JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

No. 22

MINISTRY OF INDUSTRY AND TRADE
PETROCHEMIA PLOCK S.A. (PPSA)
REPUBLIC OF POLAND

STUDY ON MODERNIZATION AND ENVIRONMENTAL POLLUTION CONTROL IN MAZOVIAN OIL REFINERY AND PETROCHEMICAL WORKS IN PLOCK, THE REPUBLIC OF POLAND

(SUMMARY)

JANUARY, 1995

UNICO International Corporation
IDEMITSU Engineering Co., Ltd.

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Contents of Executive Summary

Chapter 1 Background of the Study

The Mazowiecki Cabinet was the first post-world war II Polish non-communist administration. Established in September, 1989, it was in the forefront of the transformation of political democratization and of shifting to a free market economy. These policies have in principle been continued by the Pawlak Cabinet which was elected in September, 1993, although it appears there will be some slow-down in actual realization of the reforms. Before transformation to the market economy, Polish industries laid stress on the production of industrial goods rather than consumer goods, and large state enterprises dominated. Raw materials and products markets were closely related to the former communist counties and there was virtually no foreign capital inflow. To improve these conditions in the mid-term, industrial policy for the year 1994-1997 aims at change in the structure of industry, privatization of state enterprises, reduction of the dependence on the former communist countries for raw materials and products markets and promotion of foreign investment in Poland.

As for the energy sector in Poland, due to the previous policy of self-sufficiency in energy, the share of coal was as high as 93% in 1960. However, since then, the share of petroleum and natural gas has been gradually increasing. Yet in 1993, the share of coal was still 72%, which is much higher than the coal share in OECD countries, averaging 19%. Polish energy policy up to the year 2010 plans that the present crude oil refining capacity of 14,700,000 MT shall be increased to 25,000,000 MT by 2005. It is also characteristic of Poland, that the ratio of energy consumption to GDP is 2 to 3 times higher than in the OECD countries.

There are unfortunate consequences of these characteristics of higher energy consumption in relation to GDP and higher share of coal usage in total energy consumption, together with the delay in

taking proper measures for pollution control. Discharge of contaminants and pollutants to the ambient air and waters has been much higher than in the of OECD countries, and there has been severe damage to the forests. Contamination of the rivers is also extreme, and over 57% of the river water cannot meet the quality standards appropriate for industrial use and agriculture. In November 1990, the Ministry of Environmental Protection has published the nation's first environmental policy. This policy consists of a 3 to 4 year urgent short term plan, a mid-term plan up to the year 2,000 with the goal of enabling Poland to catch up with the EC in reduction of pollutants, and a long term plan until 2,020 for environmental improvement with sustained development.

Plock Petrochemia S.A. (PPSA) is located in the province of Plock, where population is about 520,000. The share of industry in regional product of the prefecture is 20%, and the share of agriculture is 44% in terms of employment. The un-employment ratio is 18.5%, which is higher than the average in Poland of 13.6%. PPSA accounts for 70% of industrial production in Plock, and is the largest enterprise in terms of employment, also supplying hot water to the region.

The shifts and changes of the industrial policies of Poland's Government necessitate PPSA to cope with the following situations;-

(1) PPSA is implementing a program of privatization, and for this purpose it has been placed under the administration of the Ministry of Privatization instead of the Ministry of Industry and Trade. There has been progressives liberalization of import of crude oils and sales of refined petroleum products has been progressing.

(2) Liberalization of Polish petroleum market control measures to the levels prevailing in EC countries, forces PPSA to compete

with the prices and qualities of the products of the EC countries. It is also necessary to consider changing the structures of petroleum products and increasing their volumes of output. The import of crude oil from the Middle East and North Sea now accounts for about 50%, in addition to the import of crude from Russia.

PPSA already has plans to invest in several facilities, to implement expansions and improvements such as modernization of No.1 through No.4 distillation units, revamping of No.2 FCC, construction of a desulfurization plant for lubricant oil, construction of crude oil blending facilities, improvement of No.2 ethylene plant, construction of No.3 polyethylene plant, desulfurization of flue gas of the power plant, modernization of boilers No.1 to No.3, and installation of waste water treatment facilities etc. up to the year 2,000.

This study is related exclusively to the modernization of No.1 distillation unit, and modernization of the thermal power plant which supplies the distillation unit with electric power among the various projects contemplated by PPSA.

Chapter 2 Contents of the Study

2.1 Modernization of No.1 crude oil distillation unit

The flow sheet of No.1 crude oil distillation unit at the time of the first field survey (November 1993) is shown in Attachment 1, which mainly consists of No.1 atmospheric distillation unit and No.1 vacuum distillation unit.
The main purposes of the modernization at this time are as follows:

(1) Increase in the capacity of the distillation unit, and improvement of the product quality

1) Improvement in the quality of petroleum products shall be pursued until no off-grade products are produced. The quality of the products shall in the future meet the product specifications shown in Attachment 2.

2) The throughput of No.1 atmospheric distillation unit shall be balanced to that of No.1 vacuum distillation unit to increase the throughput. The design throughput of No.1 atmospheric distillation unit is 308 t/h. However a part of the bottom oil of No.1 atmospheric distillation tower(atmospheric residue) has to be by-passed at present when the throughput of No.1 atmospheric distillation unit is over 288 t/h because the quantity of the atmospheric residue surpasses the capacity of No.1 vacuum distillation unit.

3) Treatment of the A10 fraction from the preflash column overhead in No.1 atmospheric distillation unit

Sole treatment of the A10 Fraction from No.1 atmospheric distillation unit's by separating it from the A10 fractions from other distillation units, is required because it has higher sulfur content than the other A10 fractions.

4) Revamping of the desalters was originally included in the modernization plan.
However, this was deleted from the modernization plan because in the analysis of the salt and water content in the desalted crude oil, and analysis of the oil content in the waste water from the desalters, the current performance was found to be sufficient.

(2) Saving energy

The reduction of fuel oil consumption can be achieved mainly by measures such as the installation of air preheaters, control of oxygen in the flue gas from heaters, re-arrangement of heat exchangers, removal of box water coolers, etc.

(3) Reduction of emission of offensive substances

It is necessary to reduce offensive odor from the standpoint of the environment for workers. It is planned to reduce emission of SO_2 as an air pollutant by saving energy, and to reduce emission of NOx both by saving energy and by application of a low-NOx burner.

(4) Replacement of the pneumatic instrumentation to DCS, which is necessary because of a shortage of spare parts, etc.

The assumptions for planning the modernization measures described above are as follows:

1) Crude oil to be refined in No.1 crude oil distillation unit is only Ural crude oil, properties of which are shown in Attachment 3.

2) There is no shortage in the supply of electricity consumption, which is estimated to increase by about 1 MW after the modernization.

3) After the modernization, the existing plants down stream can cope with the variation in quantity of each petroleum product which may be different from the current quantity.

4) The existing equipment can be operated continuously at its design capacity. (It is necessary to check the existing equipment in detail during the design phase.)

The study team analyzed the existing No.1 crude oil distillation unit and the same unit after modernization, by establishing a computer simulation model.

As a result, the problems and the measures to be taken for improvement are shown in Attachment 4, and points to be improved are shown in the PFD of Attachment 5. Refer to Attachment 6 for the PFD after the modernization.
By implementing these measures, the following improvements are expected:

1) The following are the actions necessary for bettering the quality of petroleum products:

   (a) Stripping steam will be injected to the strippers so that no off-grade products will be produced.
   Coalescers will be installed at the required places to minimize corrosion and plugging in the catalyst bed, which may be caused by the condensate of the stripping steam.
   (b) A stabilizer will be constructed to separate LPG from the A10 Fraction, and a splitter will be constructed to separate naphtha into light and heavy components.
   (c) The current product specifications for petroleum products will be changed to a new set of specifications, and after the modernization petroleum products will be produced by changing tray numbers between the fractions in the distillation tower, and by changing the draw-off temperatures of each fraction.
   However, the flash point of the A13 fraction will be lower than the new product specification, because no kerosene fraction is produced. This was agreed with by PPSA during the second field survey.

2) It is possible to raise the bottom temperature of No.1 atmospheric distillation tower and to reduce the atmospheric residue going to No.1 vacuum distillation tower either by increasing the outlet temperature of the Pc-2 heater or by re-arrangement of heat exchangers, without replacement of Pc-2. Because of the possibilities described above, all of the atmospheric residue can be fed to No.1 vacuum distillation tower even if 308 t/h of crude oil, which is the maximum throughput, is charged to No.1 atmospheric distillation unit.

   This measure will also contribute to increasing the production ratio of high quality products as a whole. The quality and quantity of the products at present and after the modernization are compared in Attachment 7.

3) Improvements for the purpose of controlling emission of pollutant substances are shown in Attachment 8.
   Reduction of SO_2 and NOx emissions will be accomplished by the reduction of fuel oil consumption and by the application of a low-NOx burner.

4) Attachment 9 shows the present energy consumption of the plant and the improvement after the modernization.

5) As for utility consumption, electric power and steam consumption will be increased by the installation of air preheaters, replacement of pumps, etc.
   Consumption of cooling water will be increased by the installation of a stabilizer and splitter unit.

2.2 Modernization of thermal power plant

Refer to Attachment 10 for the steam flow diagram (including boilers and electric power generators) and refer to Attachment 11 for the simplified flow diagram of the existing boiler feed water facilities.

The purposes of the thermal power plant's modernization are as follows:

(1) Boilers from No.1 to No.3:

1) Improvement of boiler efficiency

2) Reduction of NOx and SO_2 emissions

(2) Boiler feed water system:

1) Reduction of chemical consumption

2) Reduction of water consumption

3) Increase of capacity for raw water treatment

(3) Increase of electric power generation:

For planning of the modernization described above, the following assumptions were confirmed:

- The existing facility can cope with an increase of cooling water consumption by 11,000 m^3/h.
- The existing facility can be operated soundly and continuously as designed.

The above purposes for the improvement program are fulfilled by the modernization measures as shown in Attachment 12. The outline of this program is described below:

(1) The modernization of boilers from No.1 to No.3

1) Improvement of boiler efficiency

(a) Fouling of boiler tubes can be minimized by installation of soot blowers at the required places (as indicated in Attachment 13).
This will make several things possible, such as the following: prevention of degrading the heat efficiency by fouling, prolonging of the continuous operation period, and then this can be followed by rationalization of the operation plan for all boilers (Refer to Attachment 14 as an example).

(b) Improvement of burning conditions by applying new burner tips which are suitable for burning heavy fuel oil.

(c) Heat recovery from deaerator vent steam.

(d) Replacement of the existing Jung Strom, including its air preheater, makes heat efficiency increase because of improvement of heat efficiency of the Jung Strom itself, as well as reduction of electric power consumption of the blowers by reducing the air volume which is leaking to flue gas, and reduction of load to the flue gas desulfurization unit.

2) Reduction of NOx and SO_2 emissions

Basically, flue gas from all boilers will be treated in the common desulfurization/denitrification unit to satisfy the regulations on these emissions.
Therefore, the purpose for renovating boilers from No.1 to No.3 is to minimize the load on the common unit by reducing NOx and SO_2 emissions from these boilers to levels as low as possible. Possible measures include:

(a) Reducing fuel consumption and flue gas volume

(b) Application of low-NOx burner

(c) It could also be effective to change the water wall tube to welded type. However, it is difficult to apply this to the existing boilers.

Therefore, this is not proposed in the modernization plan because this modification would cost the same as the construction of a new boiler.

(2) Boiler feed water system

1) Reduction of chemical and water consumption is to be done by the following measures:
As target values it is possible to reduce the chemical unit consumption of HCl from 0.69 kg/m^3 to 0.4 kg/m^3, and of NaOH from 0.89 kg/m^3 to 0.5 kg/m^3.
However, it is impossible to reduce the raw water unit consumption from 1.4 of raw water per m^3 of purified water which is the current level, to 1.1 m^3/m^3 as a target value, and it will remain 1.3 m^3/m^3.

