	0	4 (1.2%)	8 (0.5%)
Spark of Generator Slipring Carbon Brushes	1986	0	0	0	0	0	0	0	0	0	0	0	0		
	1987	0	0	0	0	0	0	0	0	0	0	0	0		
	1988	0	0	0	0	0	0	1	1	0	0	0	0		
	1989	0	0	0	0	2	2	0	0	0	0	0	0		
	1990	0	0	0	0	0	0	0	0	0	0	0	0		
	Sub-total	0	0	0	0	2	2	1	1	0	0	0	0	3 (0.9%)	3 (0.2%)

Table 6-2-4 Summary of Plant Shutdowns

(5/5)

Cause of Shutdown	Year	Tiwi Power Plant													
		Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Unit 6		Total	
		Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days	Times	Days
Troubles of Exhaust Stack	1986	0	0	0	0	0	0	0	0	0	0	0	0		
	1987	0	0	0	0	0	0	0	0	0	0	1	2		
	1988	0	0	0	0	0	0	0	0	2	2	0	0		
	1989	0	0	2	21	0	0	0	0	1	1	0	0		
	1990	0	0	0	0	0	0	0	0	0	0	0	0		
	Sub-total	0	0	2	21	0	0	0	0	3	3	1	2	6 (1.8%)	26 (1.8%)
Grand Total		77	382	66	260	49	274	47	240	48	210	38	110	325	1,476

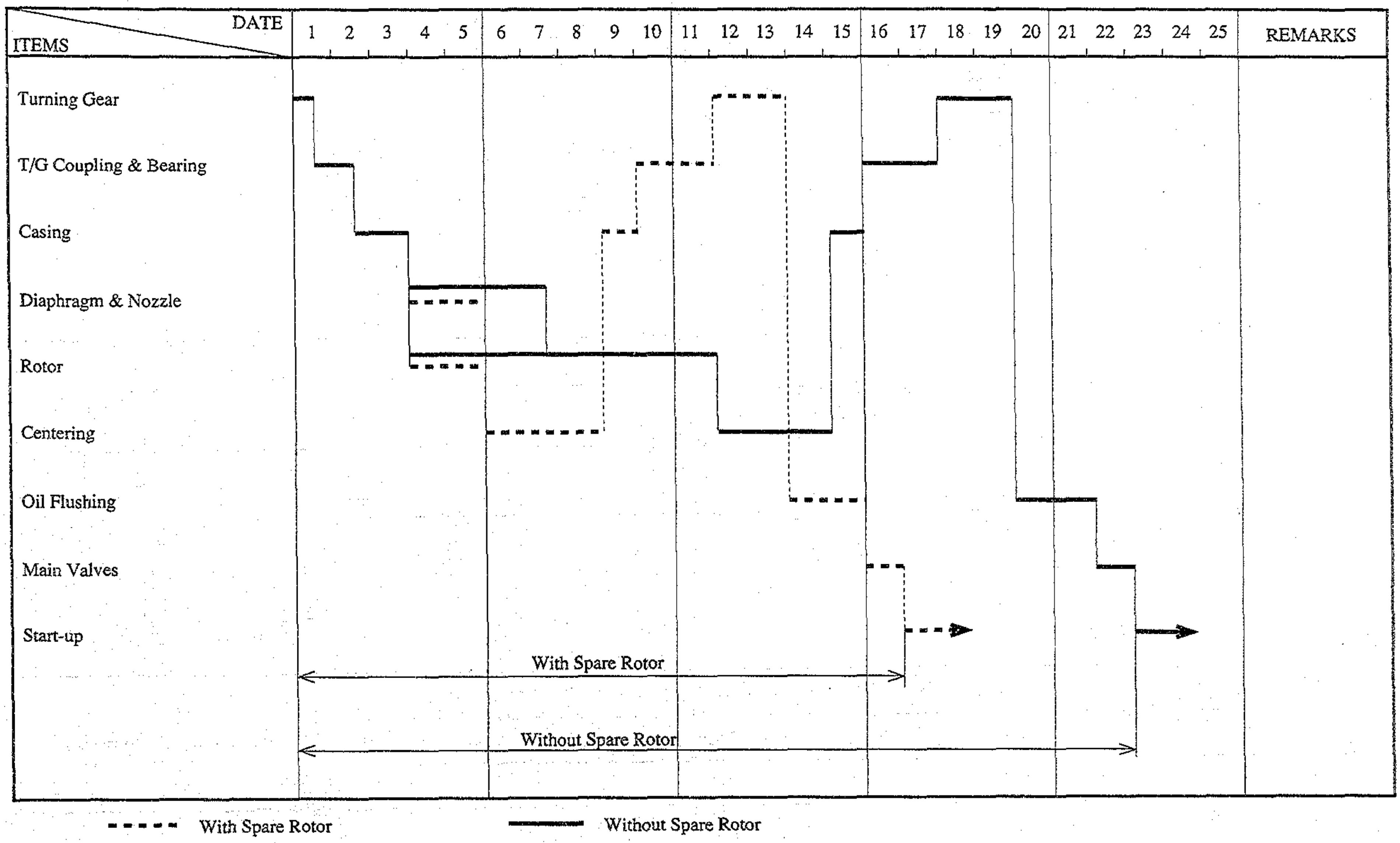
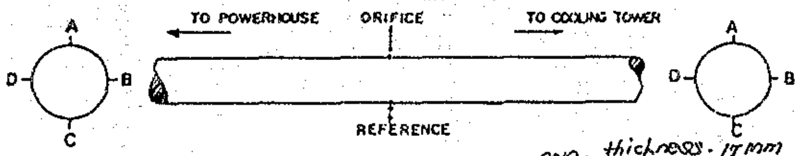


