

### 3.7 Results of the Diagnostic Survey of Factories

Results of the diagnostic survey are presented below.

#### (1) FIBRAS SINTETICAS, S.A. DE C.V.

1) Name of facility surveyed: Process boiler

#### 2) Specifications of facility

Type and maker of facility:	Water tube type (CE-RREY, 15-7VP9)
Capacity:	13 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	1,767(w) x 4,627(d) x 2,400(h)
Combustion chamber volume (m <sup>3</sup> ):	19.6
Furnace pressure (mm H <sub>2</sub> O):	+ 20
Energy saving measures:	None
Combustion control equipment:	Oil supply flow meter, etc.

#### 3) Specifications of burner

Type and model:	Outer mixing, steam atomizing
Kind of fuel at present:	Gas oil
Kind of fuel in the previous JICA study:	Heavy oil
Change of burner nozzle at the time of fuel change:	None
Combustion rate (rated):	1,200 lit/hr
Safety control equipment:	Flame eye, etc.

#### 4) Flue gas measurement data

Load or combustion rate at the time of measurement:	500 lit/hr (41.6%)
Volumetric combustion chamber load (kcal/hr/m <sup>3</sup> ):	255 x 10 <sup>3</sup>
Combustion load per sectional area (kcal/hr/m <sup>2</sup> ):	1,180 x 10 <sup>3</sup>
Current NO <sub>x</sub> emission standard (ppm):	150

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	98
O <sub>2</sub> concentration (%)	4.8
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	-
Smoke tester (#)	0
Exhaust gas temperature (°C)	230

Date and time of measurement: February 1, 1994, 13:00 - 14:00

5) Combustion efficiency during the survey: 84%

6) NO<sub>x</sub> emission control measures being employed

Fuel change from heavy oil to gas oil in 1992.

7) Exhaust gas measuring equipment: None

8) Comments

- i) The concentration of NOx in the exhaust gas satisfies the emission standard.
- ii) The NOx concentration value of 321 ppm reported in the questionnaire survey is considered to be mismeasurement.
- iii) It is regrettable that the factory stopped operation of other power generation boilers (No.1 and No.2) without inquiring into the mismeasurement.
- iv) Modification of the burner corresponding to the fuel change has not been made; its necessity has not been recognized. Installation of operation control equipment is not adequate, although the boiler is equipped with a fuel flow meter and a pressure gauge.

9) Recommended measures

- i) Burner reconstruction corresponding to the fuel change which was intended to reduce the NOx emission: e.g., selection of an atomizing nozzle suitable to the fuel change.
- ii) Installation of adequate operation control equipment for stable operation.
- iii) Installation of economizer or recuperator for energy saving.

(2) UNIROYAL, S.A.

1) Name of facility surveyed: Process boiler

2) Specifications of facility

Type and maker of facility:	Water tube type
Capacity:	12 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	1,700(w) x 5,588(d) x 2,000(h)
Combustion chamber volume (m <sup>3</sup> ):	19
Furnace pressure (mm H <sub>2</sub> O):	+ 60
Energy saving measures:	None
Combustion control equipment:	Oxygen meter, oil supply flow meter, thermometers for various parts, oxygen control unit, etc.

3) Specifications of burner

Type and model:	Outer mixing, air atomizing
Kind of fuel at present:	Gas oil
Kind of fuel in the previous JICA study:	Heavy oil
Change of burner nozzle at the time of fuel change:	Yes
Combustion rate (rated):	950 lit/hr
Safety control equipment:	Flame eye, etc.

4) Flue gas measurement data

Load or combustion rate at the time of measurement: 435 lit/hr (45.8%)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 229 x 10<sup>3</sup>  
Combustion load per sectional area (kcal/hr/m<sup>2</sup>): 1,280 x 10<sup>3</sup>  
Current NOx emission standard (ppm): 150

NOx concentration at 5% O <sub>2</sub> (ppm)	100
O <sub>2</sub> concentration (%)	7.9
CO concentration (ppm)	490
CO <sub>2</sub> concentration (%)	9.7
Smoke tester (#)	7
Exhaust gas temperature (°C)	220

Date and time of measurement: February 2, 1994, 10:45 - 11:40

5) Combustion efficiency during the survey: 74

6) NOx emission control measures being employed

All the burner units were changed to low-NOx burners in 1992.

Burner maker: Webster Eng.

7) Exhaust gas measuring equipment: oxygen control unit

8) Comments

i) Although the oxygen control unit is installed, combustion state of the burner is not good; the oxygen control unit is not effectively utilized.

ii) Although the NOx concentration of the exhaust gas satisfies the emission standards, the amount of CO generation is large and black smoke from the stack is observable by eye.

iii) Generally, over reliance on control equipment and makers' catalogues is noticeable.

9) Recommended measures

i) Reconstruction of burners to enable low-NOx combustion.

ii) Improvement of technical quality of engineers and operators in charge.

iii) Collection of spent steam drains.

(3) KIMEX, S.A.

1) Process boiler

(i) Specifications of facility

Type and maker of facility: Water tube type (CE-RREY, 12-2VP10W)  
Capacity: 14 ton/hr  
Draft and ventilation: Forced draft  
Furnace dimension (mm): 2,500(w) x 4,050(d) x 3,250(h)  
Combustion chamber volume (m<sup>3</sup>): 32.9  
Furnace pressure (mm H<sub>2</sub>O): Not clear: over scale of 20  
Energy saving measures: None  
Combustion control equipment: Oxygen meter, etc.

(ii) Specifications of burner

Type and model: Gas/oil mixed combustion, ring type for gas, outer mixing for oil  
Kind of fuel at present: Natural gas (oil burner is used for emergency)  
Kind of fuel in the previous JICA study: Natural gas and heavy oil  
Change of burner nozzle at the time of fuel change: None  
Combustion rate (rated): 1,370 Nm<sup>3</sup>/hr  
Safety control equipment: Flame eye, etc.

(iii) Flue gas measurement data

Load or combustion rate at the time of measurement: 43% (589 m<sup>3</sup>/hr)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 152 x 10<sup>3</sup>  
Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
Current NO<sub>x</sub> emission standard (ppm): 130

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	60
O <sub>2</sub> concentration (%)	4.1
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	9.2
Smoke tester (#)	0
Exhaust gas temperature (°C)	180

Date and time of measurement: February 3, 1994, 14:00 - 14:30

(iv) Combustion efficiency during the survey: 81%

2) Power generation boiler

(i) Specifications of facility

Type and maker of facility: Water tube type (Babcock and Wilcox)  
Capacity: 28 ton/hr  
Draft and ventilation: Forced draft  
Furnace dimension (mm): 3,197(w) x 5,550(d) x 5,500(h)  
Combustion chamber volume (m<sup>3</sup>): 97.6

Furnace pressure (mm H<sub>2</sub>O): Not clear  
 Energy saving measures: Recuperator  
 Combustion control equipment: Oxygen meter, etc.

(ii) Specifications of burner

Type and model: Gas/oil mixed combustion, gas lance type (outer mixing type for oil)  
 Kind of fuel at present: Natural gas (oil burner is used for emergency)  
 Kind of fuel in the previous JICA study:  
 Change of burner nozzle at the time of fuel change: None  
 Combustion rate (rated): 2,580 m<sup>3</sup>/hr  
 Safety control equipment: Flame eye, etc.

(iii) Flue gas measurement data

Load or combustion rate at the time of measurement: 65%  
 Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 161 x 10<sup>3</sup>  
 Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
 Current NO<sub>x</sub> emission standard (ppm): 120

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	75
O <sub>2</sub> concentration (%)	2.8
CO concentration (ppm)	18
CO <sub>2</sub> concentration (%)	10.0
Smoke tester (#)	0
Exhaust gas temperature (°C)	170
Air preheater exit temperature (°C)	120

Date and time of measurement: February 3, 1994, 12:00 - 12:30

(iv) Combustion efficiency during the survey: 82%

3) NO<sub>x</sub> emission control measures being employed

Fuel change to natural gas

4) Exhaust gas measuring equipment:

Installation of oxygen meter

5) Comments

- (i) The process boiler is not equipped with energy saving equipment, but the power generation boiler is equipped with a recuperator for heat recovery.
- (ii) The exhaust gas NO<sub>x</sub> concentrations of both boilers are comfortably below the limit of the emission standard.

(iii) The plant seems to have a forward-looking stance in NOx emission reduction and energy saving.

6) Recommended measures

- (i) Energy saving measures for the process boiler: economizer or recuperator
- (ii) More effects are expected by employment of the biased method and steam injection method as the next step of NOx control.

(4) CIA. PAPELERA EL FENIX, S.A. DE C.V.

1) Name of facility surveyed: Process boiler

2) Specifications of facility

Type and maker of facility: Water tube type (CE-RREY, 16-2VP10W)  
 Capacity: 16 ton/hr  
 Draft and ventilation: Forced draft  
 Furnace dimension (mm): 1,829(w) x 4,921(d) x 2,654(h)  
 Combustion chamber volume (m<sup>3</sup>): 23.9  
 Furnace pressure (mm H<sub>2</sub>O): Not clear  
 Energy saving measures: Economizer  
 Combustion control equipment: Control by sequence

3) Specifications of burner

Type and model: Gas ring type  
 Kind of fuel at present: Natural gas  
 Kind of fuel in the previous JICA study: Heavy oil  
 Change of burner nozzle at the time of fuel change: Yes  
 Combustion rate (rated): 1,301 m<sup>3</sup>/hr  
 Safety control equipment: Flame eye

4) Flue gas measurement data

Load or combustion rate at the time of measurement: Not clear  
 Volumetric combustion chamber load (kcal/m<sup>3</sup>):  
 Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
 Current NOx emission standard (ppm): 130

NOx concentration at 5% O <sub>2</sub> (ppm)	55
O <sub>2</sub> concentration (%)	8.0
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	7.0
Smoke tester (#)	0
Exhaust gas temperature (°C)	284 (boiler exit)

Date and time of measurement: February 4, 1994, 11:00 - 12:00

5) Combustion efficiency during the survey: 74%

6) NOx emission control measures being employed

Change of fuel from heavy oil to natural gas in 1992

7) Exhaust gas measuring equipment: thermometer for exhaust gas

8) Comments

- (i) The boiler was renewed at the time of the fuel change. Although sequential control is adopted to the burner, boiler operation control equipment is not adequate.
- (ii) Energy saving is realized by the installation of the economizer.
- (iii) The oxygen concentration of the exhaust gas is as high as 8%.
- (iv) Although the necessity of boiler operation control equipment is fully recognized, it is not practiced.

9) Recommended measures

- (i) Installation of adequate combustion control equipment including an economizer.
- (ii) Efforts for low oxygen combustion (this burner can be operated at about 2% oxygen).

(5) CIA. DE LUZ Y FUERZA DEL CENTRO, S.A.  
SUPT. CENTRAL ING. JORGE LUQUE

1) Power generation boiler (No.1 and No.2)

(i) Specifications of facility

Type and maker of facility:	Water tube type (Babcock and Wilcox)
Capacity:	150 ton/hr
Draft and ventilation:	Balanced draft
Furnace dimension (mm):	10,500(w) x 5,800(d) x 7,800(h)
Combustion chamber volume (m <sup>3</sup> ):	475
Furnace pressure (mm H <sub>2</sub> O):	-3 ~ 4
Energy saving measures:	Recuperator
Combustion control equipment:	All equipped

(ii) Specifications of burner

Type and model:	Front firing, multi-lance type, 6 units
Kind of fuel at present:	Natural gas
Kind of fuel in the previous JICA study:	Heavy oil/natural gas (mixed combustion)
Change of burner nozzle at the time of fuel change:	None

Combustion rate (rated): 12,093 m<sup>3</sup>/hr  
 Safety control equipment: No air pressure sensor

(iii) Flue gas measurement data (No.1 boiler)

Load or combustion rate at the time of measurement: 6,500 m<sup>3</sup>/hr (53.8%)  
 Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 116 x 10<sup>3</sup>  
 Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
 Current NOx emission standard (ppm): 100

NOx concentration at 5% O <sub>2</sub> (ppm)	337
O <sub>2</sub> concentration (%)	7
CO concentration (ppm)	220
CO <sub>2</sub> concentration (%)	
Smoke tester (#)	0
Exhaust gas temperature (°C)	184
ditto before recuperator (°C)	408
Combustion air temperature (°C)	318

Date and time of measurement: February 7, 1994, 12:00 - 13:00

(iv) Combustion efficiency during the survey: 69% (No.1 boiler)

2) Power generation boiler (No. 3 and No.4)

(i) Specifications of facility

Type and maker of facility: Water tube type (Combustion Engg.)  
 Capacity: 350 ton/hr  
 Draft and ventilation: Forced draft  
 Furnace dimension (mm): 9,240(w) x 6,930(d) x 20,700(h)  
 Combustion chamber volume (m<sup>3</sup>): 1,325  
 Furnace pressure (mm H<sub>2</sub>O):  
 Energy saving measures: Recuperator  
 Combustion control equipment: Not equipped with low water level cut-off device

(ii) Specifications of burner

Type and model: Tangential firing, 24 units  
 Kind of fuel at present: Natural gas  
 Kind of fuel in the previous JICA study: Temporarily suspended (heavy oil/natural gas mixed combustion)  
 Change of burner nozzle at the time of fuel change: None  
 Combustion rate (rated): 23,480 m<sup>3</sup>/hr  
 Safety control equipment: Not equipped with air pressure sensor

(iii) Flue gas measurement data (No.4 boiler)

Load or combustion rate at the time of measurement: 7,500 m<sup>3</sup>/hr (32%)  
 Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 48 x 10<sup>3</sup>  
 Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
 Current NOx emission standard (ppm): 100



NOx concentration at 5% O <sub>2</sub> (ppm)	70
O <sub>2</sub> concentration (%)	2.4
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	10.1
Smoke tester (#)	0
Exhaust gas temperature (°C)	120
ditto before recuperator (°C)	292
Combustion air temperature (°C)	228

Date and time of measurement: February 7, 1994, 14:00 - 15:00

(iv) Combustion efficiency during the survey: 79% (No.4 boiler)

3) NOx emission control measures being employed

The mixed combustion of heavy oil and natural gas was changed to natural gas only in September 1991.

4) Exhaust gas measuring equipment: thermometers for exhaust gas

5) Comments

(i) Boiler No.1

i) According to the data as of September 1993, presented by the plant at the time of the survey, the exhaust gas NOx concentration was 343 ppm at 90% of the rated capacity. The measurement at this showed a similar level at 337 ppm at 60% of the rated capacity.

ii) The cause of the high NOx concentration is considered to be the structure of the furnace which brings about existence of local regions in the furnace where the temperature is very high (red heat of furnace wall observed) and detention time of the combustion gas is long.

iii) No.2 boiler not operated at the time of the survey is of the same structure. Its NOx concentration shown in the questionnaire was as high as that of No.1 boiler.

iv) The cause of CO generation is considered to be the positioning of the 6 burners.

(ii) Boiler No.4

The operation is in good conditions with low NOx concentration, low oxygen level and no CO generation.

6) Recommended measures

- (i) Both No.1 and No.2 boilers are about 40 years of age with low power generation efficiency and high concentration of NOx in the exhaust gas. Since it seems that the time is ripe for renewal of the facilities, employment of advanced combined cycle (latest combined gas turbine with waste heat utilization) equipped with exhaust gas denitration is desirable.
- (ii) Although the NOx concentration of No.3 and No.4 boilers is in the low level, the NOx emission amount is large. Therefore, further NOx reduction measures such as installation of exhaust gas recirculation (EGR) system are recommended.

(6) EMPAQUES DE CARTON UNITED, S.A. DE C.V.  
(Small Carton Branch)

1) Name of facility surveyed: Process boiler (No.1)

2) Specifications of facility

Type and maker of facility:	Water tube type (CE-RREY, 10-11VP-9)
Capacity:	9.5 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	1,900(w) x 3,400(d) x 2,700(h)
Combustion chamber volume (m <sup>3</sup> ):	17.4
Furnace pressure (mm H <sub>2</sub> O):	Not clear
Energy saving measures:	None
Combustion control equipment:	Automatic combustion control and automatic water supply units are installed, but not equipped with water supply flow meter and oil supply flow meter

3) Specifications of burner

Type and model:	Steam atomizing
Kind of fuel at present:	Gas oil
Kind of fuel in the previous JICA study:	Heavy oil
Change of burner nozzle at the time of fuel change:	Burner nozzle diameter was made smaller by the instruction of the burner maker
Combustion rate (rated):	920 lit/hr
Safety control equipment:	Flame eye, no air pressure sensor

4) Flue gas measurement data

Load or combustion rate at the time of measurement:	85% (8 ton/hr)
Volumetric combustion chamber load (kcal/hr/m <sup>3</sup> ):	400 x 10 <sup>3</sup>
Combustion load per sectional area (kcal/hr/m <sup>2</sup> ):	
Current NOx emission standard (ppm):	150

NOx concentration at 5% O <sub>2</sub> (ppm)	110
O <sub>2</sub> concentration (%)	3.2
CO concentration (ppm)	10
CO <sub>2</sub> concentration (%)	-
Smoke tester (#)	4
Exhaust gas temperature (°C)	307

Date and time of measurement: February 8, 1994 ; 11:00 - 12:00

- 5) Combustion efficiency during the survey: 81%
- 6) NOx emission control measures being employed
  - (i) Fuel was changed from heavy oil to gas oil in 1991.
  - (ii) An additive for sediments dispersion is mixed into gas oil.
- 7) Exhaust gas measuring equipment

There is no fixed type measuring equipment. A portable type device (ENERAC, Model 2000) is used for measuring combustion efficiency, exhaust gas temperature, oxygen, CO, CO<sub>2</sub>, NOx, and SO<sub>2</sub>.

8) Comments

- (i) Combustion state is good. The oxygen concentration limit for smoke generation is 1.5%.
- (ii) The NOx concentration of the exhaust gas measured this time is below the emission standard value. The plant is still highly concerned with NOx reduction. Technical Cooperation of Japan is requested to reduce NOx concentration as low as some 70 ppm.
- (iii) Introduction of economizer is being planned. Materials of the heat exchanger should be carefully selected considering the use of gas oil.

9) Recommended measures

- (i) Installation of economizer
- (ii) Introduction of NOx reduction measures such as EGR, steam injection and others
- (iii) Boiler operation control by installing necessary flow meters.

(7) PAPELERA IRUÑA, S.A. DE C.V.

