3.4 Power Generation Plan

3.4.1 Present Generation Capacity of Existing Plants

The nominal and available generation capacities of the existing power plants as of 1994 have already been given in Table 3.2.1-1. Data for each generation unit at the 4 major existing power plants is given in Table 3.4.1-1.

Table 3.4.1-1 Generation Capacity of Major Power Plants

Name of Power Plant	Unit No.	Installed Capacity (MW)	Max. Available Capacity (MW) as of November, 1994	Date in Service	Years as of November, 1994	Total Operation Hours	No. of Start-Ups	Type of Fuel
Tishreen PP	#1	200	200	02/1993	1.75			HFO
	#2	200	200	04/1994	0.8			HFO, NG
	(Total)	(400)	(400)					
Katteneh PP	#3	30	0	1969	25	98,298		HFO
	#4	30	12	1969	25	60,000		HFO
	#5	30	0	1970	24	89,580		HFO
	#6	64	50	1981	13	88,824		HFO
	(Total)	(154)	(62)					
Mehardeh PP	#1	150	120	04/1979	15	92,025	558	HFO, NG
	#2	150	120	12/1979	15	92,777	570	HFO, NG
	#3	165	160	12/1988	6	41,794	336	HFO, NG
	#4	165	160	05/1989	5.5	47,341	320	HFO
	(Total)	(630)	(560)					
Banias PP	#1	170	147	10/1982	12	82,503	315	HFO
	#2	170	85	05/1983	11.5	78,323	433	HFO
	#3	170	150	04/1989	5.5	44,250	107	HFO
	#4	170	150	10/1989	5	42,858	72	HFO
	(Total)	(680)	(532)					

3.4.2 Power Plants Rehabilitation Plan and the Power Balance

The purpose of rehabilitation is to restore the available capacity to the original design levels of maximum continuous rating, which were confirmed by the initial performance test, and also to improve the net thermal efficiency.

The Government of Syria's Long-term Power Generation Plan and the power demand forecast for up to 2020, including the new power plants, are as indicated in Tables 3.4.2-1 and 3.4.2-2 and Fig. 3.4.2-1 and 3.4.2-2. According to these, the total available capacity and the guaranteed capacity are expected to be more than double over the next ten years and to exceed the peak demand from the end of 1995.

Providing that the construction of the planned new power plants goes according to this Plan, it is expected that the tight power supply situation, which lasted up until 1994 and in which periodic inspections and overhauls at the existing power plants could not be implemented, will not be repeated until 2001.

In other words, from 1997, by which time Jandar Power Plant (600 MW by the end of 1995), Nasreyah Power Plant (300 MW by 1996) and Zezoon Power Plant (300 MW by 1996) will have commenced full operations, and by which time guaranteed capacity will be in relatively large excess of peak demand, it is thought that the utilization of this reserve power will enable this period to be used for the implementation of detailed inspections and rehabilitation of the facilities at the existing power plants.

As is shown in Table 3.4.2-1, the Syria side has compiled its plans based upon the assumption that the useful life of steam turbine power generation facilities is 25 years and that the useful life of gas turbine power generation facilities is 20 years, and operations of Katteneh Power Plant and Mehardeh Power Plant Unit No.1 and No.2 are planned to be stopped due to deterioration in 2005, and Banias Power Plant Unit No.1 and No.2 are planned to be stopped in 2007.

However, in order to keep pace with the rapidly increasing power demand, it is imperative to prolong the useful lives of the power generation facilities targeted for rehabilitation and renovation through the implementation of the Rehabilitation Plan that includes detailed inspections and overhauls in the period between 1995 and 2001 when guaranteed capacity will be in excess of peak demand. The actual rehabilitation and renovation work can be commenced from 1997, when it is forecast that guaranteed capacity will be in large excess of peak demand. If the future plans for the construction of new power plants will not be backed up by the rehabilitation of existing plants, it is forecast that the power supply situation will again be deteriorated.

Table 3.4.2.-1 Available Installed Capacity of Power Plants

As End of Jan. 1995

PLANT NAME	Y E A R S																									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Thawra	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
Baeth & small hydro	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
Katteneh	70	50	50	45	45	50	48	45	45	45	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mehardeh (1,2)	270	260	250	240	280	290	280	280	270	240	260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mehardeh(3,4)	310	310	300	300	300	280	300	290	260	270	270	260	260	260	260	260	260	130	0	0	0	0	0	0	0	0
Banias (1,2)	300	310	300	315	305	295	300	315	305	295	295	295	148	0	0	0	0	0	0	0	0	0	0	0	0	0
Banias (3,4)	320	310	310	300	320	320	310	310	300	300	320	310	310	310	310	310	310	310	155	0	0	0	0	0	0	0
Tishreen thermal	360	360	360	340	320	380	380	380	380	380	380	360	360	360	360	360	360	360	360	360	360	360	360	180	0	0
Tishreen extention (GT)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	0	0	0	0	0	0
Swedie	145	150	145	140	150	145	140	150	145	140	150	140	140	84	0	0	0	0	0	0	0	0	0	0	0	0
Tayem	90	87	85	90	87	85	85	90	87	85	85	90	90	90	60	0	0	0	0	0	0	0	0	0	0	0
Gas turbine	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swedie (SPC)	85	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
RIF(H)	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
RIF(B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tishreen hydro	0	0	150	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Jandar	500	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	300	0	0	0	0	0
Basel (nasreyh)	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	0	0	0	0	0	0
Zezoon	0	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	0	0	0	0	0
Aleppo	0	0	200	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
EL-Zara	0	0	0	300	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
TOTAL	3,556	3,803	4,116	5,436	5,773	5,811	5,809	5,826	5,758	5,721	5,776	5,421	5,274	5,070	4,956	4,896	4,896	4,766	4,481	4,326	3,526	2,926	2,926	2,746	2,566	2,566

Source : MOE

Table 3.4.2.-2 Expected Power Balance

As End of Jan. 1995

	Y E A R S																									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1 Total Available Installed Capacity	3,556	3,803	4,116	5,436	5,773	5,811	5,809	5,826	5,758	5,721	5,776	5,421	5,274	5,070	4,956	4,896	4896	4,766	4,481	4,326	3,526	2,926	2,926	2,746	2,566	2,566
2 Largest unit (MW)	180	180	180	300	300	300	300	300	300	300	300	300	300	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Second Largest unit (MW)	155	155	200	200	200	200	200	200	200	200	200	200	200	0	0	0	0	0	0	0	0	0	0	0	0	0
4 Largest GTG unit	100	100	100	100	100	100	100	100	100	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0
5 Total (2+3+4)	435	435	480	600	600	600	600	600	600	600	600	600	600	0	0	0	0	0	0	0	0	0	0	0	0	0
6 Available capacity-1 (1 - 5)	3,121	3,368	3,636	4,836	5,173	5,211	5,209	5,226	5,158	5,121	5,176	4,821	4,674	5,070	4,956	4,896	4,896	4,766	4,481	4,326	3,526	2,926	2,926	2,746	2,566	2,566
7 Guarantee capacity-1 (6 x 0.95)	2,965	3,200	3,454	4,594	4,914	4,950	4,949	4,965	4,900	4,865	4,917	4,580	4,440	4,817	4,708	4,651	4,651	4,528	4,257	4,110	3,350	2,780	2,780	2,609	2,438	2,438
8 Available capacity-2 (1 x 0.9)	3,200	3,423	3,704	4,892	5,196	5,230	5,228	5,243	5,182	5,149	5,198	4,879	4,747	4,563	4,460	4,406	4,406	4,289	4,033	3,893	3,173	2,633	2,633	2,471	2,309	2,309
9 Guarantee capacity-2 (8 x 0.9 = 1 x 0.9 x 0.9)	2,880	3,080	3,334	4,403	4,676	4,707	4,705	4,719	4,664	4,634	4,679	4,391	4,272	4,107	4,014	3,966	3,966	3,860	3,630	3,504	2,856	2,370	2,370	2,224	2,078	2,078
10 Peak load demand (MW)	2,725	2,970	3,238	3,529	3,847	4,193	4,486	4,800	5,136	5,496	5,881	6,233	6,607	7,004	7,424	7,870	8,342	8,842	9,373	9,935	10,531	11,163	11,833	12,543	13,295	14,093
11 Energy demand (GWH)	16,285	17,750	19,348	21,089	22,987	25,056	26,810	28,686	30,695	32,843	35,142	37,251	39,486	41,855	44,366	47,028	49,850	52,841	56,011	59,372	62,934	66,710	70,713	74,956	79,453	84,220
12 Populatio Number	14,269	14,741	15,229	15,734	16,254	16,792	17,348	17,922	18,516	19,128	19,762	20,416	21,091	21,790	22,511	23,256	24,026	24,821	25,643	26,491	27,368	28,274	29,210	30,177	31,176	32,208
13 Kwh per one person	1.141	1.204	1.270	1.340	1.414	1.492	1.545	1.601	1.658	1.717	1.778	1.825	1.872	1.921	1.971	2.022	2.075	2.129	2.184	2.241	2.300	2.359	2.421	2.484	2.549	2.615
14 Deficit - 1 (7-10)	240	229	217	1,065	1,068	758	462	164	-236	-631	-963	-1,653	-2,167	-2,187	-2,716	-3,218	-3,690	-4,314	-5,116	-5,825	-7,181	-8,383	-9,053	-9,934	-10,858	-11,655
15 Deficit - 2 (9 - 10)	155	110	96	874	830	514	219	-81	-472	-862	-1,202	-1,842	-2,335	-2,897	-3,410	-3,904	-4,376	-4,982	-5,743	-6,431	-7,675	-8,793	-9,463	-10,319	-11,217	-12,015
16 Reserve capacity												0	0	600	600	600	600	600	600	600	600	600	600	600	600	600
17 Spining capacity												0	0	400	400	400	400	400	400	400	400	400	400	400	400	400

Source : MOE

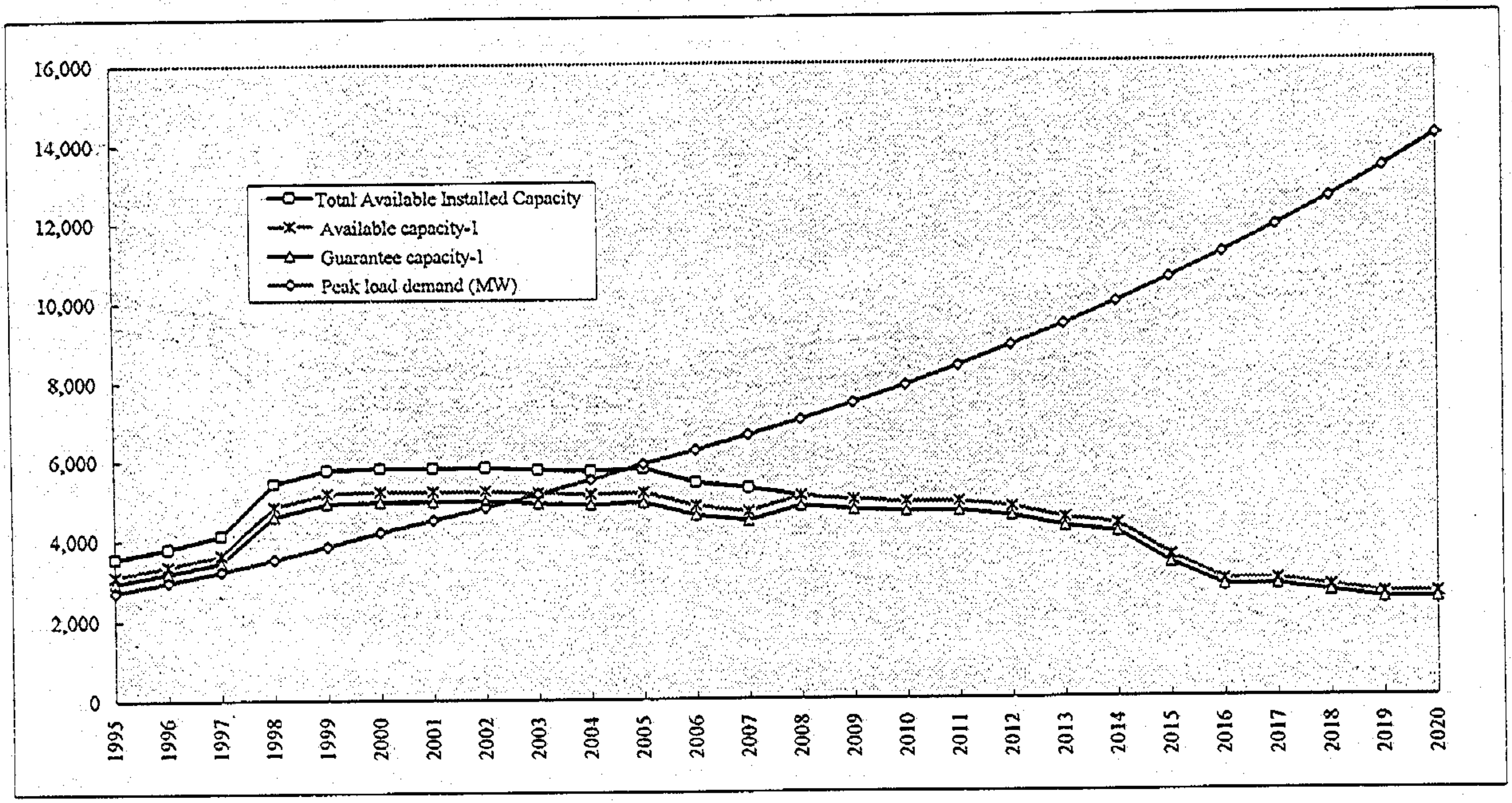


Fig 3.4.2-1 Power Balance (1)

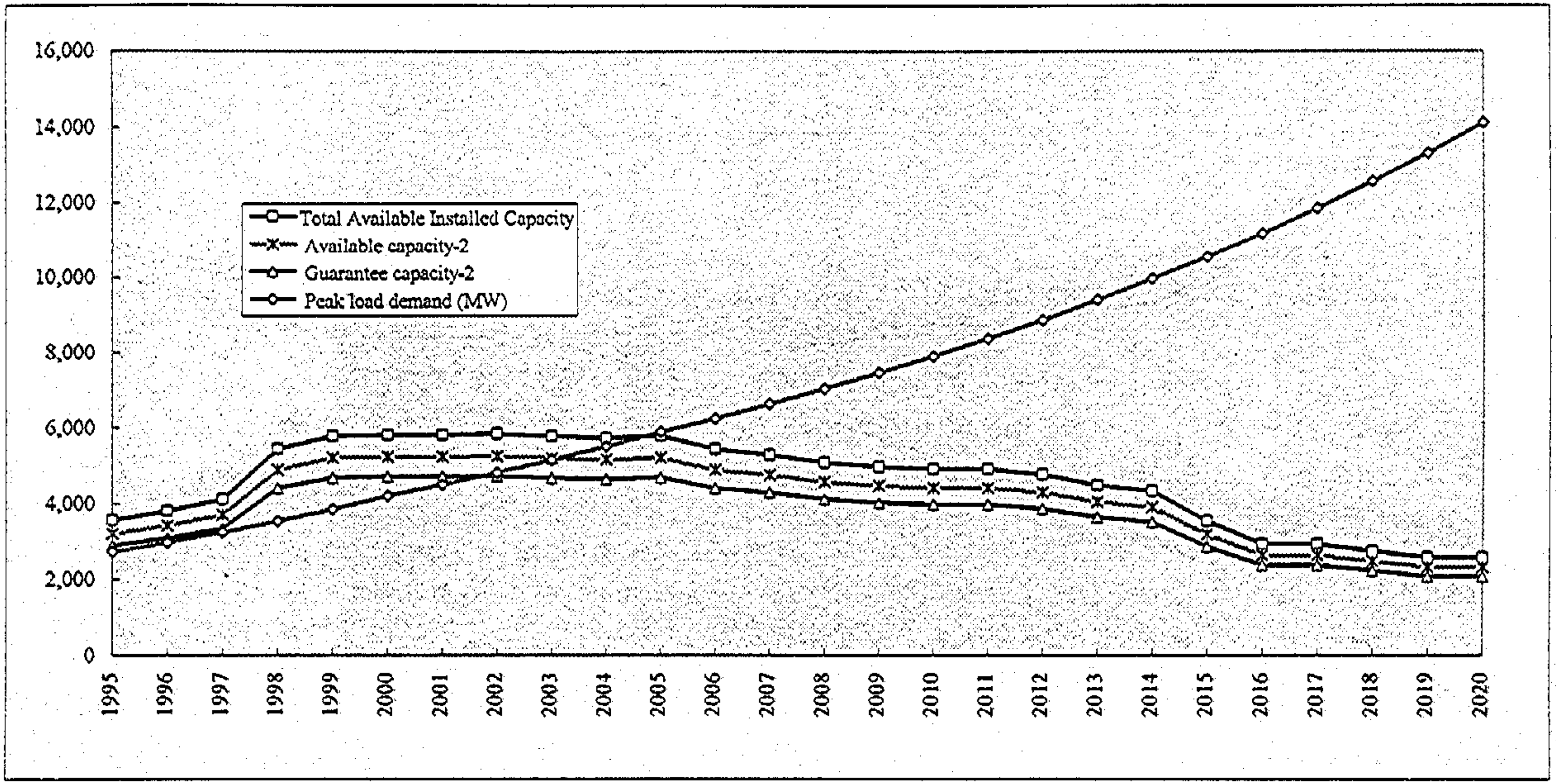


Fig 3.4.2-2 Power Balance (2)

It is therefore of the utmost importance to immediately implement in a planned fashion the Rehabilitation and Renovation Plan being proposed in this Study. It is considered that the materialization of this Plan will make a great contribution to improving the power supply situation and raising the reliability of the power supply within the Long-term Power Supply Plan for up to 2020.

The following sections proceed to state the basis for implementing the rehabilitation and renovation work in the period between 1995 and 2002, based upon the long-term demand forecasts prepared by the MOE (see Tables 3.4.2-1 and 3.4.2-2).

(1) Peak Demand

Based upon the peak demand in 1994 of 2,500 MW, the following rates of increase are forecast.

1995-2000 rate of increase	:	9%/year
2001-2005 rate of increase	:	7%/year
2006-2010 rate of increase	:	6%/year
2011-2020 rate of increase	:	6%/year (assumed)

The following two methods are adopted in order to calculate available capacity and guaranteed capacity.

(2) Available Capacity ① = Total available installed capacity - (largest unit + second largest unit + largest GTG unit)

(3) Guaranteed Capacity ① = Available capacity ① × 0.95

(4) Available Capacity ② = Total available installed capacity x 0.9

(5) Guaranteed capacity ② = Available capacity × 0.9
= Total available installed capacity x 0.81

Comparing the guaranteed capacity calculated using the above two methods with the peak demand, it can be seen that the former is in excess of the latter in the seven years between 1995 and 2001, as is shown below.

(6) Comparison (1) of Guaranteed Capacity ① with Peak Demand (1995-2002)

Year	Guaranteed Capa. ①	Peak Demand	Balance
1995	2,965 MW	2,725 MW	+ 240 MW
1996	3,200	2,970	+ 229
1997	3,454	3,238	+ 217
1998	4,594	3,529	+ 1,065
1999	4,914	3,847	+ 1,068
2000	4,950	4,193	+ 758
2001	4,949	4,486	+ 462
2002	4,965	4,800	+ 164

(7) Comparison (2) of Guaranteed Capacity ② with Peak Demand (1995-2002)

Year	Guaranteed Capa. ②	Peak Demand	Balance
1995	2,880 MW	2,725 MW	+ 155 MW
1996	3,080	2,970	+ 110
1997	3,334	3,238	+ 96
1998	4,403	3,529	+ 874
1999	4,676	3,847	+ 830
2000	4,707	4,193	+ 514
2001	4,705	4,486	+ 219
2002	4,719	4,800	- 81

There is not much of a difference between the results obtained with the two calculation methods. This indicates that, as is shown by the calculation basis for Guaranteed Capacity ①, even if operation of the two largest power generation units and the largest GTG unit in Syria should for some reason (breakdown, inspection or rehabilitation and renovation work) be stopped, there will still be an excess capacity ranging from approximately 1,000 MW to 100 MW during this period.

The necessity for periodic inspections (1.5-2.0 months per year) at the other power generation facilities not targeted for rehabilitation and renovation under this Study is as stated in Chapter 4. In particular, even if three more 200 MW units should undergo periodic inspections in addition to the above mentioned units in the three years between 1998 and 2000, it will still be possible to carry out the Rehabilitation and Renovation Plan (with overhauls lasting around five months) of this Study. Moreover, if the periodic inspections of all major thermal power plants in Syria would be carried out in accordance with a predetermined organized schedule, it will be possible to extend the implementation period of this Rehabilitation Plan up to 2001.