Fig. 6-2-3 Rehabilitation Work Schedule on 55MW × 1 unit Geothermal Power Plant (Actual Results)

HOT WATER PIPE THICKNESS RECORD

(EMBEDDED PIPE)

Equipment -



org. thickness - 17mm

NOTE: 1m interval

METERS	TO POWERHOUSE				TO COOLING TOWER			
	A	B	C	D	A	B	C	D
1	12.6	13.8	12.1	13.3	11.1	11.6	6.5	9.7
2	12.7	14.6	9.9	12.7	10.6	11.5	6.0	10.6
3	12.5	10.8	10.2	12.4	12.1	11.7	7.6	10.2
4	11.5	11.4	10.1	10.6	11.2	12.0	6.7	9.4
5	11.5	12.8	10.3	11.7	12.14	13.6	10.2	11.0
6	11.5	10.8	11.2	10.9	13.9	14.9	10	13.7
7	11.1	11.6	9.6	11.1	10.1	13.1	10.2	12.5
8	12.1	12.7	10.1	11.7	13.8	7.8	6.74	9.34
9	12.7	12.1	9.8	12.1		4.3	9.2	5.6
10	13.2	14.5	9.4	12.9	7.2	12.7	11.5	9.0
11	12.5	12.1	10.7	12.7	9.3	12.2	12.3	10.3
12	10.6	13.1	11.6	14.6	11.1	9.8	9.9	11.3
13	12.3	11.4	10.5	13.08	12.2	11.6	12.1	10.4
14	12.4	12.1	10.6	14.4	12.2	11.0	9.7	11.6
15	11.7	12.4	10.4	12.4	11.8	12.0	12.4	12.4
16					12.7	14.5	12.1	11.3
17					13.6	14.8	11.52	13.3
18					14.7	13.6	11.08	13.6
19					13.1	13.7	11.6	13.6
20					9.5	12.0	11.2	12.3
						7.7	10.9	8.2
					6.5	7.1	4.7	5.4
Average	12.06	12.41	10.43	12.44	11.44	11.51	9.72	10.67

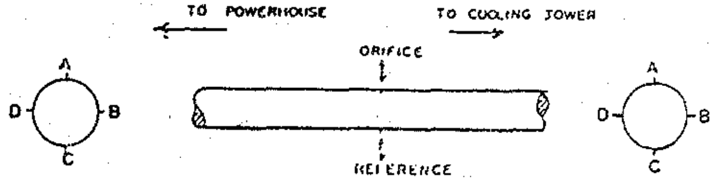
Total Average 11.34

PLANT	MB GEOTHERMAL PLANT	UNIT No. 1
EQUIPT.	HOT & COLD PIPELINE	
TYPE		
PREP'D BY:	[signature]	DATE
CHECK'D BY:		DATE

COLD WATER THICKNESS RECORD

(EMBEDDED PIPE) UNIT # 1

Equipment -



org. thickness - 15mm

NOTE: 1m interval

METERS	TO POWERHOUSE				TO COOLING TOWER			
	A	B	C	D	A	B	C	D
16					13.1	9.7	8.5	11.60
17					13.68	13.10	4.30	10.0
18						8.96	6.90	
19							6.72	9.80
20					13.32	10.58	6.28	11.72
21						12.9	8.10	12.74
22						8.5	2.2	11.13
23						5.2	8.18	9.3
24						7.2	6.9	
25								