(a) Regeneration efficiency is increased and chemical consumption will be reduced by changing chemical flow from parallel flow at present to countercurrent flow during the regeneration of ion exchange resin, and series regeneration for strong and weak cation and anion.
(b) Installation of a distributor to make treated water flow uniform in the ion exchange resin tower.
(c) Installation of a chemical collector in the ion exchange resin tower for the same reason as in (b) above.
(d) Reducing the number of dead spaces of pipe line and improving the effective use of chemicals by reducing the volume of chemicals remaining at the dead spaces.

2) Increase the capacity for treating raw water

Increasing of the capacity for treating raw water was studied, and it turned out that it will be impossible to increase the capacity for treating raw water by using the existing equipment because there is a limit of flow rate, which is

restricted by the diameter of the current ion exchange resin tower.
Therefore, there is no way to increase the capacity for treating raw water except by the installation of a new facility.
In the case increase of the capacity for treating raw water is required, application of reverse osmosis is advantageous from the stand point of raw water properties of PPSA.

(3) Increase of electric power generation

A large quantity of electric power is purchased from the outside in summer because electric power generated by the existing extraction turbine generator decreases due to the reduction of demand for steam in summer (Refer to Attachment 15).
This can be solved by installing an extraction-condensing turbine generator which enables power generation regardless of steam demand.
The effect of the reduction in purchased electric power, as a result of electric power generated by the extraction-condensing turbine, is shown in Attachment 16.

Chapter 3 Plant Cost

Investment cost requirements for the modernization of No.1 Distillation Unit and the Power Plant have been estimated for individual items of the needed renovation by asking for estimates in Poland (from PPSA, engineering companies in Poland, and manufacturers) in the case of items which can be make in Poland. For those items which cannot be manufactured in Poland, the costs have been obtained by the experience of importing similar equipment to Poland, and the prevailing prices in European countries. The results of these estimates are summarized in Attachment 17.

Chapter 4 Construction Periods

Construction periods required for the modernization differ by the nature of the projects, due to the differences of construction approach. As shown in Attachment 18, 29 months are contemplated for completing work on the No.1 Distillation Unit, and 24 months for the Power Plant.

Chapter 5 Financial and Economic Evaluation

The following are basic preconditions of financial and economic evaluation:

(1) FOB prices of crude oil and petroleum products at Rotterdam market were adopted as the basis of price estimation for the evaluation. The estimated prices are shown in Attachment 19.

(2) Utilities cost is estimated based on the international trend of energy price, and labor cost and maintenance cost are assumed from actual figures of PPSA in 1993 as per Attachment 20.

(3) Usually costs like sales expense, administration cost, other fixed costs, and income tax, are by their nature borne by the whole company. However, in this evaluation work, it was assumed that the above costs are to be shared by each Project as per Attachment 21. Value Added Tax (VAT) which is levied on crude oil, petroleum products and equipment, is excluded from the evaluation because to some extent, VAT collected by PPSA is cancelled by VAT it has to pay. In other words, capital cost excluding VAT was used in the evaluation of the Project.

Additionally, border tax is levied on crude oil but is not levied on petroleum products.
Pre-operation expenses and interest during construction have been estimated for this project and they are added to the investment cost.

(4) The account payable period is 30 days for crude oil. No inventory or accounts receivable are assumed because the output is intermediates.

(5) The source of funding is 50% on own equity and 50% from local banks.
Interest rate for the borrowing is 12.5% per annum with no grace period, and repayment is required within 5 years.

The purpose of the modernization of No.1 Distillation Unit is divided into the following two categories - one which is absolutely necessary, described in (1) to (3) below, and the other for purposes of rationalization to gain more profit, described in (4) to (6):

(1) Minimizing of off-specification intermediates will be necessary in the forthcoming free trade with the EC;

(2) Reduction of offensive odor is necessary for workers' health;

(3) Replacement of present system to DCS which is scheduled in the whole company is necessary to cope with shortage in supply of spare parts;

(4) Up-grading of products' specifications, change in the pattern of products or raising the level of production capacity;

(5) Energy saving; and

(6) Reduction of environmental pollutants.

Methods of improvement should be investigated for those modernization measures which are categorized as necessary, without which continuous production will be impossible. The effects are unquantifiable for this type of improvement. On the other hand, effects are and must be quantifiable for measures taken for the purpose of rationalization. So, investigation of whether the measure should be adopted or not will be performed after the financial evaluation.

The purposes of the modernization of the thermal power plant are:

(1) Reduction of fuel oil and reduction of SO_2 and NOx emissions;

(2) Reduction of raw water and chemicals consumption and increasing the raw water processing capacity; and

(3) Increase of electricity supply capacity by installation of an extraction-condensing turbine generator.

The results of evaluation of the No.1 CDU modernization are presented in Attachments 22 and 23. These tables show that total investment, including both the renovations absolutely necessary for continued production and measures taken for rationalization, is within the range of 20-35% of the annual profit after-tax; even in the case that operation rate is 80%. This table also shows that the repayment of debt and payment of interest is possible within 5 years.
The financial rate of return (FIRR) for the project, measured on the quantifiable effects, is fairly high and the number of payback years is within a reasonable range.

Attachment 24 shows the summary of the results of the evaluation on the modernization of the thermal power plant. Even with the

boiler operation rate of 80%, using high sulfur content fuel, the payback years of investment are within a reasonable range. However, water consumption volume after renovation will be greater than the present water processing capacity limit, and an increase in capacity for raw water processing is not be expected in the current plant. It is necessary to install a new facility in order to increase the water processing capacity.

Conclusion and Recommendation

The modernization plan for No.1 Distillation Unit has been prepared with consideration of (1) production of intermediate products of new standard quality without any off-specifications products, so that the final products of the refinery can be compatible with the European market in terms of prices and qualities; (2) prevention of offensive odor emissions; (3) Introduction of DCS; (4) shifting to higher value products (including balancing between the atmospheric tower and vacuum tower); (5) energy saving; etc.
These targets can be attained through efficient utilization of distillation towers, heat recovery, and optimization of operations such as injection of stripping steam etc.
Investment required to meet such targets will have sufficient returns. It is recommended that the above-described investments in the No.1 distillation unit shall be implemented.

As for the modernization of the thermal power plant, improvement of the boilers contributes to the reduction of fuel consumption, longer continuous operation period, etc. Revamping of water treatment facilities will enable the reduction of chemical consumption for regeneration. Installation of an extraction-condensing turbine and generator will make it possible to stabilize the supply of electric power without being affected by the steam demand, which will always be considerably lower in the

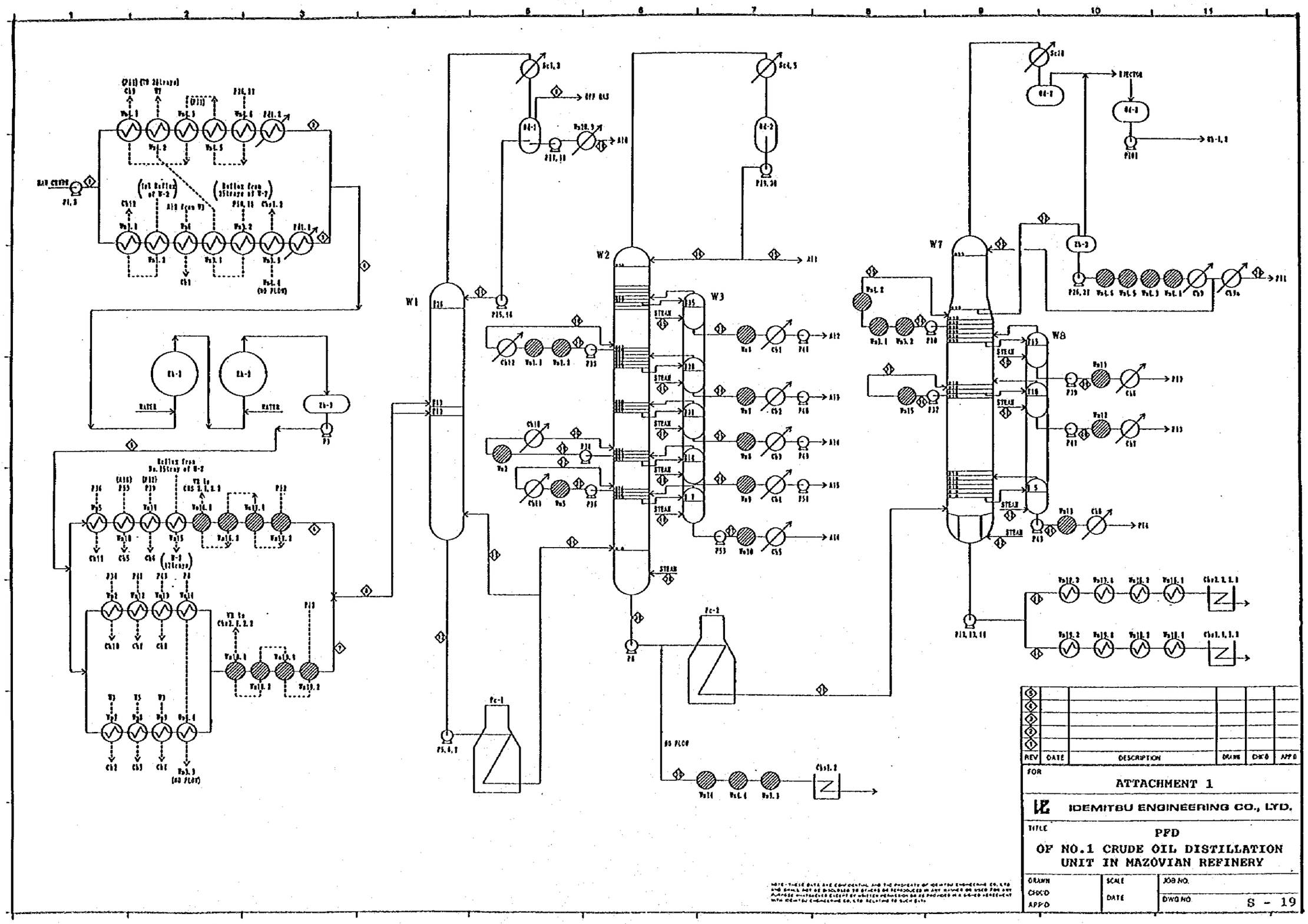
summer season; thereby greatly reducing the need for purchased power. However, increase of the capacity of existing water treatment facilities is difficult and it will be necessary to construct a new facility for the purpose. The modernization of the thermal power plant is well justifiable also, not only from technical viewpoints but also from the economic standpoint.
In summary, the proposed investment is quite rational.

Regarding air contamination, the objective item is exhausted gas from the heating furnace and boilers (1 through 3). SO_2 and NOx from these sources is reduced owing to the effect of energy saving. But this measure is not sufficient in itself, so boilers are required to have facilities for desulfurization and denitrification according to determination by PPSA; and also a shift to fuel of low sulfur content has to be taken into consideration.
Concerning water discharge, measures have been elaborated for prevention of offensive odor contained in waste water coming from each refinery top receiver.
As countermeasure, method of installation of waste water strippers and method of connection of waste water piping between gathering vessel and equipment have been taken into account and the latter one is recommendable.
And as countermeasure against hydrogen sulfide contained in receiver tank of reduction refinery and slop tank (Zb-3), installation of amine purification equipment has been contemplated but this is not economical and the method of combustion in heating furnace just like the present way may is the best one.

The profitability of investment greatly depends on operational rates. In order to secure higher profitability, it is preferable to maintain a higher operational rate of the facilities. For this, it is prerequisite that crude oil shall be supplied constantly and petroleum products can be marketed smoothly. At the same time, mechanical troubles in the facilities shall be

minimized. Proper maintenance of the facilities is required. PPSA already has a planned maintenance system of preventive maintenance and post maintenance. However, introduction of a well established system and technology for plant diagnosis will be required for the preventive maintenance plan to succeed.