3.5 Initial Environmental Examination (IEE)

3.5.1 Environmental Protection Policy

The Government of Syria has been achieving steady economic development in recent years with the transition of the planned economy to a free economy, and its national development plan emphasises the fostering of various industrial sectors together with the development of agriculture.

The ongoing industrial development is accompanied by increased pollution such as exhaust gas, waste water and noise, etc. associated with various plants, particularly in and around large cities. While emission gas and noise from automobiles cause environmental concern in such major cities as Damascus and Aleppo, exhaust gas and waste water from oil refineries, fertilizer plants and power plants, etc. are becoming causes for concern regarding their adverse impacts on the lives of the people of Homs, Syria's third largest city.

Despite increasing environmental concern, the Government of Syria did not adopt environmental protection measures until 1992 when it established the Ministry of Environment (the organizational structure of which is given in Fig. 3.5.1-1) in response to a UN recommendation. At the same time, a committee was established within the Ministry to prepare environmental standards, mainly on air and water quality, and these standards are presently being discussed by the parliament with a view to their legislation. These standards, in fact, include standards on noise and vibration and stipulate the enforcement responsibilities of the administration, compliance obligations of state enterprises and penal provisions for violations, etc. The standards are a good example of the concrete commitment of the Government of Syria to the implementation of environmental protection.

Another move by the Ministry of Environment is the establishment of the National Research Center for Science and Environment in August, 1994. The Center is designed to improve the standard of environmental study, research and monitoring technologies from the viewpoint of environmental science and to train environmental experts while acting as an auxiliary organization to assist the environmental administration of the central government. It also acts as Syria's representative to cooperate with Arab countries and international organizations in the establishment of a regional environmental monitoring system. The Center is mainly run by 15 engineers, including the director, in such fields as water quality, air quality, soil and harmful chemicals. (The Center's equipment level is quite poor and a request has been made for the Government of Japan's provision of additional equipment.)

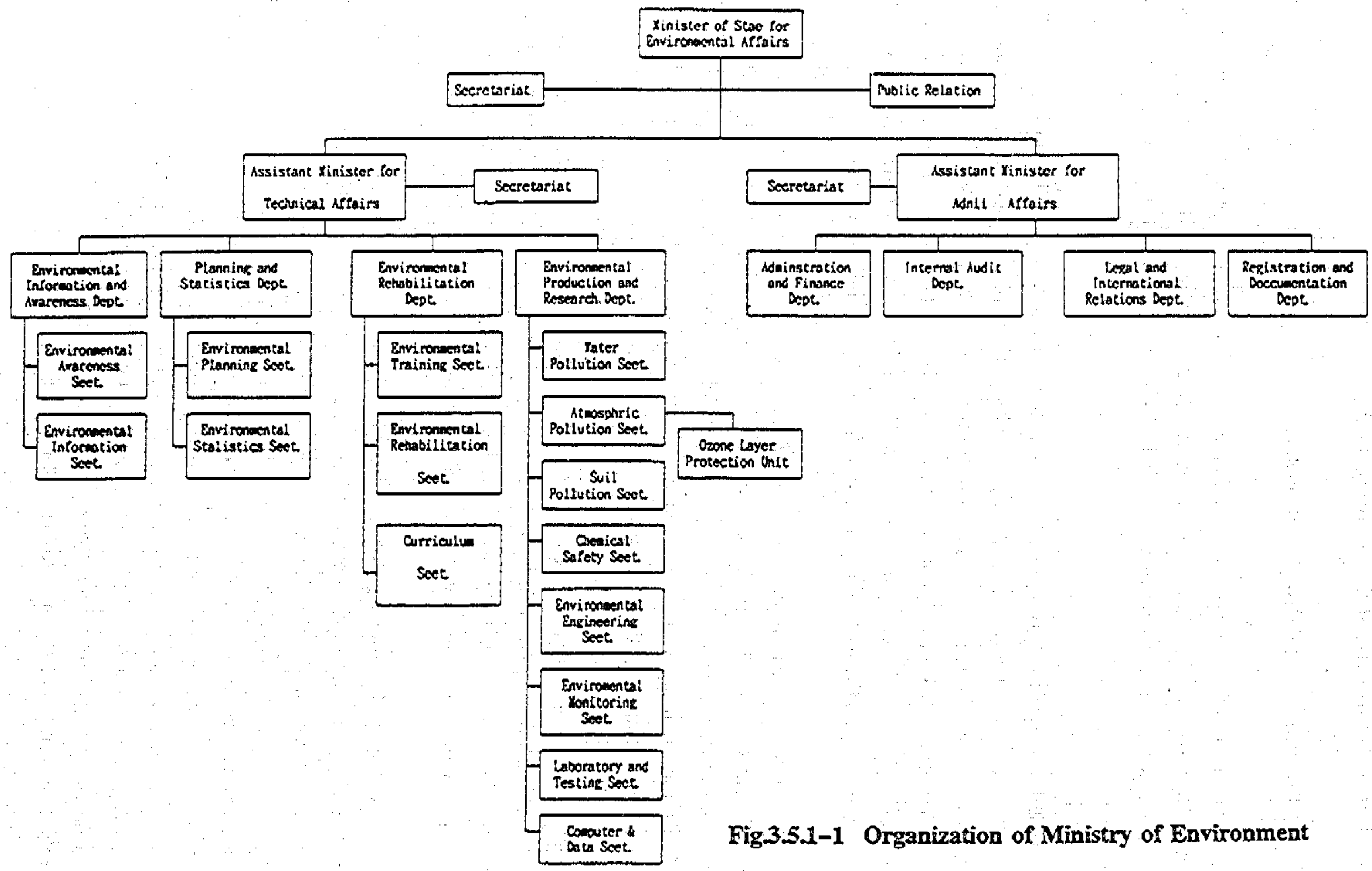


Fig.3.5.1-1 Organization of Ministry of Environment

In accordance with the commitment of the Government of Syria to environmental protection, it is planned to expand the Center's manpower to 150 in the near future and the site for a new Center (approximately 2,000 m^2) has already been secured.

3.5.2 Current Environmental Laws and Regulations

As already described in (1) above, the Government of Syria has compiled environmental standards addressing the responsibilities of administrative bodies and state enterprises, etc. and has asked parliament to legislate these standards. There are, however, no environmental standards regulating the activities of private enterprises. The Government of Syria has started to examine the report and recommendations of the Second Round Table Conference to Make Recommendations on Environmental Impacts of Various Business (Industrial) Activities in Arab Countries and has also commenced preparation of environmental standards based on the report and recommendations. The Conference was held as part of the UN Environmental Programme and the said report and recommendations were compiled by the Arab University.

The report and recommendations, in fact, suggest guidelines for exhaust gas and waste water control vis-a-vis some 50 different types of business (industrial) activities based on environmental survey reports compiled by the WHO and organizations in the US, UK, Germany and Holland, etc. In particular, clear control subjects and exhaust gas guidelines are proposed for thermal power plants which use coal, oil or natural gas as fuel. However, if the aforementioned environmental standards are approved by parliament and enforced, it needs to be realized that concentration level standards will be places on top of qualitative standards.

3.5.3 Current Conditions of Selected Plants Concerning Environmental Protection

(1) Current Environmental Protection Measures at Power Plants

Environmental considerations have been given, to some extent, to the waste water treatment, neutralization, oil separation etc., however no recent environmental protection facilities for air pollution (SO_x, NO_x dust collection) are not provided at not only the Katteneh, Mehardeh and Bauias Power Plants selected for rehabilitation, but also at all other thermal power plants in Syria. This may be a reflection of the fact that no environmental protection laws or regulations are currently in force. The present reality is that it is impossible to check whether or not the exhaust gas is harmful because of the breakdown of most of the instruments used to measure the exhaust gas density and constituents at these power plants.

According to those PEEGT engineers who were interviewed, however, the new Aleppo Power Plant, the construction agreement for which was concluded in November, 1994, has installation space for an electric precipitator to collect dust from the smoke and similar arrangements to prevent pollution are planned for all new power plants to be constructed in the future.

In the case of the Katteneh Power Plant near Homs, the third largest city in Syria, a neighbouring fertilizer plant emits far worse exhaust gas than the power plant. The adoption of environmental protection measures by only the power plant will, therefore, have a limited effect, necessitating the implementation of more comprehensive measures by the central government in accordance with an environmental protection programme.

3.6 Institutional Framework

3.6.1 Organization and Tasks of MOE

All power-related activities, from generation to distribution, in Syria are nationalised and are managed by the MOE. While the MOE supervises wide ranging subjects, from the preparation of the power demand forecast to the planning, design and work relating to power resources development, generation, transmission and distribution and further to the collection of electricity charges, the actual work is commissioned to the PEEGT (Public Establishment of Electricity for Generation and Transmission) and PEDEEE (Public Establishment for Distribution and Exploitation of Electric Energy) with ministerial approval.

As described in former sections, the reality of power supply in Syria is that the supply is trailing behind the demand, which has been steadily increasing in line with the country's economic development. At present, most cities experience power cuts lasting for several hours every day. The MOE plans to implement the following 3 measures to improve the situation.

1st Step : Establishment of an appropriate maintenance system to increase the output of the existing power plants

2nd Step : Reduction of the distribution loss

3rd Step : Construction of new power plants

The MOE has a technical institute (mechanical and electrical training institutes) at 3 locations, i.e. Adra near Damascus, Lattakia and Aleppo, for the training of new maintenance staff and the re-education of existing engineers with the purpose of increasing the output of the existing power plants, which is considered to be the first stage in the overall improvement of the power sector. These attempts to improve and consolidate the skills of maintenance staff and engineers, however, have not quite achieved their objectives due to the lack of educational/training equipment and facilities, in turn caused by insufficient budgetary allocation under Syria's tight fiscal situation.

Regarding the second stage distribution loss, preparation of a master plan for the national transmission and distribution network through aid (grant aid) from the EU was started at the end of 1994. In addition to this, it is planned that the EU will reorganize the aforementioned Aleppo Technical Institute into a Transmission and Distribution Technology Training Center, and will provide equipment and materials and also dispatch specialists, with the aim of training and retraining of transmission and distribution staff or engineers. As for the works on the improvement, strengthening and expansion of the transmission and distribution network which are scheduled for implementation through loan aid from the EU, no specific plans have as yet been drawn up.

The construction of new power plants, believed to be the third stage of power sector improvement, has been making steady progress. The Tishreen Power Plant (ST 200 MW × 2 units + GT 100 MW × 2 units) constructed with Russian assistance commenced operation in early 1994 while the GT No.1 and No.2 Units of the Jandar Power Plant (C/C 300 MW × 2 units) are already in operation with the remaining units to be commissioned by the end of 1995. Furthermore, construction agreements for the Aleppo Thermal Power Plant (ST 200 MW × 5 units) and Tishreen Hydropower Plant (HT 100 MW × 6 units) have been concluded with a Japanese and Chinese contractor respectively, and these plants have now moved to the actual construction stage. In the case of the Al-Zara Thermal Power Plant, negotiations to secure a Japanese loan are progressing.

Fig. 3.6.1-1 shows the organizational structure of the MOE, the competent ministry for the power sector.

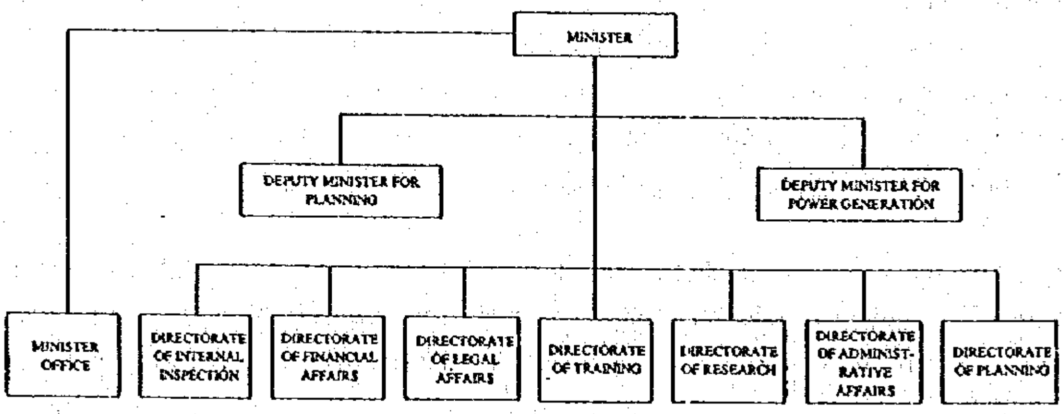


Fig. 3.6.1-1 Organizational Structure of Syrian Ministry of Electricity (MOE)

3.6.2 Organizations and Tasks of PEEGT

As explained earlier, the MOE delegates the actual power generation, transmission and distribution work to the PEEGT and PEDEEE. In fact, the Public Establishment of Electricity (PEE) was totally responsible for the practical operation of the power sector up until the end of July, 1994 when it was reorganized as the PEEGT and PEDEEE to radically rectify the situation in which power resources development to meet the increasing power demand was rather slow under the management of the PEE. At present, the restructuring of the local organizations has not yet been completed and some former PEE organizations are said to be still in operation.

The PEEGT is in charge of the planning and execution of power resources development, generation and transmission.(≧66KV). It employs some 250 people at the Head Office in Damascus and some 5,000 people at the various power plants. The Task Force Team comprising PEEGT staff is the counterpart for the present Study. The PEEGT is headed by the General Director who is assisted by 2 Deputy General Directors responsible for technical affairs and financial, legal and administrative affairs respectively. Each power plant is directly linked to the General Director. In the case of a technical problem, the Technical Department of the Head Office provides the plant management with appropriate advice. The Deputy General Director for Technical Issues supervises 9 departments while the Deputy General Director for Financial, Legal and Administrative Affairs supervises 7 departments. Fig. 3.6.2-1 shows the PEEGT's organizational structure.

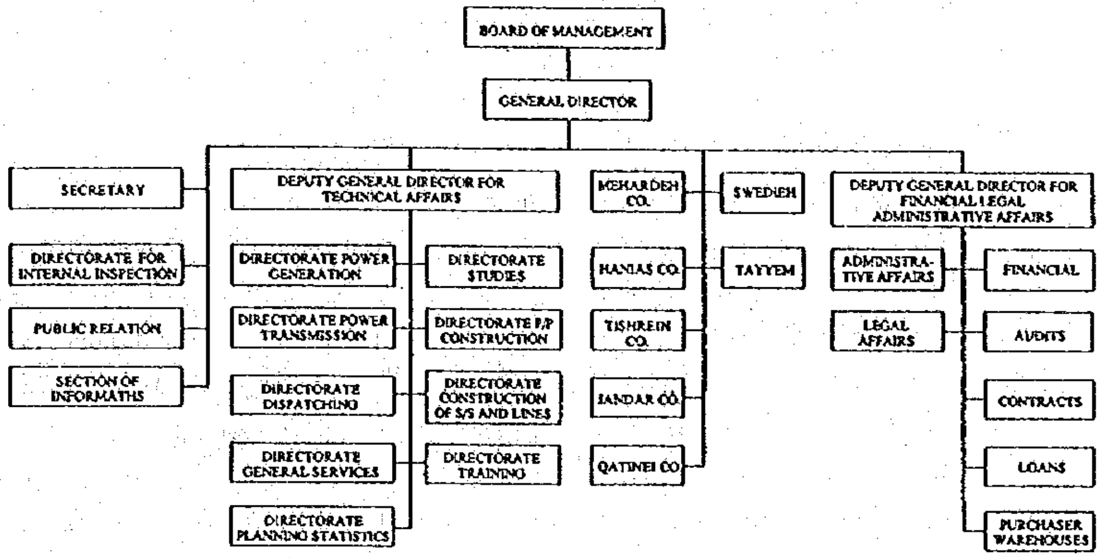


Fig. 3.6.2-1 Organizational Structure of PEEGT

3.6.3 Recommendations

(1) Operation and Maintenance Budget

While the power sector in Syria is run by the state, the collected electricity charges go to the Treasury. The MOE is operated on a budget, including a foreign currency portion, appropriated by the Ministry of Finance. This arrangement appears to strain the operation and maintenance budgets of the power plants to the point that some plants find it difficult to purchase the necessary spare parts. Although the immediate privatisation of the power sector in Syria appears impossible under the present circumstances, more freedom and independence should be granted to the power sector in that the necessary budget for the operation and maintenance of power facilities should be freely appropriated from the collected electricity charges with the approval of the central government.

(2) Electricity Charges

The electricity charges in Syria are revised every 1 - 3 years and present tariff shown in Table 3.6.3-1. The charge level is fairly low and it appears impossible to recover investment in the power sector through the electricity charges alone. As electricity is an essential commodity for national life, the charge level should not be too high in order to protect low income earners. Nevertheless, a sensible charge level is required to ensure reasonable revenues to cover the operation and maintenance cost as well as the cost of investment in new facilities. Without a sensible charge level, development of the power sector is not feasible. Although under the present charge system, large users pay a higher charge than low income earners, the charge level for large users, including state-run enterprises, should further be reviewed to raise in an appropriate manner.

(3) Collaboration of PEEGT Head Office and Power Plants

Although efforts were made to gather as much information as possible on the operation and trouble records of the power plants, the information obtained was not sufficient. In addition to strengthening the regular monitoring and inspections and providing adequate operation and maintenance records, the management of each power plant must regularly submit such records to the Head Office.Through these records, the Head Office can properly understand the generation performance and conditions of troubles, etc. at each power plant and use such knowledge to prepare personnel assignment, repair, expansion and budgetary appropriation plans. This can also be linked to the construction plan for new power plants based on future demand forecast data.

(4) Personnel Plan for Power Plants

The number of people assigned to each power plant appears to be fairly large. Compared to a Japanese power plant of a similar scale, the manpower level at a Syrian power plant is 3 - 4 times large (although simple comparison ignoring the fact that Japanese power plants today are fully automated).

The technical level of staff working at Syrian power plants is not satisfactory as described later in Chapter 5. It is said that young workers with good skills tend to move to private companies or work abroad for higher pay. This tendency is shown by the fact that the average age of the present operation and maintenance staff of the Katteneh Power Plant is 55 years. Consolidation of the training function of power sector is extremely necessary in order to improve the general technical level of staff through the fostering of young staff as well as re-training of existing staff. In addition, the working conditions, including wage level for technicians/engineers who have completed education and training, should be improved to make working at a power plant attractive for young technicians/engineers. If the number of highly capable technicians/ engineers working at power plants increases due to higher wages etc., the total number of staff members can actually be reduced to pay for the improved wages.

Table 3.6.3-1 Electricity Charges in Syria (as of December, 1993)

1. Consumption at 230 KV Level	
1.1 Average	75 Syrian Piasters/KWh
1.2 During Peak Load	95
1.3 During Day Time	75
1.4 During Night Time	65
2. Consumption at 66 KV Level	
2.1 Average	80 Syrian Piasters/KWh
2.2 During Peak Load	100
2.3 During Day Time	80
2.4 During Night Time	70
3. Consumption at 20 KV Level	
3.1 Average	90 Syrian Piasters/KWh
3.2 During Peak Load	105
3.3 During Day Time	90
3.4 During Night Time	80
4. Consumption at 20/0.4 KV for Agriculture, Irrigation and Drinking Water Pumping Station of Public Sector	
4.1 Average	80 Syrian Piasters/KWh
4.2 During Peak Load	100
4.3 During Day Time	80
4.4 During Night Time	70
5. Consumption at 20/0.4 KV for Commercial Purposes	
5.1 Average	125 Syrian Piasters/KWh
5.2 During Peak Load	175
5.3 During Day Time	125
5.4 During Night Time	100
6. Consumption at 20/0.4 KV for Industrial and Rest Purposes Other than 4 and 5 above	
6.1 Average	120 Syrian Piasters/KWh
6.2 During Peak Load	160
6.3 During Day Time	120
6.4 During Night Time	100
7. Consumption at 0.4 KV Level for Commercial Use	150 Syrian Piasters/KWh
8. Consumption at 0.4 KV Level for Public Sector Entities	75 Syrian Piasters/KWh
9. Consumption at 0.4 KV Level for Artisans Use and Other Purposes	140 Syrian Piasters/KWh
10. Consumption at 0.4 KV Level for Street Lighting	75 Syrian Piasters/KWh
11. Consumption at 0.4 KV Level for Domestic Use (according to total consumption in different strips)	
0 - 50 KWh/month	25 Syrian Piasters/KWh
51 - 100 KWh/month	35 Syrian Piasters/KWh
101 - 200 KWh/month	50 Syrian Piasters/KWh
201 - 300 KWh/month	75 Syrian Piasters/KWh
More than 300 KWh/month	150 Syrian Piasters/KWh

Source: PEEGT

CHAPTER 4

POWER PLANTS REHABILITATION PLAN

CHAPTER 4 POWER PLANTS REHABILITATION PLAN

4.1 Power Plants Rehabilitation Plan Preconditions

4.1.1 Current Conditions of Existing Power Plants

(1) Thermal Power Plants

During the First Field Survey period, the Study Team investigated the following thermal power plants in accordance with the results of consultations with the Government of Syria.