FIG. 6-2-4

PLANT	MB GEOTHERMAL PLANT	UNIT No. 11
EQUIPT.	HOT & COLD PIPE LINE	
TYPE		
PREP'D BY:	[signature]	DATE
CHECK'D BY:		DATE

4. Problems with Steam Supply System and Power Plant Facilities and Countermeasures

(1) Mechanical Facilities

a. Overhaul

The steam quality at Tiwi Geothermal Power Plant has been improved since the commissioning, and further in 1990, the steam scrubbing system was added and good results are obtained. Based on the operation records to date, it is judged that the safety of the plant will be maintained with the overhaul once or twice a year. Actually, however, there occur the clogging of the turbine inlet steam strainers and sticking of MSV and CV rather frequently, and further improvement of steam quality is needed.

b. Improvement of Steam Quality

With some units in Tiwi and Mak-Ban Power Plants, the tests of the steam scrubbing system as a means of steam quality improvement have been continued. As one year has passed since the tests were started, the test results were processed and the advisability of the addition of the steam scrubbing system to other units was studied. The past record revealed that there was decline of the output due to scaling even with the steam scrubbing system. The improvement and maintenance of the steam quality should be made on the responsibility of PGI, the steam supplier.

Recently, the water washing system was developed, and it became possible to remove the scale deposited on the turbine nozzles and blades without shutting down the unit.

As a means of protection of the plant, the water washing system should be added for the extension of the continuous operation time, prevention of decline of the output and prevention of rubbing of the rotor due to scaling.

c. Lining of Main Cooling Water Pipes

The corrosion of the main cooling water pipes and hot water pipes are conspicuous, and in the extreme case, as much as 75% of the tube wall thickness is corroded. These pipes are buried underground, over which the hybrid type gas compressors are located. Therefore, if the corrosion progresses at the present rate, it is feared that the pipes may collapse under the earth pressure and heavy loads.

It is necessary to line the pipes with stainless steel (SUS 304) pipes of wall thicknesses corresponding to the lost thicknesses and prevent the collapsing and the progress of corrosion.

d. Replacement of Auxiliary Cooling Water Pipes

Epoxy-lined carbon steel pipes are used for the auxiliary cooling water pipes, and the lining has peeled off and the pipes have been corroded.

The Supercoat lined carbon steel pipe has been proved to be very stable against the cooling water in Tiwi Power Plant, and has a high anti-corrosive property. Therefore, it is advisable to replace the cooling water pipes with Supercoat lined pipes, SUS pipes or FRP pipes.

e. Suppression of Algae

Algae growth and mud deposit in the generator hydrogen gas cooler tubes decrease the coefficient of overall heat transmission. To recover this, tube cleaning is carried out with a decreased output or unit shutdown.

The following two methods are considered as the means of preventing this decrease of the coefficient, and the selection should be made in consideration of the economy and reliability.

Plan 1.

The cooling water system to the H_2 gas cooler and lubricating oil cooler will be modified from the existing open cycle to the closed cycle and the growth of algae will be suppressed by shielding from the sun light.

Plan 2.

The H_2 gas cooler will be equipped with cleaning brushes so that the interior of the tubes may be cleaned automatically and continuously.

f. Improvement of Labyrinth Packing Material

The labyrinth packings of the main shaft of the turbine suffered from severe corrosion, but since the packings were replaced with stainless steel packings, the trouble of the labyrinth packings has been remedied.

g. Installation of Hybrid Type Gas Extractors including H_2S Gas Diffusion System

The installation of the hybrid type gas extractors for No. 1, No. 2, No. 5 and No. 6 Units is under way, by which an increase of the output (approx. 29 MW), lowered ground concentration of H_2S gas and prevention of corrosion due to scattered steam condensate, etc. are expected. No. 3 and No. 4 Units still use the steam ejectors which consume a large volume of steam for the extraction of NCG and the condensate wets the surrounding and causes corrosion.