Further, in addition to the increase of capacity utilization rate, it is required to control the facilities well, responding to changes in the operation conditions. Introduction of DCS will help make accurate measurement and operation more adequate than before.



FOR

ATTACHMENT 1

IDEMITSU ENGINEERING CO., LTD.

TITLE

PFD
OF NO.1 CRUDE OIL DISTILLATION UNIT IN MAZOVIAN REFINERY

DRAWN	SCALE	JOB NO.	
CHK'D	DATE	DWG NO.	S - 19
APP'D			

ATTACHMENT 2-1 FUTURE PRODUCT SPECIFICATION FOR NO.1 CRUDE OIL DISTILLATION UNIT (1/2)

	Use	Specification
(1)Gases	Refinery Fuel Gas	C_4 mininum
(2)LPG	Fuel for Home	C_3+C_4 content vol % max. 1.5 C_5 content vol % max. 0.5
(3)R_1	① W-5 Column in depentanization operation	Distillation(*1) IBP min. 25 ℃ FBP 85 ± 5℃ Loss+Residue max. 4 vol. %
	② W-5 Column in dehexanization operation	Distillation(*1) IBP min. 25 ℃ FBP max. 80 ℃ C_4 content max. 4 wt% C_7 content max. 1 wt%
(4)R_2	① W-5 Column in depentanization operation	Distillation(*1) IBP 78 ± 5℃ 50 vol.% recovered at ℃ 87 FBP 110 ± 5℃ 1) or C_3 – C_4 content 3 wt%
	② W-5 Column in dehexanization operation	Distillation(*1) IBP 80 ± 5℃ FBP 110 ± 5℃ C_6 content minimized
(5)A_1	①Reforming Feed	Distillation(*1) IBP 78 ± 5 ℃ FBP. max. 150 ℃
	②Pyrolysis Feed	Distillation(*1) IBP 78 ℃ FBP. max. 180 ℃
(6)A_2	①Reforming Feed	Distillation(*1) IBP min. 130 ℃ FBP max. 180 ℃
	②Pyrolysis Feed	Distillation(*1) IBP min. 130 ℃ FBP max. 230 ℃
(7)A_3	Diesel Oil Blend	Distillation(*1) FBP max. 300 ℃ Flash Point(ASTM D 93) min. 80 ℃

NOTE: (*1) ASTM D 86

ATTACHMENT 2-1 FUTURE PRODUCT SPECIFICATION FOR NO.1 CRUDE OIL DISTILLATION UNIT (2/2)

(8)A_{4}	Diesel Oil Blend	% vol. evaporated at 350°C Summer min. 85 Winter min. 90
(9)P_{10}	Diesel Oil Blend	Non Specificated
(10)P_{11}	Lubricating Oil	OPERATION: A / B Distillation(*2) (TBP) % vol.evaporated at 300 °C: max. 7 / max. 0.5 at 325 °C: max. 20 / max. 3 at 350 °C: 35-45 / max. 10 at 400 °C: min. 90 / 45-60 at 450 °C: – / min. 90 Viscosity at 100 ° C (mm²/s): 2.5-3.2 / 3.5-4.2
(11)P_{12}	Lubricating Oil	Distillation (*2) (TBP) % vol.evaporated at 300 °C: max. 0.5 / max. 0.5 at 350 °C: max. 6 / – at 400 °C: 20-30 / max.10-15 at 450 °C: 80-85 / 45-60 at 500 °C: min. 98 / 85-90 above 520 °C: – / max 15 Viscosity at 100 ° C (mm²/s): 5.0-5.6 / 6.9-7.3
(12)P_{13}	Lubricating Oil	Distillation(*2) (TBP) % vol.evaporated at 400 °C: 6.5-8.0 / max. 0.5 at 450 °C: 31-34 / max. 15 at 500 °C: 73-79 / 45-50 above 525 °C: 10-14 / 25-30 Viscosity at 100 ° C (mm²/s): 11.2-11.8 / 12.0-14.0
(13)P_{14}	Fuel Oill Blend	Flash Point: 210 °C / 210 °C
(14)Vacuum Residue	• Refinery Fuel Oil • For Asphalt Plant	Penetration 1/10 mm (ASTM D 5) max. 200 / max. 200 min. 120 / min. 120

NOTE: (*2) ASTM D 2887-78

ATTACHMENT 3-1 Properties of Ural crude oil (1/2)

Analysis of Ural Crude Oil to be used for the Modernization Study of No.1 Atmospheric Distillation Unit No.1 Vacuum Distillation Unit

DESCRIPTION	UNIT	VALUE
1. Density d^{15}_{4}		0.860
'		
API		32.3
2. Water Content	Wt %	0.23
3. Chloride Contents	mg/l	13
4. Distillation		
IBP	℃	45
Evaporated at 100℃	Vol %	10.5
150℃		19.5
200℃		28.0
250℃		30.0
300℃		47.0
350℃		61.0
5. Sulfur Content	Wt %	1.39
6. H_2S Content(Dissolved)	Wt %	
at 20 ℃		nil
50 ℃		nil
7. Viscosity		
at 10℃		20.36
20℃		13.33
37.8℃		7.64
50℃		5.84
8. Freezing Point	℃	-15
9. Pour Point	℃	-12

ATTACHMENT 3-2 Properties of Ural crude oil (2/2)

DESCRIPTION	UNIT	VALUE
10. Conradoson Carbon Residue	Wt %	3.80
11. Metal Content		
V	mg/kg	36
Ni		13
Fe		20
Na		2
K		below 0.5
Ca		below 0.5
12. Asphaltene	Wt %	1.21
13. Ash	Wt %	0.014
14. Wax Content	Wt %	2.57
Melting Point	℃	53
15. Acid Number	KOH/g	0.06
16. Reid Vapor Pressure	Pa (Kg/cm²)	392(0.4)
17. Watson K Factor		11.79

ATTACHMENT 4-1 MODERNIZATION OF No.1 CRUDE OIL DISTILLATION UNIT (1/2)

Purpose	Modernization	Note
1. Increase of No.1 Vacuum Distillation Unit throughput and improvement of product quality		
(1) Improvement of product quality	- Installation of coalescer in relation with stripping steam injection	
	- Construction of Stabilization Unit for A10 Product	
	- Construction of Rectification Unit	
(2) Increase of No.1 Vacuum Distillation Unit Throughput	- No measures is required for imbalance of atmospheric tower and vacuum tower since imbalance has eliminated by new product specifications	
(3) Reduction of Atmospheric Distillation Product Number		Number of Atmospheric Distillation Products is reduced according to the new product specifications provided by PPSA.
(4) Improvement of Vacuum Tower Fraction	- No measures is required because of new Product specification	

ATTACHMENT 4-1 MODERNIZATION OF No.1 CRUDE OIL DISTILLATION UNIT (2/2)

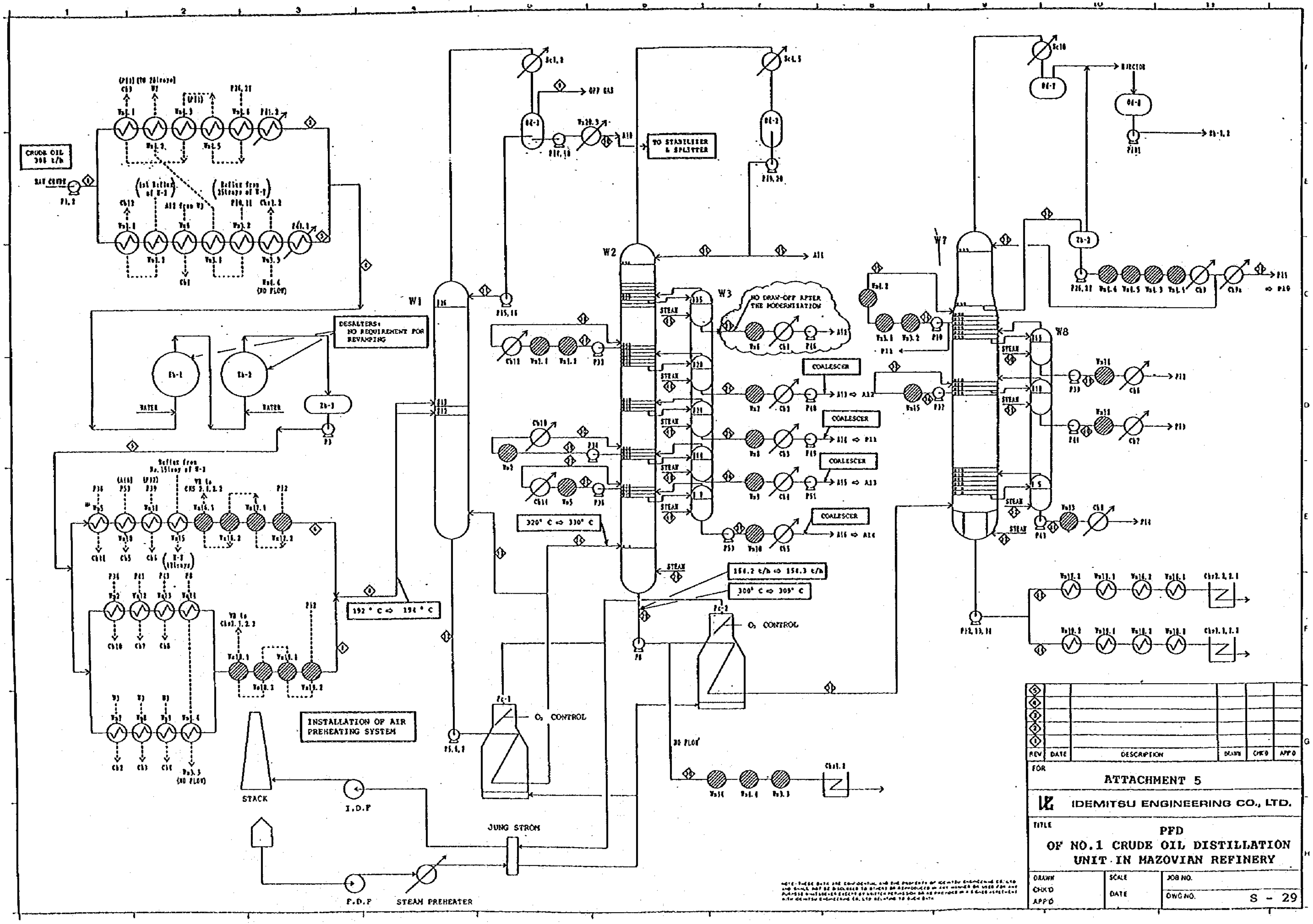
Purpose	Modernization	Note
2. Saving Energy		
(1) Improvement of heat exchange between products and crude oil	- Rearrangement of Heat Exchangers	
(2) Improvement of Process Heater efficiency	- Installation of a Jung Strom and related equipment	
(3) Removal of box coolers	- No box water coolers	
(4) Reduction of oxygen content in flue gas	- 4% oxygen in flue gas control	
3. Reduction of Pollutant Emissions		
(1) Treatment of od-8 and zb-3 emission	- Construction of amine treating facilities and related equipment	Agreed that no amine treating feacilities and related equipment will be constructed.
(2) Reduction of offensive odor substance in sewage	- Short piece of pipe connection and water sealing	
(3) SO_2 and NOx reduction of heater	- SO_2 reduction by saving energy and NOx reduction by low NOx burners	For No.1 Crude Oil Distillation Unit, SO_2 and NOx treatment is not planned.
4. Others		
(1) Application of DCS	- Replacement of resent pneumatic system to DCS	
(2) Revamping of Electrodehydrators	- Not considered	

ATTACHMENT 4-2 MODERNIZATION OF POWER PLANTS (1/2)