- Tishreen Power Plant
  Units No.1 and No.2
- Katteneh Power Plant
  Units No.3, No.4, No.5 and No.6
- Mehardeh Power Plant
  Units No.1, No.2, No.3 and No.4
- Banias Power Plant
  Units No.1, No.2, No.3 and No.4
- Hameh Power Plant (Operated and Controlled by PEDEEE)
  Units No.1, No.2 and No.3

Of the above power plants, the Tishreen Power Plant is quite new with Unit No.1 and Unit No.2 being commissioned in February, 1993 and April, 1994 respectively and both units are maintaining their rated output of 200 MW as of November 5th, 1994. The steam conditions of the boilers are also as designed, indicating that they are in good operating condition. In view of the satisfactory state of operation, it has been decided that the Tishreen Power Plant be excluded from the list of subject power plants for rehabilitation. The existing facilities of the Tishreen Power Plant are outlined below.

Current Conditions of Tishreen Power Plant

Equipment Capacity

Steam Generation Plant	:	200 MW × 2 sets
Gas Turbine	:	100 MW × 2 sets (design capacity: 128 MW × 2)
Type of Boiler	:	Natural circulation
Boiler Output Conditions		
Super Heat Outlet		
Steam Temperature	:	540°C +5, −10
Steam Pressure	:	125 Bar
Reheater Outlet		
Steam Temperature	:	540°C +5, −10
Steam Temperature	:	25 Bar
Steam Flow Rate	:	660 tons/hr at 200 MW
	:	590 tons/hr at 180 MW
Feed Water Temperature	:	247°C at 200 MW
Fuel : Unit No.1	:	HFO
Unit No.2	:	HFO, NG
Gas Turbine	:	NG/Distillate oil
Condenser Cooling Water	:	Air cooling tower system
Draft System	:	Balanced draft system (with FDF, IDF, GRF)
Type of Air Heater	:	Regenerative air heater
Unit Control/Operation	:	Remote manual operation system for boiler, turbine, generator and auxiliary Automatic operation system for cooling tower
Make Up Water Treatment	:	
Type	:	Anion, Cation and Mixed bed demineralizer, Reverse Osmosis Equipment for pre-water treatment
Capacity	:	60 m^3/hr × 2 sets
Water Quality	:	Operating performance – 0.2 μs/cm SiO_2 – 0.02 ppm expected
Auxiliary Boiler for Start Up	:	50 tons/hr × 1

Note: HFO = Heavy fuel oil
NG = Natural gas

1) Current Conditions of Katteneh Power Plant

Current conditions of the Katteneh Power Plant is shown in Fig. 4.1.1-1. As of November 6th, 1994, the Katteneh Power Plant has 4 generation units (No.3 ~ No.6) but all units were not running. (Unit No.1 and Unit No.2 had been dismantled.) The cause of the standstill was overhauling and maintenance, in the case Unit No.3 and Unit No.5 and reserve shut-down in the case of Unit No.4 and Unit No.6 which could be re-started if so requested by the National Control Centre (NCC).

Table 4.1.1-1 Current Conditions of Existing Power Plant
Name of Power Plant: Katteneh Power Plant

Unit No.	Capacity (MW)			Year Commis-sioned	Years Since Start of Operation	Total Operating Hours	Number of Start-Up	Fuel	Thermal Efficiency %		Manufacturer	
	Installed	Rating	Max. Available						Guarantee Performance	Performance in 1993	Boiler	Turbine
3	30		0	1969	25	98,296		HFO	29.5	22.3	Czecho-Slovakia Skoda/ First Brno	Skoda
4	30		12	1969	25	60,000		HFO	29.5	22.4	"	
5	30		0	1970	24	89,580		HFO	29.5	22.8	"	
6	64		50	Apr. 1981	13	88,824		HFO	32	24.1	SKODA /ABB	SKODA/ ABB

Note (1) Thermal Efficiency is Based on Low Calorific Value.
Note (2) Thermal Efficiency is of Net Efficiency (%).
Note (3) Maximum Available Capacity is as of Nov. '94.
Note (4) HFO: Heavy Fuel Oil.
Note (5) Thermal Efficiency Data Received from PEEGT.
Note (6) Maximum Available Capacities of Unit No.3 and Unit No.5 are 18 MW and 24 MW respectively as of Jun '95.

① The maximum available capacity as of November 6th, 1994 is zero for Unit No.3 and Unit No.5, and 12 MW for Unit No.4 and 50 MW for No.6.

The output decline of all the units is very obvious.

② Unit No.3, Unit No.4 and Unit No.5 have passed 24 - 25 years since their initial commissioning with total operating hours ranging from 60,000 to 98,296 hours (after restoration).

The fact that Unit No.6 is 13 years old with total operating hours of 88,824 hours indicates the relatively lengthy shut-down periods of Unit No.3, Unit No.4 and Unit No.5.

③ The thermal efficiency of each unit has much declined compared to the level of guaranteed performance.

④ The total operating hours are 98,296 hours for Unit No.3, 89,580 hours for Unit No.5 and 88,824 hours for Unit No.6, all of which are approaching 100,000 hours, at which the detailed inspection is normally required.

2) Current Conditions of Mehardeh Power Plant

Current operation data for the Mehardeh Power Plant are given in Table 4.1.1-2. As of November 7th, 1994, the operation of Unit No.1 was suspended due to oil leakage from the transformer for power station auxiliaries. Unit No.2 was in a state of reserve shut-down while Unit No.3 and Unit No.4 were operating with an output of 95 MW each according to the demand from N.C.C.

Table 4.1.1-2 Current Conditions of Existing Power Plant
Name of Power Plant: Mehardeh Power Plant

Unit No.	Capacity (MW)			Year Commissioned	Years Since Start of Operation	Total Operating Hours	Number of Start-Up	Fuel	Thermal Efficiency %		Manufacturer	
	Installed	Rating	Max. Available						Guarantee Performance	Performance in 1993	Boiler	Turbine
1	150	140	120	Apr. 1979	15	92,025	558	HFO. NG	37.5	28.9	(France) Stein Industrie	K.W.U
2	150	140	120	Dec. 1979	16	92,777	570	HFO. NG	37.5	31.2	"	"
3	165	160	160	Dec. 1988	6	41,794	336	HFO. NG	39.3	32.4	(Austria) SGP	BBC
4	165	160	160	Mar. 1989	5.5	47,341	320	HFO	39.4	32.4	"	"
GT	30			1987								

Note (1) Thermal Efficiency is Based on Low Calorific Value.
Note (2) Thermal Efficiency is of Net Efficiency (%).
Note (3) Maximum Available Capacity is as of Nov. '94.
Note (4) HFO: Heavy Fuel Oil, GT: Gas Trubine, NG: Natural Gas.
Note (5) Thermal Efficiency Data Received from PEEGT.

① An output decline is particularly noticeable in the case of Unit No.1 and Unit No.2 compared to Unit No.3 and Unit No.4.

② Unit No.1 shows a significant decline of the thermal efficiency compared to Unit No.2, Unit No.3 and Unit No.4.

③ Unit No.1 and Unit No.2 are 15 years old with total operating hours of 92,025 and 92,777 hours respectively, approaching 100,000 hours, at which the detailed inspection is normally required.

④ The actual power generation compared to the planned amount in 1993 for each unit is shown in the following table.

		Unit No.1	Unit No.2	Unit No.3	Unit No.4
Electric Power Generation (MWh)	① Actual ② Planned	462,430 690,336	713,740 855,984	918,600 1,112,706	846,985 1,098,583
	(①/②) × 100	67	83	83	77

The gap between the planned output and actual output is particularly large in the case of Unit No.1 which is assumed to come from unexpectedly long stoppage hours for the repair of a series of minor failures.

⑤ Unit No.3 and Unit No.4 showed relatively frequent stoppages compared to Unit No.1 and Unit No.2. It was explained by plant engineers that the Mehardeh Power Plant was experiencing a series of minor failures/troubles compared to other plants.

3) Current Conditions of Banias Power Plant

Current operation data for the Banias Power Plant as of November 9th, 1994 are given in Table 4.1.1-3 and the following points are particularly noted.

Table 4.1.1-3 Current Conditions of Existing Power Plant
Name of Power Plant: Banias Power Plant

Unit No.	Capacity (MW)			Year Commis-sioned	Years Since Start of Operation	Total Operating Hours	Number of Start-Up	Fuel	Thermal Efficiency %		Manufacturer	
	Installed	Rating	Max. Available						Guarantee Performance	Performance in 1993	Boiler	Turbine
1	170	170	147	Oct. 1982	12	82,503	315	HFO	40	31.6	(Italy) Ansaldo/Breda	(Italy) Ansaldo
2	170	170	85	Mar. 1983	11.5	78,223	433	HFO	40	30.0	"	"
3	170	170	150	Apr. 1989	5.5	44,250	107	HFO	41.6	37.9	(Japan) Mitsubishi	(Japan) Mitsubishi
4	170	170	150	Aug. 1989	5	42,858	72	HFO	42.0	38.6	"	"
GT	(F6) 35	35		1989	5							Japan Hitachi

Note (1) Thermal Efficiency is Based on Low Calorific Value.
Note (2) Thermal Efficiency is of Net Efficiency (%).
Note (3) Maximum Available Capacity is as of Nov. '94.
Note (4) HFO: Heavy Fuel Oil, GT: Gas Trubine, NG: Natural Gas.
Note (5) Thermal Efficiency Data Received from PEEGT.
Note (6) Maximum Available Capacity of Unit No.2 is 150 MW as of Jun '95.

① The operation of Unit No.2 was limited to a 50% load with a maximum available capacity of 85 KW because only one boiler feed water pump was available.

② The emergency gas turbine had been idle for 18 months, awaiting the supply of spare parts.

③ The main cause of the output decline of Unit No.1 and Unit No.2 is boiler trouble. Unit No.3 and Unit No.4 have been operating for 5 ~ 5.5 years and, apart from condenser tube failure, no serious damages leading to a major output decline have so far been reported.

④ Fortunately, the condenser tube failures of Unit No.3 and Unit No.4 have not resulted in failure of the boiler furnace wall tubes. The development of a serious failure could be prevented with the previous experience of the condenser tube failures of Unit No.1 and Unit No.2 leading to the infusion of seawater to the boiler feed water and boiler water, causing failure of the boiler furnace wall tubes. The successful prevention of a serious failure shows that those responsible for boiler operation and the chemical engineers at this plant have learned a good lesson from the previous incident and have applied that experience to similar incidents in subsequent years.

⑤ Some 2,350 condenser tubes of Unit No.3 have been replaced.

Some 2,000 condenser tubes of Unit No.4 have been replaced.

⑥ The condenser tubes of Unit No.1 and Unit No.2 are made of copper-nickel alloy while those of Unit No.3 and Unit No.4 are made of aluminium brass. According to the statement of the maintenance staff of this power station, the aluminium brass tubes appear to be more corrosive than the copper-nickel tubes used for Unit No.1 and Unit No.2.

⑦ The following table shows the number of start-ups of each unit in the last 5 years.

	1989	1990	1991	1992	1993
Unit No.1	28	17	31	23	24
Unit No.2	48	36	38	25	23
Unit No.3	20	9	9	15	11
Unit No.4	15	10	18	12	13

Unit No.1 and Unit No.2 experienced more start-ups than Unit No.3 and Unit No.4.

⑧ The decline of the thermal efficiency is more noticeable in the case of Unit No.1 and Unit No.2 than in the case of Unit No.3 and Unit No.4.

4) Current Conditions of Hameh Power Plant

Current operation data for the Hameh Power Plant is given in Table 4.1.1-4.

Table 4.1.1-4 Current Conditions of Existing Power Plant
Name of Power Plant: Hameh P.S.

Unit No.	Capacity (MW)			Year Commissioned	Years Since Start of Operation	Total Operating Hours	Number of Start-Up	Fuel	Thermal Efficiency %		Manufacturer	
	Installed	Rating	Max. Available						Guarantee Performance	Performance in 1993	Boiler	Turbine
1	5		Retired in '93	1956	38			HFO				Siemens
2	15		-	1973	21			HFO				BBC
3	15		5.5	1973	21			HFO				BBC

Note (1) Thermal Efficiency is Based on Low Calorific Value.
Note (2) Thermal Efficiency is of Net Efficiency (%).

① Unit No.1 and Unit No.2 were almost not used. Unit No.3 could be operated with an available capacity of 5.5 MW but it was under repair as of November 20th, 1994 due to tube failure.

② Super heater tube failures repeatedly occur every 3 - 4 months.

③ Most of the instruments in the control room and site panels were out of order, necessitating manual operation.

④ Like the boiler, the condenser had suffered from a series of problems.

⑤ No periodic inspection of the turbine under the supervision of the manufacturer had been taken place since the commencement of operation.

⑥ The plant engineers stated the following opinions:

- Unit No.1: the boiler and condenser required repair,
- Unit No.2: the boiler required repair; the condenser was in good working order,
- Unit No.3: boiler renewal was desired.

The plant engineers expected that the installation of a new boiler and periodic inspection of the turbine by engineers from the original manufacturer would recover the available capacity of Unit No.3 to some 13 MW.

⑦ Miscellaneous

- Spare parts : No specific problem existed although it appeared that hardly any spare parts had been used due to the lack of periodic inspections
- Boiler water : Untreated river water was used and waste water was discharged to the river
- Emergency power source : Diesel generator (600 - 700 KW)

Neither the MOE nor the PEEGT considers this plant to be a useful and important power generation facility. With the full-scale operation of the Jandar C/C and other new power plants in near future, the importance of existing small-scale power plants such as this will definitely decline. For other existing power plants, the proper periodic inspection and rehabilitation plans should be implemented before each unit is damaged to the situation of Hameh plant.

Given the deteriorated state of the facilities, the current conditions of the plant and its relatively meagre importance, it is difficult to justify its inclusion in the list of power plants to be rehabilitated.

(2) Gas Turbine Plants

There are 14 gas turbine generators installed at following locations;

- Damascus : 5 units
- Homs : 2 units
- Hama : 2 units
- Aleppo : 3 units
- Latakia : 2 units

The Study Team members inspected the Zamalka Power Plant , one of the 5 plants located in Damascus, on November 16th 1994. The Plant details are shown in Table 4.1.1-5.

Table 4.1.1-5 Current Conditions of Existing Power Plant
Name of Power Plant: Zamalka P.S.

Unit No.	Capacity (MW)			Year Commis-sioned	Years Since Start of Operation	Total Operating Hours	Number of Start-Up	Fuel	Thermal Efficiency %		Manufacturer	
	Installed	Rating	Max. Available						Guarantee Performance	Performance in 1993	Boiler	Turbine
GT	(F5) 24	20	17	1974	20	98,000	3,755	Distillate Oil		25		GEC Alsthom
						$\frac{98,000}{3,755}$ =26.1						

Note (1) Thermal Efficiency is Based on Low Calorific Value.
Note (2) Thermal Efficiency is of Net Efficiency (%).

① All the gas turbine plants are operated and controlled by PEDEEE and are currently in a state of reserve shut-down.

② The Zamalka Power Plant underwent dismantling 4 months ago and all the bucket nozzles were replaced.

4.1.2 Selection of Subject Power Plants for Rehabilitation and/or Renovation Study

(1) Selection Criteria

The following criteria were adopted to select the target power plants for rehabilitation and/or renovation under the this Study.

1) Selection Criteria Based on Equipment Conditions

- Deterioration of performance (output and efficiency)
- History of troubles and damages (records of troubles)
- Year of commissioning
- Total hours of operation
- Total number of starts and stops
- Recent operation status of main unit (in terms of vibration, noise and high temperature, etc.)
- Operating conditions of auxiliary equipment
- Storage conditions of spare parts and procurement problems
- Existence of manufacturer(s) of existing main equipment
- Maintenance of drawings (history of repairs)

2) Selection Criteria Based on Social and Environmental Conditions

- Importance of the plant (in terms of geographical area served and power grid efficiency)
- Generation capacity (number of beneficiaries in area served)
- Degree of pollution generation (smoke, oil and water, etc.)
- Fuel used
- Conditions of maintenance system and maintenance work in the plant (quality of staff and availability of maintenance materials and tools)

(2) Selected Power Plants for Rehabilitation and/or Renovation

Following consultations with the Government of Syria, those units of the power plants listed below were selected as the subjects for rehabilitation and/or renovation based on the First Field Survey using the selection criteria described in (1) above.

1) Katteneh Power Plant: Unit No.3, Unit No.4, Unit No.5 and Unit No.6

2) Mehardeh Power Plant: Unit No.1 and Unit No.2

3) Banias Power Plant: Unit No.1 and Unit No.2

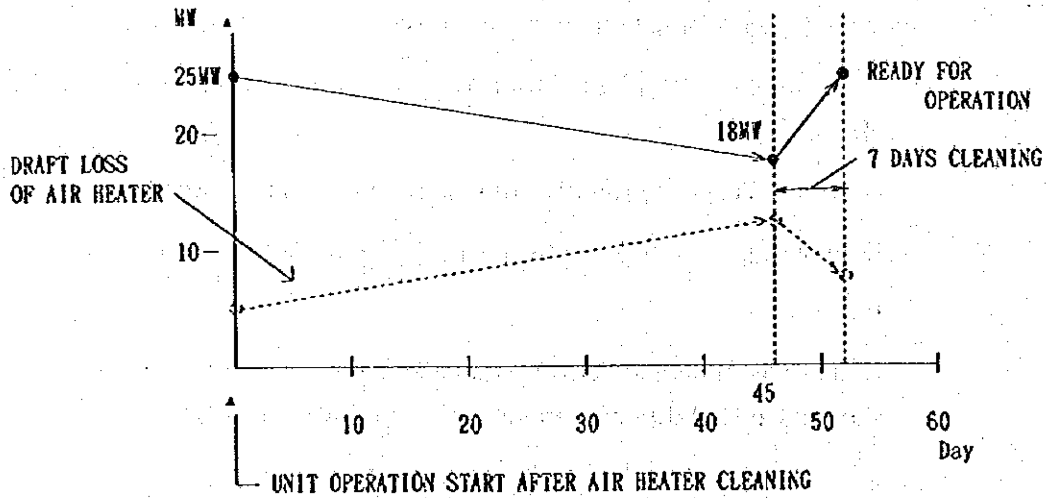
4.1.3 Current Conditions of Selected Power Plants and Their Problems

(1) Survey of Problems and Causes of Each Power Plant

1) Katteneh Power Plant

① Common problems of Unit No.3, Unit No.4 and Unit No.5 of the Katteneh Power Plant are the decline of boiler output and the decline of boiler thermal efficiency.

The main cause is failure to use the shot cleaning device (to remove soot from the boiler) for the last 10 years and it is now impossible to remove soot from the boiler during operation. The shot cleaning device has not been operated because the use of one m^3 shots led to recovery of only 0.5 m^3 of shots with the remaining shots blocking the gas passage in the air heater tubes. In other words, shot cleaning operation did not clean the boiler and worked against the boiler's continuous operation. Consequently, it was necessary for all units to stop boiler operation every one and a half months in order to conduct manual and water washing of the internal surface of the some 2,000 - 3,000 air heater tubes as well as some parts of the economisers. This is illustrated below.



Adoption of the above cleaning cycle means the stoppage of plant operation for some 49 days/year for this purpose alone. When draft loss of the gas passage of the air heater tubes increases to exceed the nominal capacity of the induced draft fan, it is necessary to reduce the quantity of air for burning in order to maintain a safe gas pressure inside the furnace. The reduced air quantity demands a fuel injection reduction to maintain the air-fuel balance, resulting in declined boiler output. This rather unbalanced operation creates a potentially dangerous situation by producing black smoke due to incomplete combustion. In addition, blockage of soot prevents the effective operation of the air heater tubes for heat exchange and the resulting insufficient heat recovery causes a decline of boiler efficiency.

As no replacement device has been installed to substitute the removed shot cleaning device, the heating surface of the primary super heater tubes and economiser tubes does not function properly due to accumulated soot, which causes the declined performance of the economiser and air heater causes increased draft loss.

② External corrosion of the economiser tubes of Unit No.3, Unit No.4 and Unit No.5.

As of November, 1994, Unit No.5 was underrepair and replacement of the economiser tubes. These tubes of Unit No.3 and Unit No.4 were replaced in 1993 and 1992 respectively because of their external corrosion.