To solve these problems, one (1) set of hybrid type gas extractor for common use should be added to No. 3 and No. 4 Units also, and an increase of the output (approx. 11 MW) and prevention of the corrosion due to scattered condensate should be achieved. (Refer to Fig. 6-2-5 (1), (2))

h. Partial Modification of Cooling Towers

The forced draft fans, hubs and such rotating parts have suffered drain attacks and the fillers have been severely damaged by long use, and they are already in the condition needing drastic repair.

The cooling towers are of wooden structures and the ceiling boards, side boards, louvers, etc. have been corroded severely by the sputtering water and strong acid droplets scattered from the steam ejectors.

Since the power plant is located right under the route of typhoons, the side boards, louvers, railings, stairs, etc. have been broken or deformed, and the performance of the cooling towers have been damaged and the safety of the cooling towers is in danger.

All the fans, hubs, fillers, side boards, louvers, ceiling boards, railings, stairs, etc. that have been severely damaged should be replaced for recovering the performance of the cooling towers.

Also one third of the upper part of the cooling tower structures and one third of the cooling fan motors should be replaced with new ones.

i. Procurement of Vehicles

At Tiwi Power Plant, there are 255 employees composed of 123 operators, 70 maintenance crew and 62 others. And the power plant has one mobile allocated to Plants A, B and C combined, and the shift operators are reporting to the job getting a lift in the day-shift employees' cars.

The working mode of operators is by the 4 group 3 shift system, but the shift changes are difficult to be made regularly because of difficult transportation.

In some cases, operators cannot help working two shifts continuously. This is a serious problem in the operation of the power plant.

Since the power plant and the residential quarters of the employees are located in the remote area, there is no public transportation available.

And the number of vehicles assigned to the power plants is short, and they are all dilapidated by age and need to be replaced.

For smooth transportation of shift operators and speedy transportation of maintenance crew and security personnel in care of power plant troubles and emergency.

It is advisable to purchase one small bus (capacity: 29 persons) and a jeep (capacity: 7 persons) equipped with a winch.

(2) Electric Facilities

a. Electric Facilities within Powerhouse

(a) Generator equipment

No problem was found with both the stators and the rotors of the generators proper so far. However, as it is more than 10 years already since the commissioning of No. 1 to 4 units, the detailed study on the necessity of the rewedging of stator windings is essential and study on rewinding of rotors, and detail inspection of retaining rings are necessary. Slip rings of the excitation circuit were found to have abrasion by sparks and the brush holders were also damaged by corrosion. Repair of the slip rings, and replacement of the brush holders and brushes are necessary. It was informed by the plant that H_2 gas leakage was larger than usual. Therefore, H_2 gas seal at the generator stator temperature sensor terminals should be thoroughly inspected. Parts of the AVR also have been corroded to the degree needing replacement.

(b) 4.16 kV and 480 V switchgears and 480 V motor control centers

These equipment are installed in the electric room partitioned from the other sections in the powerhouse and kept at a little higher pressure than the atmosphere by the air conditioners to prevent the atmospheric air from entering. Because the central air conditioners are now out of order and the doors of the electric room are left open, the air of the powerhouse containing H_2S gas enters and gives adverse affects of corrosion and deterioration of the electric equipment, relays, instruments, etc. Though the damage has not been serious so far, the replacement of the air conditioners is imperative.

(c) Addition of generator circuit breaker

As there occur frequent plant trips due to the power system faults, it is advisable to install the generator circuit breakers to facilitate the operation of the plant with the station service load only and to raise the flexibility in the plant operation.

b. Electric Facilities in Switchyard

As mentioned before, the steam and H_2S gas in the ejector exhaust cause corrosion, insulation drop, and malfunctioning of the electric facilities in the switchyard, especially the exposed parts of conductors, insulators, disconnecting switches, overhead ground wires, circuit breakers, control equipment, etc. It is noted especially that soon after the commissioning of the plant, the dielectric strength of insulators dropped because of impurities in steam and steam mist deposited on the surface of insulators, and frequent flash-overs occurred. At present, the problem is minimized by H.V.I.C. (High Voltage Insulation Compound) coated on the surfaces of insulators.

As a fundamental measures, the more effective means of diffusion of the ejector exhaust should be established.