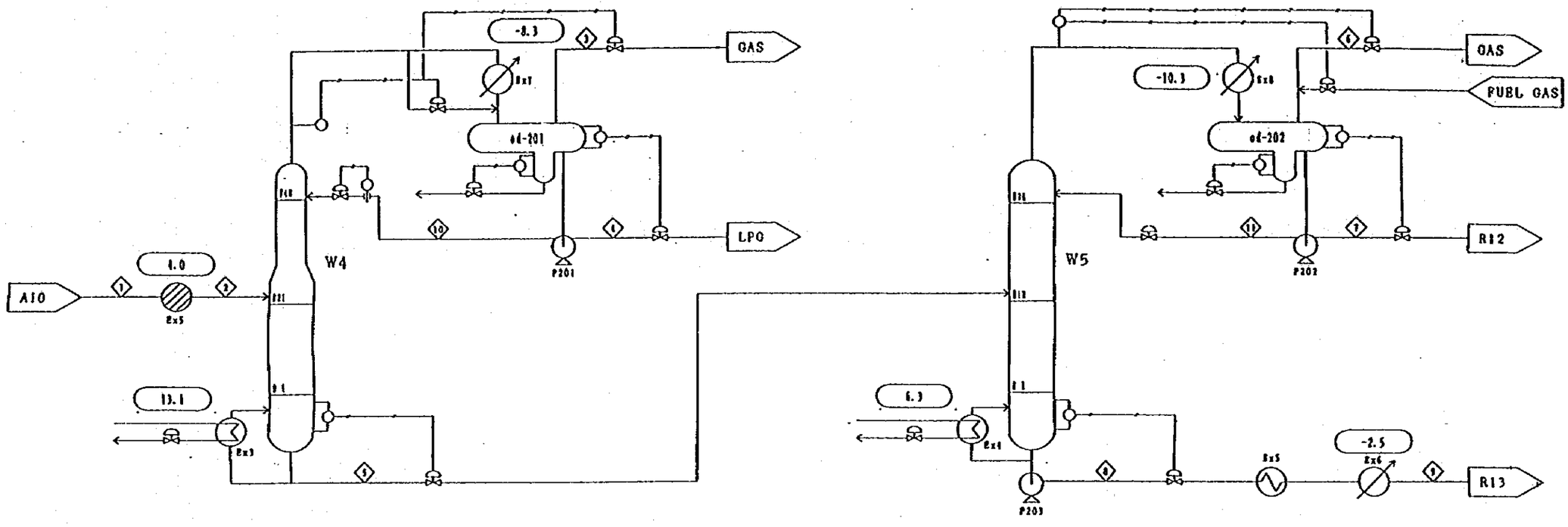
Purpose	Modernization	Note
1. Boiler No.1 to No.3		
(1) Increase of efficiency by 2 to 3%	- Remodeling of burner tips	
	- Installation of soot blowers	
	- Change of tube arrangement of economizer	For keeping the effect of soot blower
	- Heat recovery from deaerator vent steam	
(2) Reduction of excess air ratio	- Change of Jung Strom to low air leakage type	Actual 1.6 to 1.08
(3) Reduction of NOx and SO_2	- Remodeling of burner tips	
	- Biased combustion	
	- Replacement to low NOx burners	

ATTACHMENT 4-2 MODERNIZATION OF POWER PLANTS (2/2)

Purpose	Modernization	Note
2. Boiler Feed Water Treatment System		
(1) Reduction of chemicals consumption	- Modification of counter current regeneration system	
	- Series chemical feed	
	- Installation of water collector and chemical collector inside the tower	
	- Reduction of dead space	
(2) Reduction of raw water consumption	- Same measures as the reduction of chemical consumption	The recovery of back wash water from filters is not feasible because of the high replacement cost for pretreatment system.
(3) Increase of treating capacity		The present treating capacity is chose to the upper limit of resin towers.
3. New condensing/extraction power generation		
(1) Reduction of purchase of power in summer	- Installation of condensinsing/extraction turbine and generator (65 MW)	



CRUDE OIL
DESALTERS: NO REQUIREMENT FOR REVAMPING
WATER
W1
W2
W3
W7
W8
OFF GAS
TO STABILIZER & SPLITTER
NO DRAW-OFF AFTER THE MODERNIZATION
COALESCER
STEAM
EJECTOR
320° C ⇨ 330° C
192 ° C ⇨ 194 ° C
300° C ⇨ 305° C
O_2 CONTROL
INSTALLATION OF AIR PREHEATING SYSTEM
STACK
I.D.P
F.D.P
JUNG STROM
STEAM PREHEATER
REV
DATE
DESCRIPTION
DRAWN
CHK'D
APP'D
FOR
ATTACHMENT 5
IDEMITSU ENGINEERING CO., LTD.
TITLE
PFD
OF NO.1 CRUDE OIL DISTILLATION
UNIT IN MAZOVIAN REFINERY
SCALE
DATE
JOB NO.
DWG NO.
S - 29



FLOW NO.		1	2	5	7	8	9	11
FLOW RATE (kg/h)		25 096	〃	20 828	7 252	13 576	〃	20 476
TEMPERATURE (°C)		55	70	162	47	116	38	47
PRESSURE (MPa)		1.3	1.11	1.13	0.6	0.6	—	0.6
DISTILLATION (°C)	METHOD	ASTM D86	〃	〃	〃	〃	〃	〃
	IBP	-23	〃	49	35	78	〃	35
	5%	5	〃	50	—	86	〃	—
	10%	16	〃	51	—	88	〃	—
	30%	40	〃	54	—	90	〃	—
	50%	66	〃	74	—	92	〃	—
	70%	80	〃	85	40	93	〃	40
	90%	93	〃	94	57	95	〃	57
	95%	101	〃	99	66	100	〃	66
	FBP	102	〃	102	80	103	〃	80
DENSITY@20°C (g/cm³)		0.661	〃	0.684	0.638	0.711	〃	0.638

FLOW NO.		3	4	6	10
FLOW RATE (kg/h)		—	4 268	—	17 072
TEMPERATURE (°C)		38	38	47	38
PRESSURE (MPa)		1.03	1.7	0.15	1.7
COMPONENT (mol%)	C2	—	—	—	—
	C3	—	20.2	—	20.2
	iC4	—	18.4	—	18.4
	nC4	—	61.2	—	61.2
	iC5	—	0.2	—	0.2
	nC5	—	—	—	—
	cC5	—	—	—	—

( ) HEAT DUTY (GJ/h)

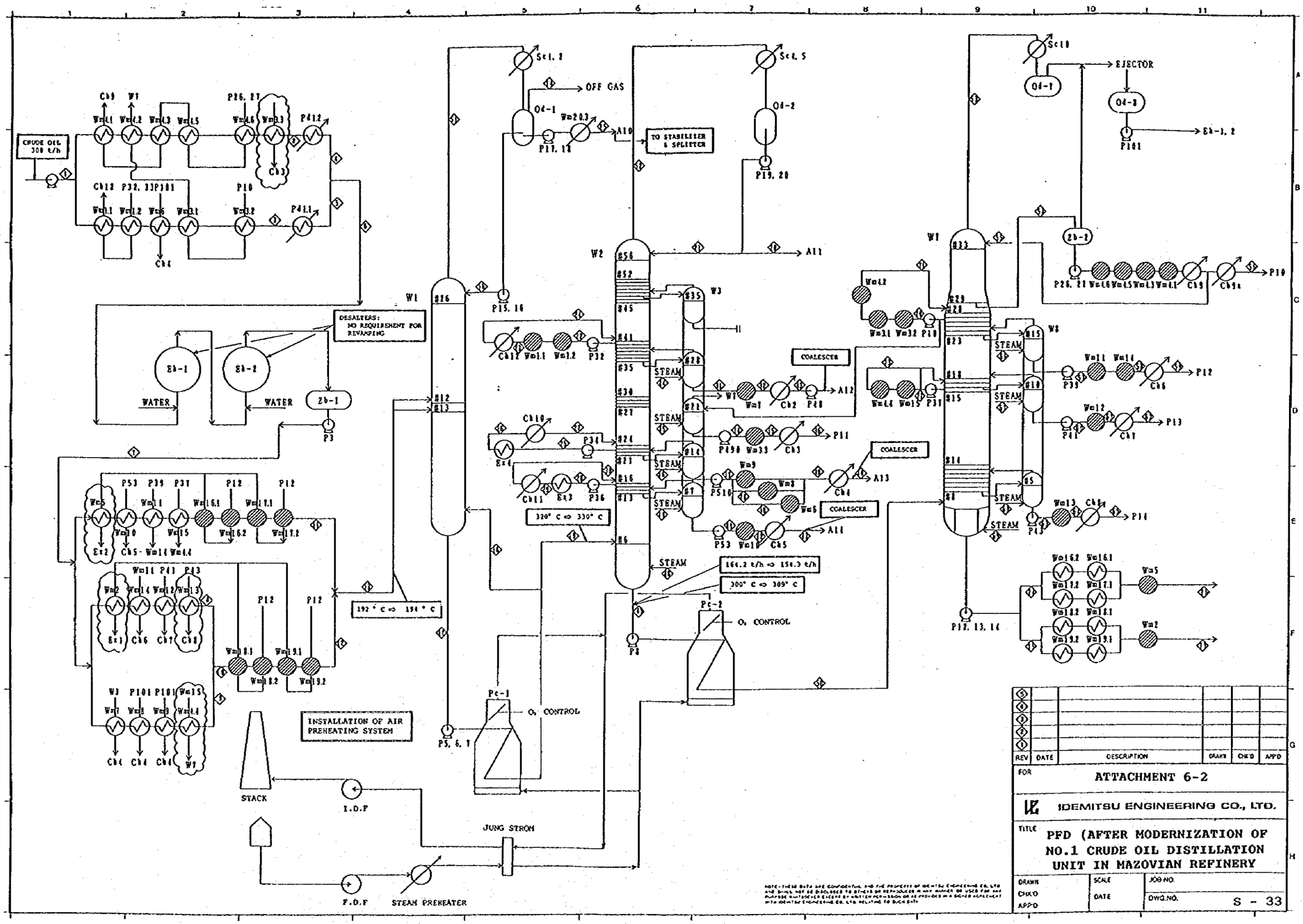
REV	DATE	DESCRIPTION	DRAWN	CHK'D	APP'D
⑤					
④					
③					
②					
①					

FOR
ATTACHMENT 6-1

IDEMITSU ENGINEERING CO., LTD.

TITLE
PFD
STABILIZATION UNIT
OF MAZOVIAN REFINERY

DRAWN	SCALE	JOB NO.	
CHK'D	DATE	DWG NO.	S - 31
APP'D			



REV	DATE	DESCRIPTION	DRAWN	CHK'D	APP'D
5					
4					
3					
2					
1					

FOR ATTACHMENT 6-2

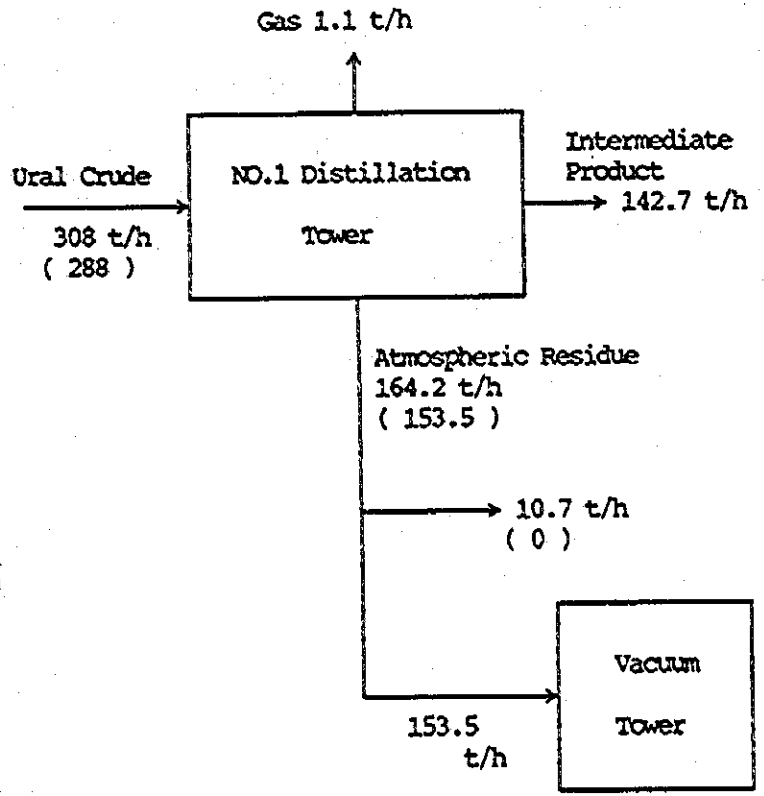
IDEMITSU ENGINEERING CO., LTD.