It can be inferred that this corrosion is low temperature corrosion caused by the some 4% sulphur content of the fuel (HFO). The corrosion mechanism is that the soot, which is stuck to the tube surface during operation, absorbs moisture from the air when boiler operation is stopped, causing sulphate corrosion. According to Table 4.1.3-1, these units are more than 25 years old and the stoppage times of Unit No.3 and Unit No.5 are equivalent to 14 years each while that of Unit No.4 is equivalent to 18 years, providing ample opportunity for sulphate to cause low temperature corrosion. In short, corrosion occurred because the boiler was stopped for a long time without removing the soot stuck to the economiser tubes.

③ Unit No.6 of the Katteneh Power Plant, declined output and declined thermal efficiency.

③ -1 Unit No.6 is currently operating at an output level of 50 MW against the nominal capacity of 64 MW. The operator supplys the maximum possible quantity of combustion air to the boiler together with a fuel input just below the level that results in black smoke. The decline of the inflow of combustion air could have been caused by the following 2 reasons.

(a) Increased draft loss of the air flow system and gas flow system

(b) Leakage of combustion air to the outside of the system

A relatively important factor in the case of draft loss is air and gas draft loss of the rotating-type regenerative air heater (rotating air heater). The increased amount of soot sticking to the heating elements increases the draft loss and the soot becomes difficult to remove by steam blowing during system operation. Meanwhile, air leakage can occur in many places, including through cracks on the connecting parts of ducts.

However, air leakage from the rotating air heater is most harmful. Relatively high pressure air leaks to the gas side of lower pressure through gaps in the rotating section and also in the form of carry-over. The amount of air leakage is generally 5 - 15% but tends to increase in accordance with longer operating hours and a longer service period.

③ -2 The operation conditions of the condenser of Unit No.6 as of November 23rd and 24th, 1994 are as follows.

	November 23rd	November 24th
Load	46 MW	47 MW
Condenser Vacuum	− 85 KPa (≈ 637.5 mmHg)	− 90 KPa (≈ 675.1 mmHg)

④ Noticeable Problems of Unit No.3, Unit No.4 and Unit No.5

The total operation hours of Unit No.3, Unit No.4 and Unit No.5 from Table 4.1.3-1 are shown below. They have been in operation for 24 to 25 years.

Table 4.1.3-1 Operation Records of Unit Nos.3, 4 & 5

Unit No.	Total Operating Hours (A)	Years from Start of Operation (B)	Total Shut-Down Hours (C)	Operation (%) $\frac{(A)}{(B)\text{ hrs}} \times 100$
3	98,296	25 (219,000 hrs)	120,704 (13.8 years)	45
4	60,000	25 (219,000 hrs)	159,000 (18.2 years)	27
5	89,580	24 (210,240 hrs)	120,660 (13.8 years)	43

< Noticeable Problems >

(a) The total shut-down hours of each unit are longer than the total operating hours. Although shut-down can be either reserve shut-down or shut-down forced by unit failure, the findings of the First Field Survey indicate that shut-down forced by unit failure is the main cause of unit shut-down.

(b) No special anti-corrosion treatment is conducted during shut-down.

(c) In general, corrosion and cracks tend to occur more frequently in the case of those units which repeat start-up, stop and re-start than those which are in continuous operation.

⑤ One of the most common problems of all the units is the breakdown of instruments.

With all the units, the gas O_2 meter which is designed to control the state of combustion is out of order. (The situation is the same at Mehardeh and Banias Power Plants.) When the O_2 meter is out of order, the operators are obliged to adjust the air and fuel supplies to maintain a desirable state of combustion by visually observing the colour of the smoke in order to prevent incomplete combustion. The operators control the excess air ratio by observing the smoke colour from time to time to achieve a desirable state of combustion. One of the most common methods of improving boiler efficiency is boiler operation with a minimum excess air ratio which is practically impossible to conduct without an O_2 meter. Containment of the excess air ratio to the minimum level also leads to the use of less air and less fuel while reducing the dry gas loss from the boiler and system loss which in turn leads to improved output. The operators of Unit No.3, Unit No.4 and Unit No.5 state that all the instruments are old and unreliable and that their repair faces the problem of the non-availability of many parts.

2) Mehardeh Power Plant

① Declined output and thermal efficiency of Unit 1 and Unit 2.

As of November 21st, 1994, Unit No.1 and Unit No.2 had an output of 70 MW and 103 MW respectively. It was intended to use gas O_2 meters at the economiser outlets, i.e. air heater inlets, but that of Unit No.2 was out of order. Similarly, the gas temperature gauges at the air heat inlet and outlet were also out of order, making it impossible to control the state of combustion and the excess air ratio during operation. The only control of combustion was conducted by observing the colour of the smoke from the stack. The output meter (MW) of Unit No.1 was out of order together with the O_2 meter. Based on the actual fuel consumption, the said output of 70 MW was presumed to be around 100 MW. The operation conditions of Unit No.2 and Unit No.4 at the time of the First Field Survey are shown below.

Unit No.	Item	November 21st	November 22nd	Remarks
2	Output	103 MW	70 MW	
	Fuel Oil Consumption	36 m^3/hr	25.5 m^3/hr	
4	Output	80 MW	—	too high
	Fuel Oil Consumption	15 m^3/hr	—	too low

The above data suggest that it is necessary to check the accuracy of Unit No.4's oil flow meter. The gas O_2 meter and gas temperature gauges at the air heater inlet and outlet were all out of order in Unit No.3 and Unit No.4.

② Unit No.1 is currently operating with a lower boiler pressure due to the impossibility to control the steam flow system located at the turbine inlet. It is necessary to check over the performance data under low pressure operation with the original supplier of the boiler.

③ One likely cause of the output decline of Unit No.1 and Unit No.2 is the fairly high level of excess air. The fact that the FDF suction vane is 100% open under a 69% load (103 MW) suggests a large amount of air leakage. In short, the main causes of the declined output (available capacity of 120 MW for both Unit No.1 and Unit No.2) are the deteriorated performance of the condenser and substantial air leakage from the rotating air heater.

④ The deteriorated condenser performance is indicated by the degree of vacuum of 86% for 103 MW operation on November 21st and 89.9% for 70 MW operation on the following day. These are poor vacuum levels.

⑤ External visual inspection of the boiler and auxiliary equipment revealed serious gas leakage from the gas ducts. Gas leakage from the ducts of Unit No.1 linked to the rotating air heater appears to give some surface damages to Unit No.2.

3) Banias Power Plant

① The operation conditions of Unit No.1 and Unit No.2 of the Banias Power Plant as of November 20th, 1994 are described below.

①-1 The FDF suction vane of Unit No.1 was 85% open with an output of 100 MW. The colour of the smoke at the stack outlet was white and the gas O_2 meter was out of order, necessitating operators to determine the state of operation by observing the smoke colour as in the case of the Mehardeh Power Plant. This unit appeared to be operating with high level excess air, as opening of the suction valve by 85% with a 59% capacity output (100 MW ÷ 170 MW 100) indicates almost full capacity flow given the characteristics of suction vane operation.

①-2 The output of Unit No.2 was 85 MW with the FDF suction vane being 100% open. The smoke colour indicated a state of over excess air. The gas O2 meter was out of order as in the case of Unit No.1. A site check of indicators of the FDF suction vane showed that opening of the A-side FDF was approximately 75%, suggesting a malfunction of the panel display in the Control Centre. The control drive of the B-side FDF was not connected to the suction vane and, therefore, the degree of opening was unknown. As the control lever of the control vane was suspended by a chain block, it appeared possible to change the degree of opening, however, manual adjustment of the degree of opening was thought to be very difficult.

①-3 Operation data and problem areas for Unit No.1 and Unit No.2 as of November 10th, 1994 are described below.

(a) Operation Data

	Unit	No.1	No.2	Remarks
Output	MW	100	145	
Fuel Flow	tons/hr	28	40	
House Power Ratio	%	7	7	(estimate)
Net Thermal Efficiency	%	29.75 (28.15)	30.20 (28.57)	Syrian base (Japanese base)

Notes
1) The Syrian base uses a low calorific value (Kcal/kg) to show the calorific value of the fuel while the Japanese base uses a high calorific value (Kcal/kg) for the same purpose.
2) The thermal efficiency is much lower than the guarantee performance test results.

(b) The super heater steam temperature at an output of 145 MW was in line with the design performance value, but the reheater temperature of 520°C was slightly lower than the design temperature of 540°C.

(c) The combustion air flow indicator pointed to the same 210 against an output of 100 MW and 145 MW, suggesting an operation system under which the maximum quantity of air was fed with the manual supply of the necessary quantity of fuel to achieve the required output. Because the gas O_2 meter was out of order, the operators appeared to be trying to ensure safe operation with a state of high level excess air to prevent incomplete combustion. This state of high level excess air, however, has a negative impact on the efficiency of the boiler, and it increases the dry gas loss as well as draft loss, reducing the operation efficiency of the boiler. Operators controlled the state of combustion to maintain an almost constant output by setting up the number of burners in operation, airflow level and fuel supply level based on past experience as well as by observing the colour of the smoke at the stack outlet. There is a danger of blow-off of the burner flame due to over excess air when the output level is low. Extra care is required to prevent this. Stringent operation control may be required in the near future in compliance with new environmental regulations to be imposed on the contents of the exhaust gas at the stack outlet.

② The maximum available capacity of 147 MW of Unit No.1 dropped to 86.5% of the installed capacity of 170 MW, as was the case in Mehardeh Power Plant's Unit No.1 and Unit No.2 and Katteneh Power Plant's Unit No.6. The gas O_2 meter reading was examined during the field survey to check air leakage from the rotating air heater in order to determine the causes of the declined performance from the viewpoint of the combustion air quantity. At the guarantee test stage, the gas O_2 volumes at the air heater inlet and outlet of Unit No.2 were 0.5% and 2.8% respectively. The air heater leakage percentage at the time of commissioning against the inlet gas volume is calculated using the following simplified equation.

(a) Simplified Equation

$$\text{Leakage (\%)} = \frac{\%\,O_2\,\text{Outlet} - \%\,O_2\,\text{Inlet}}{21 - \%\,O_2\,\text{Outlet}} \times 90$$

(b) The actual air heater leakage for Unit No.2 using the above equation is as follows.

$$\text{Leakage (\%)} = \frac{2.8 - 0.5}{21 - 2.8} \times 90 = 11.37\%$$

While the above calculation result indicates air heater leakage of 11.37%, the actual air leakage of Unit No.2 is estimated to be 34.8% based on the actual gas O_2 meter reading at the air heater outlet of 7.3% in April, 1994* and the assumed O_2 ratio at the air heater inlet of 2%. In short, it appears certain that a significant amount of air leaks from the air heater. A similar level of air leakage is also estimated for Unit No.1. Gas O_2 meter readings in April 1994* at the air heater outlet were 4.9% for Unit 3 and 4.5% for Unit 4 respectively. (*: levels measured by EKONO ENERGY Ltd.)

The air leakage for Unit 3 is estimated below.

- air heater inlet O_2 : 1.1 ~ 2.0% (assumed)
- air heater outlet O_2 : 4.9%

$$\text{Leakage (\%)} = \frac{4.9 - (1.1 \sim 2.0)}{21 - 4.9} \times 90 = 16.2 \sim 21.2\%$$

At the time of commissioning, the air leakage ratio of Unit No.3 was 5.8%, and this has now increased to 16.2 ~ 21.2%.

③ Operation data for the condenser as of November 20th, 1994 are as follows and imply that the condenser is in good working condition.

	Unit No.1	Unit No.2	(Unit No.4)
Output (MW)	100	85	(70)
Vacuum (mmHg)	720	730	(723)

(2) Common Causes for output and thermal efficiency decline

Common causes for declined output and thermal efficiency in the units in Syrian power plants are summarized in the following Fig. 4.2.1-1, concentrating on the boiler which has the direct connection to this problem.

At those Syrian power plants visited by the First Field Survey Team, the gas O_2 meter, the most important instrument for combustion and excess air control, was out of order at every unit except Unit No.1 in Mehardeh Power Plant. Moreover, most of the exhaust gas temperature gauges which instantly show the state of the boiler's thermal efficiency were out of order, making it impossible to judge whether or not the air heater responsible for the ultimate recovery of heat was properly functioning. Given the state of the instruments at these power plants, it is almost impossible to identify the exact problems of each unit. A special attention should be given to restoring the reliability of the operation control equipment and systems as described in the next chapter.

Many of the components of the power plant rehabilitation proposals described below are based on the past experience of the study team experts as necessary data was unavailable at the subject power plants. It is again almost impossible to quantitatively indicate the effects of the rehabilitation proposals even if the proposals are implemented in full.

The basic starting point to redress the output decline of a power plant is to secure a sufficient quantity of combustion air. If the performance level of the FD fan has not deteriorated, the output decline is caused by either air leakage to the stack via the air heater or by a decline of the air flow capacity due to large system loss. It is often the case that draft loss at the economiser and/or air heater has become large. The appropriate remedial measure involves soot blowing during operation, or water washing of the air heater by unit shut down in order to restore the original function of the air heater, and to completely prevent air leakage from the ducts. With the implementation of such a measure, it is possible to improve the output by means of controlling the fuel air ratio by the gas O_2 meter.

(3) Cooling Water Analysis

Environmental protection measures will be incorporated where possible in the planning of the rehabilitation plan for the selected power plants. Prior to any other area, the boiler and condenser require urgent rehabilitation. The chemical analysis of the boiler water is being conducted at all the power plants. The check items are similar to the standard check items employed in Japan (JIS B 8223, etc.) and, therefore, it appears that the check results can be trusted.

In contrast, quality analysis of the condenser cooling water is inadequate at all the power plants, resulting in damage to the condenser tubes. (More than 2,000 tubes of Unit No.3 had to be replaced recently at the Banias Power Plant.) During the second field survey period, quality analysis of the cooling water was conducted to obtain the data which are essential to prepare a rehabilitation plan and to help determining the desirable material for the condenser tubes. The selected power plants for rehabilitation currently use the following types of water for cooling purposes.

① Banias Power Plant : seawater (from the Mediterranean Sea)

② Mehardeh Power Plant : river water and lake water

③ Katteneh Power Plant : lake water

The views of the Study Team on the corrosion in the condenser tubes at each power plant based upon the findings of the cooling water analysis performed during the Second Field Survey are as follows.

1) Banias Power Plant

Banias Power Plant uses sea water for its condenser cooling water, and the results of the analysis performed on the sea water do not show any characteristic properties. However, there is much corrosion of the condenser tubes in Unit No.3 and Unit No.4, and more than 2,000 such tubes have been replaced.

The condenser tubes in Unit No.3 and Unit No.4 are made of aluminum brass, and according to the plant's maintenance staff, the rate of corrosion in these tubes is much faster compared to that in the condenser tubes of Unit No.1 and Unit No.2 which are made of copper-nickel alloy. The plant staff considered that the cause of this faster rate of corrosion was due to aluminum brass being less resistant to sea water than copper-nickel alloy, however, data obtained by the Study Team in the course of the Field Survey shows that the real cause of corrosion in the condenser tubes in Unit No.3 and Unit No.4 lies in the fact that the sea water, concentrated water and solids, were allowed to accumulate at the tube bottoms when the unit operation was suspended for a long period (1-2 months) in the initial operation test stage. It is thought that this caused the corrosion to occur consecutively in a lengthwise direction at the bottom of the tubes, from where it has continuously developed. That is to say that, if the sea water inside the condenser tubes had been blown out and the tubes kept dry during the long-term system operation suspension, the corrosion at the bottom of the tubes and lengthways spread of the corrosion from there would not have occurred.

Countermeasures for the prevention of corrosion inside the condenser tubes well involve the laying of tubes at a gradient to make them drainable or the implementation of corrosion countermeasures (cleaning and blowing) at times of suspended operation.

In addition, in cases of short term suspension of operation, the continued circulation of sea water is also a possible measure for the countering of corrosion.

2) Mehardeh Power Plant

Mehardeh Power Plant uses river water obtained from a reservoir dam built on a nearby river for its condenser cooling water. The reservoir water is dark in color, indicating the effects of pollution (industrial and domestic waste waters) from the river's upper reaches beyond the dam. Measurements showed the levels of conductivity (CND) and hardness (Ca^{++}, Mg^{++}) to be higher than in normal river water. The measurements also showed a high level of ion phosphate (PO_4^{3-}), which causes eutrophication. Readings for this in clean river water are 0.1 mg/ℓ or less.

Judging from the low DO value (dissolved oxygen concentration), it is guessed that there is a large consumption of oxygen by biological plankton (animal and plant) between the intake and the cooling tank (roughly 1 km).

The deterioration in the condenser performance is thought to be caused by the attachment of $CaCO_3$ to the condenser inner surfaces and its subsequent poor cooling effect, judging from the relatively high levels of hard substances (Ca, Mg) and high conductivity of the cooling water. The flow of polluted water from the upper reaches of the river, which provides the plant's cooling water, is expected to continue deteriorating, and the future improvement of cooling water quality cannot be hoped for. It is therefore considered that the only way to preserve the condenser performance levels will be to maintain the condenser vacuum by performing periodic and proper cleaning of the tube interiors, with one side of the condenser shut down during operation, if necessary.

3) Katteneh Power Plant

Katteneh Power Plant obtains its cooling water from Buhhayrat Qatiina (Lake Katteneh), which lies next to the plant. Water from the lake is first screened of floating solids and then directly fed to the condenser as cooling water. The distance between the intake and the condenser is about 50 m.

The lake water was found to be brown in color and minute suspended substances were observed. The water contains much biological plankton, and measurements made by the plant staff indicated high levels of organic matter and SO4 at 2.6 mg/ℓ and 27 mg/ℓ respectively.

In recent years, the advance of water pollution has been slowed down due to the imposition of laws and regulations on the discharge of industrial waste water. However, large incoming quantities of domestic waste water have made little progress in actual lake water purification.

The measurements made for the lake water and tap water are indicated in Table 4.1.3-2. The DO value in each is close to the saturated value against water temperature, and this means that improvement of condenser cooling water quality is necessary and that consideration should be given to countermeasures such as the construction of a sedimentation pond.

Table 4.1.3-2 Cooling Water Analysis Findings

Item	Banias Sample (Jan/21)		Mehardeh Sample (Jan/23)			Katteneh Sample (Jan/25)			
	Sea Water		River Water	Cooling Water		Cooling Water			Lake Water
	Measurements taken by Survey Team	Measurements taken by power plant	Measurements taken by Survey Team	Measurements taken by Survey Team	Measurements taken by power plant	Measurements taken by Survey Team	Measurements taken by power plant		Measurements taken by Survey Team
							'95 Jan./19	'94 Nov/23	
1. pH (°C)	8.23 5.0°C	8.32 17.5°C	7.43 9.9°C	8.53 15.5°C	8.8	8.80 7.0°C			
2. Conductivity μs/cm	7,570	7,700	730	862	842	345			
3. $CaCO_3$ mg/ℓ (Ca^{2+})	1,220 (488)	1,373 (550)	200 (80.1)	226 (90.5)	180 ( )	110 (44.1)	2.8 mv/l	7.5 mv/l	
4. (as $CaCO_3$) $MgCO_3$ mg/ℓ (Mg^{2+})	(5130) 5163 (1489)	(5550) 4673 (1347)	(59) 49.7 (14.3)	(105) 91.0 (26.2)	(120)	(85) 54.61 (15.8)			
5. Cl^- mgℓ		12.8‰					17.5		
6. SO_4^{--} mg/ℓ								27	
7. S^{--} Or H_2S mg/ℓ									
8. NH_4^+ mg/ℓ							0.8	1.9	
9. NO_2^- mg/ℓ									
10. NO_3^- mg/ℓ									
11. DO mg/ℓ	10.9 8.0°C		0.7 9.9°C	10.1 15.5°C		13.1 8.8°C			13.1 9.8°C
12. COF mg/ℓ								2.6	
13. Acid consumption (pH 4.8) [MRG]			217 (2.17)	237 (2.37)		174 (1.74)	M 3.2	M 2.9	
14. SIO_2^- mg/ℓ	0.196		11.5	13.2		2.8	2.5	>2.5	
15. PO_4^{3-} mg/ℓ			3.00	3.80		0.06			

4.2 Power Plant Rehabilitation Proposals

4.2.1 Common Subjects for Rehabilitation

(1) Common Subjects for Selected Power Generation Plants

Prior to presenting a rehabilitation proposal for each selected power plant, description of the basic problems faced by Syrian power plants, using the current conditions of Japanese power plants as a base, shall be made.