(3) Instrumentation and Control Equipment

Because the H_2S containing NCG discharged from the condenser is not dispersed in the air satisfactorily, several problems have occurred on the control and instrumentation facilities. Especially, the windows of the central control room are kept open to take in the outside air, because all the air conditioners of Plant A, B and C are out of order. Thus, the air contaminated with H_2S comes into the room and causes adverse effects of corrosion and insulation deterioration on the instruments and control equipment in the room. The restoration of the air conditioners is urgently needed. The details of major problems on instrumentation and control equipment are described in the following.

a. Hotwell Level Control

The automatic level control sometimes malfunctions due to the poor quality of control air. Detailed inspection of the control air system is necessary.

b. Control Board Recorders

Several sets of recorders have been out of order because of servomotor trouble, etc. These recorders should be replaced.

c. Control Board Indicators and Transmitters

Several control board indicators are malfunctioning owing to corrosion and deterioration, and need repair or replacement.

d. Control Air Supply

There are problems with the quality of the control air. Detailed inspection of the air supply system, replacement of filters, and check of dryers are necessary. Inspections of air filters and drain system of the back-up system are necessary, too.

At present, two control air compressors are in operation at each plant, and there is no spare compressor. One spare compressor each for Plants A, B and C should be provided.

e. Chemical Dosing System

The automatic control has been out of order and the system is being operated manually without particular problems. However, the automatic control system should be restored.

The above problems and their countermeasures are summarized in Tables 6-2-5 and 6-2-6.

Table 6-2-5 Problems and Basic Countermeasures (Mechanical)

Power Plant: Tiwi (1/2)

No.	Problem		Basic Countermeasure	Unit No. 1	2	3	4	5	6	Reh	OH	Remarks
M-1	Frequent and long overhaul/maintenance shutdowns	(1)	Procurement of turbine spare rotor, nozzle and diaphragms	-	-	-	-	o	-	o	-	
		(2)	Installation of water washing system with demineralizers	o	o	o	o	o	o	o	-	
		(3)	Procurement of honing machine	-	-	o	-	-	-	o		
M-2	Corroded cooling water pipe and vacuum low and water leakage, entailing burst pipe in the future	(1)	Internal lining of main cooling water pipe with stainless steel	o	o	o	o	o	o	o	-	
		(2)	Additional installation of electrolytic protection system	o	o	o	o	o	o	o	-	
		(3)	Replacement of aux. cooling water pipeline including the headers	o	o	o	o	o	o	o	-	
M-3	Decreased performance of H_2 gas cooler by algae growth	(1)	Installation of automatic tube cleaner or modification of cooling water system from open cycle to closed cycle	o	o	o	o	o	o	o	-	

Note: Reh = Rehabilitation OH = Overhaul

Table 6-2-5 Problems and Basic Countermeasures (Mechanical)

Power Plant: Tiwi (2/2)

No.	Problem	Basic Countermeasure	Unit No.						Reh	OH	Remarks
			1	2	3	4	5	6			
M-4	Decreased performance of cooling tower resulting in high cooling water temperature	Replacement of erroded and poor materials	o	o	o	o	o	o	o	-	
M-5	Corroded surrounding equipment by steam splutter from steam ejector	Installation of hybrid type gas extraction system including removal of exhaust steam discharge point to down-stream of cooling tower fans	-	-	o	-	-	-	o	-	Common use with unit No.4
M-6	Difficult operator shift change because of car shortage	Procurement of new vehicles	o	-	-	-	-	-	o	-	
M-7	Steam supplier trouble										
	1) Geothermal steam short by 80 MW equivalent of output power	Drilling of additional steam production wells	o	o	o	o	o	o	-	-	By PGI, steam supplier
	2) Low steam quality	Installation of steam addition scrubber system	-	-	o	-	-	-	-	-	-Ditto-
	3) Steam supply system trouble	Three (3) small size rupture disks to be fitted instead of one (1) large size rupture disk	o	o	o	o	o	o	-	-	-Ditto-

Table 6-2-6 Problems and Basic Countermeasures (Electrical and I&C)

Power Plant: Tiwi (1/2)