TITLE PFD (AFTER MODERNIZATION OF NO.1 CRUDE OIL DISTILLATION UNIT IN MAZOVIAN REFINERY

DRAWN	SCALE	JOB NO.	
CHK'D	DATE	DWG.NO.	S - 33
APP'D			

ATTACHMENT 7 MODERNIZATION PLAN OF NO.1 CRUDE OIL DISTILLATION UNIT

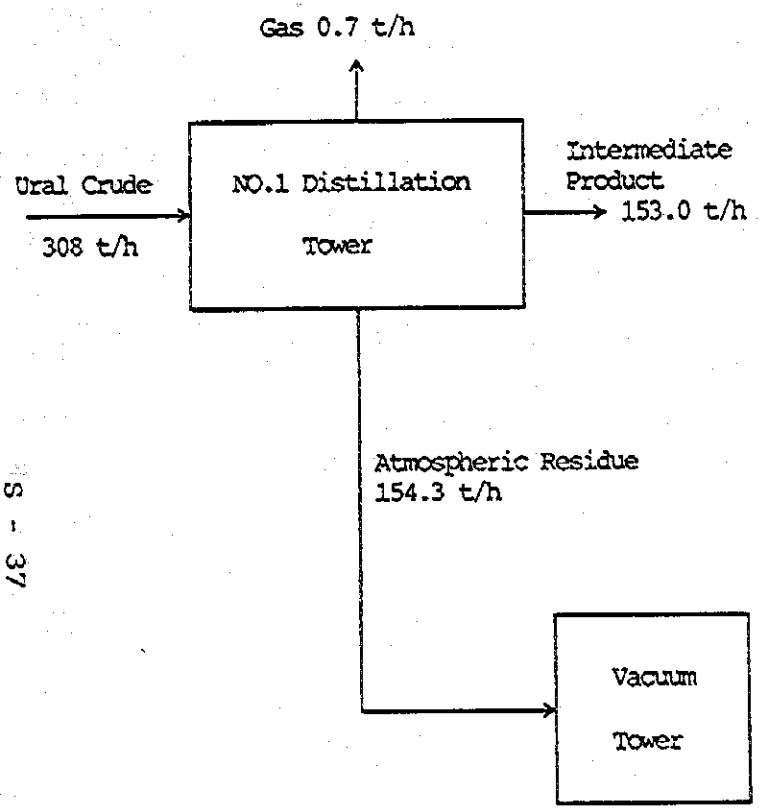
1. Before Modernization



Intermediate Products	Specification	Product Quantity (t/h)	Remarks
Gas	——		
Full range Naphtha (A10)	IBP min. 25° C FBP max. 180° C	25	
Light Naphtha (A11)	IBP 78.5 ± 5° C FBP 148 ± 5° C	20.9	IBP:Out of Spec. Gap:Not Satisfactory
Heavy Naphtha (A12)	IBP 130 ° C FBP 190 ° C	13.6	IBP:Out of Spec. Gap:Not Satisfactory
Kerosene (A13)	FBP 220 ° C % vol. evaporated at 200 ° C - 50 Flash Point < 55 °	20.5	IBP:Out of Spec. FP :Out of Spec.
Light Gas Oil (A14)	IBP 180 ° C Density 0.81 ~ 0.835 Flash Point < 66 °	18.2	IBP:Out of Spec. FP :Out of Spec.
Gas Oil (A15)	Density 0.83 ~ 0.850 % vol. evaporated at 350 ° C - 87	25.1	Lower than IBP of A16
Heavy Gas Oil (A16)	Density 0.85 ~ 0.870 % vol. evaporated at 350 ° C - 80	19.4	
Atmospheric Residue	——	164.2	

Intermediate Products	Specification	Product Quantity (t/h)	Remarks
Gas Oil (P11)	FBP < 460 ° C Density 0.88 ~ 0.895 Flash Point > 120° C Freezing Point < 8° C	41.0	Specific Gravity: Out of Spec.
Gas Oil (P12)	FBP < 460 ° C Flash Point > 120° C	17.1	FBP : Out of Spec.
Gas Oil (P13)	Density 0.91 ~ 0.925 Viscosity 10.5~ 12.5 mm^2/s Flash Point > 220° C Freezing Point <37° C IBP > 400 ° C FBP < 545 ° C FBP-IBP ≦ 120° C	34.2	Vis : Out of Spec. FBP-IBP : Out of Spec.
Gas Oil (P14)	Flash Point < 210° C	11.4	
Vacuum Residue	Penetration (Softening Point R-B Method) 43.6 ~ 46.5	60.4	Penetration : Out of Spec.

2. After Modernization



Intermediate Products	Specification	Product Quantity (t/h)	Remarks
Gas	——		
LPG	C1+C2 < 1.5 vol. % C5 < 0.5 vol. %	4.3	
Light Naphtha (R12)	IBP > 25° C FBP 85 ± 5° C	7.2	
Light Naphtha (R13)	IBP 78 ± 5° C 50vol.% recovered at ° C 87 FBP 110 ± 5° C	13.6	
Light Naphtha (A11)	IBP 78 ± 5° C FBP < 150° C	24.5	
Heavy Naphtha (A12)	IBP < 130° C FBP < 180° C	9.7	
Light Gas Oil (A13)	FBP < 300° C Flash Pont > 80° C	65.7	FP : Out of Spec.
Heavy Gas Oil (A14)	% vol. evaporated at 350 ° C Summer > 85 winter > 90	28.0	
Atmospheric Residue	——	154.3	

Intermediate Products	Specification	Product Quantity (t/h)	Remarks
Gas Oil (P10)		12.0	
Gas Oil (P11)	% vol. evaporated at 300 ° C < 0.5 325 ° C < 3 350 ° C < 10 400 ° C 45 - 60 450 ° C > 90 Vis. at 100 ° C 3.5 - 4.2	36.0	
Gas Oil (P12)	% vol. evaporated at 300 ° C < 0.5 350 ° C — 400 ° C max. 10 - 15 450 ° C 45 - 60 500 ° C 85 - 90 above 520° C < 15 Vis. at 100 ° C 6.9 - 7.3	26.0	
Gas Oil (P13)	% vol. evaporated at 400 ° C < 5 450 ° C < 15 500 ° C 45 - 50 above 520° C 25 - 30 Vis. at 100 ° C 12.0 - 14.0	9.9	
Gas Oil (P14)	Flash Point 210° C	10.0	
Vacuum Residue	Penetration 120 — 200 (ASTM D 1321)	60.4	The same as value before Modernization

ATTACHMENT 8

(kg/h)

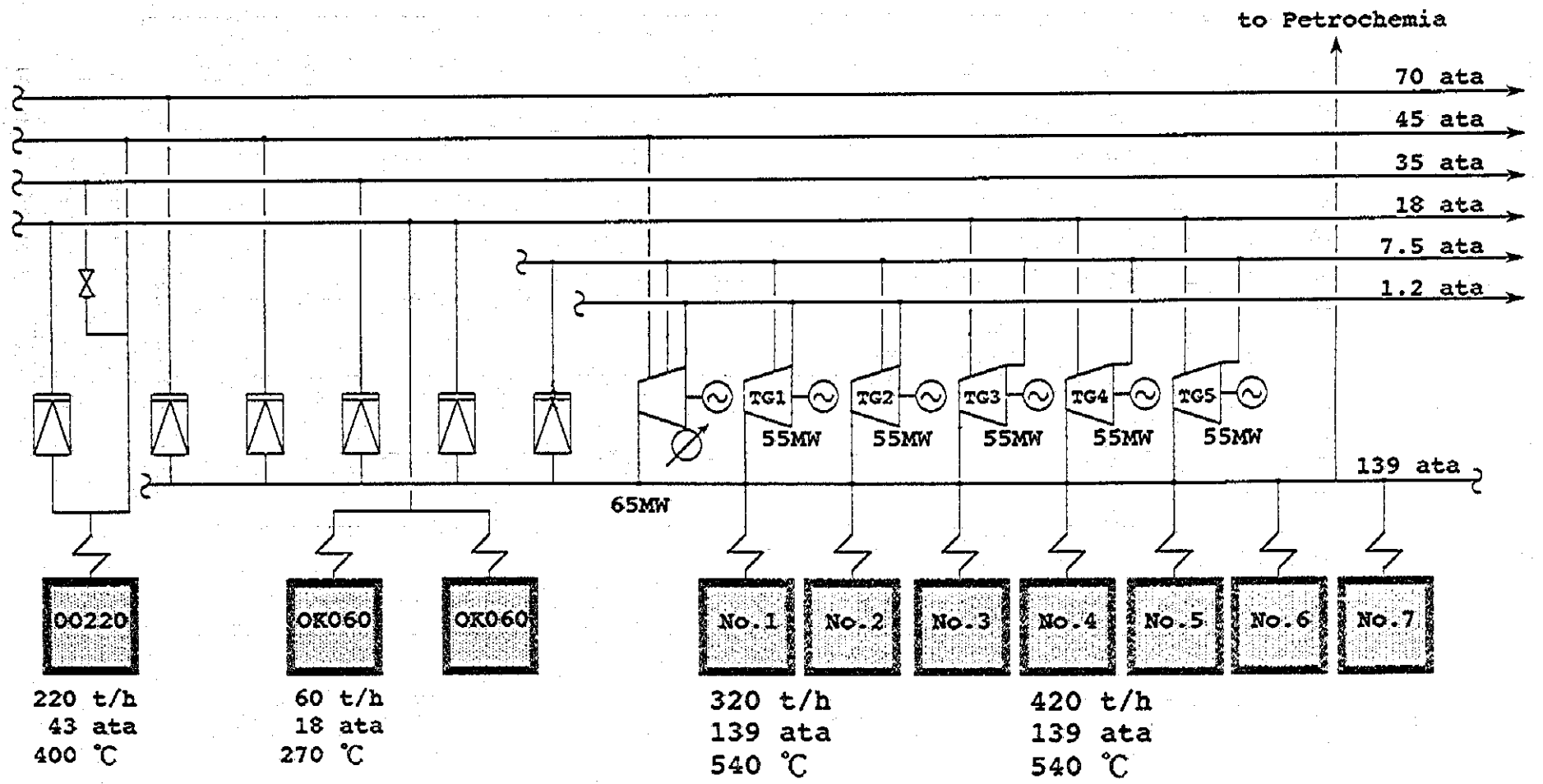
Furnace	Allowable Limit SO_2 (1993)	Before modernization		After modernization	
		Fuel consumption base	Heat balance base	Fuel consumption base	Heat balance base
Pc-1	56.6	179.3	292.3	133.0	246.0
Pc-2	20.3	91.2	97.0	64.9	70.0

