JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NATIONAL INSTITUTE OF ECOLOGY
THE UNITED MEXICAN STATES

THE STUDY ON THE COMBUSTION TECHNOLOGIES FOR THE AIR POLLUTION CONTROL OF STATIONARY SOURCES IN THE METROPOLITAN AREA OF THE CITY OF MEXICO

Final Report

Appendix

Operation and Maintenance Manual for Combustion Test Plant

SEPTEMBER 1995

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO
In association with
JAPAN ENVIRONMENT ASSESSMENT CENTER CO., LTD., TOKYO

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OPERATION AND MAINTENANCE MANUAL FOR COMBUSTION TEST PLANT

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PART I OPERATION MANUAL

1. Boiler Operating Procedure

1.1 Procedures According to Operating Conditions

(1) When boiler is cold

Start the boiler with diesel fuel and atomization air.

(2) When drum pressure is below 6.0 Kg/cm^2:

Start the boiler with diesel fuel and atomization air until drum pressure is above 6.0 Kg/cm^2. When fuel oil is the fuel, it is heated by generated steam until fuel oil's temperature reaches 80°C at the pump unit's intake.

(3) When drum pressure is below 6.0 Kg/cm^2:

When fuel oil is used and once temperature reaches 80°C with procedure (2) combustion may be stopped After chamging the valve, combustion may be started upagain with fuel oil and atomization air.

(4), (5) Normal operation:

When drum pressure is above 6.0 Kg/cm^2 a normal control operation is proportional to drum pressure, with diesel and atomization steam, or with fuel oil and atomization air.

(6) Terminating fuel-oil operation:

After combustion with fuel oil, the boiler should be operated with diesel and air atomization for a time so as to sustitute the fuel oil, remaining in the equipment and tubes, with diesel and so as to facilitate the next start-up.

Note) Changing fuel or the manner of atomization should be done once the combustion has been interrupted.

1.2 Operating the Boiler

(1) Preparations

i) Select and define the equipment to be used and check the opening of the valves; depending on the kind of fuel, atomization and state of the boiler.

ii) Check that all switches or breakers on control panel are in an "OFF" position.

iii) Open the inlet valve of the fuel feeder tube for the pilot burner.

iv) Hook up the power supply for the control panel (MCB - 1) and to check the electrical current.

v) Set switches to "ON", sending power to the internal cables of the control panel **(MMCB- 1, 2, 3, 4, MCB- 2, 3, 4, 5 and 6)**.

vi) Select control panel switch switches according to operating conditions.

(2) Operation

See item 2 of this volume concerning combustion system. Peripheral equipments used appears in the following tables.

i) Water - feed pump

When the CS-1 selector switch (manual- stop - automático) is set on "automatic", the water - feed pump will work and stop its working, controlled by the water - level control device of the boiler, keeping it within a certain range. If for any reason the boiler water level drops below a certain range, low water level switch will function (two phases): interruption because of low water level (first phase) and discharge because of abnormal water level (second phase), if the water level continues in decreasing, suspending combustion in both cases. When the SC-1 selector switch (manual- stop -automatic) is set on "manual", the water- feed pump will work independently of the boiler water level.

ii) Reagent feed pump

When the SC-2 selector switch (manual- stop - automatic) is set on "automatic", the reactives pump will work with the feed water pump simultaneously; starting and stopping at the same time.

When the SC-2 selector switch (manual -stop- automatic) is set on "manual", the reagent feed pump will work independently of the starting or stopping of the water-feed pump.

iii) Electromagnetic continuous purge valve

When the CS-3 selector switch (manual- stop - automatic) is set on "automatic", the electromagnetic solenoid continuous purge valve will work in synch with the water - feed pump, starting and stopping at the same time; as the latter. When the CS-3 selector switch (manual- stop -automatic) is set on "manual", the electromagnetic solenoid continuous purge valve will work independently of starting or stopping of the feed - water pump.