No.	Problem	Basic Countermeasure	Unit No. 1	2	3	4	5	6	Reh	OH	Remarks
E-1	Yearly deterioration of generator	(1) Rewedging of generator stator windings	o	o	o	o	o	o	o	-	
		(2) Detail inspection of generator rotor winding	o	o	o	o	-	-	o	-	
E-2	Leakage of H_2 gas	Replacement of generator stator temp. sensor terminal board, etc.	o	o	o	o	-	-	-	o	
E-3	Generator rotor slip ring spark and brush and brush holder corrosion	Repair and machining of the slip ring, and replacement of brushes and brush holders	o	o	o	o	o	o	-	o	
E-4	Generator exciter AVR malfunction	Replacement of corroded parts	o	o	o	o	o	o	-	o	
E-5	4.16 kV & 480 V switchgears and 480 V M.C.C. corrosion	(1) Replacement of corroded parts and servicing of contactors, relays, etc.	o	o	o	o	o	o	-	o	
		(2) Replacement of air conditioner	o	o	o	o	o	o	o	-	
E-6	Switchyard equipment corrosion (1) Corroded disconnecting switches	(1) Replacement of defective disconnecting switches	o	o	o	o	-	-	-	o	
	(2) Circuit breaker malfunction	(2) Replacement of circuit breaker	o	o	-	-	-	-	o	-	6sets of SF6 CB for PlantA
		(3) Installation of N.C.G. abatement system	o	o	o	o	o	o	o	-	
E-7	Inflexible Generator Operation	Installation of SF6 generator circuit breaker	o	o	o	o	o	o	o	-	Under planning

Table 6-2-6 Problems and Basic Countermeasures (Electrical and I&C)

Power Plant: Tiwi (2/2)

No.	Problems	Basic Countermeasure	Unit No.						Reh	OH	Remarks
			1	2	3	4	5	6			
IC-1	Malfunction of hotwell level control	(1) Overhaul of hotwell level control system	o	o	o	o	o	o	-	o	
		(2) Servicing and repair of instrument/control air system including piping	o	o	o	o	o	o	-	o	
		(3) Rehabilitation of existing control air compressors	o	o	o	o	o	o	-	o	
		(4) Additional installation of control air compressor	o	-	o	-	o	-	o	-	3sets
IC-2	Deterioration/corrosion of control board recorders	(1) Replacement/repair of recorders	o	o	o	o	o	o	o	-	Detailed investigation is needed.
		(2) Repair of air conditioners	o	o	o	o	o	o	o	-	
IC-3	Deterioration/corrosion of control board indicators/transmitters	Replacement/repair of indicators/transmitters	o	o	o	o	o	o	o	-	-Ditto-
IC-4	Malfunction of TSI	Replacement of TSI	o	o	o	o	-	-	o	-	
IC-5	Malfunction of turbine governor system	(1) Overhaul/servicing of turbine governor system	o	o	o	o	o	o	-	o	-Ditto-
		(2) Training of I&C personnel of the plant	o	-	o	-	o	-	o	-	
IC-6	Malfunction of chemical dosing system	Replacement of automatic dosing system(PH control)	o	o	o	o	o	o	o	-	