(Note) The assumed conditions are the same as those in Table 3.7-2 with 100% oil

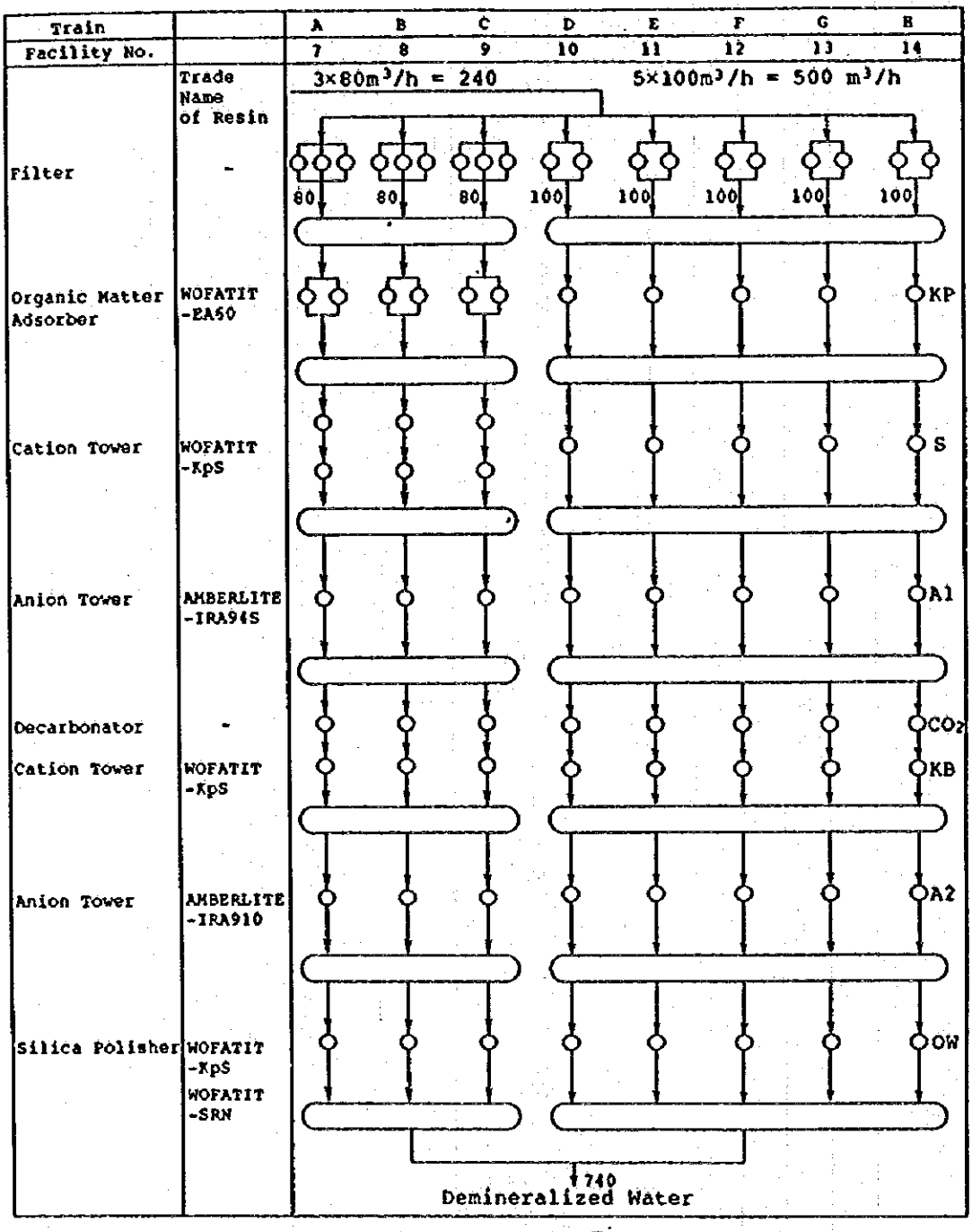
ATTACHMENT 9 DIFFERENCE OF ESTIMATED UTILITIES' CONSUMPTION BEFORE AND AFTER THE MODERNIZATION OF NO.1 CRUDE OIL DISTILLATION UNIT

ITEM NUMBER	FUEL OIL (kg/h)	ELECT-RICITY (kw)	STEAM (t/h)	COOLING WATER (t/h)	NOTE
(1) Heaters					• Including Saving Energy Items (Air Preheating and O_2 Control).
Pc-1	-1,371.2				• Lower calorific value of fuel oil : 9,443 kcal/kg
Pc-2	-305.5				• Minus means decrease of consumption.
(2) Stabilizer & Splitter					
P-210 A,B		1.5			- One pump operation.
P-202 A,B		1.5			- One pump operation.
P-203 A,B		1.1			- One pump operation.
(3) Re-arrangement of H.E					
Pumps		182.5			- One pump operation.
Ex-6				40	
Ex-7				130	
Ex-8				165	
Stripping Steam			4.5(0.7 MPa)		W-2, W-3, W-7, W-8
Pd-1.1 & Pd-1.2			4.0(1.7 MPa)		14kg/cm²G(205 ° C)
(4) Air Preheat					
Jung Stram		2.2			• Current utility consumption informed by PPSA -Electric Power:1,501 kwh -Instrument air: 234 nm³/h -Steam (1.7 MPa): 5.447 t/h -Steam (0.6 MPa):14.580 t/h (including steam for steam trace- 6 t/h)
Soot Blower		0.2			
Steam Air Heater			7.8(1.7 MPa)		
Forced Fan		500			
Induced Fan		400			
(5) Removal of existing pumps					
P-46		-9.6			Information from PPSA
P-49		-16.0			Information from PPSA
P-51		-30.0			Information from PPSA
(6) DCS		25			
	-1,676.7	1,058.0	16.3	335	

ATTACHMENT 10 SIMPLIFIED STEM DIAGRAM AFTER INSTALLATION OF NEW CONDENSING



ATTACHMENT 11 SCHEMATIC FLOW DIAGRAM OF CURRENT DE-MINERALIZER FACILITIES

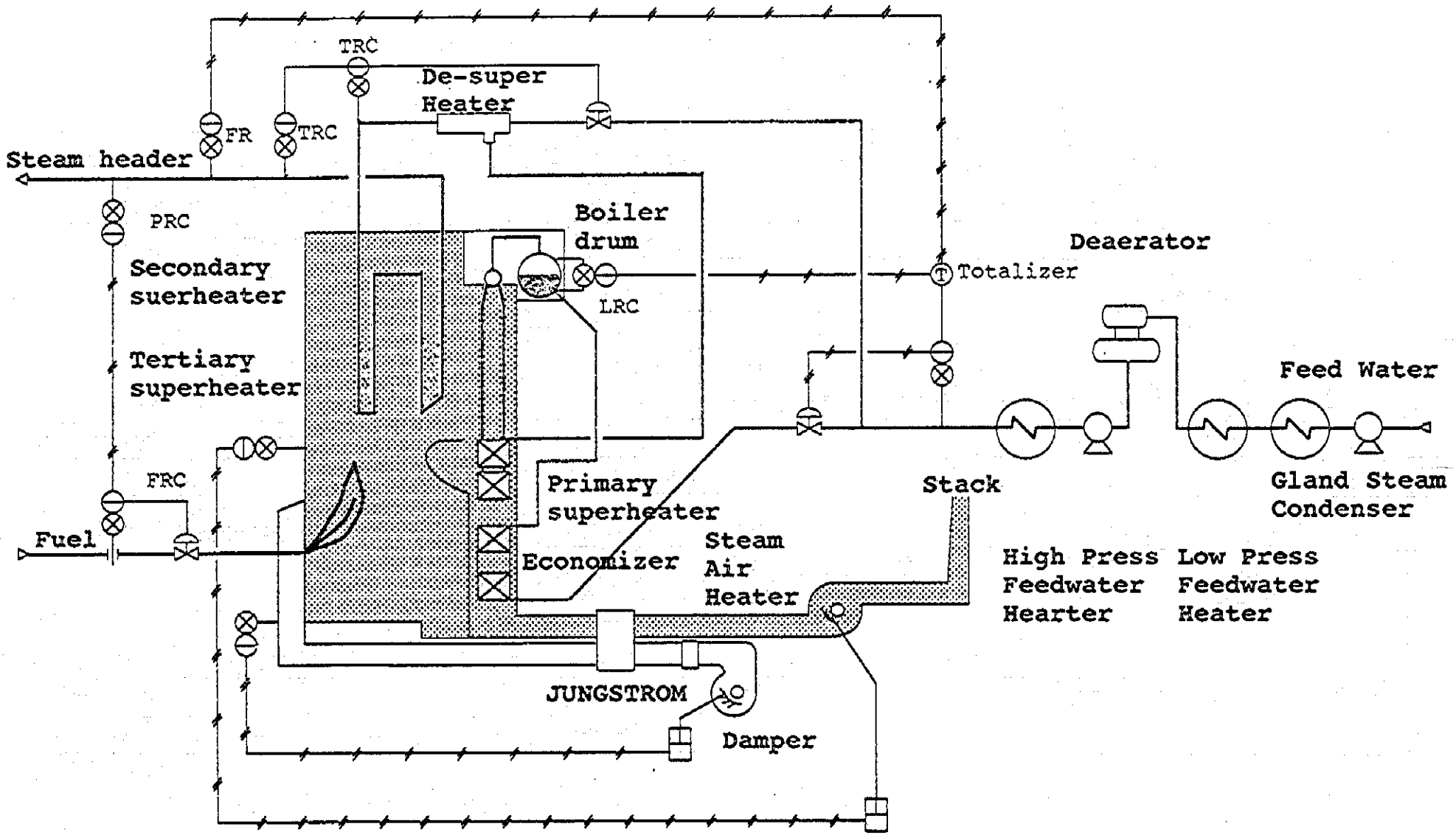


Source: PPSA

ATTACHMENT 12 MODERNIZATION OF POWER PLANT

Purpose	Modernization	Effect			
Boiler No.1 to No.3		Fuel oil	Electricity	Steam	NOx / SOx
Increase of efficiency by 2 to 3 %	- Remodeling of burner tips - Installation of soot blower - Change of tube arrangement of economizer - Heat recovery from continuous blow water - Heat recovery from deaerator vent steam	△ 1,000 kg/h		4.2 t/h	
Reduction of excess air ratio	- Change of Jungstrom to low air leakage type (- Replacement to low NOx burners)	△ 200 kg/h	△ 1,200 kW・h/h		0 /△ 729 kg/h
Reduction of NOx and SOx	- Replacement to low NOx burners				△ 318 / 0 kg/h
Boiler Feed Water Treatment System		NaOH	HCl	Raw Water	
Reduction of chemical consumption	- Modification to counter current regeneration system - Series chemical feed - Installation of water distributor inside the tower - Installation of chemical collector inside the tower - Reduction of dead space in piping	△ 0.4 kg/m³-P.W.	△ 0.4 kg/m³-P.W.		
Reduction of raw water consumption	- Save as measures the reduction of chemical consumption			△ 0.1 m³/m³-P.W.	
Increase of treating capacity	(- Installation of new plant) *1				
New condensing/extraction power generation		Electricity	Steam	Cooling Water	
Reduction of purchase of power in summer	- Installation of condensing/extraction turbine and generator (65 MW)	65 kW・h/h	186 t/h	7,700 t/h	