The common problems of the units of Syrian power plants are decline of the generation output and decline of the net thermal efficiency due to ageing. In Japan, regardless of the operating hours, the approved output (by MITI) of each unit confirmed by the performance test at the time of commissioning does not fall in subsequent years. This is because, as part of the periodic inspection and maintenance requiring 1.5 - 2 months each year, the confirmation test of the maximum approved output is conducted to confirm the availability of the maximum output which was approved the previous year. Only after confirmation of the availability of the maximum output does commercial operation of the unit in question resume. The net thermal efficiency does not significantly decline although it does fluctuate in accordance with changes of the fuel properties. Such stability is ensured by continuous efforts to anticipate possible problems on the basis of measured data and to solve/deal with potential problems to achieve highly efficient operation. It is, therefore, quite rare for any instrument to be out of order.

The common subjects for power generation plants in Syria are as follows.

1) Maintaining continuous output was treated as the highest priority issue at each of the power plants and units, and this meant that the repair of minor defects such as gas leakage was reluctantly postponed in deference to the continuation of operations.

   As a result of this, it is inferred that the minor defects were allowed to grow and eventually lead to major damage. For example, gas leaks would cause the corrosion of site instrumentation, transmitters, wiring and insulation cover plates.

2) Each of the units selected for rehabilitation and/or renovation has, until now, undergone overhaul involving the prior ordering and arrangement of materials and work. At Mehardeh Power Plant, for example, renewal work on the reheater, which had suffered damage from high temperature corrosion from the effects of vanadium, required the shut down of Unit No.1 and Unit No.2 for roughly seven weeks.

This indicates that necessary repair work has been conducted only when it has become necessary.

However, mere partial repair work has not led to the overall improvement or recovery of performance because sufficient maintenance work has not been carried out on other areas. Unless many defects which have occurred during operation are repaired simultaneously during the same shut down period, it will not be possible to restore declined output and thermal efficiency to original levels.

3) The problem that is common to most of the power plants is that the cleaning has not been carried out for long period.

The fuel for the boiler, HFO, is a so-called low quality oil containing 4% sulfur, and if its soot is allowed to stick to tubes, it will cause tube corrosion. In cases where a long term shut down is forecast, it is first of all necessary to clean low temperature gas flow sections, i.e. economizers and air heaters.

4) Table 4.2.1-1 indicates the overhaul work involving long term shut down that has been conducted by each power palnt, however, this overhaul work differs from the general overhaul being proposed in this Report. It appears to have been directed at the repair of areas which have been damaged through troubles. It was informed that these overhaul works have been conducted under the guidance of the original suppliers with the prior purchase of parts and materials.

Table 4.2.1-1 PEEGT Examples of Implemented Overhaul Works which have Entailed Long Term Suspension of Operation

No.	Power Plant	Unit No.	Type of Overhaul	Implementation Period
①	Mehardeh P.S.	Unit No.2	Replacement of boiler reheater	April 3rd - May 23rd, 1986
②	Mehardeh P.S.	Unit No.1	Replacement of boiler reheater	September 2nd - October 19th, 1989
③	Mehardeh P.S.	Unit No.2	General overhaul of turbine and generator	November 8th, 1992 - January 22nd, 1993
④	Katteneh P.S.	Unit No.6	General overhaul of boiler and turbine	March 1st - May 31st, 1993
⑤	Banias P.S.	Unit No.2	General overhaul of turbine and generator	March 14th - August 30th, 1993
⑥	Katteneh P.S.	Unit No.6	General overhaul of generator and excitor	April 26th - July 23rd, 1994

Note 1) The replacement of the high temperature reheater in Unit No.1 and Unit No.2 at Mehardeh Power Plant is recorded as a typical case of reheater tube consecutive failure resulting from high temperature corrosion caused by Vanadium of HFO ash.
It is said that on this occasion, the wearing down of tube thickness from 6 mm to 2 mm resulted the failure.

2) In Banias Power Plant Unit No.1, an 800 m length of furnace tube and the first floor burner were replaced in 1993. In Unit No.2, the replacement of the first floor burner was made in 1994 and about 1,650 m length of furnace rear and side wall tubes were replaced in 1993.

5) Management and Control Conditions at the Power Plants

In 1994 at Banias Power Plant, a system was introduced whereby defects are picked up using work request cards and confirmed in meetings of related department members, following which the ordering and arrangement of materials and work is carried out and the relevant data is compiled into computer for use as reference in future work budget making and control. Judging from this, it can be expected that a basis for preventive maintenance is gradually being established.

At Mehardeh Power Plant, the work order format is used, though data processing by computer is not introduced yet, and it is hoped that the plant control situation will move in the same direction as that at Banias Power Plant.

(2) Common Items in the Rehabilitation and/or Renovation Proposals for Selected Power Plants

1) Countermeasures for Defect Potential

Fig. 4.2.1-1 indicates potential defects and countermeasures against them. It can be seen that many of these involve cleaning and the renewal of deteriorated parts and/or portions.

Good effects from these measures can be expected provided that within the general overhaul period, cleaning is performed carefully and the required materials are prepared in advance, and also provided that according to type of device or necessity, the work is surely performed while receiving confirmation from original supplier supervisors and specialists. The Rehabilitation Proposals recommend that detailed inspections be carried out especially on boiler pressure retaining parts, which are capable of causing critical damage to units. This is because the long periods required in procuring and processing the necessary materials make it necessary to make arrangements for renewal before actual failure occurs.

2) Common Items for Electrical Equipment and Instrumentation

① Basic Concept for Study

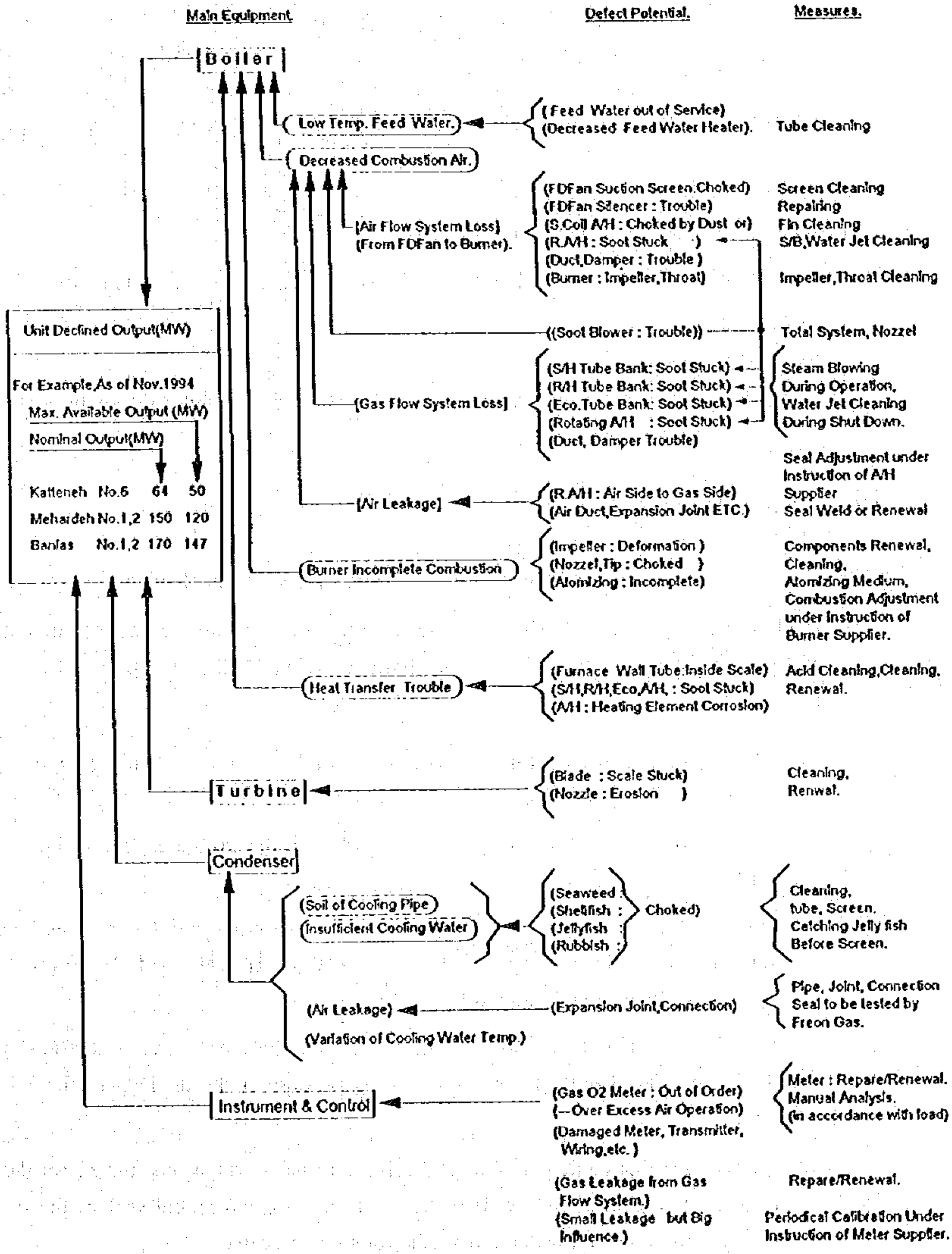
In principle, the idea of rehabilitation is not appropriate for electrical items and instruments for the following reasons.

- Heavy electrical equipment (generators and transformers, etc.) is highly efficient equipment which does not incur substantial deterioration of performance (except damages due to accidents, etc.)
- The performance deterioration of circuit breakers or instruments means that they immediately become useless, requiring replacement of the parts or replacement of the equipment itself.

Consequently, it has been decided that replacement/remodelling proposals will be made for aged electrical equipment and systems from the viewpoint of easy, safe and reliable handling/operation, while rehabilitation proposals will be made for boilers and turbines to reverse the derating of the power plants.

FIG. 4.2.1-1

Causes of Unit Declined Output,Declined Efficincy and Measures in HFO fired Unit.



② Common Renewal Proposals

The renewal proposals for each of the subject power plants are described in the following sections. However, it is a common fact at all the power plants that many instruments have been left unrepaired or have not been replaced, regardless of the need for safe and easy operation. Because of the importance of safe, easy and reliable operation, all the rehabilitation proposals for each power plant include the replacement of instruments (detectors, switches and indicators, etc.)

3) Basic Concepts of Rehabiltation Proposals

The Rehabilitation Proposals shall be concluded with the following basic items.

a) Cleaning
b) Detailed inspection
c) The simultaneous implementation of all defect countermeasures during the same shut down periods

4.2.2 Banias Power Plant

(1) Examination of Rehabilitation Plan for Unit No.1 and Unit No.2 (Mechanical)

1) Implementation of the following measures is proposed to restore the declined output and declined thermal efficiency of Unit No.1 and Unit No.2 of the Banias Power Plant.

① All operation control equipment which is currently out of order will be replaced or rehabilitated (refer to 4.2.2 (2) for further details).

② All instruments which are in serviceable order will be calibrated (refer to 4.2.2 (2) for further details).

③ The gas O_2 % at both the air heater inlet and outlet will be measured to determine the rate of air leakage from the rotating air heater and also to check the thermal efficiency of the boiler.

④ In the case of Unit No.2, priority will be given to the repair or rehabilitation of the temperature gauges to measure gas temperature at the air heater inlet and outlet.

⑤ Thorough maintenance and the replacement of parts will be conducted for the rotor post seals (hot and cold), radial seal and circumferential seal of the air heater to minimise air leakage from the rotating air heater.

⑥ In order to maximise the use of the heating surface of the rotating air heater, the units will be stopped for washing of the heating elements and recording of the corrosion loss. However, the renewal of heater elements is recommended, depending upon the results of the detailed inspection.

2) Detailed Inspection of All Parts of Unit No.1 and Unit No.2

Given the current total operating hours of Unit No.1 and Unit No.2, their total operating hours will exceed 100,000 hours in approximately 3 years time, necessitating the detailed inspection of all parts. The establishment of regions requiring inspection and the subject items for inspection is important to determine an appropriate inspection process. While the establishment of many regions and many subject items for inspection has better safety implications, it also means a high inspection cost and lengthy inspection process. A list of vulnerable regions (parts) should, in principle, be prepared using the past failure records of each unit and the list of detailed inspection items supplied by the original manufacturer of the unit in question prepared on the basis of failure statistics on similar generating units. As no power plant in Syria has detailed records of past unit failures, however, detailed inspection of the boiler turbine condenser after long total operating hours (100,000 hours) is proposed, upon obtaining a list of the subject inspection items from the unit manufacturer.

In order to make this possible, the work contract with the original supplier supervisor should include his participation in detailed inspection implementation from the inspection planning stage up to the confirmation of results and preparation of the actual renewal plan.

The detection of defects in boiler pressure retaining parts is relatively difficult. Therefore, the items and contents relating to these parts which should be included in the detailed inspection are proposed in Fig. 4.2.2-2 and 4.2.2-3 based upon the past experience of Study Team.

(2) Examination of Rehabilitation Plan for Unit No.1 and Unit No.2 (Electrical and Instrumentation)

1) Renewal of existing instrumentation system

The existing instrumentation system is based on the pneumatic mechanism and ageing of the system has resulted in such problems as air leakage and blockage by silica powder. Replacement of the entire system is more realistic than conducting piece-meal repairs to fundamentally solve all the problems. The electric system is the mainstay of power plant instrumentation systems today due to its easy operation and maintainability in addition to preventing the problems associated with the pneumatic mechanism. It is, therefore, proposed that the existing pneumatic system be replaced by the electric system for easy maintenance and repair as well as for the easy procurement of spare parts.

2) Replacement of instruments

Instruments should be replaced in accordance with the adoption of the electric instrumentation system described above, including those instruments of which the procurement of spare parts and readjustment are difficult or impossible due to the models being outdated.

(3) Proposal of Rehabilitation Plan for Unit No.1 and Unit No.2 (Mechanical)

1) Rehabilitation Master Time Schedule

Fig. 4.2.2-1 indicates the rehabilitation master time schedule. It is proposed that the rehabilitation program consist of plant shut down to allow first stage general overhaul, second stage general overhaul and following that, periodic overhauls on a continuous basis. The contents of each type of overhaul are indicated below.

<u>First Stage General Overhaul</u>

The proposed first stage general overhaul is of medium scale and is designed to identify all of the rehabilitation items to be simultaneously carried out in the second stage larger scale overhaul, which will be carried out 13 months later.

The first stage overhaul includes the following work.

① Detailed inspection planning (implementation plan)

② Detailed inspection implementation

③ Invitation of the original supplier supervisor or specialist to have guidance for the following rehabilitation items and to confirm results

No.	Item	Supervisor or Specialist
a.	Detailed inspection of boiler parts	S/V from original supplier
b.	Inspection of pressure parts	Specialist
c.	Burner/combustion adjustment	S/V from original supplier

d.	Rotating air heater (seal adjustment and confirmation of air leakage ratio)	S/V from original supplier
e.	Instrumentation and control (meter calibration, control adjustment)	S/V from original supplier
f.	Turbines	S/V from original supplier
g.	Condenser (cleaning, air leakage check)	S/V from original supplier
h.	Performance test for boiler, turbine and generator, total management, coordination work between B, T & G	S/V from original supplier

The fundamental roles or responsibilities of the above mentioned supervisor or specialist are the confirmation and implementation of the detailed inspection items for each area, compilation of the inspection report and preparation of the damaged components renewal plan.

④ Confirmation of general overhaul results through performance test

2) Second Stage General Overhaul

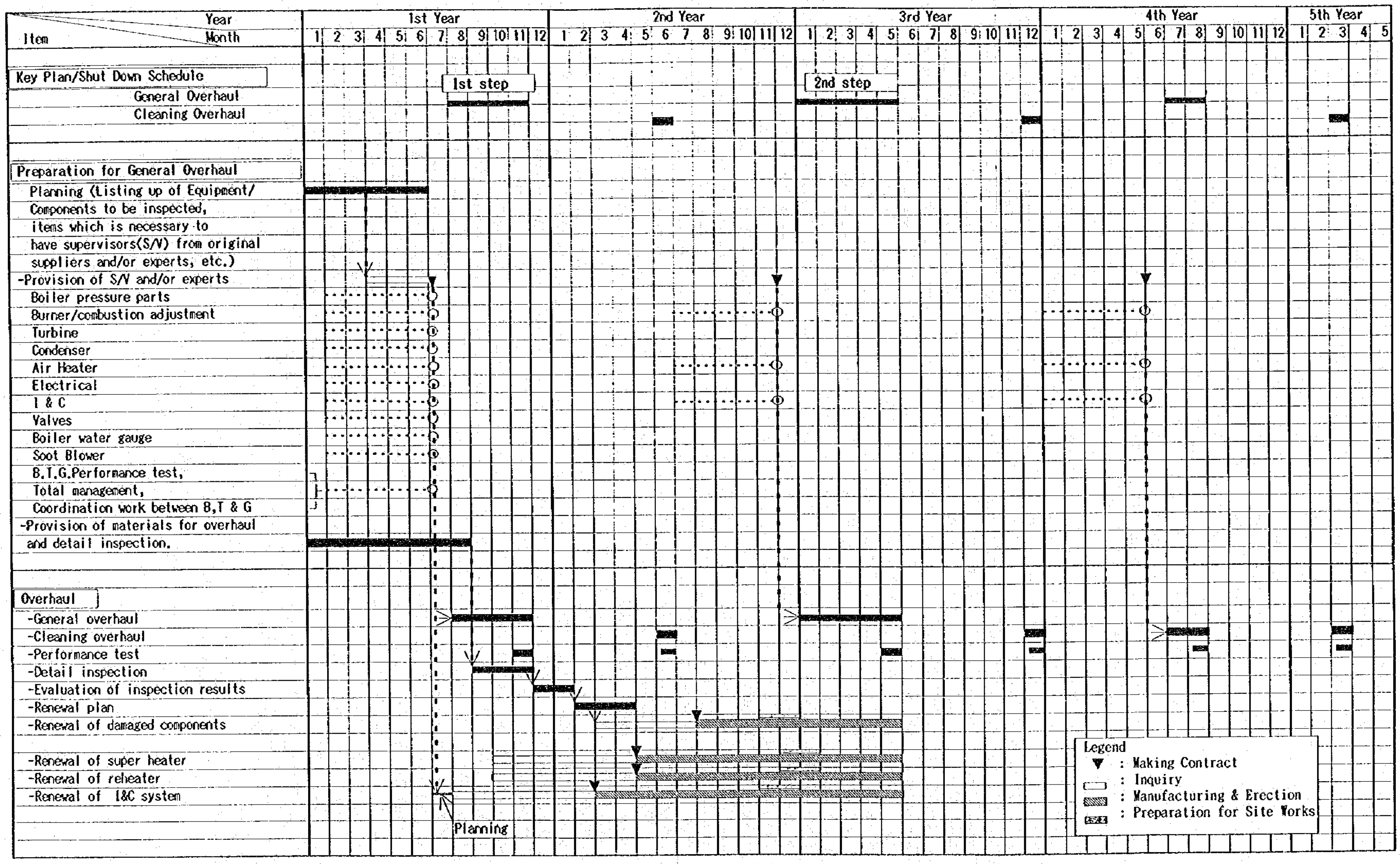
Based upon the results of the detailed inspection conducted as part of the first stage general overhaul and following the cleaning overhaul which will be implemented six months after that, the large scale second stage general overhaul will be implemented 13 months after the first stage general overhaul. This will involve the renewal of instruments and control equipment, repair of the reheater and superheater in high temperature zones, where damage is forecast to occur, and renewal work in other areas.

On the other hand, the rehabilitation of rotating auxiliary equipment such as boiler feed water pump, combustion air fans, HFO pumps, valves, casing and ducts etc. which are not stated in the rehabilitation master time schedule will have to be carried out beforhand in the first stage general overhaul. It is absolutely necessary to carry out complete repairs of all defects in the second stage general overhaul without any remainders.

3) Subsequent Periodic Overhauls

It is proposed that cleaning overhauls are implemented every six months following the general overhaul work. (As HFO is a low quality fuel, the cleaning frequency will need to be increased). Moreover, data on tube thicknesses shall be recorded in every second periodic overhaul and upon comparing these with the tube thickness

Fig.4.2.2-1 Rehabilitation Master Time Schedule for Unit Nos. 1&2 in Banias P.S.



data recorded during the detailed inspection, they will be used as reference data in deciding the scope of next rehabilitation work.

4) Detailed Inspection Target Items

① Fig. 4.2.2-2 (Inspection Items on Pressure Parts for Banias No.1 & 2) indicates the items chosen for detailed inspection based on the past experience of the Study Team members.

Regarding the detailed inspection work to be implemented in the first stage general overhaul, it is proposed that the views of the supervisors or specialists from the original supplier be taken into consideration.

② The same thing is proposed for the Other Proposed Items detailed in Fig. 4.2.2-3.

③ Moreover, Appendix-4 (Periodic Inspection Procedure for Boiler and Turbine) describes in detail the inspection items, work procedures, related items, and boiler and turbine and auxiliary equipment etc., and it is proposed to conduct the detailed inspection in accordance with this Appendix-5.