- 1) Name of facility surveyed: Process boiler (No.2, No.3 and No.5)

2) Specifications of facility

Type and maker of facility: Flue and smoke tube type (Cleaver Brooks, CB-500)  
 Capacity: 7.8 ton/hr  
 Draft and ventilation: Forced draft  
 Furnace dimension (mm): 1,067( $\phi$ ) x 4,260(L)  
 Combustion chamber volume (m<sup>3</sup>): 3.8 (sectional area: 0.89 m<sup>2</sup>)  
 Furnace pressure (mm H<sub>2</sub>O): Not clear  
 Energy saving measures: None  
 Combustion control equipment: Thermometer, pressure gauge, etc. (no flow meters)

3) Specifications of burner

Type and model: Outer mixing, air atomizing  
 Kind of fuel at present: Gas oil  
 Kind of fuel in the previous JICA study: Heavy oil  
 Change of burner nozzle at the time of fuel change: None  
 Combustion rate (rated): 650 lit/hr  
 Safety control equipment: Flame eye, etc.

4) Flue gas measurement data

Load or combustion rate at the time of measurement: Not clear (no flow meter)  
 Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): Not clear  
 Combustion load per sectional area (kcal/hr/m<sup>2</sup>): Not clear  
 Current NO<sub>x</sub> emission standard (ppm): 150

Boiler No.	No.2	No.3	No.5
NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	134	113	147
O <sub>2</sub> concentration (%)	2.3	4.5	7.4
CO concentration (ppm)	0	0	0
CO <sub>2</sub> concentration (%)	13.9	12.3	10.2
Smoke tester (#)	3	6	1
Exhaust gas temperature (°C)	190	145	196

Date and time of measurement: February 9, 1994, 11:00 - 14:30

5) Combustion efficiency during the survey: No.2: 86%  
 No.3: 87%  
 No.5: 83%

6) NO<sub>x</sub> emission control measures being employed

Fuel was changed from heavy oil to gas oil in November 1992.

7) Exhaust gas measuring equipment: thermometer for exhaust gas only

8) Comments

(i) No burner modification was made upon the fuel change.

- (ii) Poor provision of boiler operation control equipment (esp. no flow meter)
- (iii) Although the exhaust gas NO<sub>x</sub> concentrations of 130 - 140 ppm are below the emission standard value, the concentration is likely to exceed at higher combustion loads.

9) Recommended measures

- (i) Boiler operation control equipment should be provided adequately. Especially, fuel supply flow meter should be provided.
- (ii) Energy saving measure such as economizer or drain recovery.
- (iii) Changing atomizing method from air atomizing to steam atomizing.

(8) QUIMICA LUCAVA, S.A. DE C.V.

1) Name of facility surveyed: Process boiler

2) Specifications of facility

Type and maker of facility:	Flue and smoke tube boiler (Cleaver Brooks, CB-200)
Capacity:	3.1 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	572(φ) x 4,242(L)
Combustion chamber volume (m <sup>3</sup> ):	1.09 (sectional area: 0.26 m <sup>2</sup> )
Furnace pressure (mm H <sub>2</sub> O):	Not clear
Energy saving measures:	Drain recovery unit (50 - 60% recovery of spent steam)
Combustion control equipment:	Automatic combustion control unit, water level gauge, automatic water supply unit (no oil and supply water flow meters)

3) Specifications of burner

Type and model:	Outer mixing, air atomizing
Kind of fuel at present:	Gas oil
Kind of fuel in the previous JICA study:	Heavy oil
Change of burner nozzle at the time of fuel change:	Yes (burner tip changed by the plant's own judgment)
Combustion rate (rated):	250 lit/hr (estimated)
Safety control equipment:	Flame eye and pressure gauges (no air pressure sensor)

4) Flue gas measurement data

Load or combustion rate at the time of measurement:	Not clear
Volumetric combustion chamber load (kcal/hr/m <sup>3</sup> ):	1,830 x 10 <sup>3</sup> (estimated rated capacity)
Combustion load per sectional area (kcal/hr/m <sup>2</sup> ):	7,680 x 10 <sup>3</sup> (same as above)

Current NOx emission standard (ppm): 150

NOx concentration at 5% O <sub>2</sub> (ppm)	200
O <sub>2</sub> concentration (%)	9.7
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	8.4
Smoke tester (#)	0
Exhaust gas temperature (°C)	177

Date and time of measurement: February 10, 1994, 11:00 - 11:40

5) Combustion efficiency during the survey: 82%

6) NOx emission control measures being employed

Fuel change was made in 1992: from heavy oil to gas oil for the boiler, and from diesel only to gas oil (50%) + diesel (50%) for the triacetate furnace.

7) Exhaust gas measuring equipment: none

8) Comments

- (i) The NOx concentration of the exhaust gas exceeds the emission standard value. It is because that the volumetric and the sectional combustion chamber loads are high, and also the oxygen concentration of the exhaust gas is high.
- (ii) Energy saving efforts are being made by recovering 50 - 60% of the spent drain.
- (iii) The triacetate furnace is of a small capacity (less than 10 lit/hr). No particular measure is necessary.
- (iv) The plant is planning further fuel change: from gas oil to natural gas.

9) Recommended measures

- (i) Employment of steam atomizer and low-NOx burner as NOx reduction measures.
- (ii) Boiler operation control by installing necessary flow meters.

(9) PENWALT, S.A. DE C.V.

1) Name of facility surveyed: Process boiler (No.3)

2) Specifications of facility

Type and maker of facility: Flue and smoke tube type (Fabricaciones Mecanicas Ind.)  
Capacity: 9.4 ton/hr  
Draft and ventilation: Forced draft

Furnace dimension (mm): 990( $\phi$ ) x 4,953(L)  
 Combustion chamber volume (m<sup>3</sup>): 3.8  
 Furnace pressure (mm H<sub>2</sub>O): Not clear  
 Energy saving measures: Steam drain recovery (spent steam drain is collected into the water supply tank)  
 Combustion control equipment: Thermometer for exhaust gas, etc.

3) Specifications of burner

Type and model: Gas/gas oil mixed combustion type, gas ring type (outer mixing for gas oil burner which is used in an emergency)  
 Kind of fuel at present: Natural gas  
 Kind of fuel in the previous JICA study: Natural gas  
 Change of burner nozzle at the time of fuel change: -  
 Combustion rate (rated): 720 m<sup>3</sup>/hr  
 Safety control equipment: Flame eye, etc.

4) Flue gas measurement data

Load or combustion rate at the time of measurement: 365.3 m<sup>3</sup>/hr (50.7%)  
 Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 817 x 10<sup>3</sup>  
 Combustion load per sectional area (kcal/hr/m<sup>2</sup>): 4,040 x 10<sup>3</sup>  
 Current NO<sub>x</sub> emission standard (ppm): 130

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	87
O <sub>2</sub> concentration (%)	6.1
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	8.1
Smoke tester (#)	0
Exhaust gas temperature (°C)	165

Date and time of measurement: February 11, 1994, 12:00 - 13:00

5) Combustion efficiency during the survey: 82%

6) NO<sub>x</sub> emission control measures being employed

No particular NO<sub>x</sub> reduction measures are considered because of the use of natural gas from the beginning.

7) Exhaust gas measuring equipment

A handy type measuring device is used to measure NO<sub>x</sub>, oxygen, CO, CO<sub>2</sub>, SO<sub>2</sub>.

8) Comments

(i) Keen on collection of technical information on NO<sub>x</sub> reduction measures for the future.

(ii) Drain recovery is partially employed, but the amount of the recovery is unknown.

(iii) A gas flow meter installed is for measuring the plant's total consumption according to the contract between the gas company. It should be also provided for each boiler before the burner.

(iv) Water supply meter is also not provided.

9) Recommended measures

(i) Enhancement of drain recovery.

(ii) Adequate provision of boiler operation control equipment, especially flow meters.

(10) CERVECERIA MODELO, S.A. DE C.V.

1) Power generation boiler (No.3225)

(i) Specifications of facility

Type and maker of facility:	Water tube type (CE-RREY)
Capacity:	27 ton/hr
Draft and ventilation:	Balanced draft
Furnace dimension (mm):	4,750(w) x 4,000(h) x 3,150(l)
Combustion chamber volume (m <sup>3</sup> ):	59.84
Furnace pressure (mm H <sub>2</sub> O):	+ 5
Energy saving measures:	Recuperator
Combustion control equipment:	Generally well equipped

(ii) Specifications of burner

Type and model:	Front firing, gas/gas oil mixed combustion type, gas ring type (outer mixing for gas oil)
Kind of fuel at present:	Natural gas and gas oil
Kind of fuel in the previous JICA study:	Natural gas
Kind of fuel at the time of the survey:	Natural gas
Change of burner nozzle at the time of fuel change:	None
Combustion rate (rated):	2,308 m <sup>3</sup> /hr (577 m <sup>3</sup> /hr x 4 units)
Safety control equipment:	Flame eye, etc.

(iii) Flue gas measurement data

Load or combustion rate at the time of measurement:	15.5 ton/hr (1,110 m <sup>3</sup> /hr) (48%)
Volumetric combustion chamber load (kcal/m <sup>3</sup> ):	158 x 10 <sup>3</sup>
Combustion load per sectional area (kcal/hr/m <sup>2</sup> ):	
Current NO <sub>x</sub> emission standard (ppm):	120



NOx concentration at 5% O <sub>2</sub> (ppm)	110
O <sub>2</sub> concentration (%)	6.5
CO concentration (ppm)	21
CO <sub>2</sub> concentration (%)	7.9
Smoke tester (#)	0
Exhaust gas temperature (°C)	196
Combustion air temperature (°C)	125

Date and time of measurement: February 14, 1994, 13:30 - 14:10

(iv) Combustion efficiency during the survey: 80%

2) Power generation boiler (No.4884)

(i) Specifications of facility

Type and maker of facility:	Water tube type (CE-RREY)
Capacity:	60 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	4,620(w) x 7,784(h) x 4,150(l)
Combustion chamber volume (m <sup>3</sup> ):	149.22
Furnace pressure (mm H <sub>2</sub> O):	+ 50
Energy saving measures:	Recuperator
Combustion control equipment:	Generally well equipped

(ii) Specifications of burner

Type and model:	Corner tangential firing, gas/gas oil mixed combustion-gas nozzle type (outer mixing for gas oil)
Kind of fuel at present:	Natural gas and gas oil
Kind of fuel in the previous JICA study:	Heavy oil
Kind of fuel at the time of the survey:	Natural gas
Change of burner nozzle at the time of fuel change:	None
Combustion rate (rated):	5,545 m <sup>3</sup> /hr (1,386 m <sup>3</sup> /hr x 4 units)
Safety control equipment:	Flame eye, etc.

(iii) Flue gas measurement data

Load or combustion rate at the time of measurement: 2,900 m<sup>3</sup>/hr (52.3%)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 165 x 10<sup>3</sup>  
Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
Current NOx emission standard (ppm): 120

NOx concentration at 5% O <sub>2</sub> (ppm)	34 (EGR operated)
O <sub>2</sub> concentration (%)	2.3
CO concentration (ppm)	320
CO <sub>2</sub> concentration (%)	10.2
Smoke tester (#)	3
Exhaust gas temperature (°C)	179
Combustion air temperature	174

Date and time of measurement: February 14, 1994, 12:50 - 13:20

(iv) Combustion efficiency during the survey: 78%

### 3) Power generation boiler (No.VU-60II)

#### (i) Specifications of facility

Type and maker of facility: Water tube type (CE-RREY)  
Capacity: 82 ton/hr  
Draft and ventilation: Forced draft  
Furnace dimension (mm): 3,250(w) x 11,367(h) x 3,658(l)  
Combustion chamber volume (m<sup>3</sup>): 135.13  
Furnace pressure (mm H<sub>2</sub>O): + 50  
Energy saving measures: Recuperator  
Combustion control equipment: Generally adequate but thermometer recorders for various parts are under repair

#### (ii) Specifications of burner

Type and model: Corner tangential firing, gas/gas oil mixed firing nozzle (outer mixing for gas oil)  
Kind of fuel at present: Natural gas and gas oil  
Kind of fuel in the previous JICA study: Heavy oil  
Kind of fuel at the time of the survey: Natural gas  
Change of burner nozzle at the time of fuel change: None  
Combustion rate (rated): 6,991 m<sup>3</sup>/hr (873.9 x 8 units)  
Safety control equipment: Flame eye, etc.

#### (iii) Flue gas measurement data

Load or combustion rate at the time of measurement: 3,200 m<sup>3</sup>/hr (45.8%)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 201 x 10<sup>3</sup>  
Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
Current NO<sub>x</sub> emission standard (ppm): 120

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	97
O <sub>2</sub> concentration (%)	3.1
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	9.8
Smoke tester (#)	0
Exhaust gas temperature (°C)	142

Date and time of measurement: February 14, 1994, 11:50 - 12:20

(iv) Combustion efficiency during the survey: 77%

### 4) NO<sub>x</sub> emission control measures being employed

- (i) EGR has been installed on No.4884 boiler (60 ton/hr), and now being installed on a 100 ton/hr boiler.
- (ii) Preparation works for installation of EGR is under way for No.VU-60II boiler, and the installation will be made following the 100 ton /hr boiler.

5) Exhaust gas monitoring equipment

A continuous exhaust gas monitoring system is provided and now being tested. The system can be used for exhaust gas from any of the existing boilers to measure NO<sub>x</sub>, CO, CO<sub>2</sub>, SO<sub>2</sub> and oxygen concentrations. Maker is ALTECH SYSTEM.

6) Comments

- (i) Since the recirculation rate of the EGR system for No. 4884 boiler is too high, CO generation is as high as 320 ppm.
- (ii) No sufficient attention is paid to the generation of CO.
- (iii) Boiler operation control equipment is generally adequate.
- (iv) In April through October, the boilers use gas oil only or natural gas and gas oil in mix. In occasion of the government warning for high air pollution, however, fuel is to be switched to natural gas only.

7) Recommended measures

- (i) Early completion of EGR installation works for all the boilers
- (ii) Promotion of applying appropriate exhaust gas recirculation rates; target CO concentration of exhaust gas should be 0.

(11) CEMENTOS ANAHUAC, S.A. DE C.V.

1) Name of facility surveyed: Cement kiln (No.7 and No.9)

2) Specifications of facility

Type and maker of facility:	Suspension preheater (SP) kiln
Capacity:	
Draft and ventilation:	Induced draft
Furnace dimension (mm):	No.7: 3,800(φ) x 60,000(L) No.9: 4,800(φ) x 75,000(L)
Combustion chamber volume (m <sup>3</sup> ):	No.7: 680 (sectional area: 11.3 m <sup>2</sup> ) No.9: 1,356 (sectional area: 18.0 m <sup>2</sup> )
Furnace pressure (mm H <sub>2</sub> O):	Not clear
Energy saving measures:	None
Combustion control equipment:	Fully equipped with necessary devices

3) Specifications of burner

Type and model:	Pressure atomizing two flow type, (PILLARD, low NO <sub>x</sub> burner for No.9 kiln)
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Kind of fuel at present: Heavy oil  
 Kind of fuel in the previous JICA study: Heavy oil  
 Change of burner nozzle at the time of fuel change: -  
 Combustion rate (rated): No.7: 3,500 kg/hr  
 No.9: 9,400 kg/hr  
 Safety control equipment: Fully equipped

4) Flue gas measurement data (measured by the plant)

Load or combustion rate at the time of measurement: No.7: 2,950 lit/hr (84.3%)  
 No.9: 7,600 lit/hr (80.9%)  
 Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): No.7: 43 x 10<sup>3</sup>  
 No.9: 55 x 10<sup>3</sup>  
 Combustion load per sectional area (kcal/hr/m<sup>2</sup>): No.7: 2,570 x 10<sup>3</sup>  
 No.9: 5,140 x 10<sup>3</sup>  
 Current NOx emission standard (ppm): Not specified

Kiln No.	No.7	No.9
NOx concentration at 5% O <sub>2</sub> (ppm)	343	320
O <sub>2</sub> concentration (%)	14.3	8.7
CO concentration (ppm)	460	1,900
CO <sub>2</sub> concentration (%)	10.0	19.2
SO <sub>2</sub> concentration (ppm)	49	33

Date of the visit: February 15, 1994 (Data were presented by the plant.)

- 5) Combustion efficiency: not measured
- 6) NOx emission control measures being employed

No measure is taken for No.7 kiln. Burners in No.9 kiln were changed to low-NOx burners (PILLARD ROTAFLAM).

7) Exhaust gas measuring equipment

Exhaust gas compositions of 3 kilns, i.e., No.7, No.8 (under regular maintenance works), and No.9, are continuously monitored through the data logger introduced in November 1991.

8) Comments

- (i) This plant is the only one which uses heavy oil (bunker C) in the Mexico City metropolitan area.
- (ii) Exhaust gas analysis data from the data logger are regularly submitted to INE.

9) Recommended measures

- (i) Installation of precalciners to the SP kilns and installation of ducts for sending hot air from the clinker cooler to the precalciners in order to achieve energy saving.

(ii) Efforts for low air ratio combustion

(12) EMPAQUES DE CARTON UNITED, S.A. DE C.V.

(Box Manufacturing Branch)

1) Name of facility surveyed: Process boiler (No.1)

2) Specifications of facility

Type and maker of facility: Water tube type (CE-RREY, VP)  
Capacity: 8 ton/hr  
Draft and ventilation: Forced draft  
Furnace dimension (mm): 2,000(w) x 3,020(d) x 2,100(h)  
Combustion chamber volume (m<sup>3</sup>): 12.7  
Furnace pressure (mm H<sub>2</sub>O): Not clear  
Energy saving measures: Simple type economizer  
Combustion control equipment: Oil supply flow meter equipped, but no water supply flow meter

3) Specifications of burner

Type and model: Outer mixing, steam atomizing  
Kind of fuel at present: Gas oil  
Kind of fuel in the previous JICA study: Heavy oil  
Change of burner nozzle at the time of fuel change: Burner ports made smaller by the instruction of the burner maker  
Combustion rate (rated): 660 lit/hr (estimated)  
Safety control equipment: Flame eye, etc.(no air pressure sensor)

4) Flue gas measurement data

Load or combustion rate at the time of measurement: 34% of the rated capacity (225 lit/hr)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 177 x 10<sup>3</sup>  
Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
Current NO<sub>x</sub> emission standard (ppm): 150

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	65
O <sub>2</sub> concentration (%)	3.0
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	13.5
Smoke tester (#)	
Exhaust gas temperature (°C)	180
ditto at boiler exit (°C)	215

Date and time of measurement: February 16, 1994, 11:00 - 11:40

5) Combustion efficiency during the survey: 85%

6) NO<sub>x</sub> emission control measures being employed

Fuel was changed from heavy oil to gas oil in December 1991.

7) Exhaust gas measuring equipment:

There is no fixed monitoring devices. The portable combustion test equipment (ENERAC 200) co-owned with the adjacent small carton manufacturing branch is used for the measurement.

8) Comments

- (i) This boiler and the boiler in the adjacent small carton branch are operated by the same operators, and well aware of importance of NOx reduction and energy saving.
- (ii) A coil type economizer made from carbon steel is installed within the stack.
- (iii) The exhaust gas analysis data show no particular problems in oxygen and NOx concentrations.
- (iv) The exhaust gas temperature of this boiler equipped with the economizer is 180 °C which is lower than that of the boiler (9.5 ton/hr) in the adjacent small carton branch. The temperature should be kept above 160 °C for prevention of corrosion.