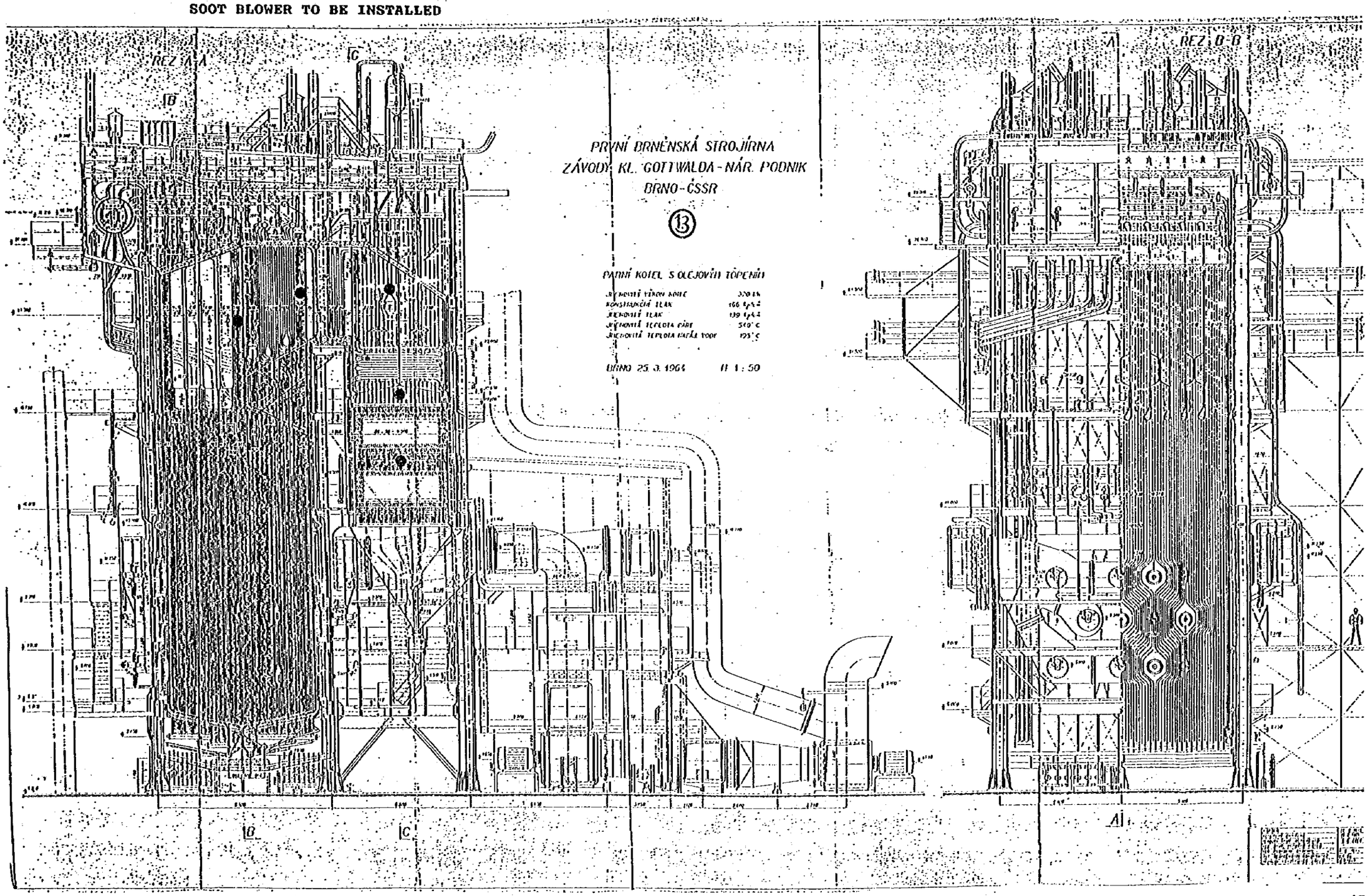
*1 ; the capacity of existing units are not enough.



ATTACHMENT 13-1

SIMPLIFIED FLOW DIAGRAM OF BOILER

ATTACHMENT 13-2 RECOMMENDED POSITION OF SOOT BLOWER TO BE INSTALLED



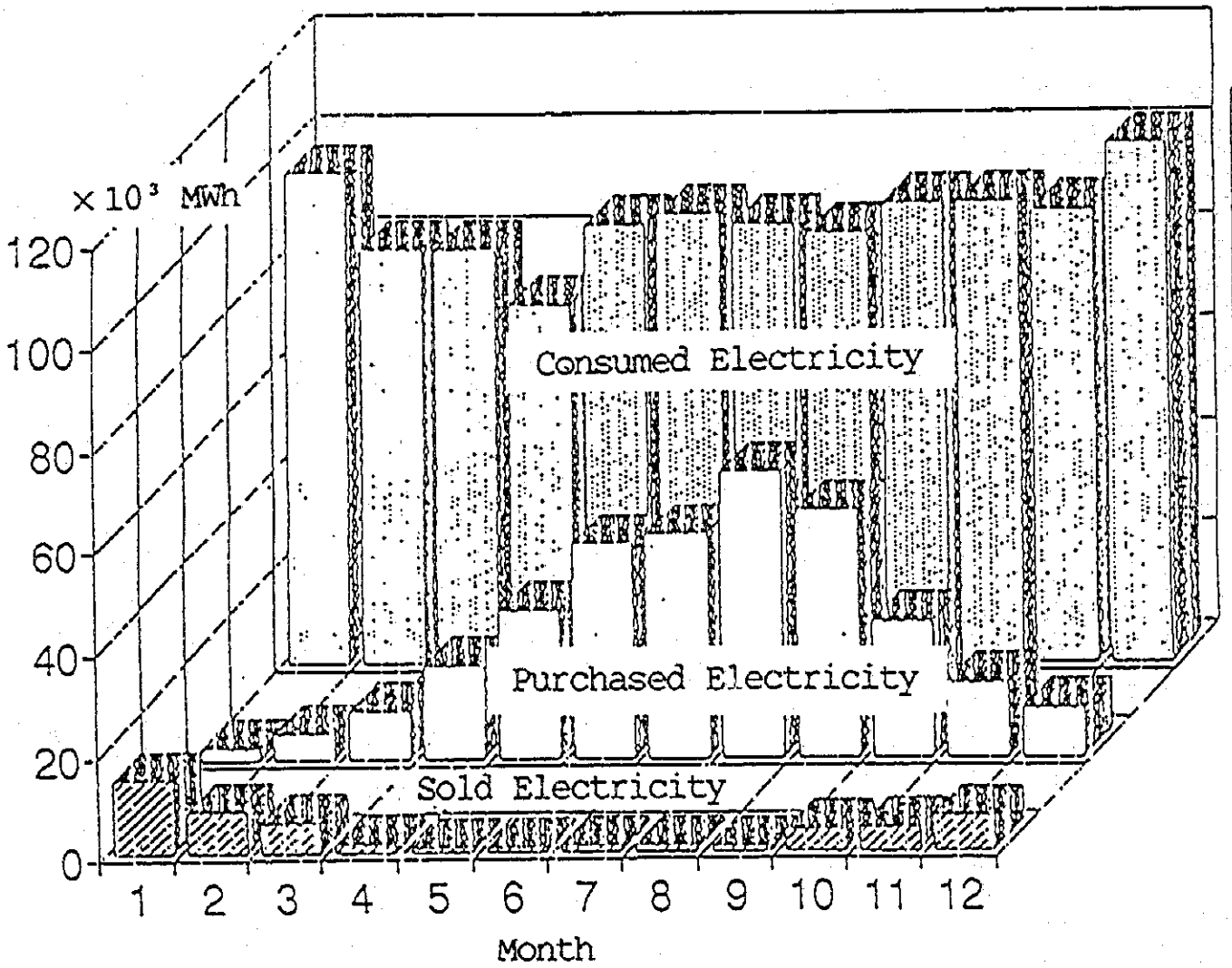
ATTACHMENT 14

ONE SAMPLE OF BOILER LOAD BALANCE AT THE CASE OF 1,470 T/H OF TOTAL STEAM DEMAND

boiler number	load	% of rated load
No.1	260 t/h	80% of rated load
No.2	260 t/h	80% of rated load
No.3	out of use	
* No.4	316 t/h	75% of rated load
* No.5	316 t/h	75% of rated load
* No.6	318 t/h	76% of rated load
No.7	out of use	

Note: * means for load adjustment

ATTACHMENT 15 ELECTRICITY BALANCE OF PPSA IN 1992



Production	1.033.416 MWh
Consumption	1.172.193 MWh
Sale	53.027 MWh
Purchase	301.814 MWh
Loss	110.010 MWh

Source ; P.P.S.A.

ATTACHMENT 16 ELECTRICITY BALANCE AFTER MODERNIZATION

Month	Electricity generated	Electricity consumed	Sold electricity	Purchased electricity
	(kW•h/h)	(kW•h/h)	(kW•h/h)	(kW•h/h)
Jan.	65,000	2,960	62,040	0
Feb.	65,000	7,440	57,560	0
Mar.	65,000	11,290	53,710	0
Apr.	65,000	24,860	40,140	0
May	65,000	38,300	26,700	0
Jun.	65,000	57,780	7,220	0
Jul.	65,000	58,870	6,130	0
Aug.	65,000	65,000	0	10,000
Sep.	65,000	65,000	0	2,200
Oct.	65,000	34,950	30,050	0
Nov.	65,000	20,140	44,860	0
Dec.	65,000	12,900	52,100	0
Total *1	569,400,000	292,658,160	276,741,840	9,038,400
Total *2	514,800,000	264,595,050	250,204,950	8,171,700

Note: *1 Annual cumulative value (kW•h/year)
*2 Annual cumulative value correlated with 330 days/year

ATTACHMENT 17-1 SUMMARY OF NO.1 CDU

Unit: US$

		Equipment & Material		Field work	EPS-MH and expenses	Sub total	Import duty	VAT	Total
		Foreign	Local						
1	Rearrangement of heat exchange	-	992,946	2,232,550	433,920	3,569,416	-	804,078	4,463,494
2	Installation of air preheater	306,250	656,000	708,180	189,990	1,860,420	150,063	341,917	2,352,400
3	O_2 control in flue gas from Pc-1 and Pc-2	15,400	65,000	51,600	19,800	151,800	7,546	30,008	189,354
4	Replacement to DCS	633,000	794,200	242,800	214,080	1,884,080	310,170	275,238	2,469,488
5	Reducing offensive odor sub stance in sewages	-	6,400	10,000	-	16,400	-	3,608	20,008
6	Installation of coalescer	338,000	-	84,600	12,700	435,800	165,865	22,790	624,455
	Grand Total	1,292,650	2,514,546	3,329,730	870,490	8,007,916	633,644	1,477,639	10,119,199