④ According to the report (*) presented on furnace tube failure in the Banias Power Plant No.2 boiler in the course of the Second Field Survey (January 12th to February 7th, 1995), the tube was cracked in a window shape due to the brittleness of the metal resulting from the effects of hydrogen, and the same report recommends that a complete examination be made on all tubes.

This type of failure is closely similar to hydrogen damage where large quantities of sea water enter the condenser, and are fed to the boiler and cause scale accumulated inside of boiler furnace tubes and eventually result in tube destruction.

In order to counter this problem, it is necessary to perform tests on all tube sections to detect micro fissures caused by hydrogen brittleness and renew the sections where micro fissures exist. (Inspection items are added to Fig. 4.2.2-2 for detection of Hydrogen Damage.)

(*) Report presented by the Industrial Testing & Research Institute on March 9th, 1993

FIG. 4.2.2-2

Inspection Items on Pressure Parts for Banias No. 1&2

Drum
(1) VI.
(2) PT Of Weld Parts (Drum Inside) ;
Weld Seam, Nozzle and Lugs.
(3) MT Of Weld Parts (Drum Outside) ; .
Selected Parts of Longitudinal Seam .
Nozzle..

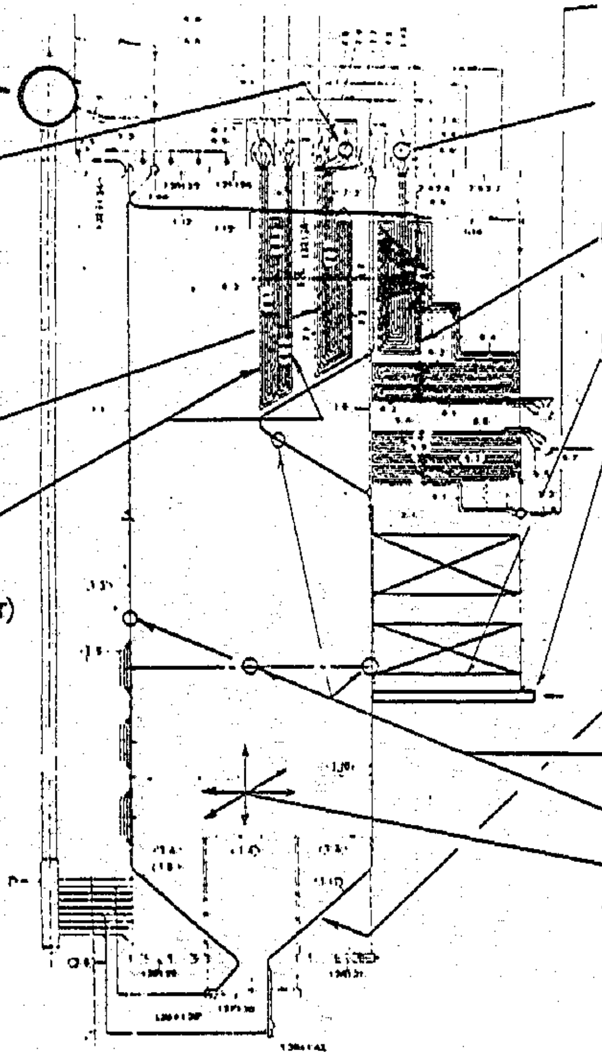
(SH-3) Outlet Header
(1) MT Of Weld Parts of Tube Stubs.
(2) MT Of Weld Parts of Drain Nozzle.
(3) ST Of Outside Surface of Welded Part of Outlet Nozzle.
(4) VI(Fiber-scope) Of Inside Surface of Outlet Nozzle.

Super Heater Tube (SH-3),— (7.1),(7.2),(7.3)
(1) Wall Thickness.(UT)
(2) MT Of Weld Parts of Lugs.
(3) Tube Sampling Investigation.

Super Heater Tube (SH-2),— (6.3:Element Front & Rear)
(1) Wall Thickness.(UT)
(2) MT Of Weld Parts of Lugs.

Main Steam Pipe
(1) MT Of Weld Parts of Support Lugs.
(2) VI(Fiber-scope) Of Internal Surface (for drain attack)

Hot Reheat Pipe
(1) MT Of Weld Parts of Support Lugs.
(2) VI(Fiber-scope) Of Internal Surface (for drain attack)



(SH-1) Inlet Header
(1) MT Of Weld Parts of Tube Stubs.
(2) MT Of Weld Parts of Drain Nozzle.

Reheater Outlet Header
(1) MT Of Weld Parts of Tube Stubs.
(2) MT Of Weld Parts of Drain Nozzle.
(3) ST Of Outside Surface of Welded Part of . Outlet Nozzle.

Reheater Tube (8.3),(8.4),(8.5)
(1) Wall Thickness.(UT)
(2) MT Of Weld Parts of Lugs.
(3) Tube Sampling Investigation.

Economizer Tube (Eco.)
(1) Wall Thickness.(UT)
(2) VI.Tube Outside Surface.(Corrosion)

Economizer Inlet Header
(1) VI(Fiber-scope) Of Inside Surface of Tube Stubs.

Furnace W/W Tube
(1)VI & PT Of Weld Parts at Menbrane-bars for.
Each opening,such as Burner Throats,
A D openings and S B openings.
(2) PT Of Welded Connection of Tie-bars for Buckstay.
(3) VI Of Corner Condition of Buckstay.
(4) PT Of Weld Parts of lugs on side wall for Furnace Hopper Support Girders.
(5)Thickness Of every W/W Tube ; Side Walls, Front & Rear Walls.(UT)
(6) Tube Sampling Investigation ; Front and Rear Wall Left & Rear Walls(Burner Level), Slope Ports
(7) All W/W Tube (UT with Transducer)

SH Attemperator
(1) PT Of Spray Nozzle for Fatigue Crack.
(2) VI (Fiber-scope) Of Internal Pipe for Fatigue Crack.

RH Attemperator
(1) PT Of Spray Nozzle for Fatigue Crack.
(2) VI (Fiber-scope) Of Internal Pipe for Fatigue Crack.

Note ; MT:Magnetic particle test. PT:Penetration test. VI:Visual inspection. ST:Sump. test (replica) UT:Ultra sonic test.
SB: Soot Blower. AD:Access Door.

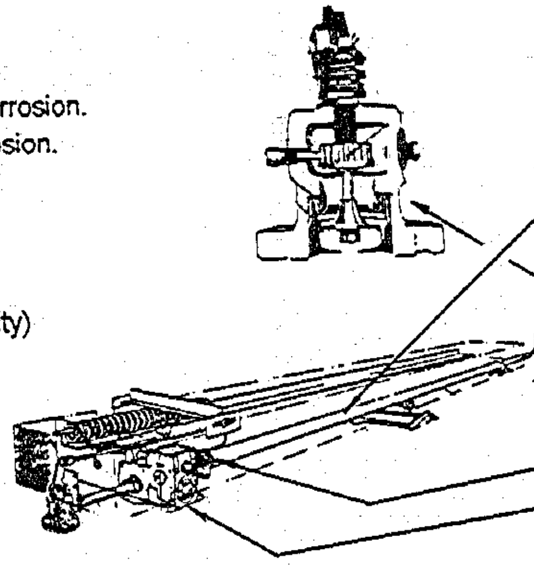
FIG. 4.2.2-3
Banias P.S

Other Inspection Items

Burner,Atomizer Inspection / Replace
Factor

- Burner ; Atomizer ; Erosion,Corrosion.
- Impeller ; High Temp. Oxidation,Corrosion.
- Air Register ; Thermal Deformation Erosion.
- Ignition Torch; Erosion, Deterioration.
- Automated Facilities ;
- -Flame Detector ; Deterioration(Sensitivity)
- -Limit Switch ; Deterioration
- -Air Cylinder ; Deterioration
- -Motor Drive ; Deterioration

(Burner Maintenance and Combustion Adjustment under Instruction of Burner Supplier every Year to be Carried Out)



Soot Blower System.

a. Nozzle, Lance Tube.(VI)
(1) Blockade of Blowing Nozzle
(2) Boiler Tube Damage due to Soot Blowing
(3) Nozzle ; (VI) Erosion, Corrosion,Crack(PT).
(4) Lance Tube, Feed Pipe ; Corrosion,Deformation.
(5) Gland ; Erosion, Corrosion.
(6) Start Point of Steam Blowing

b. Head Valve
(1) Valve Body, Valve Spindle.
(2) Valve Seat, Spring.

c. Wall Box.

d. Drive System.
(1) Gear Box.
(2) Gear,Bearing,Chain.
(3) Lubricant.

Air Heater

a. Heating Element.
(1) Element ;Corrosion / Erosion(VI),Weight
(2) Stiffener ; Corrosion / Erosion(VI),Plate Thickness(VI).

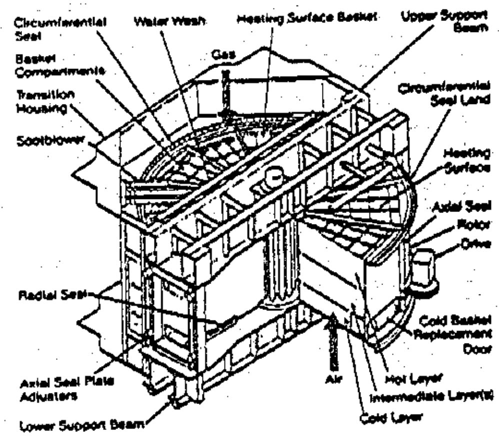
b. Seal Component.
(Radial Seal,Circumferential Seal,Rotor Seal.
(1) Corrosion / Erosion(VI)
(2) Clearance of Seal Materials(VI).,Adjustment.
c. Rotor.
(1) Welded Parts of Rotor ; (VI),(PT)
(2) Fit up Bolts, Pin Rack ; (VI).

d. Housing.(VI)
(1) Corrosion
(2) Deformation

e. Bearing(VI)

f. Rotor Balance

g. Confirmation of Seal,Clearance.
Confirmation of Air Leakage Percent During Performance Test.
(—Under Instruction of the Air Heater Supplier)



Note ; PT:Penetration test. VI:Visual inspection.

(4) Proposal of Rehabilitation Plan for Unit No. 1 and Unit No. 2 (Electrical and Instrumentation)

1) Renewal of Existing Instrumentation Systems

Based upon the factors described in 4.2.2(2), the existing instrumentation systems (pneumatic) shall be remodeled to electrical systems. In line with this remodeling, the following instruments shall be replaced with electrical items:

- Controller (press. controller, level controller),
- Valve positioner/diaphragm with transmitter,
- Differential pressure transmitter,
- Others.

2) Instrument Renewal

① Renewal of the following deteriorated instruments shall be carried out:

- Central control room indicators,
- Level switches,
- Detectors, transducers,
- Thermo-couples, thermo-resistors,
- Gas O_2 meters.

② Old fashioned instruments related to 1) above shall thus be renewed:

- Flow counter,
- Flow transmitter,
- Pulse counter (fuel and gas),
- Smoke density meter,
- Others.

③ Based upon the results of the first stage inspection overhaul, the following instruments and equipment may undergo renewal or rehabilitation:

a) Instruments for which plant-wide standardization is desirable:

- Thermo-switch,
- Pressure switch,
- Differential pressure switch,
- Others.

b) Laboratory equipment renewal

- CO_2 analyzer
- O_2 analyzer,

c) Cable protection tubes (PVC flexible tubes)

d) Sampling room equipment renewal

e) Demineraliser plant renewal

3) Calibration of Instruments

Whether instruments are renewed, rehabilitated or left as they are, calibration shall be carried out on all instruments and meters.

4.2.3 Mahardeh Power Plant

(1) Examination of Rehabilitation Plan for Unit No.1 and Unit No.2 (Mechanical)

1) Rehabilitation Proposals for Unit No.1 and Unit No.2

Restoration of the reliability of the operation control equipment and systems is firstly necessary to rectify the decline of the output and decline of the thermal efficiency of these units. To be more precise, it is essential to repair or renew all instruments and control systems which are currently out of order. Those instruments which are serviceable must be calibrated.

Restoration priority should be given to the O_2 meters and output meter (Unit No.1), steam flow control system at the turbine inlet (Unit No.1) and gas temperature gauge at the economiser outlet (air heater inlet) as well as the air heater outlet gas temperature gauge in order to determine the real causes of the output and thermal efficiency decline. Refer to 4.2.3 (2) for details of electrical and instrumentation rehabilitation. In addition, measurement of the gas O_2 % at the air heater gas inlet and outlet positions is proposed to establish the rate of air leakage from the air heater. While measurement points are established on the gas inlet side in the case of Unit No.1 and Unit No.2, no measurement transmitter is installed on the gas outlet side, necessitating manual measurement. (Unit No.3 and Unit No.4 have a system to measure the gas O_2 at both the gas inlet and gas outlet sides of the gas air heater although the system is currently out of order.)

2) Given the gas air heater air leakage example of the Banias Power Plant, it appears necessary to conduct maintenance work and replacement of the parts of the rotor

post seals (hot and cold), radial seal and circumferential seal of the air heater to minimise air leakage from the rotating air heater.

3) Air and gas leakages from the ducts must be completely eliminated and the completion of repair must be confirmed by the air pressure and soap bubble test. The insulation materials and cover plates should also be repaired and rehabilitated.

4) Recommendations and Proposal on Detailed Inspection of All Regions of Unit No.1 and Unit No.2

Given the current total operating hours of Unit No.1 and Unit No.2, their total operating hours will exceed 100,000 hours in approximately one year, necessitating the detailed inspection of all parts. The establishment of regions requiring inspection and the subject items for inspection is important to determine an appropriate inspection process. While the establishment of many regions and many subject items for inspection has better safety implications, it also means a high inspection cost and lengthy inspection process. A list of vulnerable regions (parts) should, in principle, be prepared using the past failure records of each unit and the list of detailed inspection items supplied by the original manufacturer of the unit in question prepared on the basis of failure statistics on similar generating units. As no power plant in Syria has detailed records of past unit failures, however, detailed inspection of the boiler turbine condenser after long total operating hours (100,000 hours) is proposed, upon obtaining a list of the subject inspection items from the unit manufacturer.

In order to make this possible, the work contract with the original supplier supervisor should include his participation in detailed inspection implementation from the inspection planning stage up to the confirmation of results and preparation of the actual renewal plan.

The detection of defects in boiler pressure retaining parts is relatively difficult. Therefore, the items and contents relating to these parts which should be included in the detailed inspection based upon the past experience of Study Team are proposed in Fig. 4.2.3-2 and 4.2.3-3.

(2) Examination of the Rehabilitation Plan for Unit No.1 and No.2 (Electrical and Instrumentation)

1) Renewal of existing instrumentation system

The existing instrumentation system is based on the pneumatic mechanism and ageing of the system has resulted in such problems as air leakage and blockage by silica powder. Replacement of the entire system is more realistic than conducting piece-meal repairs to fundamentally solve all the problems. The electric system is the mainstay of power plant instrumentation systems today due to its easy operation and maintainability in addition to preventing the problems associated with the pneumatic mechanism. It is, therefore, proposed that the existing pneumatic system be replaced by the electric system for easy maintenance and repair as well as for the easy procurement of spare parts.

2) Replacement of instruments

Instruments should be replaced in accordance with the adoption of the electric instrumentation system described above, including those instruments of which the procurement of spare parts and readjustment are difficult or impossible due to the models being outdated.

(3) Proposal of Rehabilitation Plan for Unit No.1 and Unit No.2 (Mechanical)

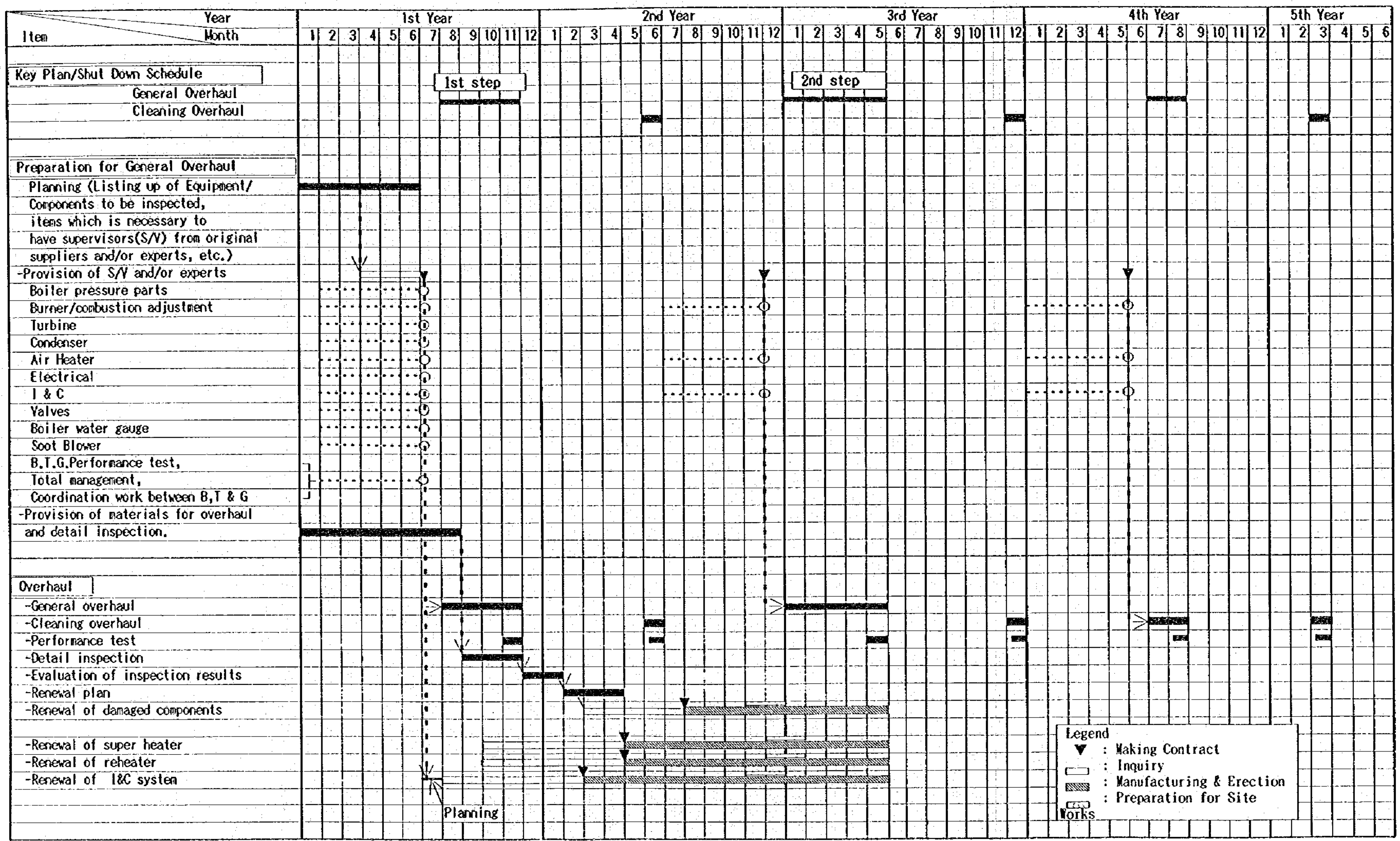
1) Rehabilitation Master Time Schedule

Fig. 4.2.3-1 indicates the rehabilitation master time schedule. It is proposed that the rehabilitation program consist of plant shut down to allow first stage general overhaul, second stage general overhaul and following that, periodic overhauls on a continuous basis. The contents of each type of overhaul are indicated below.

First Stage General Overhaul

The proposed first stage general overhaul is of medium scale and is designed to identify all of the rehabilitation items to be simultaneously carried out in the second stage larger scale overhaul, which will be carried out 13 months later.

Fig.4.2.3-1 Rehabilitation Master Time Schedule for Unit Nos. 1&2 in Mehardeh P.S.



The first stage overhaul will include the following work.

① Detailed inspection planning (implementation plan)

② Detailed inspection implementation

③ Invitation of the original supplier supervisor or specialist to provide guidance for the following rehabilitation items and to confirm results

No.	Item	Supervisor or Specialist
a.	Detailed inspection of boiler parts	S/V from original supplier
b.	Inspection of pressure parts	Specialist
c.	Burner/combustion adjustment	S/V from original supplier
d.	Rotating air heater (seal adjustment and confirmation of air leakage ratio)	S/V from original supplier
e.	Instrumentation and control (meter calibration, control adjustment)	S/V from original supplier
f.	Turbines	S/V from original supplier
g.	Condenser (cleaning, air leakage check)	S/V from original supplier
h.	Performance test for boiler, turbine and generator, total management, coordination work between B, T, and G	S/V from original supplier

The fundamental roles or responsibilities of the above mentioned supervisor or specialist are the confirmation and implementation of the detailed inspection items for each area, compilation of the inspection report and preparation of the damaged components renewal plan.