9) Recommended measures

Further reduction of NOx emission can be achieved by the following measures.

- (i) Low-NOx burner
- (ii) Employment of measures such as EGR and steam injection
- (iii) Enhancement of boiler operation control by appropriate measures such as installation of a water supply flow meter and measurement of boiler efficiency.

(13) GRUPO CRISOBA, S.A. DE C.V.

1) Name of facility surveyed: Process boiler

2) Specifications of facility

Type and maker of facility:	Water tube type (CE-RREY, 25-VP12W)
Capacity:	45.4 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	2,891(w) x 4,000(h) x 4,661 - 7,676(l)
Combustion chamber volume (m <sup>3</sup> ):	71.33
Furnace pressure (mm H <sub>2</sub> O):	Not clear
Energy saving measures:	Drain recovery, recuperator
Combustion control equipment:	Generally adequate with gas flow meter, water flow meter, etc.

3) Specifications of burner

Type and model: Center firing, gun type, for gas only  
Kind of fuel at present: Natural gas  
Kind of fuel in the previous JICA study: Natural gas  
Change of burner nozzle at the time of fuel change: -  
Combustion rate (rated): 3,200 m<sup>3</sup>/hr  
Safety control equipment: Flame eye, etc.

4) Flue gas measurement data

Load or combustion rate at the time of measurement: 2,170 m<sup>3</sup>/hr (67.8%)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 259 x 10<sup>3</sup>  
Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
Current NOx emission standard (ppm): 120

NOx concentration at 5% O <sub>2</sub> (ppm)	140
O <sub>2</sub> concentration (%)	5.1
CO concentration (ppm)	629
CO <sub>2</sub> concentration (%)	8.6
Smoke tester (#)	2
Exhaust gas temperature (°C)	200
ditto at boiler exit (°C)	308

Date and time of measurement: February 17, 1994, 13:00 - 14:00

5) Combustion efficiency during the survey: 72%

6) NOx emission control measures being employed

The plant stated that no measures were necessary for control of NOx and CO, because both emissions were meeting the regulated values. However, the result of the measurement shows otherwise.

7) Exhaust gas measuring equipment

A continuous exhaust gas monitoring system (ALTEC system) was established in July 1993 for monitoring NOx, CO, SO<sub>2</sub>, and oxygen concentrations, and the system is now being tested. However, the standard gas cylinders for NOx measurement have been empty since one week ago.

8) Comments

- (i) The plant stated that the responsibility for the abnormal value of exhaust gas NOx concentration reported in the questionnaire did not belong the plant but to the measurement service company
- (ii) The plant is keen on energy saving and air pollution control so as to practice drain

recovery and install continuous exhaust gas monitoring system. However, since NO<sub>x</sub> and CO concentrations exceed the regulated values, change of burner is desirable.

9) Recommended measures

Change of the burner to the ring type

(14) JABON LA CORONA, S.A. DE C.V.

1) Process boiler (No. B)

(i) Specifications of facility

Type and maker of facility:	Water tube type (Babcock and Wilcox)
Capacity:	15.5 ton/hr
Draft and ventilation:	Balanced draft
Furnace dimension (mm):	2,800(w) x 3,300(h) x 4,200(l)
Combustion chamber volume (m <sup>3</sup> ):	38.8
Furnace pressure (mm H <sub>2</sub> O):	+ 5
Energy saving measures:	None
Combustion control equipment:	Gas flow meter, thermometer, draft meter, etc. (no water supply flow meter)

(ii) Specifications of burner

Type and model:	Lance type for gas (3 piece lance x 2)
Kind of fuel at present:	Natural gas
Kind of fuel in the previous JICA study:	Natural gas
Change of burner nozzle at the time of fuel change:	-
Combustion rate (rated):	1,250 m <sup>3</sup> /hr
Safety control equipment:	Flame eye, etc.

(iii) Flue gas measurement data

Load or combustion rate at the time of measurement:	800 m <sup>3</sup> /hr (64%)
Volumetric combustion chamber load (kcal/hr/m <sup>3</sup> ):	175 x 10 <sup>3</sup>
Combustion load per sectional area (kcal/hr/m <sup>2</sup> ):	
Current NO <sub>x</sub> emission standard (ppm):	130

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	77
O <sub>2</sub> concentration (%)	7.1
ditto at boiler exit (%)	4.7
CO concentration (ppm)	3
CO <sub>2</sub> concentration (%)	7.6
Smoke tester (#)	0
Exhaust gas temperature (°C)	249
Water temperature (°C)	105

Date and time of measurement: February 18, 1994, 11:00 - 11:30



(iv) Combustion efficiency during the survey: 78%

2) Process boiler (No. D)

(i) Specifications of facility

Type and maker of facility:	Water tube type (Babcock and Wilcox)
Capacity:	6 ton/hr
Draft and ventilation:	1,600(w) x 2,000(h) x 2,600(l)
Furnace dimension (mm):	Forced draft
Combustion chamber volume (m <sup>3</sup> ):	8.32
Furnace pressure (mm H <sub>2</sub> O):	+ 50
Energy saving measures:	None
Combustion control equipment:	Thermometer, draft meter, etc. (no flow meters)

(ii) Specifications of burner

Type and model:	Ring type for gas firing
Kind of fuel at present:	Natural gas
Kind of fuel in the previous JICA study:	Natural gas
Change of burner nozzle at the time of fuel change:	-
Combustion rate (rated):	487 m <sup>3</sup> /hr
Safety control equipment:	Flame eye, etc.

(iii) Flue gas measurement data

Load or combustion rate at the time of measurement: 220 m<sup>3</sup>/hr (45.2%)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 225 x 10<sup>3</sup>  
Combustion load per sectional area (kcal/hr/m<sup>2</sup>):  
Current NO<sub>x</sub> emission standard (ppm): 130

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	88
O <sub>2</sub> concentration (%)	3.0
CO concentration (ppm)	2.8
CO <sub>2</sub> concentration (%)	9.7
Smoke tester (#)	0
Exhaust gas temperature (°C)	280
Water temperature (°C)	75

Date and time of measurement: February 18, 1994, 11:50 - 12:50

(iv) Combustion efficiency during the survey: 79%

3) NO<sub>x</sub> emission control measures being employed

Since natural gas is used as fuel, no particular measure is considered by the plant.

4) Exhaust gas measuring equipment: Orsat analyzer

5) Comments

(i) There were mistakes in the answer to the questionnaire concerning methods of

exhaust gas analysis.

- (ii) The concentrations of NO<sub>x</sub> and CO in the exhaust gas measured this time satisfies the emission standard values.
- (iii) There are adequate number of chemical engineers in the plant, but the number of boiler operator being only one is not sufficient as a plant having 6 units of boilers.
- (iv) Although energy saving measures are not sufficient, the factory plans to install a recuperator within the year of 1994.

6) Recommended measures

- (i) Introduction of the recuperator may cause higher exhaust gas NO<sub>x</sub> concentration due to increased combustion air temperature. In such a case, NO<sub>x</sub> reduction measures such as steam injection are necessary.
- (ii) Boiler operation control equipment, particularly flow meters, should be adequately provided.

(15) ALCOMEX, S.A. DE C.V.

1) Name of facility surveyed: Aluminum melting furnace

2) Specifications of facility

Type and maker of facility:	Reverberatory furnace
Capacity:	20 ton/charge
Draft and ventilation:	Forced draft
Furnace dimension (mm):	3,960(w) x 3,860(d) x 1,715(h)
Combustion chamber volume (m <sup>3</sup> ):	26.2
Furnace pressure (mm H <sub>2</sub> O):	- 2
Energy saving measures:	None
Combustion control equipment:	Automatic combustion control unit, furnace draft meter

3) Specifications of burner

Type and model:	High speed gas burner
Kind of fuel at present:	Natural gas
Kind of fuel in the previous JICA study:	Natural gas
Change of burner nozzle at the time of fuel change:	-
Combustion rate (rated):	264 m <sup>3</sup> /hr
Safety control equipment:	No gas flow meter

4) Flue gas data

No flue gas measurement was made by the JICA Study Team at the time of the visit on

February 21, 1994. The exhaust gas NOx concentration was informed to be in an order of 10 ppm.

Current NOx emission standard (ppm): None

5) NOx emission control measures being employed

None because of use of natural gas

6) Exhaust gas measuring equipment: None

7) Comments

(i) Exhaust gas measurement is made regularly by VPR ANALISIS AMBIENTALES, S.A. DE C.V. being entrusted by the plant.

(ii) Exhaust gas management is made through a stack installed on this small capacity furnace.

8) Recommended measures

(i) No NOx control measure is necessary since the NOx concentration is far below the regulated value of 130 ppm.

(ii) Management of combustion efficiency by installing a fuel flow meter.

(16) AMERICAN TEXTIL, S.A. DE C.V.

1) Name of facility surveyed: Process boiler

2) Specifications of facility

Type and maker of facility:	Water tube type
Capacity:	8.3 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	2,000(w) x 3,000(d) x 2,400(h)
Combustion chamber volume (m <sup>3</sup> ):	14.4
Furnace pressure (mm H <sub>2</sub> O):	Not known
Energy saving measures:	None
Combustion control equipment:	No water supply flow meter

3) Specifications of burner

Type and model:	Steam atomizing type
Kind of fuel at present:	Gas oil
Kind of fuel in the previous JICA study:	Heavy oil
Change of burner nozzle at the time of fuel change:	None because of the suggestion by an engineer of COMBUSTIBLES CASSO, S. A. that no change is necessary

Combustion rate (rated):  
Safety control equipment:

Not clear  
No air pressure sensor

4) Flue gas data

No flue gas measurement was made by the JICA Study Team at the time of the visit on February 22, 1994.

Current NOx emission standard (ppm): 150

5) NOx emission control measures being employed

Heavy oil fuel was changed to gas oil after the notice by PEMEX in the autumn of 1991 that the supply of heavy oil was no longer possible.

6) Exhaust gas measuring equipment

Smoke tester, gas detection tube, MAX 5, and smoke and soot measuring device, all of the portable type

7) Comments

- (i) A person who had been in charge of the boiler operation quit the job, and no successor has been appointed yet. The answers of the plant to the questions of the Study Team were unreliable without sufficient technical grounds.
- (ii) Safety control of the boiler is not reliable.
- (iii) The NOx concentration of exhaust gas answered on the questionnaire form was the unreasonably low value of 3.8 ppm. When the Study Team asked about the validity of the measurement data to the consultant who was entrusted by the plant, no concrete answer was returned.
- (iv) Change of gas oil to natural gas is being planned.

8) Recommended measures

- (i) Fostering of technical personnel for boiler operation and maintenance
- (ii) Improvement of boiler efficiency aided by installation of necessary control equipment

(17) CARTONAJES ESTRELLA, S.A. DE C.V.

- 1) Name of facility surveyed: Power generation boiler

2) Specifications of facility

Type and maker of facility: Water tube type (ZURN)  
 Capacity: 107 ton/hr  
 Draft and ventilation: Forced draft  
 Furnace dimension (mm): 2,740(w) x 2,080(h) x 13,120(l)  
 Combustion chamber volume (m<sup>3</sup>): 74.8  
 Furnace pressure (mm H<sub>2</sub>O): Not known  
 Energy saving measures: Economizer, drain recovery  
 Combustion control equipment: Generally adequate

3) Specifications of burner

Type and model: Multi-lance type for natural gas  
 Kind of fuel at present: Natural gas  
 Kind of fuel in the previous JICA study: Natural gas  
 Change of burner nozzle at the time of fuel change: -  
 Combustion rate (rated): 8,900 m<sup>3</sup>/hr  
 Safety control equipment: Generally adequate including flame eye

4) Flue gas measurement data

No flue gas measurement was made by the JICA Study Team at the time of the visit on February 23, 1994.

Current emission standards (ppm): NO<sub>x</sub>: 100 CO: 400

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	90
O <sub>2</sub> concentration (%)	6
CO concentration (ppm)	250
CO <sub>2</sub> concentration (%)	-
Smoke tester (#)	-
Exhaust gas temperature (°C)	180

Measured data in November 1993 presented by the plant

5) NO<sub>x</sub> emission control measures being employed

The plant uses natural gas only and the boiler exhaust gas meets the emission standards, therefore, no NO<sub>x</sub> reduction measures are employed at present. However, the plant is consulting with boiler makers on possible measures considering more stringent regulations in the future.

6) Exhaust gas measuring equipment

The plant has a Bacharach #300 unit which is capable of measuring oxygen, CO<sub>2</sub>, SO<sub>2</sub>, and NO<sub>x</sub>.

7) Comments

- (i) The oxygen concentration at 6% is high for combustion of natural gas only. Operation at 3% oxygen is desirable.
- (ii) The plant is keen on energy saving so as to employing an economizer and recovering drain.
- (iii) Boiler operation control equipment is generally adequate.

8) Recommended measures

Modification of the burner for enabling low-oxygen operation

(18) VITRO FIBRAS, S.A. DE C.V.

1) Name of facility surveyed: Melting furnace for glass fiber material

2) Specifications of facility

Type and maker of facility:	Melting furnace with soaking pit
Capacity:	30.5 ton/day
Draft and ventilation:	Forced draft of oxygen
Furnace dimension (mm):	2,400(w) x 1,080(h) x 7,200(l)
Combustion chamber volume (m <sup>3</sup> ):	18.66
Furnace pressure (mm H <sub>2</sub> O):	+ 2
Energy saving measures:	Oxygen burner
Combustion control equipment:	Generally adequate

3) Specifications of burner

Type and model:	Gun-type for natural gas firing and oxygen forced draft (20 pieces)
Kind of fuel at present:	Natural gas
Kind of fuel in the previous JICA study:	Natural gas
Change of burner nozzle at the time of fuel change:	-
Combustion rate (rated):	416 m <sup>3</sup> /hr (20.8 m <sup>3</sup> /hr x 20 pieces)
Safety control equipment:	Generally adequate

4) Flue gas measurement data

No flue gas measurement was made by the JICA Study Team at the time of the visit on February 24, 1994.

Current NO<sub>x</sub> emission standard (ppm): None

NOx concentration at 5% O <sub>2</sub> (ppm)	6
O <sub>2</sub> concentration (%)	4.5
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	-
Smoke tester (#)	0
Exhaust gas temperature (°C)	550

Measured data in January 1994 presented by the plant

5) NOx emission control measures being employed

Use of the oxygen burner

6) Exhaust gas measuring equipment

Oxygen analyzer

7) Comments

- (i) The plant is investing for energy saving and air pollution control (exhaust gas and dust control) based on a comprehensive 3 year plan from 1993.
- (ii) Refractory bricks of the furnace are noticeably damaged, because the furnace temperature is 1,550 °C while the bricks used are suitable up to 1,500 °C.
- (iii) Employment of the oxygen burners has resulted in successes in NOx emission reduction and energy saving. Present exhaust gas NOx concentration is reported to be 6 ppm as compared with 1,200 ppm at the time of the previous JICA study. The plant explained that due to high temperature combustion by oxygen burners, total energy was being saved by 5%. However, certain measures are necessary against the problem stated in ii) above.

8) Recommended measures

- (i) Repair of the furnace body and use of refractory bricks resistible with higher temperature
- (ii) Improvement in precision of furnace body by appropriate construction method

(19) SILICATOS Y DERIVADOS, S.A. (GRUPO DE VITRO QUIMICA, FIBRAS Y MINERIA)

1) Heating Furnace

- (i) Specifications of facility

Type and maker of facility: Tank furnace

Capacity: 200 ton/charge  
 Draft and ventilation: Induced draft  
 Furnace dimension (mm): 8,300(w) x 23,400(d) x 3,500(h)  
 Combustion chamber volume (m<sup>3</sup>): 680  
 Furnace pressure (mm H<sub>2</sub>O): Negative pressure (value not known)  
 Energy saving measures: Recuperator (30 °C → 900 °C)  
 Combustion control equipment: All equipped

(ii) Specifications of burner

Type and model: Gun-type for gas fuel  
 Kind of fuel at present: Natural gas  
 Kind of fuel in the previous JICA study: Natural gas  
 Change of burner nozzle at the time of fuel change: -  
 Combustion rate (rated): 1,000 m<sup>3</sup>/hr  
 Safety control equipment: All equipped

(iii) Flue gas data

No flue gas measurement was made by the JICA Study Team at the time of the visit on February 25, 1994.

Current emission standards (ppm): NO<sub>x</sub>: none, smoke dust: 0.226 gr/Nm<sup>3</sup>

NO <sub>x</sub> concentration at actual O <sub>2</sub> (ppm)	500
O <sub>2</sub> concentration (%)	17.0
CO concentration (ppm)	0
CO <sub>2</sub> concentration (%)	1.0
Smoke dust (gr/Nm <sup>3</sup> )	0.17
Exhaust gas temperature (°C)	371

Measured data in December 1992 presented by the plant

2) Process Boilers

(i) Specifications of facility

Type and maker of facility: Flue and smoke tube type (Cleaver Brooks)  
 Capacity: 9.4 ton/hr (600 hp) x 2 units  
 6.2 ton/hr (400 hp) x 1 unit  
 Draft and ventilation: Forced draft  
 Furnace dimension (mm): 600 hp: 1,200(dia) x 4,200(l)  
 400 hp: 900(dia) x 3,800(l)  
 Combustion chamber volume (m<sup>3</sup>): 600 hp: 4.75  
 400 hp: 2.42  
 Furnace pressure (mm H<sub>2</sub>O): Not clear  
 Energy saving measures: None  
 Combustion control equipment: No furnace pressure gauges

(ii) Specifications of burner

Type and model: Gas ring type  
 Kind of fuel at present: Natural gas  
 Kind of fuel in the previous JICA study: Natural gas  
 Combustion rate (rated): 600 hp: 860 m<sup>3</sup>/hr



Safety control equipment: 400 hp: 570 m<sup>3</sup>/hr  
All equipped

(iii) Flue gas data

No flue gas measurement was made by the JICA Study Team at the time of the visit on February 25, 1994.

Current NOx emission standard (ppm): 130

3) NOx Emission Control Measures Being Employed

Natural gas only is used

4) Exhaust Gas Measuring Equipment

ENERAC 2000 (portable type) is used for measurements of oxygen, CO, CO<sub>2</sub>, NOx, and SO<sub>2</sub> concentrations in the exhaust gas and combustion efficiency.

5) Comments

(i) Heating furnace

i) The ceiling height of the furnace was changed, in December 1992, from 5 m to 3.5 m. As a result, unit fuel consumption decreased from 150 m<sup>3</sup>/ton to 115 m<sup>3</sup>/ton; operation efficiency improved.

ii) The flue gas measurement data in January 1994 indicates that the smoke dust concentration meets the emission standard.

iii) Meetings are regularly held among the companies of the Group on energy saving. Topics on improvement of facilities such as for exhaust gas utilization have been studied, and measures considered to be effective are to be realized.

iv) A gas flow meter is installed for each of 4 gas burners.