Note: EPS-MH; Engineering, Procurement and Supervising Man-hours

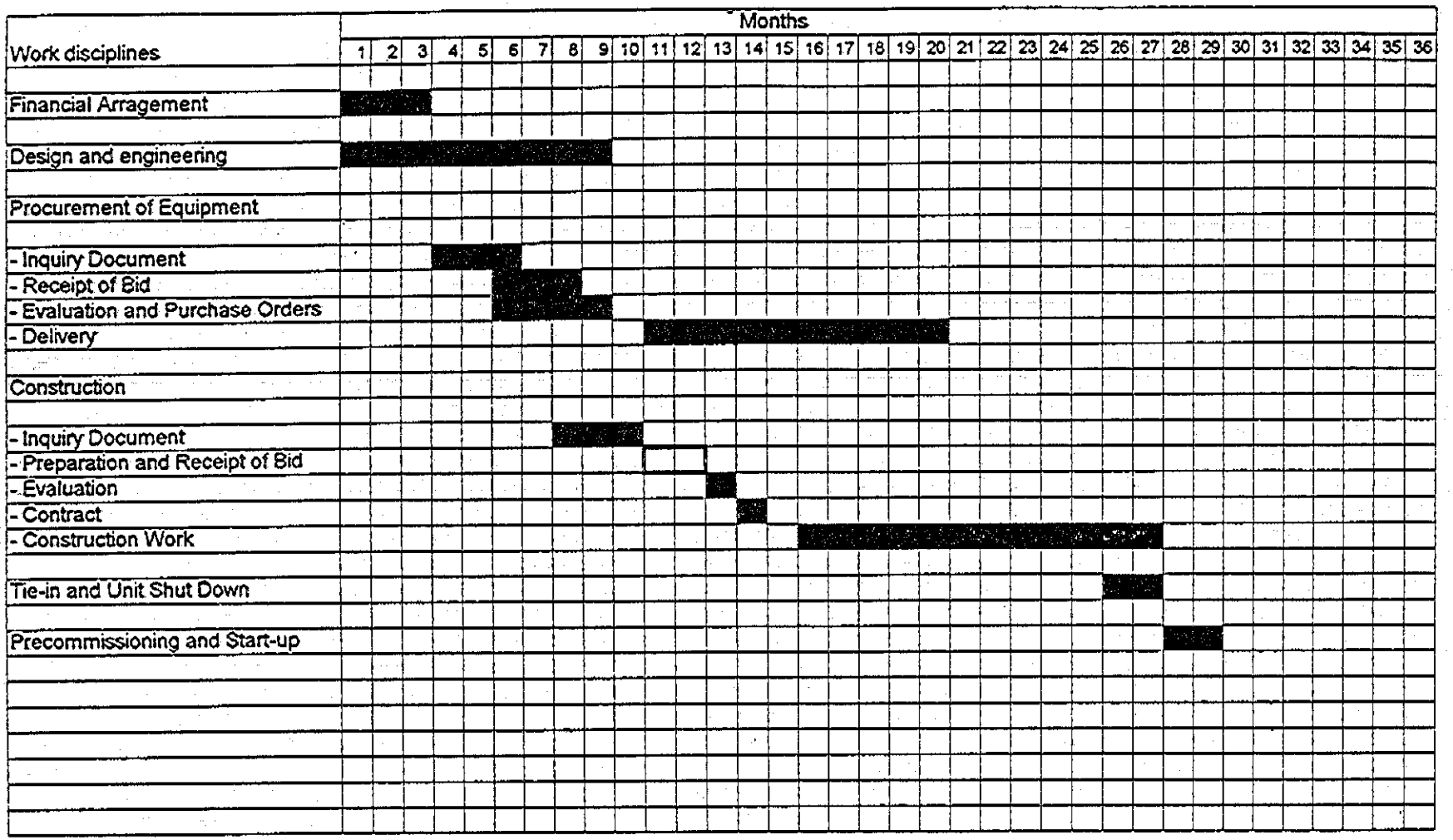
ATTACHMENT 17-2 SUMMARY OF POWER PLANT

Unit: US$

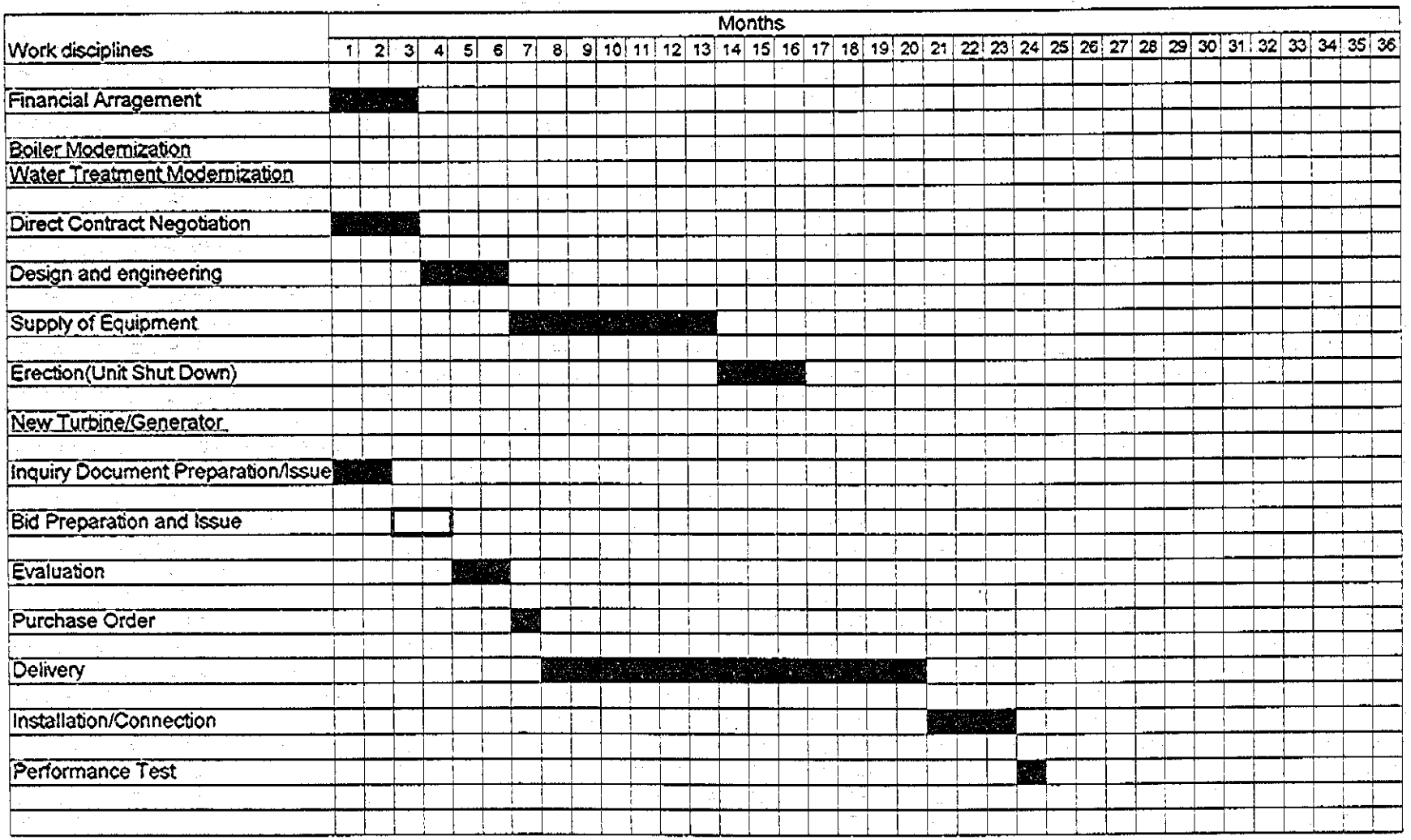
		Equipment & Material		Field work	EPS-MH and expenses	Sub total	Import duty	VAT	Total
		Foreign	Local						
B-1	Modification of 3 Boilers	1,973,100	2,355,960	647,110	212,230	5,188,400	966,819	707,366	6,862,585
G-1	Condensing Turbine Generator	8,000,000	5,500,000	6,272,680	1,676,868	21,449,548	3,920,000	958,901	26,328,449
W-1	Boiler feed water facilities	66,000	28,800	348,760	89,130	532,690	32,340	102,672	667,702
	Grand Total	10,039,100	7,884,760	7,268,550	1,978,228	27,170,638	4,919,159	1,768,939	33,858,736

ATTACHMENT 18-1 IMPLEMENTATION SCHEDULE

(NO. 1 DISTILLATION UNIT)



ATTACHMENT 18-2 IMPLEMENTATION SCHEDULE (POWER PLANT)



ATTACHMENT 19 PRICE OF CRUDE OIL AND PETROLEUM PRODUCTS (SUPPLEMENTED ON ROTTERDAM FOB BIRGE)

Crude Oil (Ural)	US$ 130/ton
Fuel gas	US$ 105/ton
LPG	120
L/H Naphtha	170
Kerosene	190
Gas Oil	180
V.G.O.	160
Fuel oil (Low sulfur)	85
Fuel oil (High sulfur)	65

ATTACHMENT 20 UTILITIES COST, LABOR COST AND MAINTENANCE COST (ESTIMATED ON ACTURAL FIGURES OF PPSA IN 1993)

Electricity	US$ 0.05/kwh
Cooling water	0.03/cu m
Demineralized water	1.00/ton
Fuel gas	105.00/ton
Fuel oil	85.00/ton
Steam (HP)	8.05/ton
Steam (MP)	7.05/ton
Steam (LP)	6.95/ton
Labor	US$ 470.00/MM
Maintenance cost	
- #1 CDU	US$ 517,028/Y
- Power Plant	US$ 5,289,000/Y

ATTACHMENT 21 SALES EXPESE, ADMINISTRATION COST, OTHER FIXED COST AND INCOME TAX (WHOLE PPSA)

Sales expense:	0.6% of sales (= output value)
Administration cost:	0.6% of sales (= output value)
Technical development cost:	0.1% of sales (= output value)
Income tax:	40.0% of net profit (=output value)

ATTACHMENT 22-1 COMPARISON OF OUTPUT VOLUME AND AMOUNT BETWEEN "WITHOUT" AND "WITH" CASES (OPERATIONAL RATE : 100%)

Intermediates	Output Volume (t/h)		Price (US$)	Output Amount (US$ 1,000)	
	Without	With		Without	With
<Topping>					
Fuel Gas	1.1	0.7	105	915	582
LPG	-	4.3	120	0	4,087
L/H Naphtha (A10/11/12)	59.5	-	170	80,111	0
L/H Naphtha (R12/13,A11/12)	-	55.0	170	0	74,052
Kerosene (A13)	20.5	-	190	30,848	0
Gas Oil (A13/14)	-	93.7	180	0	133,579
Gas Oil (A14/15/16)	62.7	-	180	89,385	0
Fuel Oil	10.7	-	65	5,508	0
Sub Total	154.5	153.7		206,767	212,300
<Vacuum>					
Fuel Gas	0.1	0.0	105	83	0
Vacuum Gas Oil (P10/11/12/13)	86.3	83.9	160	109,359	106,318
Fuel Oil (Low Sulfur)	10.7	10.0	85	7,203	6,732
Fuel Oil (High Sulfur)	56.4	60.4	65	29,035	31,094
Sub Total	153.5	154.3		145,680	144,144
Grand Total	308.0	308.0		352,448	356,444

Source: Estimated by the Team

ATTACHMENT 22-2 COMPARISON OF OUTPUT VOLUME AND AMOUNT BETWEEN "WITHOUT" AND "WITH" CASES (OPERATIONAL RATE : 100%)

Intermediates	Output Volume (t/h)		Price (US$)	Output Amount (US$ 1,000)	
	Without	With		Without	With
<Topping>					
Fuel Gas	1.1	0.7	105	915	582
LPG	-	4.3	120	0	4,087
L/H Naphtha (A10/11/12)	59.5	-	170	80,111	0
L/H Naphtha (R12/13,A11/12)	-	55.0	170	0	74,052
Kerosene (A13)	20.5	-	190	30,848	0
Gas Oil (A13/14)	-	93.7	180	0	133,579
Gas Oil (A14/15/16)	62.7	-	180	89,385	0
Fuel Oil	10.7	-	65	5,508	0
Sub Total	154.5	153.7		206,767	212,300
<Vacuum>					
Fuel Gas	0.1	0.0	105	83	0
Vacuum Gas Oil (P10/11/12/13)	86.3	83.9	160	109,359	106,318
Fuel Oil (Low Sulfur)	10.7	10.0	85	7,203	6,732
Fuel Oil (High Sulfur)	56.4	60.4	65	29,035	31,094
Sub Total	153.5	154.3		145,680	144,144
Grand Total	308.0	308.0		352,448	356,444

Source: Estimated by the Team

ATTACHMENT 23 COMPARISON AMONG CASES OF FINANCIAL EVALUATION THROUGH PROJECT LIFE (OPERATIONAL RATE : 80%)

Case	WITHOUT		INCREMENTAL		WITH
	(A)	(B)	(W-W/O (A))	(W-W/O (B))	
Gross Capital Expenditure (US$ 1,000)	0	3,435	9,075	5,640	9,075
Gross Cash Inflow (US$ 1,000)	273,280	273,280	46,772	46,772	320,052
Before Tax Net Inflow (US$ 1,000)	273,280	269,846	37,698	41,132	310,978
After Tax Net Inflow (US$ 1,000)	166,113	164,408	23,569	25,274	189,682
FIRR on Before Tax Inflow (US$ 1,000)	-	-	30.1	46.5	-
FIRR on After Tax Inflow (US$ 1,000)	-	-	21.7	33.0	177.9
Debt Service Ratio in 2000 (Times)	2.68	2.42	1.62	2.38	2.41
Yearly Benefit (US$ 1,000)	-	-	3,104	3,104	3,104
Payback Years	-	-	2.92	1.82	2.92

Source: Table 9.1-3, 9.1-4

ATTACHMENT 24 FINANCIAL EVALUATION OF POWER PLANT MODERNIZATION

Facility	Investment(US$)	Benefits(US$)	Payback Years
Boiler plants			
100% operation	6,463,000	1,320,483	4.89
80% operation	6,463,000	1,017,716	6.35
Boiler feed water Processing system	594,000	845,225	0.70
Condensing turbine	26,638,000	7,026,703	3.78