④ Confirmation of general overhaul results through performance test

2) Second Stage General Overhaul

Based upon the results of the detailed inspection conducted as part of the first stage general overhaul and following the cleaning overhaul which will be implemented six months after that, the large scale second stage general overhaul will be implemented 13 months after the first stage general overhaul. This will involve the renewal of instruments and control equipment, repair of the reheater and superheater in high temperature zones, where damage is forecast to occur, and renewal work in other areas.

On the other hand, the rehabilitation of rotating auxiliary equipment such as boiler feed water pump, combustion air fans, HFO pumps, valves, casing and ducts etc. which are not stated in the rehabilitation master time schedule will have to be carried out beforehand in the first stage general overhaul. It is absolutely necessary to carry out complete repairs of all defects in the second stage general overhaul without any remainders.

3) <u>Subsequent Periodic Overhauls</u>

It is proposed that cleaning overhauls are implemented every six months following the general overhaul work. (As HFO is a low quality fuel, the cleaning frequency will need to be increased). Moreover, data on tube thicknesses shall be recorded in every second periodic overhaul and upon comparing these with the tube thickness data recorded during the detailed inspection, they will be used as reference data in deciding the scope of next rehabilitation work.

4) Detailed Inspection Target Items

① Fig. 4.2.3-2 (Inspection Items on Pressure Parts for Mehardeh No.1 & 2) indicates the items chosen for detailed inspection based on the past experience of the Study Team members.

Regarding the detailed inspection work to be implemented in the first stage general overhaul, it is proposed that the views of the specialists or supervisors from the original maker are taken into consideration.

② The same thing is proposed for the Other Proposed Items detailed in Fig. 4.2.3-3.

③ Moreover, Appendix-5 (Periodic Inspection Procedure for Boiler and Turbine) describes in detail the inspection items, work procedures, related items, and boiler and turbine and auxiliary equipment etc., and it is proposed to conduct the detailed inspection in accordance with this.

(4) Preparation of the Rehabilitation Plan for Unit No. 1 and Unit No. 2 (Electrical and Instrumentation)

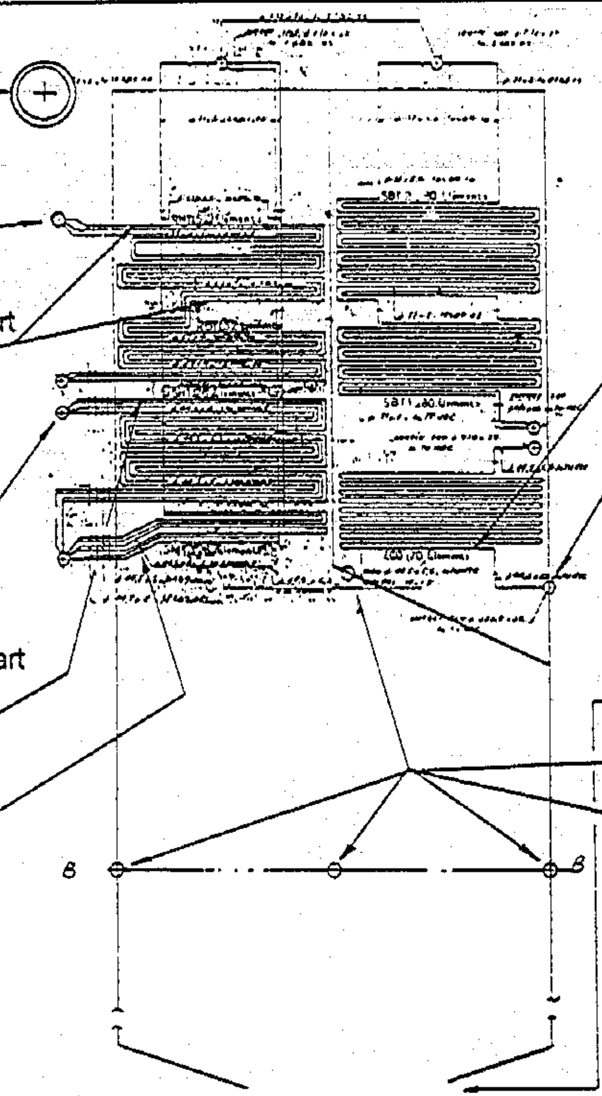
1) Remodeling of Existing Instrumentation Systems

Based upon the factors described in 4.2.3(2), the existing instrumentation systems (pneumatic) shall be remodeled to electrical systems.

FIG. 4.2.3-2

Mehardeh P.S

Inspection Items on Pressure Parts for Mehardeh No. 1&2



Drum
(1) VI.
(2) PT Of Weld Parts (Drum Inside) ;
Weld Seam, Nozzle and Lugs.
(3) MT Of Weld Parts (Drum Outside) ;
Selected Parts of Longitudinal Seam .
Nozzle.

Reheater Outlet Header
(1) MT Of Weld Parts of Tube Stubs.
(2) MT Of Weld Parts of Drain Nozzle.
(3) ST Of Outside Surface of Welded Part
of Outlet Nozzle.

Reheater Tube
(1) Wall Thickness.(UT)
(2) MT Of Weld Parts of Lugs.
(3) Tube Sampling Investigation.

(SHT) Outlet Header
(1) MT Of Weld Parts of Tube Stubs.
(2) MT Of Weld Parts of Drain Nozzle.
(3) ST Of Outside Surface of Welded Part
of Outlet Nozzle.
(4) VI(Fiber-scope) Of Inside Surface
of Outlet Nozzle.

Super Heater Tube (SHT)
(1) Wall Thickness.(UT)
(2) MT Of Weld Parts of Lugs.
(3) Tube Sampling Investigation.

Super Heater Tube (SMT)
(1) Wall Thickness.(UT)
(2) MT Of Weld Parts of Lugs.

Main Steam Pipe
(1) MT Of Weld Parts of Support Lugs.
(2) VI(Fiber-scope) Of Internal Surface
(for drain attack)

Hot Reneat Pipe
(1) MT Of Weld Parts of Support Lugs.
(2) VI(Fiber-scope) Of Internal Surface
(for drain attack)

Economizer Tube (Eco.)
(1) Wall Thickness.(UT)
(2) VI.Tube Outside Surface.(Corrosion)

Economizer Inlet Header
(1) VI(Fiber-scope) Of Inside Surface of Tube Stubs.

Furnace W/W Tube
(1) VI & PT Of Weld Parts at Menbrane-bars for.
Each opening,such as Burner Throats,
AD openings and SB openings.
(2) PT Of Welded Connection of Tie-bars for Buckstay.
(3) VI Of Corner Condition of Buckstay.
(4) PT Of Weld Parts of lugs on side wall for
Furnace Hopper Support Girders.
(5) Thickness Of every W/W Tube ; Side Walls,
Front & Rear Walls.(UT)
(6) Tube Sampling Investigation ; Front and Rear Wall
Left & Rear Walls(Burner Level), Slope Ports

SH Attemperator
(1) PT Of Spray Nozzle for Fatigue Crack.
(2) VI (Fiber-scope) Of Internal Pipe for Fatigue Crack.

RH Attemperator
(1) PT Of Spray Nozzle for Fatigue Crack.
(2) VI (Fiber-scope) Of Internal Pipe for Fatigue Crack.

Note ; MT:Magnetic particle test. PT:Penetration test. VI:Visual inspection. ST:Sump. test (replica) UT:Ultra sonic test.
SB: Soot Blower. AD:Access Door.

Other Inspection Items

Burner,Atomizer Inspection / Replace

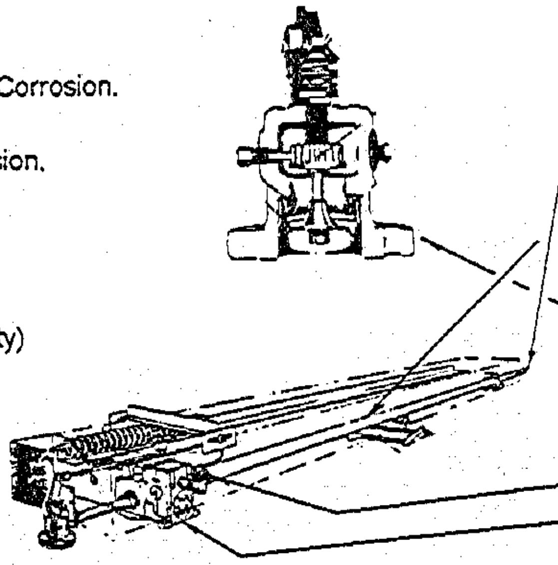
Factor

Oil Gun ; } Erosion,Corrosion.
Air Nozzle ; } High Temp. Oxidation,Corrosion.

Air Nozzle ; Thermal Deformation Erosion.
Ignition Torch; Erosion, Deterioration.

Automated ; }
Facilities ; }
-Flame Detector ; Deterioration(Sensitivity)
-Limit Switch ; Deterioration
-Air Cylinder ; Deterioration

(Burner Maintenance and Combustion Adjustment under Instruction of Burner Supplier every Year to be Carried Out)



Soot Blower System.

a. Nozzle, Lance Tube.(VI)
(1) Blockade of Blowing Nozzle
(2) Boiler Tube Damage due to Soot Blowing
(3) Nozzle ; (VI) Erosion, Corrosion,Crack(PT).
(4) Lance Tube, Feed Pipe ; Corrosion,Deformation.
(5) Gland ; Erosion, Corrosion.
(6) Start Point of Steam Blowing

b. Head Valve
(1) Valve Body, Valve Spindle.
(2) Valve Seat, Spring.

c. Wall Box.

d. Drive System.
(1) Gear Box.
(2) Gear,Bearing,Chain.
(3) Lubricant.

Air Heater

a. Heating Element.
(1) Element ;Corrosion / Erosion(VI),Weight.
(2) Stiffener ; Corrosion / Erosion(VI),Plate Thickness(VI).

b. Seal Component.
(Radial Seal,Circumferential Seal,Rotor Seal.
(1) Corrosion / Erosion(VI)
(2) Clearance of Seal Materials(VI).,Adjustment.

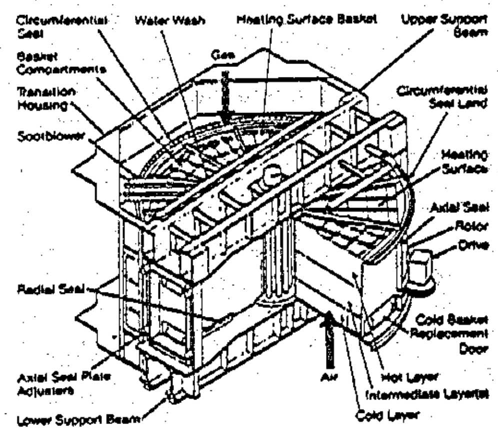
c. Rotor.
(1) Welded Parts of Rotor ; (VI),(PT)
(2) Fit up Bolts, Pin Rack ; (VI).

d. Housing.(VI)
(1) Corrosion
(2) Deformation

e. Bearing(VI)

f. Rotor Balance

g. Confirmation of Seal,Clearance.
Confirmation of Air Leakage Percent During Performance Test.
(—Under Instruction of the Air Heater Supplier)



Note ; PT:Penetration test. VI:Visual inspection.

2) Renewal of Instruments

Based upon the results of the first stage inspection overhaul, renewal and repair of instruments shall be carried out.

3) Calibration of Instruments

Whether instruments are renewed, rehabilitated or left as they are, calibration shall be carried out on all items.

4.2.4 Katteneh Power Plant

(1) Examination of Rehabilitation Plan for Unit No.3, Unit No.4 and Unit No.5 (Mechanical)

One way to avoid the boiler output decline due to the effects of soot contained in the combustion gas, is to change the currently used fuel (HFO) to natural gas (NG) to in order to minimize soot generation. Another way is to examine the following rehabilitation plans that assume the continued use of HFO.

1) Change of Fuel to NG for Unit No.3, Unit No.4 and Unit No.5 and Related Issues

a) Change of firing burners to NG firing burners.

b) In this case, the present boiler furnace, super heater, economiser, air heater, FD fan and ID fan, etc. will remain the same but the burning units and accessories will be changed. In determining the maximum available output under these conditions, important issues to be examined are (i) reduction of the heating surface to prevent an excessive increase of the super heater steam temperature, (ii) spray capacity of the attemperator and (iii) heat absorption control of the economiser and air heater, etc.

c) Installation of gas piping and valves.

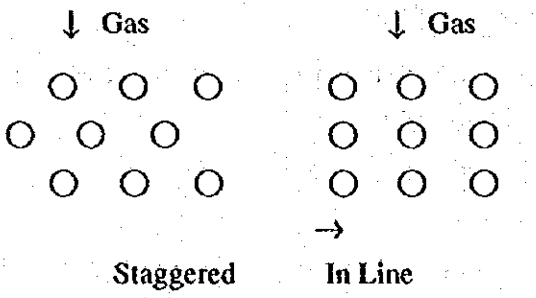
d) Installation of additional instruments and control equipment.

Note: This proposal requires the agreement of the original supplier.

2) Rehabilitation Proposal Presupposing Use of HFO and Related Issues

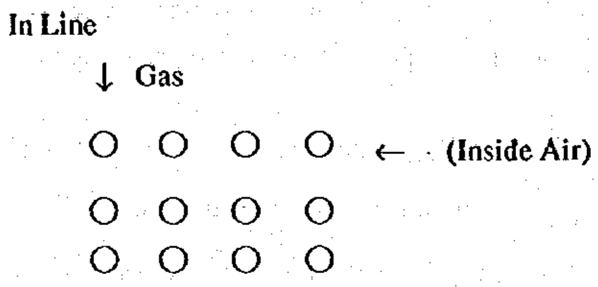
a) Change of Tube Arrangement for Economiser

In addition to the installation of a soot blower, the economiser tube arrangement will be changed from the current staggered type to the in-line type in order to improve the soot blowing performance.



As a result, the heating surface will be increased to improve the soot blowing performance.

b) The horizontal tubular air heater with the in-line type tube arrangement will be used to improve the soot blowing performance. The tube exteriors contact the gas while air flows inside the tubes.



c) In relation to the above modifications, the necessary changes will be made to the capacity of such electrical items as the ID fan, FD fan and motor, etc.

d) A soot blower will be installed to the super heater, economiser and air heater.

e) The necessary changes will be made to the duct routes.

f) The use of a rotating regenerative air heater is possible instead of the horizontal tubular air heater referred to in b) above.

Note: This proposal has already been made by BABCOCK (Germany).

3) Rehabilitation Plan for Unit No.3, Unit No.4 and Unit No.5

The following was found as a result of a detailed study conducted during the Second Field Survey. Unit No.3, Unit No.4 and Unit No.5 were originally commissioned 25 years ago and the boiler has a total stoppage time of equivalent 14 years in the case of Unit No.3 and Unit No.5 and equivalent 18 years in the case of Unit No.4 with no anti-rust treatment of the internal surfaces of pressure areas.

It is difficult to estimate how much the overall reliability of these units can be improved even if some of the components are renewed as part of the rehabilitation work. Diagnosis of the remaining life of those components which will not be renewed is common-sense as is the preparation of a renovation plan prior to the actual implementation of any renovation work. The key point of such diagnosis of the remaining life and system reliability is to decide how detailed the diagnosis or inspection should be. This decision is almost impossible to make for Unit No.3, Unit No.4 and Unit No.5 because the decision must take into consideration the original reliability of the manufacturing plants, materials used and quality control systems 25 years ago.

Therefore, the rehabilitation of Unit No.3, Unit No.4 and Unit No.5 shall not be considered in our proposal, and instead, the installation of a new NG and HFO fired unit (200 MW) is proposed as Unit No.7 to cover not only the output of Unit No.3, Unit No.4 and Unit No.5 but also the output of Unit No.6. This Unit No.7 will also act as a back-up for the Tishreen 200 MW unit. The proposed specifications for Unit No.7 are described in Section 4.2.4 (5) 3).

(2) Examination of Rehabilitation Plan for Unit No.3, Unit No.4 and Unit No.5 (Electrical and Instrumentation)

If the above mentioned 1) is implemented, the additional installation of electrical, instrumentation and control equipment will become necessary, whereas if 2) is implemented, the remodeling and additional installation of electrical equipment for the control of FD fans, ID fans, super heaters, economizers, air heaters and other auxiliary equipment will become necessary. However, as is mentioned above, the rehabilitation of Unit No. 3, Unit No. 4 and Unit No. 5 will not be considered in deference to the installation of a new 200 MW unit. The rehabilitation of these units will thus not be examined.

(3) Examination of Rehabilitation Plan for Unit No.6 (Mechanical)

1) The gas O_2 meter will be renewed to change the current state of over excess air to low excess air operation in order to improve both the output and thermal efficiency. Please refer to 4.2.4 (4) for renovation of the instrumentation.

2) The rotating type regenerative air heater will be regularly washed using water.

3) The highly corroded heating elements of the rotating air heater will be renewed.

4) The rotor post seals (hot and cold), radial seals and circumferential seals will be undergone maintenance and parts will be replaced where necessary to minimise air leakage from the rotating air heater.

5) Air leakage and gas leakage from the ducts will be totally blocked. Following the completion of repair work, the sealing performance will be confirmed by the air pressure and soap bubble test. The heat insulation materials and cover plates will also be repaired or rehabilitated.

6) Recommendation of Detailed Inspection of All Parts of Unit No.6

Given the current total operating hours of Unit No.6, detailed inspection of all its parts will be necessary within approximately 2 years. The establishment of regions requiring inspection and the subject items for inspection is important to determine an appropriate inspection process. While the establishment of many regions and many subject items for inspection has better safety implications, it also means a high inspection cost and lengthy inspection process. A list of vulnerable regions (parts) should, in principle, be prepared using the past failure records of each unit and the list of detailed inspection items supplied by the original manufacturer of the unit in question prepared on the basis of failure statistics on similar generating units. As no power plant in Syria has detailed records of past unit failures, however, detailed inspection of boiler, turbine, condenser and generator after long total operating hours (100,000 hours) is proposed, upon obtaining a list of the subject inspection items from the unit manufacturer.

In order to make this possible, the work contract with the original supplier supervisor should include his participation in detailed inspection implementation from the inspection planning stage up to the confirmation of results and preparation of the actual renewal plan.

The detection of defects in boiler pressure retaining parts is relatively difficult. Therefore, the items and contents relating to these parts which should be included in the detailed inspection based upon the past experience of Study Team are proposed in Fig. 4.2.4-2 and 4.2.4-3.

(4) Examination of the Rehabilitation Plan for Unit No. 6 (Electrical and Instrumentation)

The areas of Unit No. 6 and common areas throughout the plant for which rehabilitation and renewal is desirable are as follows.

1) Renewal of Deteriorated Electrical Equipment

① DC Systems

The plant DC systems are common to all the units, however, the 220 V system and 24 V system are both old fashioned having been installed more than 20 years ago and 15 years ago respectively. Moreover, the 110 V system and 60 V system are supplied as branches of the 220 V system, and thus there are doubts about reliability.

It is therefore proposed to make each of the systems independent, and provided with normal and stand-by systems.

② 380 V Switchgears

These are all more than twenty years old and are extremely deteriorated. It is therefore proposed to replace all items.

2) Renewal of the Existing Instrumentation System

The renewal shall involve conversion from pneumatic systems to electrical systems, as in the case of Banias Power Plant.

3) Renewal of Instruments

In addition to the remodeling of electrical systems, renewal of deteriorated instruments shall also be performed simultaneously.

① Deteriorated Instruments to be Renewed

- Central control room indicators,
- Recorders,
  (including new panel installation due to the adoption of chart recorders for electrical instruments)
- Transmitters, transducers,
- Level switches,
- Detectors (including thermo-couples, thermo-resistors),
- Others.

② Instruments to be Renewed in Line with Remodeling from Pneumatic to Electrical Systems

- Controllers (pressure controller, level controller),

- Valve positioner/diaphragm with transmitter,
- Differential pressure transmitter,
- Others.

③ Calibration of all instruments

4) Renewal and New Installation of Electrical Laboratory Equipment

- Voltmeter,
- Ammeter,
- Wattmeter,
- Relay tester,
- Megger,
- Withstand voltage tester (75 KW DC)

5) Instruments for which Renewal is Desirable for Standardization Throughout the Plant

- Thermo-switch,
- Pressure switch,
- Differential pressure switch,
- Others.

6) Voltage Regulator Remodeling

The existing voltage regulator (with excitor) is manually operated. This shall thus be remodeled to an automatic voltage regulator.

7) New Data Logger Installation

The plant does not currently possess a data logging system, so this shall be newly installed. The new system shall include a fault recorder.