(ii) Boilers

No measure has been taken since only natural gas is used.

6) Recommended measures

(i) Heating furnace

i) The NOx concentration increases as the combustion efficiency increases. Reduction of NOx generation should be tried under consideration for cost efficiency.

ii) Use quality insulating material for furnace wall to reduce heat loss through the wall.

(ii) Boilers

Installation of an economizer to raise the temperature of the supply water as a energy saving measure.

(20) PROCTER & GAMBLE DE MEXICO, S.A. DE C.V.

1) Name of facility surveyed: Process boiler

2) Specifications of facility

Type and maker of facility: Once-through type (CLAYTON DE MEXICO)  
 Capacity: 6 ton/hr (the 9.1 ton/hr boiler reported in the questionnaire form is now for the spare)  
 Draft and ventilation: Forced draft  
 Furnace dimension (mm): 1,600(dia) x 3,000(l)  
 Combustion chamber volume (m<sup>3</sup>): 6.03  
 Furnace pressure (mm H<sub>2</sub>O): Not known  
 Energy saving measures: Economizer  
 Combustion control equipment: Generally adequate

3) Specifications of burner

Type and model: Switch able for gas or oil, ring type (gas burner), outer mixing (oil burner)  
 Kind of fuel at present: Natural gas  
 Kind of fuel in the previous JICA study: Not studied  
 Combustion rate (rated): 500 m<sup>3</sup>/hr  
 Safety control equipment: Flame eye, etc.

4) Flue gas data

No flue gas measurement was made by the JICA Study Team at the time of the visit on February 2, 1994. The following data were presented by the plant.

Load or combustion rate at the time of measurement: 78% (390 m<sup>3</sup>/hr)  
 Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 550 x 10<sup>3</sup>  
 Current emission standards (ppm): NOx: 130 CO: 400

NOx concentration at 5% O <sub>2</sub> (ppm)	43
O <sub>2</sub> concentration (%)	4.8
CO concentration (ppm)	15
CO <sub>2</sub> concentration (%)	9.0
Smoke tester (#)	-
Exhaust gas temperature (°C)	135

Date and time of measurement by the plant: February 8, 1994

5) NOx emission control measures being employed

This boiler for natural gas combustion was newly installed. Operation of the old one for diesel has been suspended, but it is not abandoned so that it can be used in an emergency.

6) Exhaust gas measuring equipment

A continuous exhaust gas monitoring system for measurements of NOx, CO, CO<sub>2</sub>, SO<sub>2</sub> and oxygen concentrations and a thermometer are installed.

7) Comments

- (i) Boiler operation control is being made including measurement of boiler efficiency.
- (ii) Energy saving and increased combustion efficiency are being achieved by the renewal of boiler. The boiler efficiency of the boiler is 91%.
- (iii) The plant seems to be keen on heat management and air pollution control.

8) Recommended measures

None in particular

(21) CIA. HULERA TORNEL, S.A. DE C.V.

1) Process Boiler (200 hp)

(i) Specifications of facility

Type and maker of facility:	Flue and smoke tube boiler (Cleaver Brooks)
Capacity:	200 hp (3.136 ton/hr)
Draft and ventilation:	Forced draft
Furnace dimension (mm):	570(dia) x 3,600(l)
Combustion chamber volume (m <sup>3</sup> ):	0.918
Furnace pressure (mm H <sub>2</sub> O):	Not known
Energy saving measures:	Drain recovery (partial)
Combustion control equipment:	No oil flow meter

(ii) Specifications of burner

Type and model:	Oil burner, outer mixing, air atomizing
Kind of fuel at present:	Diesel
Kind of fuel in the previous JICA study:	Diesel
Combustion rate (rated):	250 lit/hr (estimated)
Safety control equipment:	Flame eye, etc.

(iii) Flue gas data

No flue gas measurement was made by the JICA Study Team at the time of the visit on March 1, 1994. The following data were presented by the plant.

Load or combustion rate at the time of measurement: 120 lit/hr (48%)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 1,150 x 10<sup>3</sup>  
Combustion load per sectional area (kcal/hr/m<sup>2</sup>): 4,000 x 10<sup>3</sup>  
Current NOx emission standard (ppm): 150

NOx concentration at 5% O <sub>2</sub> (ppm)	104
O <sub>2</sub> concentration (%)	5.6
CO concentration (ppm)	12
CO <sub>2</sub> concentration (%)	11.3
Smoke tester (#)	-
Exhaust gas temperature (°C)	156

Date of measurement by the plant: February 8, 1994

2) Process Boiler (125 hp)

(i) Specifications of facility

Type and maker of facility: Flue and smoke tube boiler (Cleaver Brooks)  
Capacity: 125 hp (1.96 ton/hr)  
Draft and ventilation: Forced draft  
Furnace dimension (mm): 560(dia) x 2,840(l)  
Combustion chamber volume (m<sup>3</sup>): 0.7  
Furnace pressure (mm H<sub>2</sub>O): Not known  
Energy saving measures: Drain recovery (partial)  
Combustion control equipment: No oil flow meter

(ii) Specifications of burner

Type and model: Oil burner, outer mixing, air atomizing  
Kind of fuel at present: Diesel  
Kind of fuel in the previous JICA study: Diesel  
Combustion rate (rated): 150 lit/hr (estimated)  
Safety control equipment: Flame eye, etc.

(iii) Flue gas data

The following data were presented by the plant.

Load or combustion rate at the time of measurement: not known  
Current NOx emission standard (ppm): None

NOx concentration at 5% O <sub>2</sub> (ppm)	139
O <sub>2</sub> concentration (%)	5.3
CO concentration (ppm)	167
CO <sub>2</sub> concentration (%)	9.6
Exhaust gas temperature (°C)	135

Date of measurement by the plant: February 8, 1994

### 3) Heat Transfer Medium Process Boiler

#### (i) Specifications of facility

Type and maker of facility:	Box shape, oil tube type
Capacity:	1,150 x 10 <sup>3</sup> kcal/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	4,200(w) x 4,000(h) x 5,460(l)
Combustion chamber volume (m <sup>3</sup> ):	91.7
Furnace pressure (mm H <sub>2</sub> O):	Not known
Energy saving measures:	None
Combustion control equipment:	No oil flow meter

#### (ii) Specifications of burner

Type and model:	Oil burner, outer mixing, air atomizing
Kind of fuel at present:	Diesel
Kind of fuel in the previous JICA study:	Diesel
Combustion rate (rated):	150 lit/hr
Safety control equipment:	Flame eye, etc.

#### (iii) Flue gas data

The following data were presented by the plant.

Load or combustion rate at the time of measurement:	135 lit/hr (90%)
Volumetric combustion chamber load (kcal/hr/m <sup>3</sup> ):	113 x 10 <sup>3</sup>
Current NOx emission standard (ppm):	None

NOx concentration at 5% O <sub>2</sub> (ppm)	73
O <sub>2</sub> concentration (%)	7.9
CO concentration (ppm)	41
CO <sub>2</sub> concentration (%)	-
Smoke tester (#)	-
Exhaust gas temperature (°C)	135

Date of measurement by the plant: February 8, 1994

### 4) NOx Emission Control Measures Being Employed

Fuel was changed to diesel in 1992. Since then, the exhaust gas NOx concentration has been meeting the emission standard.

### 5) Exhaust Gas Measuring Equipment

- (i) A handy type equipment (made by Test Term) capable of measuring NOx, CO, CO<sub>2</sub>, and oxygen concentrations and combustion efficiency
- (ii) Orsat analyzer

## 6) Comments

- (i) Under the overall plant reviewing program including production processes, energy saving efforts are being made with the target of 20% reduction of electricity, water and fuel consumption.
- (ii) Regarding energy saving on boilers, drain recovery is being strengthened by deliberately applying heat insulation for steam piping.
- (iii) The plant is well aware of necessity of boiler operation control using measuring equipment such as flow meters, and included installation of such equipment in the subsequent program.
- (iv) From above, the plant seems to have good understanding in energy saving and capability of executing such measures.

## 7) Recommended Measures

- (i) Enhancement of drain recovery
- (ii) Adequate installation of boiler operation control equipment, especially flow meters

## (22) CRISOBA INDUSTRIAL, S.A. DE C.V., PLANTA SAN RAFAEL

1) Name of facility surveyed: Process boiler

### 2) Specifications of facility

Type and maker of facility:	Water tube type (Babcock & Wilcox)
Capacity:	60 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	5,000(w) x 5,000(h) x 6,600(l)
Combustion chamber volume (m <sup>3</sup> ):	165
Furnace pressure (mm H <sub>2</sub> O):	Not known
Energy saving measures:	Recuperator
Combustion control equipment:	Generally adequate, but no low water level cut-off device

### 3) Specifications of burner

Type and model:	Inner mixing, steam atomizing type for heavy oil
Kind of fuel at present:	Heavy oil
Kind of fuel in the previous JICA study:	Heavy oil
Change of burner nozzle at the time of fuel change:	None
Combustion rate (rated):	3,200 lit/hr (800 lit/hr x 4 pieces)
Safety control equipment:	Draft pressure sensor, oil pressure gauge and atomizing steam pressure gauge only

#### 4) Flue gas data

No flue gas measurement was made by the JICA Study Team at the time of the visit on March 2, 1994. The following data were presented by the plant.

Load or combustion rate at the time of measurement: 2,800 lit/hr (87.5%)  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 130 x 10<sup>3</sup>  
Current emission standards: NOx: 230 ppm  
CO: 400 ppm  
smoke dust: 300 mg/Nm<sup>3</sup>

NOx concentration at 5% O <sub>2</sub> (ppm)	150
O <sub>2</sub> concentration (%)	4.2
CO concentration (ppm)	-
CO <sub>2</sub> concentration (%)	-
Smoke dust (mg/Nm <sup>3</sup> )	277
Exhaust gas temperature (°C)	210
Combustion air temperature (°C)	160

Date of measurement by the plant: February, 1994

#### 5) NOx Emission Control Measures Being Employed

The plant is located out of the metropolitan area, and uses heavy oil under the permissions of the authorities.

#### 6) Exhaust Gas Measuring Equipment

Now planning installation of a continuous exhaust gas monitoring system capable of measuring NOx, SO<sub>2</sub>, CO, CO<sub>2</sub> and oxygen.

#### 7) Comments

- (i) Energy saving measures employed are: a) installation of a recuperator, b) heat insulation of steam and other pipes, and c) calibration of burners, esp. in terms of exhaust gas oxygen concentration.
- (ii) There is no low water level shut-off device among necessary combustion control equipment. Among necessary safety control equipment, flame eye is not provided. These indicate that safety of boiler operation is not adequately insured.
- (iii) Although the concentration of smoke dust is within the limit of the emission standard (300 mg/Nm<sup>3</sup>), it is relatively high at 277 mg/Nm<sup>3</sup>. In case more stringent emission standard is enforced in the future, smoke dust emission of the plant may not satisfy the standard.

8) Recommended measures

- (i) Adequate provision of boiler combustion control equipment
- (ii) Smoke dust emission control measures such as installation of a dust collector.

(23) HULE INDUSTRIAL, S.A. DE C.V.

1) Name of facility surveyed: Process boiler

2) Specifications of facility

Type and maker of facility:	Flue and smoke tube type (Cleaver & Brooks)
Capacity:	0.94 ton/hr (60 hp)
Draft and ventilation:	Forced draft
Furnace dimension (mm):	500(dia) x 2,500(l)
Combustion chamber volume (m <sup>3</sup> ):	0.49
Furnace pressure (mm H <sub>2</sub> O):	Not known
Energy saving measures:	None
Combustion control equipment:	No water and oil supply flow meters, oil thermometer, and chamber pressure gauge

3) Specifications of burner

Type and model:	Mechanical atomizing
Kind of fuel at present:	Diesel
Kind of fuel in the previous JICA study:	Diesel
Combustion rate (rated):	82 lit/hr (estimated)
Safety control equipment:	No air pressure sensor

4) Flue gas data

No flue gas measurement data were available at the time of the visit on March 3, 1994.

5) NO<sub>x</sub> emission control measures being employed: none

6) Exhaust gas measuring equipment

Only an exhaust gas thermometer (bimetal type) is installed.

7) Comments

- (i) Exhaust gas emission of this boiler is out of the emission regulation because of its small size. There is no record on the measurement of NO<sub>x</sub> emission.
- (ii) Maintenance of the boiler is entrusted to a service company who, according to the plant, conducts adjustment of burner combustion as well. But it is doubtful that the maintenance company is able to do that work.



8) Recommended measures

- (i) Management of fuel consumption per unit output by installing water supply and oil flow meters.
- (ii) Exhaust gas oxygen control using a portable oxygen analyzer

(24) INDUSTRIAS DE HULE GALGO, S.A. DE C.V.

1) Name of facility surveyed: Process boiler

2) Specifications of facility

Type and maker of facility:	Flue and smoke tube type (Cleaver Brooks, CB-200)
Capacity:	3.13 ton/hr (200 hp)
Draft and ventilation:	Forced draft
Furnace dimension (mm):	610(dia) x 4,242(l)
Combustion chamber volume (m <sup>3</sup> ):	1.24
Furnace pressure (mm H <sub>2</sub> O):	Not known
Energy saving measures:	None
Combustion control equipment:	No water supply and oil flow meters, oil thermometer, and chamber pressure gauge

3) Specifications of burner

Type and model:	Outer mixing, air atomizing
Kind of fuel at present:	Diesel
Kind of fuel in the previous JICA study:	Heavy oil
Change of burner nozzle at the time of fuel change:	None
Combustion rate (rated):	250 lit/hr (estimated)
Safety control equipment:	Flame eye only

4) Flue gas data

Current emission standards : NO<sub>x</sub> : 150 ppm, smoke dust : 100 mg/Nm<sup>3</sup>

The following flue gas measurement data were reported by the plant at the time of the visit on March 4, 1994.

NO<sub>x</sub>: 40 ppm      smoke dust: 11 mg/Nm<sup>3</sup>

5) NO<sub>x</sub> emission control measures being employed

Fuel was changed from heavy oil to diesel in 1992.

6) Exhaust gas measuring equipment

A portable type measuring equipment is used.

## 7) Comments

- (i) Drain is recovered by 100%. Steam pipe insulation and leaking are regularly inspected and repaired.
- (ii) The plant stated a desire of changing diesel to LPG. But it seems not necessary since emissions of both NO<sub>x</sub> and smoke dust meet the emission standard values.

## 8) Recommended measures

Management of boiler and fuel consumption per unit output by installing water supply and oil flow meters

## (25) CENTRAL TERMOELECTRICA VALLE DE MEXICO

### 1) Power Generation Boiler (U-1)

#### (i) Specifications of facility

Type and maker of facility:	Water tube type (Combustion Engineering)
Capacity:	476.2 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	7,900(w) x 7,900(l) x 18,500(h)
Combustion chamber volume (m <sup>3</sup> ):	1,155
Furnace pressure (mm H <sub>2</sub> O):	Not clear
Energy saving measures:	Recuperator
Combustion control equipment:	Generally adequate

#### (ii) Specifications of burner

Type and model:	Tangential, multi-fuel combustion for gas and oil, lance type for gas, inner mixing type for oil
Kind of fuel at present:	Natural gas (gas oil used in an emergency)
Kind of fuel in the previous JICA study:	Natural gas
Combustion rate (rated):	32,400 m <sup>3</sup> /hr (1,620 m <sup>3</sup> /hr x 20 pieces)
Safety control equipment:	Generally adequate

#### (iii) Flue gas data

Current emission standards : NO<sub>x</sub> : 100 ppm

No flue gas measurement was made by the JICA Study Team at the time of the visit on March 7, 1994. The following data were reported by the plant.

Load or combustion rate at the time of measurement: 70%  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 167 x 10<sup>3</sup>

NOx concentration at 5% O <sub>2</sub> (ppm)	55
O <sub>2</sub> concentration (%)	4.0
CO concentration (ppm)	10
CO <sub>2</sub> concentration (%)	-
Smoke dust (gr/Nm <sup>3</sup> )	-
Combustion air temperature (°C)	315
Exhaust gas temperature (°C)	135

Date of the measurement by the plant: Not known

## 2) Power Generation Boiler (U-2 and U-3)

### (i) Specifications of facility

Type and maker of facility:	Water tube type (Babcock & Wilcox)
Capacity:	503.5 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	9,000(w) x 9,000(l) x 24,000(h)
Combustion chamber volume (m <sup>3</sup> ):	1,944
Furnace pressure (mm H <sub>2</sub> O):	Not clear
Energy saving measures:	Recuperator
Combustion control equipment:	Generally adequate

### (ii) Specifications of burner

Type and model:	Tangential, multi-fuel combustion for gas and oil, lance type for gas, mechanical atomizing for oil
Kind of fuel at present:	Natural gas (gas oil used in an emergency)
Kind of fuel in the previous JICA study:	Natural gas
Combustion rate (rated):	35,200 m <sup>3</sup> /hr (2,200 m <sup>3</sup> /hr x 16 pieces)
Safety control equipment:	Generally adequate

### (iii) Flue gas data

Current emission standards : NOx : 100 ppm

The following data were reported by the plant.

Load or combustion rate at the time of measurement: 70%  
 Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 108 x 10<sup>3</sup>

	U-2	U-3
NOx concentration at 5% O <sub>2</sub> (ppm)	35	40
O <sub>2</sub> concentration (%)	4.0	4.0
CO concentration (ppm)	200	200
CO <sub>2</sub> concentration (%)	-	-
Smoke dust (gr/Nm <sup>3</sup> )	-	-
Combustion air temperature (°C)	315	315
Exhaust gas temperature (°C)	135	135

Date of the measurement by the plant: Not known

### 3) Power Generation Boiler (U-4)

#### (i) Specifications of facility

Type and maker of facility:	Water tube type (Babcock & Wilcox)
Capacity:	904.8 ton/hr
Draft and ventilation:	Forced draft
Furnace dimension (mm):	9,745(w) x 9,745(l) x 32,900(h)
Combustion chamber volume (m <sup>3</sup> ):	3,124
Furnace pressure (mm H <sub>2</sub> O):	Not clear
Energy saving measures:	Recuperator
Combustion control equipment:	Generally adequate

#### (ii) Specifications of burner

Type and model:	Frontal, multi-fuel combustion for gas and oil, lance type for gas, Y-jet type for oil
Kind of fuel at present:	Natural gas (gas oil used in an emergency)
Kind of fuel in the previous JICA study:	Natural gas
Combustion rate (rated):	75,000 m <sup>3</sup> /hr (5,000 m <sup>3</sup> /hr x 15 pieces)
Safety control equipment:	Generally adequate

#### (iii) Flue gas data

Current emission standards : NO<sub>x</sub> : 100 ppm

The following data were reported by the plant.