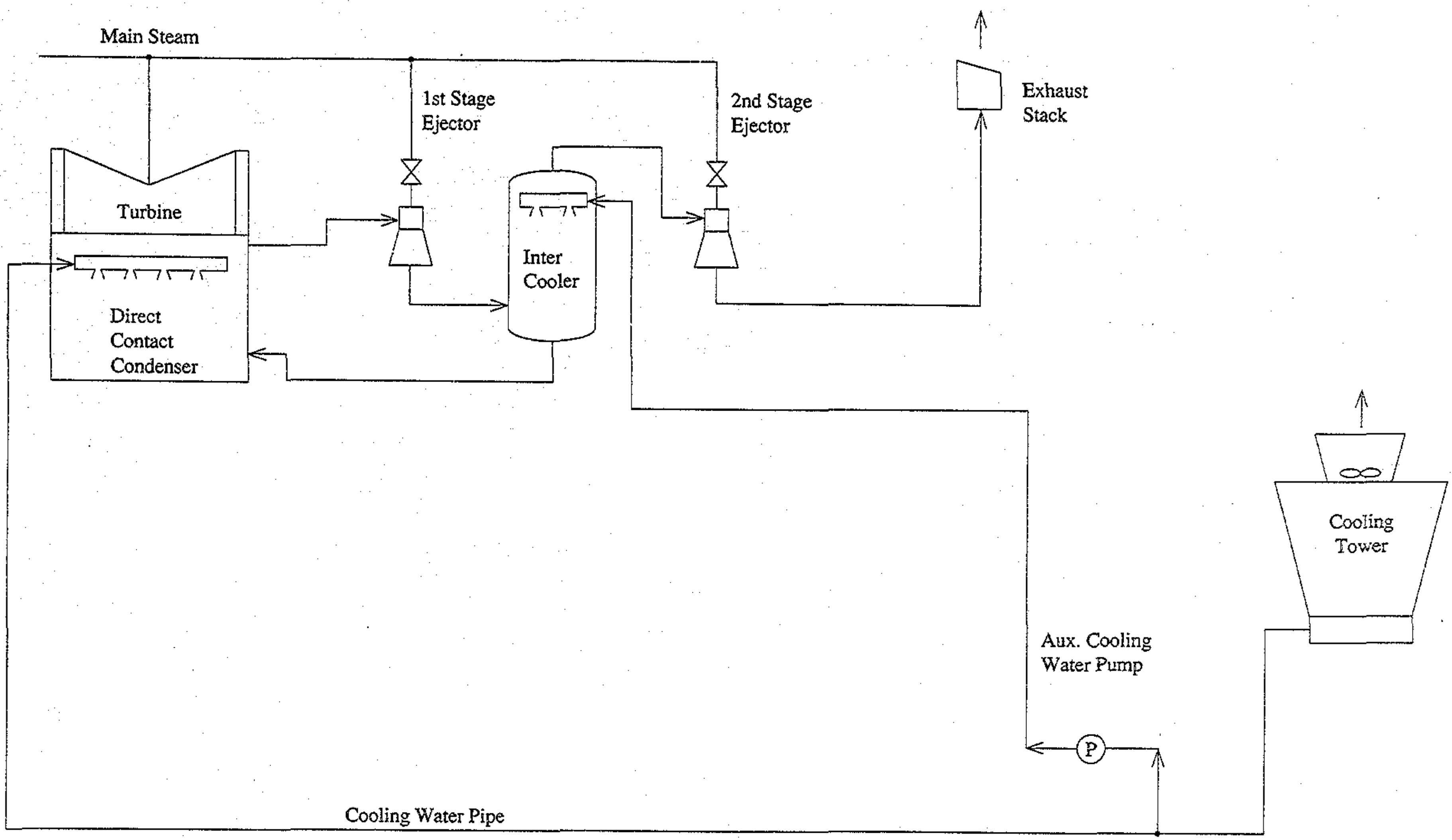


Fig. 6-2-5 (1) Tiwi Geothermal Power Plant Gas Extraction System Diagram (Existing)
(No.1～No.6 Unit)