(5) Proposal of Rehabilitation Plan for Unit No.3, Unit No.4 and Unit No.5

1) Unit No.3, Unit No.4 and Unit No.5 were manufactured in the former Czechoslovakia and originally commissioned in the sixties. Deterioration of the units has progressed so far that it is thought that there is little hope of restoring declining output and thermal efficiency levels and, moreover, when one considers the short remaining service life of the plant itself, the rehabilitation of the units now cannot be described as a wise policy. It is therefore proposed that, instead of carrying out

rehabilitation of the existing units, a new installation of NG and/or HFO fired 200 MW unit (steam or gas turbine) is proposed.

As for the existing Unit No.3, Unit No.4 and Unit No.5, new economizer tubes were installed in Unit No.4 in 1992. Unit No.3 in 1993 and Unit No.5 in 1994. It is desirable to continue the implementation of such partial repair work and also to carry out cleaning overhauls on each units (every one to one and a half months) in an effort to extend the remaining service lives of the units and utilize their remaining capacity to the fullest degree. These three units shall be used as short term operation reserve units and indeed this form of utilization has already begun.

2) Installation of the above mentioned new 200MW steam or gas turbine generating unit is designed to provide some leeway in the total generating capacity of all Syria's power plants in order to allow time to carry out the rehabilitation work and the ensuring overhaul work, which will involve shut down of the target units, being proposed under the Master Plan. It is therefore desirable to complete the installation work for the new unit by the end of 1999, (see FG 4.3.1-1 REHABILITATION MASTER SCHEDULE) at which time there will be an excess of guaranteed capacity over peak demand, and commence its operation from 2000.

3) Composition of the New Generating Unit

① The building that houses the existing Unit No.1 and Unit No.2 will be removed and in its place and also using the space on the north-east side of the site, a new turbine-generator house will be built to house the boiler, turbine and generator for the new steam turbine generating unit.

② As a water cooling system may raise the temperature of Katteneh Lake, an air cooling system shall be used.

③ The main transformer and unit transformer will be placed alongside the turbine-generator house and a new transformer station will be built on the opposite side of the plant road. The existing electrical equipment in this area will have to be removed or transferred.

④ The existing demineralizing plant will be removed to make way for a new demineralizing plant.

⑤ The fuel oil tank will be removed and its site will be used for the installation of a new tank. The location of the gas regulating station will depend on the gas pipe line routing, however it will be placed alongside the tank yard.

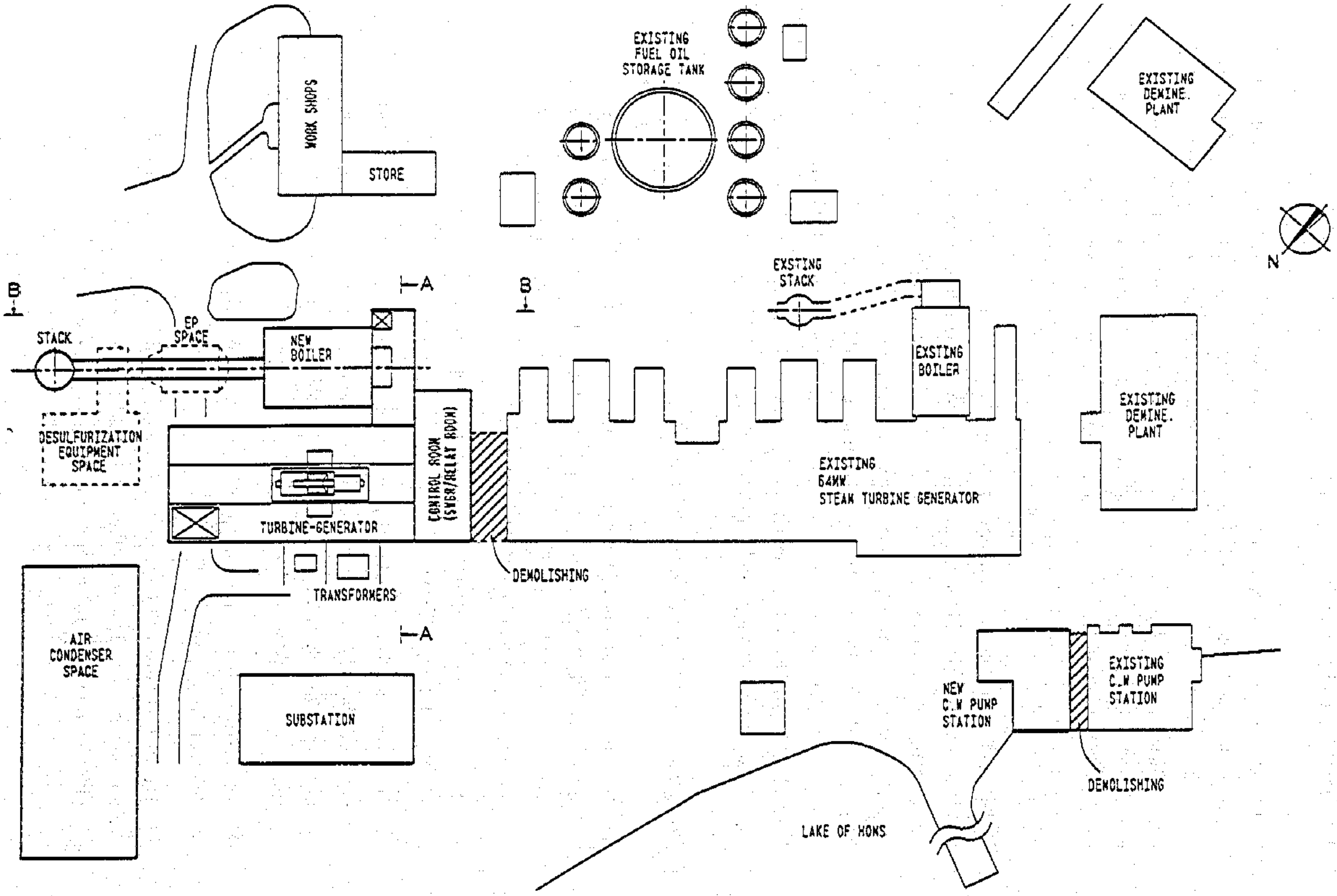


FIG. 4.2.4-4

PLAN
200MW S.T.G UNIT EXTENSION
IN KATTENEH P/S

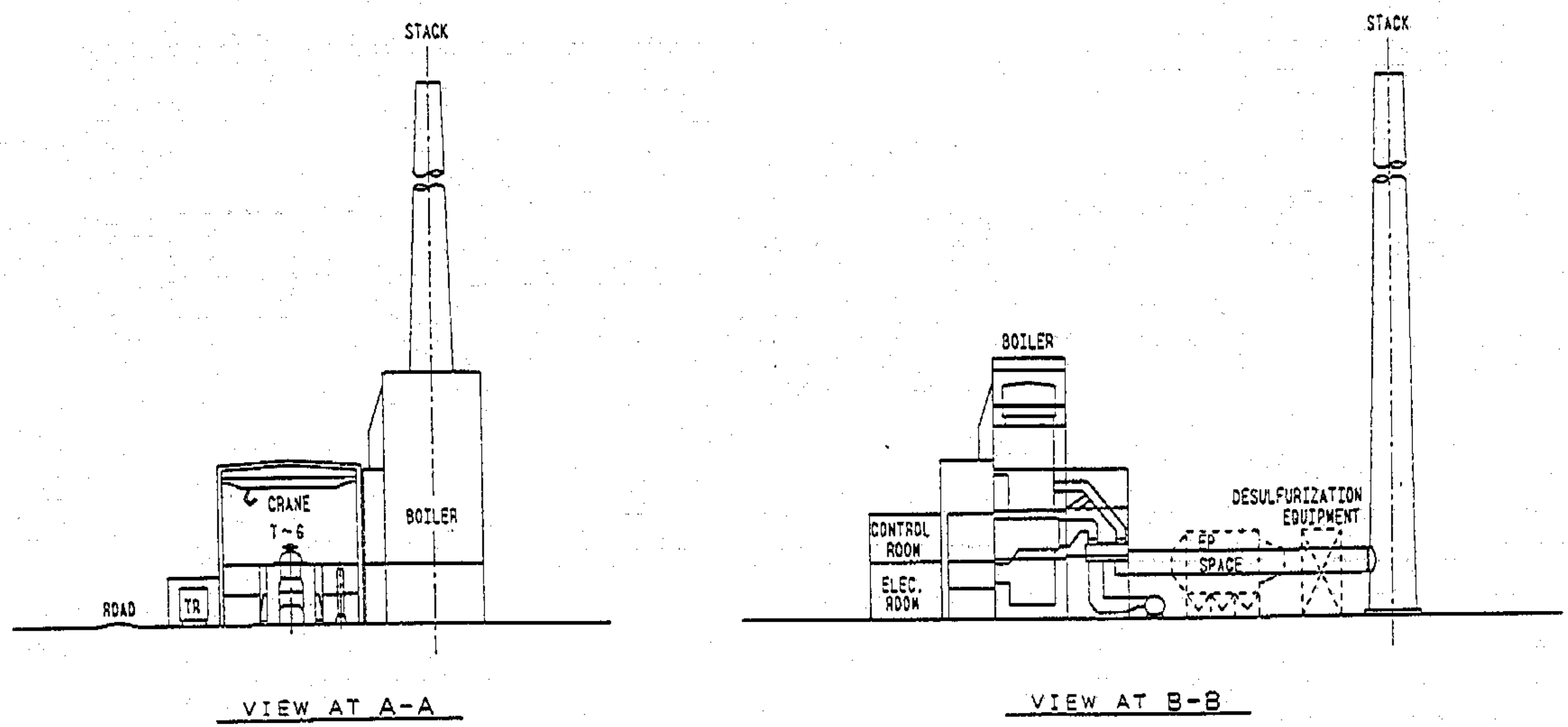


FIG. 4.2.4-5 SECTIONS
200MW S.T.G UNIT EXTENSION
IN KATTENEH P/S

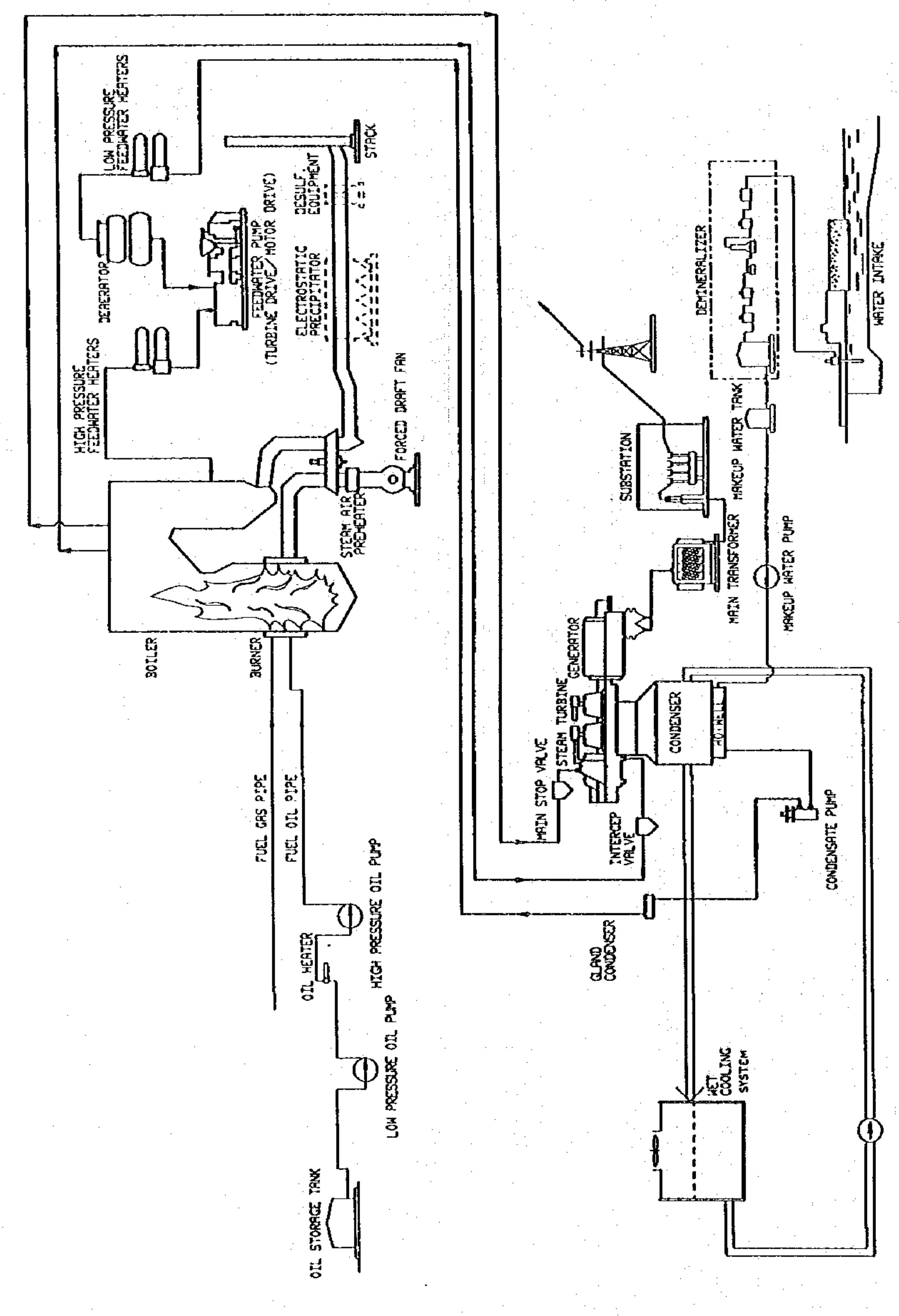


FIG. 4.2.4-6 SYSTEM FLOW DIAGRAM
200MW S.T.G UNIT EXTENSION
IN KATTENEH P/S

⑥ Based upon the above proposals the basic specifications will be as follows; the layout of the new steam turbine generating units will be as indicated in Fig. 4.2.4-4, 5 and 6.

Capacity	:	200 MW class
Fuel	:	NG or HFO
Burner	:	low NOx burner

Furthermore, the introduction of a flue gas desulphurisation system should be taken into consideration as a future environmental preservation measure.

(6) Proposal of Rehabilitation Plan for Unit No.6 (Mechanical)

1) Rehabilitation Master Time Schedule

Fig. 4.2.4-1 indicates the rehabilitation master time schedule. It is proposed that the rehabilitation program consist of plant shut down to allow first stage general overhaul, second stage general overhaul and following that, periodic overhauls on a continuous basis. The contents of each type of overhaul are indicated hereunder.

First Stage General Overhaul

The proposed first stage general overhaul is of medium scale and is designed to identify all of the rehabilitation items to be simultaneously carried out in the second stage larger scale overhaul, which will be carried out 13 months later.

The first stage overhaul will include the following work.

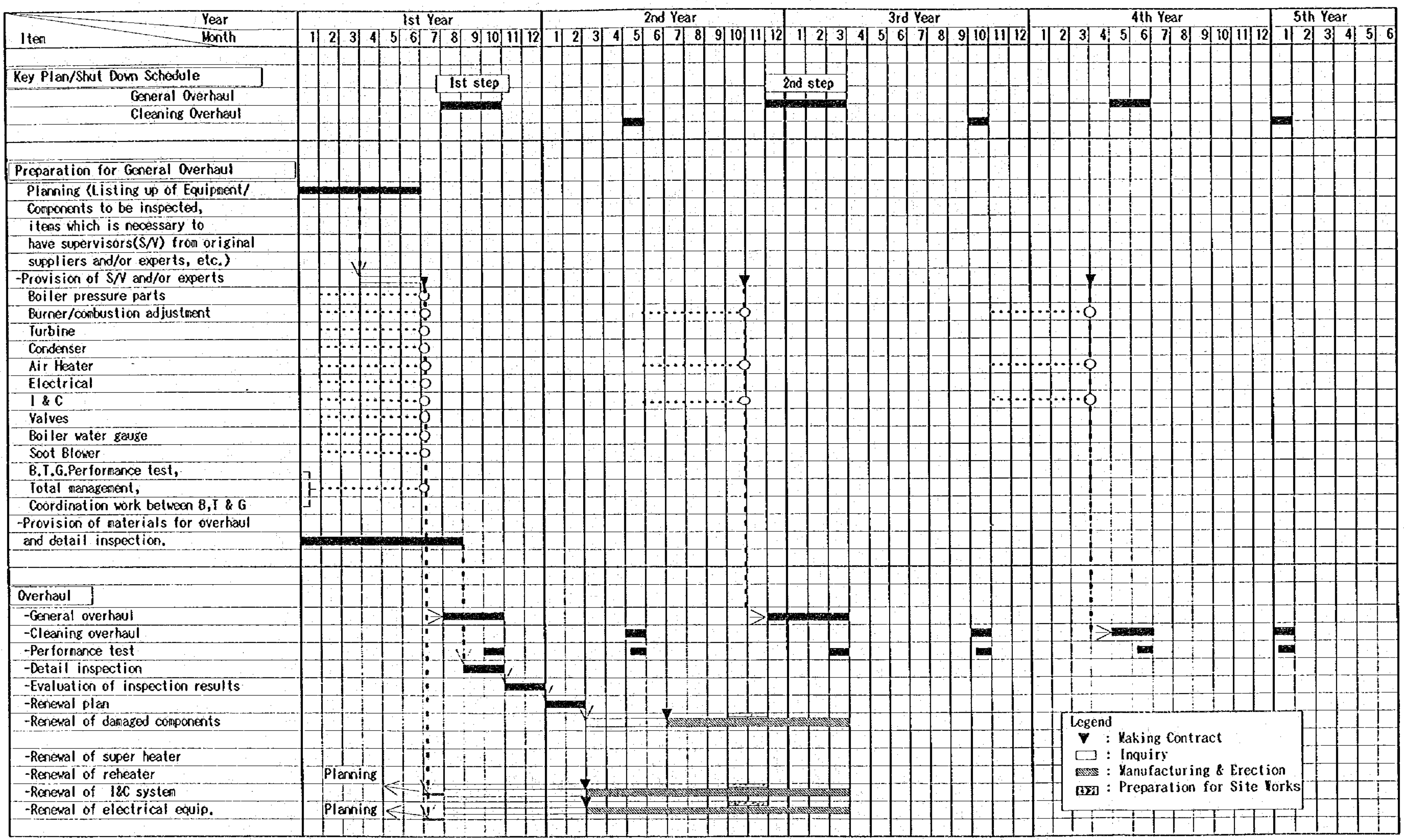
① Detailed inspection planning (implementation plan)

② Detailed inspection implementation

③ The invitation of the original supplier supervisor or specialist to provide guidance for the following rehabilitation items and to confirm results

No.	Item	Supervisor or Specialist
a.	Detailed inspection of boiler parts	S/V from original supplier
b.	Inspection of pressure parts	Specialist
c.	Burner/combustion adjustment	S/V from original supplier
d.	Rotating air heater (seal adjustment and confirmation of air leakage ratio)	S/V from original supplier

Fig.4.2.4-1 Rehabilitation Master Time Schedule for Unit No.6 in Katteneh P.S.



e. Instrumentation and control (meter calibration, control adjustment)	S/V from original supplier
f. Turbines	S/V from original supplier
g. Condenser (cleaning, air leakage check)	S/V from original supplier
h. Performance test for boiler, turbine and generator, total management coordination work between B, T and G	S/V from original supplier

The fundamental roles or responsibilities of the above mentioned supervisor or specialist are the confirmation and implementation of the detailed inspection items for each area, compilation of the inspection report and preparation of the damaged components renewal plan.

④ Confirmation of general overhaul results through performance test

2) Second Stage General Overhaul

Based upon the results of the detailed inspection conducted as part of the first stage general overhaul and following the cleaning overhaul which will be implemented six months after that, the large scale second stage general overhaul will be implemented 13 months after the first stage general overhaul. This will involve the renewal of instruments and control equipment and renewal work in other areas.

On the other hand, the rehabilitation of rotating auxiliary equipment such as boiler feed water pump, combustion air fans, induced draft fan, HFO pumps, valves; casing and ducts etc. which are not stated in the rehabilitation master time schedule will have to be carried out beforehand in the first stage general overhaul. It is absolutely necessary to carry out complete repairs of all defects in the second stage general overhaul without any remainders.

3) Subsequent Periodic Overhauls

It is proposed that cleaning overhauls are implemented every six months following the general overhaul work. (As HFO is a low quality fuel, the cleaning frequency will need to be increased). Moreover, data on tube thicknesses shall be recorded in every second periodic overhaul and upon comparing these with the tube thickness data recorded during the detailed inspection, they will be used as reference data in deciding the scope of next rehabilitation work.