Load or combustion rate at the time of measurement: 70%  
Volumetric combustion chamber load (kcal/hr/m<sup>3</sup>): 143 x 10<sup>3</sup>

NO <sub>x</sub> concentration at 5% O <sub>2</sub> (ppm)	120
O <sub>2</sub> concentration (%)	6.0
CO concentration (ppm)	200
CO <sub>2</sub> concentration (%)	-
Smoke dust (gr/Nm <sup>3</sup> )	-
Combustion air temperature (°C)	322
Exhaust gas temperature (°C)	126

Date of the measurement by the plant: Not known

#### 4) NO<sub>x</sub> Emission Control Measures Being Employed

Natural gas only is used for all 4 boilers. EGR is employed for U-1 boiler.

#### 5) Exhaust Gas Measuring Equipment

All 4 boilers are equipped with a continuous exhaust gas monitoring system to measure NO<sub>x</sub>, oxygen, and CO concentrations and a thermometer.

## 6) Comments

- (i) Exhaust gas oxygen concentration is generally high as power generation boilers: 4.0% for U-1, U-2, U-3 boilers, and 6% for U-4 boiler.
- (ii) Exhaust gas NOx concentration of U-4 boiler is high at 120 ppm.
- (iii) It is ideal to control the operation in terms of fuel consumption per unit output of electricity.

## 7) Recommended measures

- (i) Reduction of NOx emission from U-4 boiler, e.g., by EGR.
- (ii) Systematic control of boiler efficiency and unit power generation cost

### 3.8 Results of Diagnostic Survey of Boilers in Service and Commercial Institutions

#### (1) Institutions Surveyed

In addition to the synoptic and diagnostic surveys of factories, on-site surveys of boilers in service and commercial institutions were conducted. Institutions surveyed were selected from those proposed by DDF and EDOMEX as shown below.

Name of Institution	Type of Business	Date of Visit in 1993	Number of Employees (Laborers)
(1) Hospital ABC	Hospital	July 28	610 (558)
(2) Hospital General de México	Hospital	July 29	132
(3) Hotel Camino Real	Hotel	July 30	850
(4) Quinonas de México	Medicine	August 3	170 (107)
(5) Club Deportivo Chapultepec	Sport center	August 7	214

The following institutions were visited but not surveyed because of the indicated reasons.

Name of Institution	Type of Business	Date of Visit	Reason for Not Surveyed
Hotel María Isabel Sheraton	Hotel	July 31	Survey refused by the hotel
Shell México	Gasoline	August 4	Fuel and water consumption rates not measurable
Sutsa Print de México	Printing	August 6	Ditto
Envases Cuevas	Packing	August 9	Ditto
Pinturas Para México	Paint	August 10	Ditto

(2) Result of the Survey

1) Existence of Combustion and Safety Control Equipment

For boilers of the selected institutions, existence of combustion control equipment and safety control equipment was first checked. The result is shown below.

	(1) Hospital ABC	(2) Hospital General Mexico	(3) Camino Real	(4) Quinonas de Mexico	(5) Centro Deportivo Chapulte.
<b><u>Combustion Control Equipment</u></b>					
1) Automatic combustion control unit	Yes	Yes	Yes	Yes	Yes
2) Water level gauge	Yes	Yes	Yes	Yes	Yes
3) Low water level cut-off device	Yes	Yes	Yes	Yes	Yes
4) Steam pressure gauge	Yes	Yes	Yes	Yes	Yes
5) Automatic water supply device	Yes	Yes	Yes	Yes	Yes
6) Water supply flow meter	No	No	No	No	Yes
7) Oil supply flow meter	No	No	No	No	No
8) Oil temperature gauge	No	Yes	No	No	No
9) Steam temperature gauge	No	No	No	No	No
10) In-furnace pressure gauge	No	No	No	No	No
<b><u>Safety Control Equipment</u></b>					
1) Frame eye (frame detector)	Yes	Yes	Yes	Yes	Yes
2) Shut-off valve unit	Yes	No	Yes	Yes	Yes
3) Air pressure sensor		No	No	No	Yes
4) Oil pressure gauge	Yes*	Yes	No	No	Yes
5) Atomizing steam pressure gauge	No	Yes	No	No	Yes
6) Pressure gauge after regulator	Yes*	Yes	Yes	No	No
7) Pressure gauge after shut-off valve	No	No	Yes	No	No
8) Burner inlet gas pressure gauge	No	No	Yes	No	No
9) Gas pressure limits switch	No	No	Yes	No	Yes
10) Purge valve (test cock)	Yes	No	Yes	Yes	Yes
11) Gas flow meter	No	No	No	No	No

Note: \* Not functioning

2) Hospital ABC (The American British Cowdray Hospital)

(i) Outline of Combustion Facility

Combustion equipment	Water-tube boiler No.1	Water-tube boiler No.2	Water-tube boiler No.3
Manufacturer	Queen City Engineering	Queen City Engineering	Queen City Engineering
Age (year)	28	28	28
Maximum capacity	1.96 ton/h 125 HP	1.96 ton/h 125 HP	1.96 ton/h 125 HP
Kind of fuel	Gas oil	Gas oil	Gas oil
Fuel consumption	25.46 lit/h	25.46 lit/h	25.46 lit/h
Combustion chamber Shape			
Dimension (W*D*H m)	1.23*1.94*1.45	1.23*1.94*1.45	1.23*1.94*1.45
Sectional area (m <sup>2</sup> )	1.78	1.78	1.78
Volume (m <sup>3</sup> )	3.45	3.45	3.45
Thermal load (kcal/m <sup>3</sup> h)	490,000	490,000	490,000
Burner type	Rotary	Rotary	Rotary
Burner maker	Marked as PETRO		
Max. fuel consumption per burner x number	170 lit/h x 1	170 lit/h x 1	170 lit/h x 1
Diameter and number of burner-tip holes	Not clear	Not clear	Not clear
Spraying angle	Not clear	Not clear	Not clear
Atomizing media	Air	Air	Air
Mixing method	Outer	Outer	Outer
Air drafting method	Induced draft		
Operation hours	Not clear		



(ii) Observation

Three (3) water-tube boilers of Queen City Engineering are used for utilities of the hospital. Out of these, two (2) were operated at the time of the visit. One was operated at a fixed combustion rate of 50% loading (0.98 ton/h), and another was operated at varying rates to meet variable loading.

Previously used heavy oil was replaced by gas oil in 1990, but the burners for heavy oil are still used without any modification. Operation is made at a high air ratio. Flame is luminous and carbon particle burning is partly observable around the flame head indicating coarse particles of atomized gas oil.

(iii) Recommended Measures

- i) Change the air nozzle and the oil spraying head of the burner to those for gas oil in order to have fine fuel particles. Operate at a low air ratio by adjusting the primary and secondary air dampers.
- ii) Employ low-NOx burner and steam injection.
- iii) Renew the boilers as commented by the hospital.

(iv) Fuel Quality

The Study Team analyzed a sample of the gas oil taken at the time of the survey. The result is shown below, which indicates normal quality as gas oil.

<u>Item</u>	<u>Analytical Method</u>	<u>Value</u>
Specific gravity (20/4°C)	ASTM D-70	0.8699
Viscosity (40°C)	ASTM D-445	7.33 cSt
S content	ASTM D-2622	1.19%
N content	ASTM D-4629	0.0595%

3) Hospital General De Mexico

(i) Outline of Combustion Facility

Combustion equipment	Smoke-tube boiler No.1	Smoke-tube boiler No.2	Smoke-tube boiler No.3	Smoke-tube boiler No.4
Operation	Yes	No	No	Overhauling
Manufacturer	Cleaver Brooks, Mexico	Cleaver Brooks U.S.A.	Power Master	Cleaver Brooks Mexico
Age (year)	23	33	40	9
Maximum capacity	9.4 ton/h 600 HP	2.5 ton/h 160 HP	1.5 ton/h 100 HP	5.5 ton/h 350 HP
Kind of fuel	Diesel	Diesel	Diesel	Diesel
Fuel consumption	400 lit/h	200 lit/h	128 lit/h	300 lit/h
Combustion chamber				
Shape	Cylindrical	Cylindrical	Cylindrical	Cylindrical
Dimension (Dia x L m)	1.20 x 4.20	0.60 x 3.80	0.50 x 2.80	0.80 x 4.00
Sectional area (m <sup>2</sup> )	1.13	0.28	0.2	0.5
Volume (m <sup>3</sup> )	4.75	1.07	0.54	2
Thermal load (kcal/m <sup>3</sup> h)	1,840,000	2,170,000	2,580,000	2,560,000
Burner type	Jet	Jet	Jet	Jet
Burner maker	Cleaver Brooks	Cleaver Brooks	Cleaver Brooks	Cleaver Brooks
Max. fuel consumption per burner x number	820 lit/h x 1	218 lit/h x 1	131 lit/h x 1	480 lit/h x 1
Diameter and number of burner-tip holes	1/12" x 16	1/12" x 16	1/12" x 16	1/12" x 16
Spraying angle				
Atomizing media	Air	Air	Air	Air
Mixing method	Inner	Inner	Inner	Inner
Air drafting method	Forced draft			
Operation hours	12: 00- 14:00, 7 days/week, 48 weeks/year			

Fuel pressure: 1.8 kg/cm<sup>2</sup> Air pressure: 1.0 kg/cm<sup>2</sup>

(ii) Observation

Three (3) smoke-tube boilers of Cleaver Brooks and one smoke boiler of Power Master are installed for utilities of the hospital. Boiler No.1 was operated at the time of the visit. The burner is of air-atomizing and semi-inner mixing type. The nozzle for heavy oil is used without modification.

Amount of combustion air is controlled by variable slit linked to the drafting duct. The air reaches to the nozzle through a swirler. A perforated plate is provided circumferentially in the neighborhood of the nozzle jetting range. Refractory bricks form a front part of inner wall of the combustion chamber. Therefore, when fuel is sprayed at a wide angle, the refractory material may be red-heated thereby causing high NO<sub>x</sub> concentration.

At the time heavy oil was replaced by diesel, the hospital made a test of changing atomizing medium from air to self-generated steam. It was said that the steam atomizing caused highly pulsating combustion, therefore, the hospital employed air atomizing again. This phenomenon is considered to be caused by large amount of drain mixed in the steam. It is recommended to try steam atomizing combustion again.

A comparative study on the existing nozzle having a perforated plate and a low-NO<sub>x</sub> steam atomizing nozzle is desirable.

All 4 boilers have a simple dust collector on top of the stack. They were installed when heavy oil was used aiming to prevent emission of acid mud which was falling on the nearby roads and automobiles. They are said to have a considerable effect. However, since it seems difficult to meet the emission standards, additional measures are needed.

(iii) Recommended Measures

- i) Change the burners to the type specified for diesel oil and operate at an appropriate air ratio.
- ii) Use low-NO<sub>x</sub> burner.
- iii) Employ exhaust gas recirculation and steam injection combustion.
- iv) Install an oil supply flow meter and a water supply flow meter on each boiler for regular checking of boiler efficiency and energy saving.

4) Camino Real Mexico, S.A. De C.V.

(i) Outline of Combustion Facility

Combustion facility	Smoke-tube boiler No.2
Manufacturer	Cleaver Brooks
Age (year)	25
Maximum capacity	7.84 ton/h
Kind of fuel	LPG
Fuel consumption	305 m <sup>3</sup> /h
Combustion chamber	
Shape	Cylindrical
Dimension (Dia. x L m)	1.067 x 4.572
Sectional area (m <sup>2</sup> )	0.894
Volume (m <sup>3</sup> )	4.88
Thermal load (kcal/m <sup>3</sup> h)	1,210,000
Burner type	DIFUSOR
Max. fuel consumption of burner	515 m <sup>3</sup> /h
Atomizing media	Air
Mixing method	Not clear
Air drafting method	Forced draft

(ii) Observation

Three (3) smoke-tube boilers of Cleaver Brooks are installed for utilities of the hotel. No.1 and No.2 boilers are for LPG combustion, and No.3 boiler is a spare specified for diesel combustion. At the time of the visit, only No.2 boiler was operated under automatic operation.

The central part of the flame is transparent. Combustion begins in the vicinity of the burner tile end with violet-red flame. The combustion chamber heat load exceeded 1,000,000 kcal/m<sup>3</sup>h. The chamber inner wall is formed by refractory bricks up to about 1.5 m from the burner. The bricks may be red-heated at high load combustion resulting in high concentration of NOx.

(iii) Recommended Measures

- i) Employ low-NO<sub>x</sub> burners and steam injection combustion.
- ii) Install inflammable gas detection and warning system in the boiler room located in the second basement floor.
- iii) Install a fuel supply flow meter and a water supply flow meter on each boiler for regular checking of boiler efficiency and energy saving.

5) Quinonas De Mexico, S.A. De C.V.

(i) Outline of Combustion Facility

Combustion facility	Boiler
Manufacturer	Caldela Mundes De 75
Age (year)	14
Maximum capacity	1.17 ton/h (2.65 GJ/h)
Kind of fuel	Diesel
Fuel consumption	31.25 lit/h
Combustion chamber	
Shape	Rectangular
Dimension (W x D x H m)	1.0 x 3.5 x 3.0
Sectional area (m <sup>2</sup> )	2.73
Volume (m <sup>3</sup> )	9.55
Thermal load (kcal/m <sup>3</sup> h)	1,040,000
Burner type	Rotary
Max. fuel consumption of burner x number of burners	102.3 lit/h x 1
Atomizing media	Air
Mixing method	Outer
Air drafting method	Natural draft

(ii) Observation

The boiler is of the horizontal and multi-tube type, and steam is used for drying chemicals. Particle size of the atomized diesel fuel is coarse. Since the combustion chamber load is low at 230,000 kcal/hm<sup>3</sup>, one may consider the NO<sub>x</sub> concentration to be low also. However, since the actual boiler efficiency is 60% in comparison to the design efficiency of 70%, and non-uniformity of heat distribution is possible due to the boiler structure, the NO<sub>x</sub> concentration may become high.

(iii) Recommended Measures

- i) Improvement of boiler efficiency
- ii) Change the natural draft to the forced draft, and precisely control the oxygen concentration.
- iii) Renew the boiler

6) Club Deportivo Chapultepec, A.C.

(i) Outline of Combustion Facility

Combustion facility	Water-tube boiler No.2	Boiler
Operation	Yes	No
Manufacturer	Babcock & Wilcox	Babcock & Wilcox
Age (year)	12	30
Maximum capacity	9.0 ton/h (580 HP)	5.0 ton/h
Kind of fuel	Gas oil	Gas oil
Fuel consumption	230 lit/h	
Combustion chamber Dimension (W x D x H m) Sectional area (m <sup>2</sup> ) Volume (m <sup>3</sup> )	1.60 x 3.56 x 2.375  13.53	
Thermal load (kcal/m <sup>3</sup> h)	570,000	
Burner type	Y jet	MSAF (B & W) FLUJO CIRCULAR
Max. fuel consumption per burner x number of burners	780 lit/h x 1 (210 lit/h at the survey)	
Number and dia. of burner tip holes	5 x 2.5 mm	5 x 2.5 mm
Atomizing media	Steam	Steam
Mixing method	Outer	Outer
Air drafting method	Forced draft	Forced draft
Operation hours	6:00 - 21:00/d, 7 ds/wk, 52 wks/y	

(ii) Observation

The boiler steam of Babcock & Wilcox de Mexico is used for warming swimming pool water and utilities in this sport and recreational center. Boiler No.2, 9,072 kg/h (580 HP) was on operation at the time of the visit. The burner is of steam atomizing, outer mixing type which is widely used in Mexico City. This type tends to cause higher NO<sub>x</sub> concentration in comparison to inner mixing types. The boiler was operated at combustion loading below 50% exhibiting divergent flame shape. When the boiler load was increased, the flame converged. Operation at more than 50% loading is desirable. The flame was deflected because of the deflected flow of combustion air. Upon the request of the survey team, combustion was tried at nearly 100% of the rated capacity. There was still a considerable space left for the flame at rear part of the combustion chamber.

There is an Orsat analyzer for these boilers, but regular measurement of exhaust gas has been done by a measurement company.

The data for the past measurement on exhaust gas were presented to be as follows:

Date	O <sub>2</sub> (%)	CO <sub>2</sub> (%)
March 23, 1993	8.4, 6.6, 6.2, 6.0	7.8, 9.2, 9.4, 9.6
March 29, 1993	9.0, 8.6, 7.4, 6.2	8.2, 8.2, 8.8, 9.8
July 10, 1993	8.4, 6.6, 6.2, 6.0	7.8, 9.2, 9.4, 9.6

All data above show excess air combustion.

The burner unit is a modified version of COEN, USA, which is also commonly used in Japan for medium-size boilers. There is a cavitation zone around the burner cap, and back flow of combustion gas towards the burner shield is considerably high. Although the boiler loading is low, the NO<sub>x</sub> concentration is considered to be around the limit of the emission standard or slightly higher, since the nozzle is of outer mixing type and the combustion is under excess air with the exhaust gas oxygen concentration at 6 - 9%.