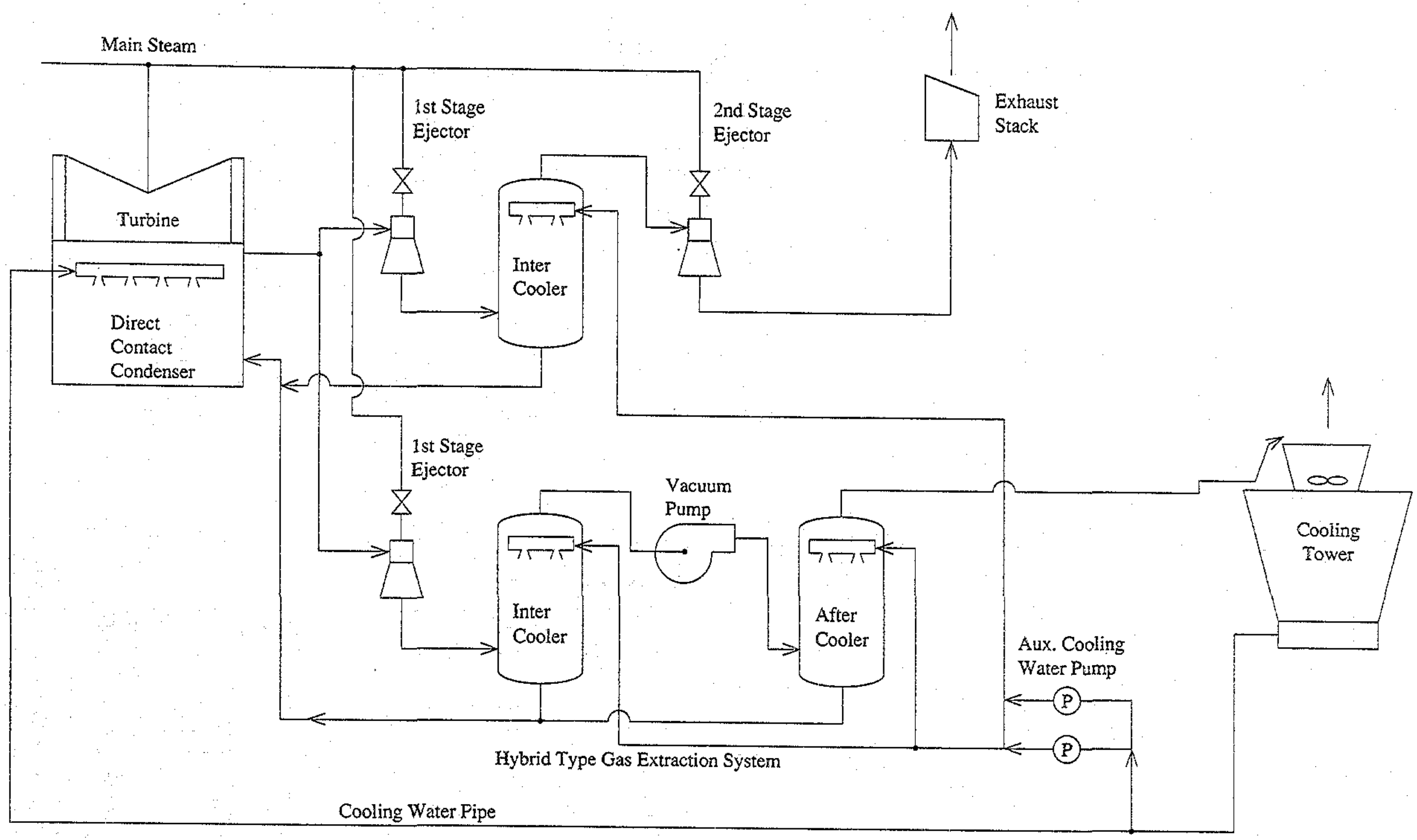


Fig. 6-2-5 (2) Tiwi Geothermal Power Plant Gas Extraction System Diagram (Improvement Plan)
(No.1, 2, 5, 6 Unit : Under Construction)
(No.3 Unit : Planning) (Common use with No. 4 Unit)

6.2.2 Present Situation and Problems in Mak-Ban Geothermal Power Plant

1. Outline of Mak-Ban Geothermal Power Plant

Mak-Ban Geothermal Power Plant is located at Bay & Calawan in Laguna Province, Luzon, at about 70 km south from Metropolitan Manila. The power plant consists of 3 plants, Plants A, B and C, and each plant has 55 MW x 2 units. The commissioning dates are as tabulated below:

Plant	Unit	Commissioned in
A	Unit-1	September 1979
A	Unit-2	November 1979
B	Unit-3	August 1980
B	Unit-4	October 1980
C	Unit-5	September 1984
C	Unit-6	December 1984

The design of Plant A (Units 1 and 2) and Plant B (Units 3 and 4) is nearly the same. As Tiwi Power Plant, Units 1 to 4 were originally designed as the double flash system but were converted later to the single flash system. Units 5 and 6 of Plant C were designed as the single flash system from the beginning.

With the units in Plants A and B, 3 units each of the non-condensable gas extraction compressors (1st stage to 3rd stage) are installed, but since surging occurs among the compressors and the operation becomes unsteady sometimes, the steam ejectors are used normally.

As a means of getting better diffusion of noncondensable gas from the steam ejector and lower ground concentration of H_2S gas, the exhaust steam from the 2nd stage ejector is directly discharged into the atmosphere, and the condensate of steam wets the surrounding and accelerates the corrosion of the outdoor equipment, piping, structures, measuring instruments, etc.

In Plant C (Units No. 5 and 6), packaged gas compressors are used for NCG extraction and the NCG exhaust is discharged from the top of the cooling tower. Because of the sufficient H_2S gas diffusion, there has been no problems experienced with Plants A and B.

2. Geothermal Steam Supply

There is no indication of shortage of geothermal steam supply as shown in Fig. 6-2-6, (1), (2) and (3). The geothermal reservoir area and the locations of the wells are shown in Fig. 6-2-7.