(iv) Recommended Measures

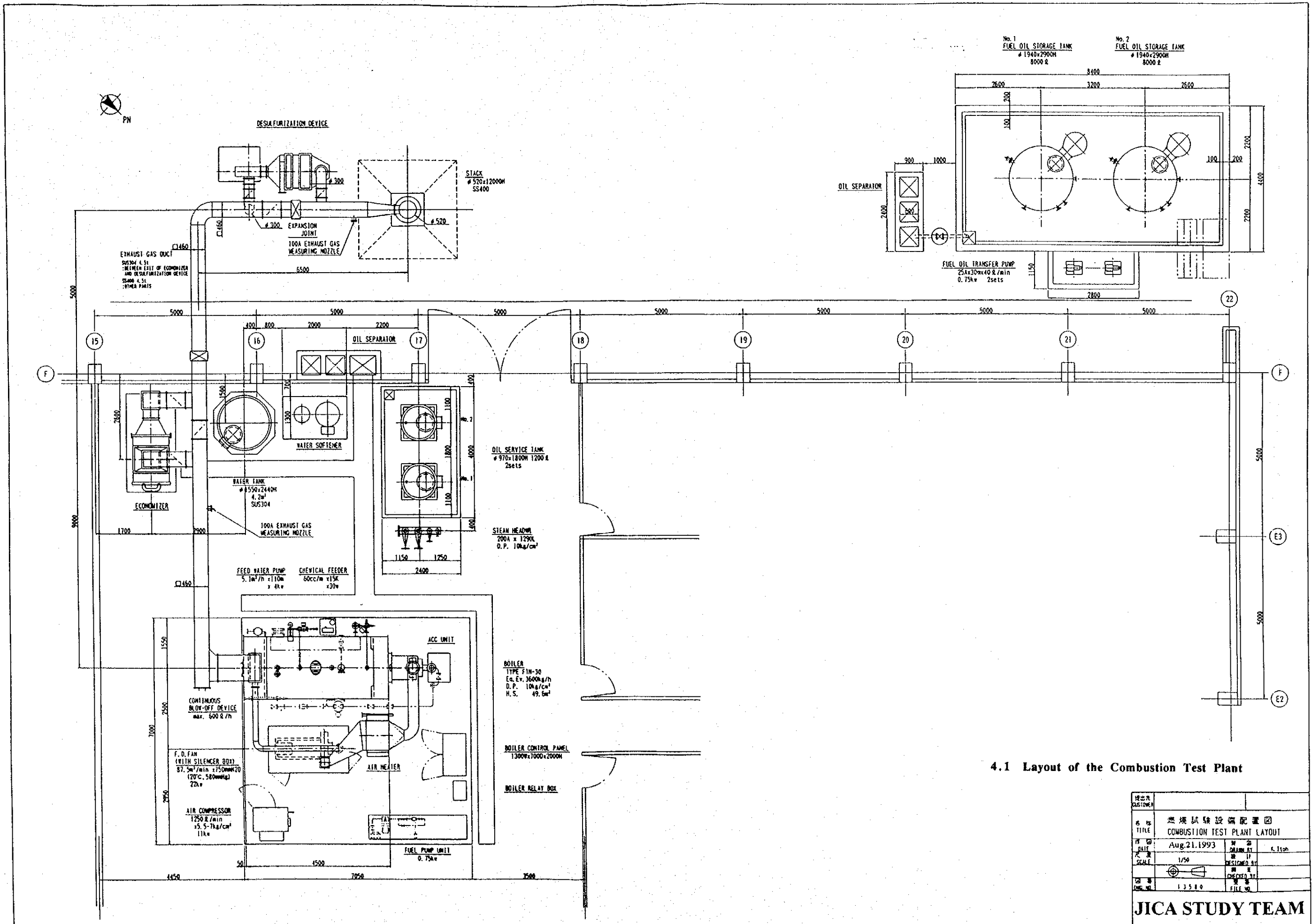
- i) Practice low oxygen combustion as pointed out at the time of the visit in the previous JICA study.
- ii) Consider change of the burner atomizer to the type enabling low NO<sub>x</sub> generation (change to an inner mixing type)

iii) Consider means to cause uniform flow of combustion air at the burner throat.

iv) Install a fuel supply flow meter on each boiler, and consider improvement of boiler efficiency and energy saving.



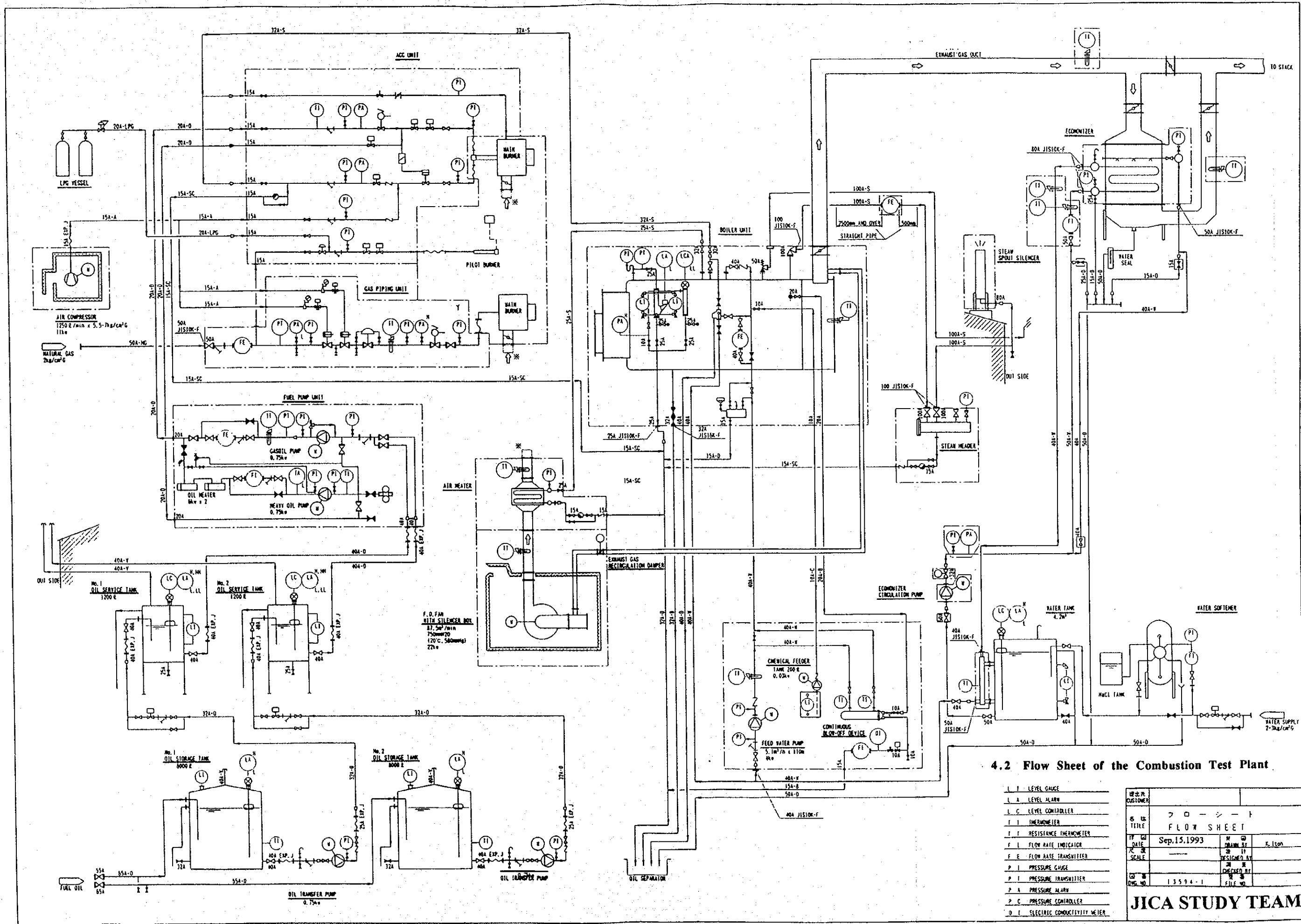
**Data for Chapter 4**



4.1 Layout of the Combustion Test Plant

提出先 CUSTOMER			
名称 TITLE	燃焼試験設備配置図 COMBUSTION TEST PLANT LAYOUT		
日付 DATE	Aug. 21, 1993	製図者 DRAWN BY	K. Itoh
縮尺 SCALE	1/50	設計者 DESIGNED BY	
検査者 CHECKED BY		確認者 CONFIRMED BY	
図番 FIG. NO.	1.3.1.0	FILE NO.	

JICA STUDY TEAM

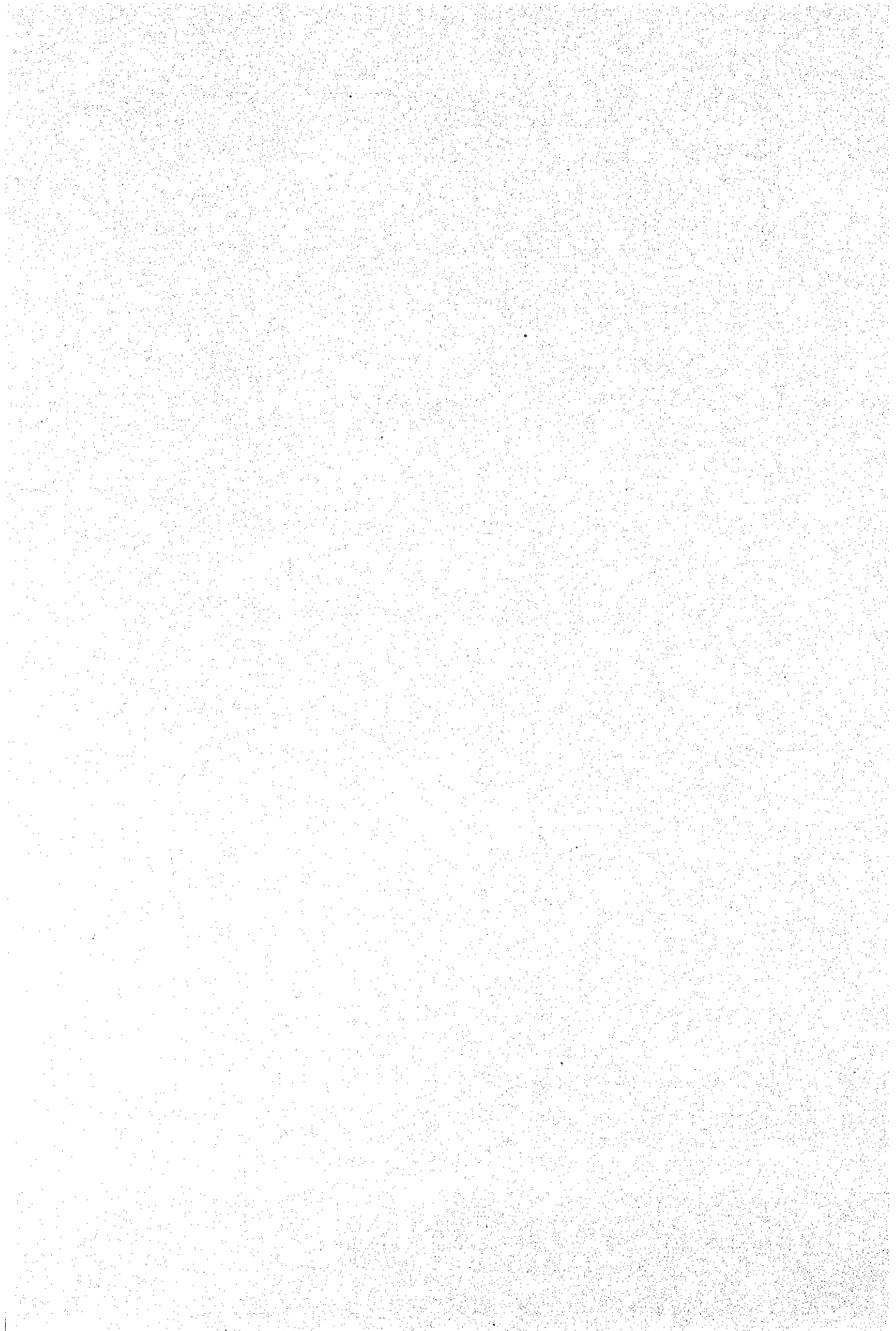


4.2 Flow Sheet of the Combustion Test Plant

- L I LEVEL GAUGE
- L A LEVEL ALARM
- L C LEVEL CONTROLLER
- T I THERMOWELL
- T R RESISTANCE THERMOWELL
- F I FLOW RATE INDICATOR
- F E FLOW RATE TRANSMITTER
- P I PRESSURE GAUGE
- P T PRESSURE TRANSMITTER
- P A PRESSURE ALARM
- P C PRESSURE CONTROLLER
- D I DIELECTRIC CONDUCTIVITY MEAS.

REV. NO.	CUSTOMER	フオロシート		
IS TA	TITLE	FLOW SHEET		
DATE	DATE	DESIGNED BY	DRAM BY	FILE NO.
SCALE	SCALE	DESIGNED BY	DRAM BY	FILE NO.
NO. 1	NO. 2	CHECKED BY	FILE NO.	
NO. 3	NO. 4	CHECKED BY	FILE NO.	
NO. 5	NO. 6	CHECKED BY	FILE NO.	
NO. 7	NO. 8	CHECKED BY	FILE NO.	
NO. 9	NO. 10	CHECKED BY	FILE NO.	
NO. 11	NO. 12	CHECKED BY	FILE NO.	
NO. 13	NO. 14	CHECKED BY	FILE NO.	
NO. 15	NO. 16	CHECKED BY	FILE NO.	
NO. 17	NO. 18	CHECKED BY	FILE NO.	
NO. 19	NO. 20	CHECKED BY	FILE NO.	
NO. 21	NO. 22	CHECKED BY	FILE NO.	
NO. 23	NO. 24	CHECKED BY	FILE NO.	
NO. 25	NO. 26	CHECKED BY	FILE NO.	
NO. 27	NO. 28	CHECKED BY	FILE NO.	
NO. 29	NO. 30	CHECKED BY	FILE NO.	
NO. 31	NO. 32	CHECKED BY	FILE NO.	
NO. 33	NO. 34	CHECKED BY	FILE NO.	
NO. 35	NO. 36	CHECKED BY	FILE NO.	
NO. 37	NO. 38	CHECKED BY	FILE NO.	
NO. 39	NO. 40	CHECKED BY	FILE NO.	
NO. 41	NO. 42	CHECKED BY	FILE NO.	
NO. 43	NO. 44	CHECKED BY	FILE NO.	
NO. 45	NO. 46	CHECKED BY	FILE NO.	
NO. 47	NO. 48	CHECKED BY	FILE NO.	
NO. 49	NO. 50	CHECKED BY	FILE NO.	
NO. 51	NO. 52	CHECKED BY	FILE NO.	
NO. 53	NO. 54	CHECKED BY	FILE NO.	
NO. 55	NO. 56	CHECKED BY	FILE NO.	
NO. 57	NO. 58	CHECKED BY	FILE NO.	
NO. 59	NO. 60	CHECKED BY	FILE NO.	
NO. 61	NO. 62	CHECKED BY	FILE NO.	
NO. 63	NO. 64	CHECKED BY	FILE NO.	
NO. 65	NO. 66	CHECKED BY	FILE NO.	
NO. 67	NO. 68	CHECKED BY	FILE NO.	
NO. 69	NO. 70	CHECKED BY	FILE NO.	
NO. 71	NO. 72	CHECKED BY	FILE NO.	
NO. 73	NO. 74	CHECKED BY	FILE NO.	
NO. 75	NO. 76	CHECKED BY	FILE NO.	
NO. 77	NO. 78	CHECKED BY	FILE NO.	
NO. 79	NO. 80	CHECKED BY	FILE NO.	
NO. 81	NO. 82	CHECKED BY	FILE NO.	
NO. 83	NO. 84	CHECKED BY	FILE NO.	
NO. 85	NO. 86	CHECKED BY	FILE NO.	
NO. 87	NO. 88	CHECKED BY	FILE NO.	
NO. 89	NO. 90	CHECKED BY	FILE NO.	
NO. 91	NO. 92	CHECKED BY	FILE NO.	
NO. 93	NO. 94	CHECKED BY	FILE NO.	
NO. 95	NO. 96	CHECKED BY	FILE NO.	
NO. 97	NO. 98	CHECKED BY	FILE NO.	
NO. 99	NO. 100	CHECKED BY	FILE NO.	

JICA STUDY TEAM



### 4.3 Daily Record of the Combustion Test

#### Record of Combustion Test

Date 94/8/17

Place	Pachuca	Atmosphere		766 mmb			
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Normal Oil Burner						
Kind of fuel	Diesel Oil						
Number		1	2	3	4	5	6
Pressure of boiler	kg/cm <sup>2</sup>	6.5	7.2	7.2	7.1	7.4	7.3
atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	6.4	7.0	7.0	6.9	7.2	7.1
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.9	9.9	9.9	9.9	9.9	9.9
Oil temp. at AC valve inlet	°C	27	27	27	27	26	26
Flow of oil or gas	l/h, m <sup>3</sup> /h	123	123	123	123	164	164
Pressure of oil or gas	kg/cm <sup>2</sup>	0.8	0.9	0.9	0.9	1.0	0.9
Pressure of steam(air)	kg/cm <sup>2</sup>	1.7	1.9	1.9	1.8	1.8	1.8
Oil temp. at burner inlet	°C	27	27	27	27	26	26
Draft							
Pressure at FDF outlet	mmaq	780	766	777	774	768	773
Pressure of primary wind box	mmaq	111	74	93	82	198	173
Pressure of secondary wind box	mmaq						
Pressure of furnace	mmaq	61	41	52	45	115	98
Temperature							
Temp. of air for combustion	°C	41	42	42	42	41	41
Temperature of exhaust gas	°C	197	198	204	202	227	228
Damper							
Primary damper opening		2.8	2.5	2.7	2.6	3.3	3.1
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		5	5	5	5	6	6
Analysis of exhaust gas							
NOx	ppm	74	67	67	68	74	75
CO	ppm	0	94	0	0	0	0
CO <sub>2</sub>	%	11.4	14.8	12.8	14.1	11.8	12.8
O <sub>2</sub>	%	7.5	2.4	5.5	3.6	7.0	5.5
SO <sub>2</sub>	ppm	109	188	147	168	120	142
NOx(converted at 5% O <sub>2</sub> )	ppm	88	58	69	63	85	77
Smoke tester(BC)	No.	0	6	0	3	0	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	83	86	84	85	82	83
Remarks							

## Record of Combustion Test

Date 94/8/17

Place	Pachuca	Atmosphere	766 mmb				
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Normal Oil Burner						
Kind of fuel	Diesel Oil						
Number		7	8	9	10	11	12
Pressure of boiler	kg/cm <sup>2</sup>	7.2	6.9				
atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	7.0	6.8				
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.9	9.9				
Oil temp. at AC valve inlet	°C	26	26				
Flow of oil or gas	l/h, m <sup>3</sup> /h	165	165				
Pressure of oil or gas	kg/cm <sup>2</sup>	0.9	0.8				
Pressure of steam (air)	kg/cm <sup>2</sup>	1.8	1.8				
Oil temp. at burner inlet	°C	26	26				
Draft							
Pressure at FDF outlet	mmaq	779	779				
Pressure of primary wind box	mmaq	140	135				
Pressure of secondary wind box	mmaq						
Pressure of furnace	mmaq	80	78				
Temperature							
Temp. of air for combustion	°C	41	41				
Temperature of exhaust gas	°C	225	226				
Damper							
Primary damper opening		2.9	2.9				
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		6	6				
Analysis of exhaust gas							
NOx	ppm	72	71				
CO	ppm	51	191				
CO <sub>2</sub>	%	14.6	14.8				
O <sub>2</sub>	%	2.8	2.4				
SO <sub>2</sub>	ppm	181	190				
NOx (converted at 5% O <sub>2</sub> )	ppm	63	61				
Smoke tester (BC)	No.	6	7				
Water content	%						
Exhaust gas recirculation (EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	85	85				
Remarks							

Record of Combustion Test

Date 94/8/19

Place	Pachuca	Atmosphere		765 mmb			
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Normal Oil Burner						
Kind of fuel	Diesel Oil						
Number		1	2	3	4	5	6
Pressure of boiler	kg/cm <sup>2</sup>	6.8	7.3	7.0	7.1	7.1	7.1
atomization							
Pressure of air atomization	kg/cm <sup>2</sup>	6.5	7.0	6.3	7.0	7.0	7.0
Pressure of steam atomization	kg/cm <sup>2</sup>						
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.9	9.9	9.9	9.9	9.9	9.6
Oil temp. at AC valve inlet	°C	23	23	23	23	23	23
Flow of oil or gas	l/h, m <sup>3</sup> /h	123	125	127	128	130	164
Pressure of oil or gas	kg/cm <sup>2</sup>	1.89	1.79	1.52	1.90	1.88	2.10
Pressure of steam(air)	kg/cm <sup>2</sup>	3.3	3.2	3.1	3.4	3.4	3.5
Oil temp. at burner inlet	°C	23	23	23	23	23	23
Draft							
Pressure at FDF outlet	mmaq	795	792	785	783	785	766
Pressure of primary wind box	mmaq	103	150	93	88	205	310
Pressure of secondary wind box	mmaq						
Pressure of furnace	mmaq	57	95	60	55	127	190
Temperature							
Temp. of air for combustion	°C	36	37	38	39	38	37
Temperature of exhaust gas	°C	225	242	239	239	252	269
Damper							
Primary damper opening		2.7	3.0	2.5	2.4	3.2	3.8
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		5	5	5	5	5	6
Analysis of exhaust gas							
NOx	ppm	108	91	117	119	77	82
CO	ppm	0	0	171	755	0	0
CO <sub>2</sub>	%	12.8	10.7	14.2	14.8	9.5	9.8
O <sub>2</sub>	%	3.0	5.0	1.0	0.7	7.4	6.9
SO <sub>2</sub>	ppm	168	95	176	215	100	103
NOx(converted at 5% O <sub>2</sub> )	ppm	96	91	94	94	91	93
Smoke tester(BC)	No.	0	0	3	4	0	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	85	83	85	85	80	80
Remarks							

## Record of Combustion Test

Date 94/8/19

Place	Pachuca	Atmosphere			765 mmB		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Normal Oil Burner						
Kind of fuel	Diesel Oil						
Number		7	8	9	10	11	12
Pressure of boiler	kg/cm <sup>2</sup>	7.2	7.2	7.2	7.2	7.2	7.2
atomization							
Pressure of air atomization	kg/cm <sup>2</sup>	6.8	6.9	6.8	6.8	6.8	6.2
Pressure of steam atomization	kg/cm <sup>2</sup>						
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.5	9.5	9.5	10.0	10.0	9.4
Oil temp. at AC valve inlet	°C	23	23	23	23	23	22
Flow of oil or gas	l/h, m <sup>3</sup> /h	165	166	166	201	199	196
Pressure of oil or gas	kg/cm <sup>2</sup>	2.08	1.86	1.93	2.22	2.10	2.20
Pressure of steam(air)	kg/cm <sup>2</sup>	3.4	3.5	3.0	3.2	3.0	3.0
Oil temp. at burner inlet	°C	23	23	23	23	23	22
Draft							
Pressure at FDF outlet	mmaq	772	780	782	763	778	750
Pressure of primary wind box	mmaq	249	200	149	280	220	345
Pressure of secondary wind box	mmaq						
Pressure of furnace	mmaq	155	127	95	182	145	222
Temperature							
Temp. of air for combustion	°C	38	39	39	39	34	38
Temperature of exhaust gas	°C	271	269	264	279	279	286
Damper							
Primary damper opening		3.4	3.2	2.9	3.5	3.2	3.9
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		6	6	6	7	7	7
Analysis of exhaust gas							
NO <sub>x</sub>	ppm	95	106	121	120	128	96
CO	ppm	0	244	0	268	0	0
CO <sub>2</sub>	%	11.2	12.7	14.8	13.0	15.0	11.3
O <sub>2</sub>	%	5.2	3.1	0.7	2.9	0.5	4.9
SO <sub>2</sub>	ppm	123	154	205	153	203	124
NO <sub>x</sub> (converted at 5% O <sub>2</sub> )	ppm	96	95	95	106	100	95
Smoke tester(BC)	No.	0	0	3	0	2	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	81	83	84	82	84	81
Remarks							



Record of Combustion Test

Date 94/8/19

Place	Pachuca	Atmosphere	765 mmb				
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Normal Oil Burner						
Kind of fuel	Diesel Oil						
Number		13	14	15	16	17	18
Pressure of boiler	kg/cm <sup>2</sup>	7.2	7.2	7.0	7.1	7.2	
atomization							
Pressure of air atomization	kg/cm <sup>2</sup>	7.2					
Pressure of steam atomization	kg/cm <sup>2</sup>		6.9	6.8	6.8	7.0	
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.6	9.7	9.8	9.8	9.8	
Oil temp. at AC valve inlet	°C	22	22	22	22	22	
Flow of oil or gas	l/h, m <sup>3</sup> /h	196	203	203	202	202	
Pressure of oil or gas	kg/cm <sup>2</sup>	2.42	1.21	1.20	1.24	1.34	
Pressure of steam(air)	kg/cm <sup>2</sup>	3.8	2.5	2.4	2.5	2.7	
Oil temp. at burner inlet	°C	22	22	22	22	22	
Draft							
Pressure at FDF outlet	mmaq	722	707	747	772	777	
Pressure of primary wind box	mmaq	437	492	390	300	250	
Pressure of secondary wind box	mmaq						
Pressure of furnace	mmaq	270	300	235	190	160	
Temperature							
Temp. of air for combustion	°C	38	36	33	25	34	
Temperature of exhaust gas	°C	290	283	286	284	281	
Damper							
Primary damper opening		4.5	4.8	4.1	3.6	3.3	
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		7	7	7	7	7	
Analysis of exhaust gas							
NOx	ppm	84	60	72	78	73	
CO	ppm	0	0	0	0	404	
CO <sub>2</sub>	%	10.0	9.8	11.3	13.0	14.6	
O <sub>2</sub>	%	6.7	6.9	4.9	2.8	1.0	
SO <sub>2</sub>	ppm	99	96	128	164	187	
NOx(converted at 5% O <sub>2</sub> )	ppm	94	68	72	69	58	
Smoke tester(BC)	No.	0	-	0	0	6	
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	79	79	83	85	85	
Remarks							

## Record of Combustion Test

Date 94/8/27

Place	Pachuca	Atmosphere	766 mmb				
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Diesel Oil						
Number		1	2	3	4	5	6
Pressure of boiler	kg/cm <sup>2</sup>	6.9	6.8	7.2	7.2	6.9	7.0
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	6.8	6.5	7.0	7.0	6.5	6.8
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	10.2	10.2	10.2	10.2	10.0	10.0
Oil temp. at AC valve inlet	°C	20	20	20	20	21	21
Flow of oil or gas	l/h, m <sup>3</sup> /h	122	122	121	122	161	162
Pressure of oil or gas	kg/cm <sup>2</sup>	1.28	1.13	1.27	1.20	1.24	1.25
Pressure of steam(air)	kg/cm <sup>2</sup>	2.7	2.5	2.7	2.6	2.6	2.7
Oil temp. at burner inlet	°C	20	20	20	20	21	21
Draft							
Pressure at FDF outlet	mmaq	782	785	680	553	780	770
Pressure of primary wind box	mmaq	80	110	65	50	105	130
Pressure of secondary wind box	mmaq	538	525	445	365	525	530
Pressure of furnace	mmaq	82	100	70	50	105	125
Temperature							
Temp. of air for combustion	°C	36	36	36	36	36	37
Temperature of exhaust gas	°C	193	206	208	210	234	238
Damper							
Primary damper opening		1.4	1.7	1.0	1.0	1.6	1.9
Secondary damper opening							
Primary air ratio	%						
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		1	1	1	1	2	2
Analysis of exhaust gas							
NOx	ppm	35	42	35	39	49	54
CO	ppm	0	0	0	150	99	0
CO <sub>2</sub>	%	11.7	10.2	13.5	15.3	15.0	13.3
O <sub>2</sub>	%	5.1	6.9	2.7	0.6	1.1	3.1
SO <sub>2</sub>	ppm	250	220	290	320	310	290
NOx(converted at 5% O <sub>2</sub> )	ppm	35	48	31	31	39	48
Smoke tester(BC)	No.	0	0	0	1	4	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	85	84	86	86	86	85
Remarks							

## Record of Combustion Test

Date 94/8/27

Place	Pachuca	Atmosphere			766 mmb		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Diesel Oil						
Number		7	8	9	10	11	12
Pressure of boiler	kg/cm <sup>2</sup>	7.3	7.2	7.3	7.2	7.2	-
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	7.1	7.0	7.1	7.0	7.1	-
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	10.2	10.2	10.0	10.0	10.0	-
Oil temp. at AC valve inlet	°C	20	20	20	20	20	-
Flow of oil or gas	l/h, m <sup>3</sup> /h	161	162	201	201	201	200
Pressure of oil or gas	kg/cm <sup>2</sup>	1.31	1.28	1.36	1.30	1.27	-
Pressure of steam(air)	kg/cm <sup>2</sup>	2.7	2.7	2.8	2.7	2.6	-
Oil temp. at burner inlet	°C	20	20	20	20	20	-
Draft							
Pressure at FDF outlet	mmaq	760	745	762	740	719	-
Pressure of primary wind box	mmaq	165	220	195	230	295	-
Pressure of secondary wind box	mmaq	532	535	540	540	540	-
Pressure of furnace	mmaq	155	190	170	205	250	-
Temperature							
Temp. of air for combustion	°C	36	37	38	38	37	38
Temperature of exhaust gas	°C	245	254	267	274	281	-
Damper							
Primary damper opening		2.2	2.8	2.2	2.8	3.4	-
Secondary damper opening							
Primary air ratio	%						
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		2	2	3	3	3	-
Analysis of exhaust gas							
NOx	ppm	53	53	61	61	63	73
CO	ppm	0	0	286	79	0	0
CO <sub>2</sub>	%	11.8	10.2	14.6	14.3	13.0	11.7
O <sub>2</sub>	%	4.8	7.0	1.3	1.7	3.3	5.0
SO <sub>2</sub>	ppm	310	230	310	250	280	250
NOx(converted at 5% O <sub>2</sub> )	ppm	52	61	50	51	57	73
Smoke tester(BC)	No.	0	0	6	5	0	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	83	81	85	84	83	82
Remarks							

Record of Combustion Test

Date 94/8/27

Place	Pachuca	Atmosphere			766 mmb		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Diesel Oil						
Number		13	14	15	16	17	18
Pressure of boiler	kg/cm <sup>2</sup>	7.2	6.8	7.2	7.2	7.5	7.5
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>		6.0	6.5	6.7	6.8	6.5
Pressure of steam atomization	kg/cm <sup>2</sup>	7.0					
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	10.0	10.2	10.2	10.2	10.2	9.8
Oil temp. at AC valve inlet	°C	21	21	21	21	21	22
Flow of oil or gas	l/h, m <sup>3</sup> /h	200	123	123	123	123	162
Pressure of oil or gas	kg/cm <sup>2</sup>	1.28	1.57	1.54	1.58	1.45	1.86
Pressure of steam(air)	kg/cm <sup>2</sup>	2.6	2.6	2.9	2.9	2.8	3.0
Oil temp. at burner inlet	°C	21	21	21	21	21	22
Draft							
Pressure at FDF outlet	mmaq	666	550	655	772	777	760
Pressure of primary wind box	mmaq	390	55	62	80	110	160
Pressure of secondary wind box	mmaq	540	365	442	512	525	528
Pressure of furnace	mmaq	320	52	66	80	105	140
Temperature							
Temp. of air for combustion	°C	38	37	38	38	38	38
Temperature of exhaust gas	°C	295	241	237	234	234	245
Damper							
Primary damper opening		4.7	1.0	1.2	1.4	1.8	2.1
Secondary damper opening							
Primary air ratio	%						
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		3	1	1	1	1	2
Analysis of exhaust gas							
NOx	ppm	55	47	44	46	58	70
CO	ppm	0	43	0	0	0	0
CO <sub>2</sub>	%	10.0	15.0	13.4	11.5	9.8	11.7
O <sub>2</sub>	%	7.0	1.0	2.8	5.1	7.3	4.9
SO <sub>2</sub>	ppm	220	310	240	200	210	250
NOx(converted at 5% O <sub>2</sub> )	ppm	63	38	39	46	68	70
Smoke tester(BC)	No.	5	2	0	0	0	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	79	86	85	84	82	83
Remarks							

## Record of Combustion Test

Date 94/8/27

Place	Pachuca	Atmosphere			766 mmb		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Diesel Oil						
Number		19	20	21	22	23	24
Pressure of boiler	kg/cm <sup>2</sup>	7.4	7.4	7.4	7.4	7.2	7.2
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>	6.5	6.5	6.7	6.5	6.5	6.6
Pressure of steam atomization	kg/cm <sup>2</sup>						
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.8	9.8	9.8	9.5	9.5	9.5
Oil temp. at AC valve inlet	°C	22	22	22	23	23	23
Flow of oil or gas	l/h, m <sup>3</sup> /h	162	164	165	205	205	205
Pressure of oil or gas	kg/cm <sup>2</sup>	1.76	1.79	1.68	1.86	1.87	1.82
Pressure of steam(air)	kg/cm <sup>2</sup>	2.8	3.0	2.9	2.5	2.6	2.6
Oil temp. at burner inlet	°C	22	22	22	23	23	23
Draft							
Pressure at FDF outlet	mmaq	735	770	770	750	740	716
Pressure of primary wind box	mmaq	212	122	105	190	230	290
Pressure of secondary wind box	mmaq	538	525	525	530	538	542
Pressure of furnace	mmaq	185	120	95	170	210	242
Temperature							
Temp. of air for combustion	°C	35	35	36	37	36	36
Temperature of exhaust gas	°C	257	257	256	260	267	276
Damper							
Primary damper opening		2.8	1.8	1.6	2.4	2.8	3.4
Secondary damper opening							
Primary air ratio	%						
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		2	2	2	3	3	3
Analysis of exhaust gas							
NOx	ppm	64	63	56	69	70	75
CO	ppm	0	0	96	151	0	0
CO <sub>2</sub>	%	10.0	13.3	14.8	14.3	13.0	11.7
O <sub>2</sub>	%	7.1	2.8	1.1	1.5	3.2	5.0
SO <sub>2</sub>	ppm	220	270	310	310	280	210
NOx(converted at 5% O <sub>2</sub> )	ppm	74	55	45	57	63	75
Smoke tester(BC)	No.	0	0	4	5	0	0
Water content	%						5.2
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	81	85	86	84	83	82
Remarks							

## Record of Combustion Test

Date 94/8/27

Place	Pachuca	Atmosphere	766 mmh				
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Diesel Oil						
Number		25	26	27	28	29	30
Pressure of boiler	kg/cm <sup>2</sup>	7.3					
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>	7.0					
Pressure of steam atomization	kg/cm <sup>2</sup>						
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.5					
Oil temp. at AC valve inlet	°C	23					
Flow of oil or gas	l/h, m <sup>3</sup> /h	203					
Pressure of oil or gas	kg/cm <sup>2</sup>	1.82					
Pressure of steam(air)	kg/cm <sup>2</sup>	2.7					
Oil temp. at burner inlet	°C	23					
Draft							
Pressure at PFD outlet	mmaq	657					
Pressure of primary wind box	mmaq	400					
Pressure of secondary wind box	mmaq	527					
Pressure of furnace	mmaq	320					
Temperature							
Temp. of air for combustion	°C	38					
Temperature of exhaust gas	°C	290					
Damper							
Primary damper opening		4.8					
Secondary damper opening							
Primary air ratio	%						
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		3					
Analysis of exhaust gas							
NOx	ppm	74					
CO	ppm	0					
CO <sub>2</sub>	%	10.1					
O <sub>2</sub>	%	7.0					
SO <sub>2</sub>	ppm	230					
NOx(converted at 5% O <sub>2</sub> )	ppm	85					
Smoke tester(BC)	No.	0					
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	80					
Remarks							

Record of Combustion Test

Date 94/8/29

Place	Pachuca	Atmosphere		766 mmb			
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Gas Oil(720ppm)						
Number		1	2	3	4	5	6
Pressure of boiler	kg/cm <sup>2</sup>	6.5	7.2	7.2	7.2	7.1	7.2
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>	6.5	6.5	6.5	6.5	6.5	6.5
Pressure of steam atomization	kg/cm <sup>2</sup>						
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	10.8	10.8	10.8	10.8	10.2	10.2
Oil temp. at AC valve inlet	°C	21	21	21	22	22	22
Flow of oil or gas	l/h, m <sup>3</sup> /h	119	119	120	165	167	167
Pressure of oil or gas	kg/cm <sup>2</sup>	1.62	1.92	1.74	1.90	2.19	2.16
Pressure of steam(air)	kg/cm <sup>2</sup>	2.6	3.3	3.3	3.4	3.4	3.5
Oil temp. at burner inlet	°C	21	21	21	22	22	22
Draft							
Pressure at FDF outlet	mmaq	777	780	630	555	728	745
Pressure of primary wind box	mmaq	115	85	75	58	245	205
Pressure of secondary wind box	mmaq	512	525	420	367	540	535
Pressure of furnace	mmaq	110	85	75	57	225	180
Temperature							
Temp. of air for combustion	°C	35	35	36	37	36	36
Temperature of exhaust gas	°C	205	209	213	212	249	252
Damper							
Primary damper opening		1.7	1.3	1.5	1.0	3.0	2.5
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		1	1	1	1	2	2
Analysis of exhaust gas							
NOx	ppm	93	81	80	82	104	107
CO	ppm	0	0	79	0	0	0
CO <sub>2</sub>	%	9.9	11.6	14.9	9.5	9.8	11.1
O <sub>2</sub>	%	7.1	5.9	3.3	0.9	6.7	5.0
SO <sub>2</sub>	ppm	700	820	910	1050	710	810
NOx(converted at 5% O <sub>2</sub> )	ppm	107	86	72	65	116	107
Smoke tester(BC)	No.	1	1	1	4	0	2
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	83	85	85	86	81	83
Remarks							

## Record of Combustion Test

Date 94/8/29

Place	Pachuca	Atmosphere		766 mmb			
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Gas Oil(720ppm)						
Number		7	8	9	10	11	12
Pressure of boiler	kg/cm <sup>2</sup>	7.2	7.1	7.3	7.2	7.2	7.0
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>	6.5	6.5	6.5	6.5	6.5	6.5
Pressure of steam atomization	kg/cm <sup>2</sup>						
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	10.2	10.2	9.8	9.8	9.8	9.8
Oil temp. at AC valve inlet	°C	22	22	22	22	23	23
Flow of oil or gas	l/h, m <sup>3</sup> /h	167	167	192	205	205	193
Pressure of oil or gas	kg/cm <sup>2</sup>	1.80	1.88	2.29	2.30	2.52	2.50
Pressure of steam(air)	kg/cm <sup>2</sup>	3.0	3.0	3.4	3.8	3.8	3.7
Oil temp. at burner inlet	°C	22	22	22	22	23	23
Draft							
Pressure at FDF outlet	mmaq	748	762	690	721	725	745
Pressure of primary wind box	mmaq	168	120	310	230	210	170
Pressure of secondary wind box	mmaq	521	515	525	515	520	530
Pressure of furnace	mmaq	150	120	250	205	180	145
Temperature							
Temp. of air for combustion	°C	36	37	37	37	38	37
Temperature of exhaust gas	°C	251	248	249	259	269	267
Damper							
Primary damper opening		2.1	1.7	4.0	5.0	2.8	2.3
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		2	2	3	3	3	3
Analysis of exhaust gas							
NOx	ppm	111	93	115	118	113	110
CO	ppm	0	149	0	0	0	0
CO <sub>2</sub>	%	12.6	14.8	9.8	11.5	12.5	12.4
O <sub>2</sub>	%	3.4	0.9	6.8	4.8	3.3	1.4
SO <sub>2</sub>	ppm	910	1060	710	880	900	1000
NOx(converted at 5% O <sub>2</sub> )	ppm	101	74	130	117	102	90
Smoke tester(BC)	No.	1	6	1	1	1	4
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	84	85	81	83	83	84
Remarks							



## Record of Combustion Test

Date 94/8/29

Place	Pachuca	Atmosphere		766 mmB			
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Gas Oil(720ppm)						
Number		13	14	15	16	17	18
Pressure of boiler	kg/cm <sup>2</sup>	7.1	7.0	7.1	7.0	7.0	7.1
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	7.0	6.9	6.9	7.0	6.9	6.9
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	10.8	10.8	10.8	10.8	10.0	10.0
Oil temp. at AC valve inlet	°C	23	23	23	23	23	23
Flow of oil or gas	l/h, m <sup>3</sup> /h	119	120	120	120	161	161
Pressure of oil or gas	kg/cm <sup>2</sup>	1.40	1.40	1.58	1.55	1.57	1.56
Pressure of steam(air)	kg/cm <sup>2</sup>	3.0	3.0	2.9	3.2	3.2	3.1
Oil temp. at burner inlet	°C	23	23	23	23	23	23
Draft							
Pressure at FDF outlet	mmaq	765	777	600	572	720	755
Pressure of primary wind box	mmaq	90	68	58	50	220	150
Pressure of secondary wind box	mmaq	515	505	400	375	520	530
Pressure of furnace	mmaq	85	70	55	40	190	125
Temperature							
Temp. of air for combustion	°C	38	38	38	37	38	37
Temperature of exhaust gas	°C	233	230	226	221	251	247
Damper							
Primary damper opening		1.7	1.3	1.5	1.0	3.0	2.3
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		1	1	1	1	2	2
Analysis of exhaust gas							
NOx	ppm	83	74	77	80	81	98
CO	ppm	0	0	0	0	0	0
CO <sub>2</sub>	%	9.5	11.1	12.3	14.3	8.9	11.2
O <sub>2</sub>	%	7.0	5.0	3.5	1.1	7.6	4.8
SO <sub>2</sub>	ppm	670	790	870	1000	650	800
NOx(converted at 5% O <sub>2</sub> )	ppm	95	74	70	64	97	97
Smoke tester(BC)	No.	1	1	1	1	1	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	82	85	85	87	80	83
Remarks							

## Record of Combustion Test

Date 94/8/29

Place	Pachuca	Atmosphere			766 mmb		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(1)						
Kind of fuel	Gas Oil(720ppm)						
Number		19	20	21	22	23	24
Pressure of boiler	kg/cm <sup>2</sup>	7.1	7.0	7.1	7.2	7.2	7.2
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	7.0	7.0	7.0	6.9	7.1	7.1
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	10.0	10.0	9.4	9.4	9.4	9.4
Oil temp. at AC valve inlet	°C	23	23	23	23	23	23
Flow of oil or gas	l/h, m <sup>3</sup> /h	160	162	202	201	200	200
Pressure of oil or gas	kg/cm <sup>2</sup>	1.60	1.60	1.66	1.71	1.70	1.72
Pressure of steam(air)	kg/cm <sup>2</sup>	3.1	3.2	3.2	3.3	3.2	3.2
Oil temp. at burner inlet	°C	23	23	23	23	23	23
Draft							
Pressure at FDF outlet	mmaq	765	780	645	705	715	755
Pressure of primary wind box	mmaq	115	80	365	285	210	163
Pressure of secondary wind box	mmaq	512	510	505	520	520	523
Pressure of furnace	mmaq	100	80	280	225	175	150
Temperature							
Temp. of air for combustion	°C	38	38	38	38	38	38
Temperature of exhaust gas	°C	244	242	279	278	274	268
Damper							
Primary damper opening		2.0	1.6	4.8	3.5	2.8	2.3
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		2	2	3	3	3	3
Analysis of exhaust gas							
NOx	ppm	96	90	99	104	108	100
CO	ppm	0	122	0	0	0	52
CO <sub>2</sub>	%	12.7	14.7	9.2	10.7	12.5	14.0
O <sub>2</sub>	%	3.0	0.9	6.9	5.2	3.2	1.5
SO <sub>2</sub>	ppm	890	1040	670	870	900	1000
NOx(converted at 5% O <sub>2</sub> )	ppm	85	72	112	105	97	82
Smoke tester(BC)	No.	0	5	1	1	0	5
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	84	85	79	81	83	84
Remarks							

**Record of Combustion Test**

Date 94/9/27

Place	Pachuca	Atmosphere			763 mmb		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(2)						
Kind of fuel	Gas Oil(720ppm)						
Number		1	2	3	4	5	6
Pressure of boiler	kg/cm <sup>2</sup>	7.4	7.0	7.0	7.3	7.1	7.1
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	7.2	6.8	6.8	7.1	6.9	6.9
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.7	9.6	9.6	9.6	9.6	9.6
Oil temp. at AC valve inlet	°C	20	20	20	20	20	20
Flow of oil or gas	l/h, m <sup>3</sup> /h	160	160	160	160	160	160
Pressure of oil or gas	kg/cm <sup>2</sup>	2.20	2.12	2.10	2.20	2.14	2.13
Pressure of steam(air)	kg/cm <sup>2</sup>	2.8	2.6	2.6	2.8	2.7	2.7
Oil temp. at burner inlet	°C	20	20	20	20	20	20
Draft							
Pressure at FDF outlet	mmaq	800	795	785	780	795	800
Pressure of primary wind box	mmaq	210	330	260	285	250	230
Pressure of secondary wind box	mmaq	180	226	300	305	250	185
Pressure of furnace	mmaq	100	120	150	155	125	105
Temperature							
Temp. of air for combustion	°C	34	34	35	35	35	35
Temperature of exhaust gas	°C	218	224	232	235	234	233
Damper							
Primary damper opening		3.0	3.1	3.1	3.5	3.3	3.1
Secondary damper opening		1.5	2.1	2.7	2.7	2.1	1.5
Primary air ratio		0.47	0.48	0.47	0.52	0.51	0.51
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		5	5	5	5	5	5
Analysis of exhaust gas							
NOx	ppm	89	85	81	77	83	85
CO	ppm	0	0	0	0	0	0
CO <sub>2</sub>	%	13.1	11.7	10.2	9.8	11.5	13.1
O <sub>2</sub>	%	3.1	4.7	6.8	6.9	5.0	3.2
SO <sub>2</sub>	ppm	823	721	644	563	715	907
NOx(converted at 5% O <sub>2</sub> )	ppm	80	83	91	87	83	76
Smoke tester(BC)	No.	3	2	1	1	2	3
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	85	84	82	81	83	84
Remarks							

## Record of Combustion Test

Date 94/9/27

Place	Pachuca	Atmosphere			763 mmB		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(2)						
Kind of fuel	Gas Oil(720ppm)						
Number		7	8	9	10	11	12
Pressure of boiler	kg/cm <sup>2</sup>	7.1	7.1	7.2	7.0	7.2	7.2
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	6.9	6.9	7.0	6.8	7.0	7.0
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.5	9.5	9.6	9.6	9.6	9.6
Oil temp. at AC valve inlet	°C	22	22	22	23	23	23
Flow of oil or gas	l/h, m <sup>3</sup> /h	160	160	160	160	160	160
Pressure of oil or gas	kg/cm <sup>2</sup>	2.16	2.17	2.19	2.16	2.18	2.18
Pressure of steam(air)	kg/cm <sup>2</sup>	2.7	2.7	2.7	2.7	2.7	2.7
Oil temp. at burner inlet	°C	22	22	22	23	23	23
Draft							
Pressure at FDF outlet	mmaq	775	790	795	770	785	785
Pressure of primary wind box	mmaq	350	315	295	475	440	440
Pressure of secondary wind box	mmaq	300	210	165	255	180	145
Pressure of furnace	mmaq	160	120	100	160	130	110
Temperature							
Temp. of air for combustion	°C	35	36	36	37	37	38
Temperature of exhaust gas	°C	244	243	241	251	248	246
Damper							
Primary damper opening		4.0	3.9	3.9	5.0	4.8	4.8
Secondary damper opening		1.5	1.4	1.3	2.0	1.3	1.2
Primary air ratio		0.60	0.61	0.60	0.78	0.80	0.81
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		5	5	5	5	5	5
Analysis of exhaust gas							
NOx	ppm	82	92	95	101	114	121
CO	ppm	0	0	0	0	0	0
CO <sub>2</sub>	%	9.8	11.7	13.2	10.0	11.7	12.9
O <sub>2</sub>	%	7.1	4.8	3.0	6.8	4.8	3.1
SO <sub>2</sub>	ppm	618	710	697	641	732	808
NOx(converted at 5% O <sub>2</sub> )	ppm	94	91	84	114	113	108
Smoke tester(BC)	No.	1	1	0	1	0	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	81	83	84	81	82	84
Remarks							

Record of Combustion Test

Date 94/9/27

Place	Pachuca	Atmosphere	763 mmb				
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(2)						
Kind of fuel	Gas Oil(720ppm)						
Number		13	14	15	16	17	18
Pressure of boiler	kg/cm <sup>2</sup>	7.1	7.0	7.2	7.3	7.4	7.4
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	6.9	6.8	7.0	7.1	7.2	7.2
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.6	9.6	9.6	8.8	8.8	8.8
Oil temp. at AC valve inlet	°C	24	24	24	24	24	24
Flow of oil or gas	l/h, m <sup>3</sup> /h	160	160	160	200	200	200
Pressure of oil or gas	kg/cm <sup>2</sup>	2.16	2.16	2.16	2.60	2.63	2.65
Pressure of steam(air)	kg/cm <sup>2</sup>	2.7	2.6	2.7	3.0	3.0	3.0
Oil temp. at burner inlet	°C	24	24	24	24	24	24
Draft							
Pressure at FDF outlet	mmaq	770	780	785	725	750	770
Pressure of primary wind box	mmaq	570	535	510	620	575	530
Pressure of secondary wind box	mmaq	255	175	130	425	310	245
Pressure of furnace	mmaq	170	130	110	250	200	170
Temperature							
Temp. of air for combustion	°C	38	38	38	38	38	38
Temperature of exhaust gas	°C	253	249	245	268	267	267
Damper							
Primary damper opening		6.0	5.8	5.7	7.0	6.1	5.8
Secondary damper opening		1.8	1.2	1.2	3.2	2.5	1.5
Primary air ratio		0.89	0.90	0.91	0.67	0.69	0.68
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		5	5	5	6	6	6
Analysis of exhaust gas							
NOx	ppm	107	120	128	95	111	117
CO	ppm	0	0	0	0	0	0
CO <sub>2</sub>	%	9.7	11.6	13.3	10.2	11.7	13.2
O <sub>2</sub>	%	7.2	5.0	3.2	7.0	5.0	3.2
SO <sub>2</sub>	ppm	609	718	818	625	739	823
NOx(converted at 5% O <sub>2</sub> )	ppm	124	120	115	109	111	105
Smoke tester(BC)	No.	0	1	1	0	1	1
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	80	82	84	80	81	83
Remarks							

## Record of Combustion Test

Date 94/9/27

Place	Pachuca	Atmosphere			763 mmh		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(2)						
Kind of fuel	Gas Oil(720ppm)						
Number		19	20	21	22	23	24
Pressure of boiler	kg/cm <sup>2</sup>	7.1	7.2	7.1	7.0	7.0	7.0
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	6.9	7.0	6.9	6.8	6.8	6.8
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	8.8	8.8	8.8	8.8	8.8	8.8
Oil temp. at AC valve inlet	°C	24	24	24	24	24	24
Flow of oil or gas	l/h, m <sup>3</sup> /h	200	200	200	200	200	200
Pressure of oil or gas	kg/cm <sup>2</sup>	2.56	2.56	2.57	2.54	2.55	2.52
Pressure of steam(air)	kg/cm <sup>2</sup>	2.9	2.9	2.9	2.8	2.9	2.8
Oil temp. at burner inlet	°C	24	24	24	24	24	24
Draft							
Pressure at FDF outlet	mmaq	725	750	770	725	760	770
Pressure of primary wind box	mmaq	565	535	490	485	440	410
Pressure of secondary wind box	mmaq	430	325	255	465	335	260
Pressure of furnace	mmaq	245	200	170	240	190	160
Temperature							
Temp. of air for combustion	°C	38	38	39	38	39	39
Temperature of exhaust gas	°C	271	270	268	270	269	267
Damper							
Primary damper opening		6.0	5.7	5.2	5.0	4.5	4.3
Secondary damper opening		3.3	2.5	1.8	3.4	2.7	2.2
Primary air ratio		0.64	0.63	0.64	0.56	0.55	0.56
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		6	6	6	6	6	6
Analysis of exhaust gas							
NOx	ppm	91	104	112	79	91	97
CO	ppm	0	0	0	0	0	41
CO <sub>2</sub>	%	10.1	11.7	13.0	10.2	12.1	13.4
O <sub>2</sub>	%	6.8	5.1	3.2	6.8	4.8	2.9
SO <sub>2</sub>	ppm	624	735	774	631	760	857
NOx(converted at 5% O <sub>2</sub> )	ppm	103	105	101	89	90	86
Smoke tester(BC)	No.	1	1	0	1	0	2
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	80	81	83	80	81	83
Remarks							

Record of Combustion Test

Date 94/9/27

Place	Pachuca	Atmosphere			763 mmb		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Low NOx Oil Burner(2)						
Kind of fuel	Gas Oil(720ppm)						
Number		25	26	27	28	29	30
Pressure of boiler	kg/cm <sup>2</sup>	6.8	7.0	7.0	7.1	7.2	7.2
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>						
Pressure of steam atomization	kg/cm <sup>2</sup>	6.6	6.8	6.8	6.9	7.0	7.0
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	8.8	8.8	8.8	8.8	8.8	8.8
Oil temp. at AC valve inlet	°C	24	24	24	24	24	24
Flow of oil or gas	l/h, m <sup>3</sup> /h	200	200	200	200	200	200
Pressure of oil or gas	kg/cm <sup>2</sup>	2.52	2.56	2.54	2.58	2.58	2.58
Pressure of steam(air)	kg/cm <sup>2</sup>	2.8	2.9	2.8	2.9	2.9	2.9
Oil temp. at burner inlet	°C	24	24	24	24	24	24
Draft							
Pressure at FDF outlet	mmaq	725	750	770	720	750	770
Pressure of primary wind box	mmaq	400	355	320	335	280	240
Pressure of secondary wind box	mmaq	490	390	295	565	410	325
Pressure of furnace	mmaq	235	195	160	250	190	150
Temperature							
Temp. of air for combustion	°C	39	39	39	39	39	39
Temperature of exhaust gas	°C	266	264	262	265	263	259
Damper							
Primary damper opening		4.1	3.9	3.9	3.4	3.1	3.0
Secondary damper opening		3.7	3.1	2.5	4.2	3.2	2.8
Primary air ratio		0.46	0.45	0.45	0.33	0.34	0.34
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		6	6	6	6	6	6
Analysis of exhaust gas							
NOx	ppm	78	84	85	82	92	97
CO	ppm	0	0	75	0	0	0
CO <sub>2</sub>	%	10.3	11.6	13.3	9.9	11.8	13.3
O <sub>2</sub>	%	6.7	5.2	3.2	7.1	4.9	3.0
SO <sub>2</sub>	ppm	659	710	831	636	753	828
NOx(converted at 5% O <sub>2</sub> )	ppm	87	85	76	94	91	86
Smoke tester(BC)	No.	1	2	4	3	1	3
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	80	81	83	80	82	83
Remarks					Singing furnace	Singing furnace	Singing furnace

## Record of Combustion Test

Date 94/10/3

Place	Pachuca	Atmosphere			761 mmB		
Type of boiler	FTN-30 flue and smoke-tube packaged type						
Type of burner	Normal Oil Burner						
Kind of fuel	Gas Oil(720ppm)						
Number		1	2	3	4	5	6
Pressure of boiler	kg/cm <sup>2</sup>	7.0	7.0	7.0	7.0	7.0	7.0
Atomization							
Pressure of air atomization	kg/cm <sup>2</sup>	6.6	6.6	6.6	6.6	6.7	6.7
Pressure of steam atomization	kg/cm <sup>2</sup>						
Fuel							
Pressure of fuel supply unit	kg/cm <sup>2</sup>	9.4	9.3	9.3	9.3	8.7	8.7
Oil temp. at AC valve inlet	°C	22	22	22	22	22	22
Flow of oil or gas	l/h, m <sup>3</sup> /h	120	121	120	120	158	164
Pressure of oil or gas	kg/cm <sup>2</sup>	1.68	1.66	1.67	1.66	2.12	2.13
Pressure of steam(air)	kg/cm <sup>2</sup>	2.6	2.6	2.6	2.5	3.0	3.0
Oil temp. at burner inlet	°C	22	22	22	22	22	22
Draft							
Pressure at FDF outlet	mmaq	790	790	785	780	775	775
Pressure of primary wind box	mmaq	160	100	80	70	230	195
Pressure of secondary wind box	mmaq						
Pressure of furnace	mmaq	80	60	50	40	135	125
Temperature							
Temp. of air for combustion	°C	36	36	36	37	36	35
Temperature of exhaust gas	°C	198	198	198	197	228	227
Damper							
Primary damper opening		3.0	2.9	2.8	2.6	3.5	3.4
Secondary damper opening							
Primary air ratio							
Steam injection	kg/cm <sup>2</sup>						
Opening of AC valve		4	4	4	4	5	5
Analysis of exhaust gas							
NOx	ppm	111	125	135	115	115	129
CO	ppm	0	0	0	61	0	0
CO <sub>2</sub>	%	10.0	11.9	13.2	14.4	10.3	11.7
O <sub>2</sub>	%	7.1	4.8	3.2	1.7	6.8	5.1
SO <sub>2</sub>	ppm	582	682	762	832	597	632
NOx(converted at 5% O <sub>2</sub> )	ppm	128	123	121	95	130	130
Smoke tester(BC)	No.	0	1	1	3	1	0
Water content	%						
Exhaust gas recirculation(EGR)							
Damper opening							
Rate of EGR	%						
Combustion efficiency	%	84	85	86	86	83	85
Remarks							