(3) PERIPHERAL EQUIPMENT'S OPERATION

CASE	OPERATION CONDITIONS	ATOMIZATION	FUEL	FORCED DRAFT FAN	WATER PUMP	REAGENT PUMP	ATOMIZATION PUMP	AIR COMPRESSOR	OIL HEATER	OIL HEATER TEMP. (GRADE C)	
										No.1	No.2
1	COLD BOILER STARTING	AIR	DIESEL	○ CS-4 AUTOMATIC	○ CS-1 AUTOMATIC	○ CS-2 AUTOMATIC	○	○ CS-10 OPERATION	● CS-8.9 "OFF"	-	-
2	LOW DRUM PRESSURE and NORMAL FUEL OIL TEMP.	AIR	FUEL OIL	○ CS-4 AUTOMATIC	○ CS-1 AUTOMATIC	○ CS-2 AUTOMATIC	○	○ CS-10 OPERATION	● CS-8.9 "OFF"	-	-
3	LOW DRUM PRESSURE and NORMAL FUEL OIL TEMP.	AIR	FUEL OIL	○ CS-4 AUTOMATIC	○ CS-1 AUTOMATIC	○ CS-2 AUTOMATIC	○	○ CS-10 OPERATION	○ CS-8.9 "ON"	110	120
4	NORMAL OPERATION (AIR ATOMIZATION)	AIR	DIESEL	○ CS-4 AUTOMATIC	○ CS-1 AUTOMATIC	○ CS-2 AUTOMATIC	○	○ CS-10 OPERATION	● CS-8.9 "OFF"	-	-
5	(STEAM ATOMIZATION)	STEAM	DIESEL	○ CS-4 AUTOMATIC	○ CS-1 AUTOMATIC	○ CS-2 AUTOMATIC	○	● CS-10 OPERATION	● CS-8.9 "OFF"	-	-
6	END of FUEL OIL COMBUSTION	AIR	DIESEL	○ CS-4 AUTOMATIC	○ CS-1 AUTOMATIC	○ CS-2 AUTOMATIC	○	○ CS-10 OPERATION	● CS-8.9 "OFF"	-	-
7	GAS COMBUSTION		GAS	○ CS-4 AUTOMATIC	○ CS-1 AUTOMATIC	○ CS-2 AUTOMATIC	●	● CS-10 OPERATION	● CS-8.9 "OFF"	-	-

○ : IT IS USED ● : IT ISN'T USED

NOTE 1:

Case 1 : Cold boiler starting.
Drum pressure : cero, fuel oil temperature (pumping unit intake) : below 80°C.

Case 2 : Low drum pressure, low temperature of fuel oil.
Drum pressure : below 6.0 Kg/cm2, fuel oil temperature (pumping unit intake) : below 80°C.

Case 3 : Drum low pressure, normal fuel oil temperature.
Drum pressure : below 6.0 Kg/cm2, fuel oil temperature (pumping unit intake) : 80°C or more.

Case 4 : Normal operation.
Drum pressure : 6.0 Kg/cm2 or more, diesel fuel.

Case 5 : Normal operation.
Drum pressure : 6.0 Kg/cm2 or more, diesel fuel.

Case 6 : End of fuel oil combustion.
Changing of fuel oil by diesel, to prepare next starting.

NOTE 2: Oil heater temperature, the drum pressure and fuel oil temperature, which are mentioned in Note 1 must be defined according to the characteristics of fuel oil used.

2. Burner Operating Procedure

2.1 Oil Combustion

(1) Preparations: Check the position of the switches on the control panel, if they are "ON" or "OFF", before operating the burner.

i) Switch without fuse [OFF]
(MCB-1, MCB-2, MCB-3, MCB-4, MCB-5, MCB-6)
(MMCB-1, MMCB-2, MMCB-3, MMCB-4)

ii) Selector switch
(CS-4, CS-5, CS-6, CS-7, CS-8,9, CS-10) [STOP]

iii) Master control switch (COS l) [STOP]

iv) Boiler start/ stop switch (CS-7) [STOP]

(2) Burner operation :

i) Switch without fuse [ON]
(MCB-1, MCB-2, MCB-3, MCB-4, MCB-5, MCB-6)
(MMCB-1, MMCB-2, MMCB-3, MMCB-4)
When combustion is with light oil [OFF]
(MCB-5, 6)

ii) Selector switch [ON]
(CS-4, CS-6, CS-8,9, CS-10)

iii) Master control switch **(COS-1)** [STOP]

iv) Fuel Selector switch **(CS-5)** [OIL]

v) Reset button for abnormalities **(PB-1)** [ON]

vi) Boiler start/stop switch **(CS-7)** [STOP]

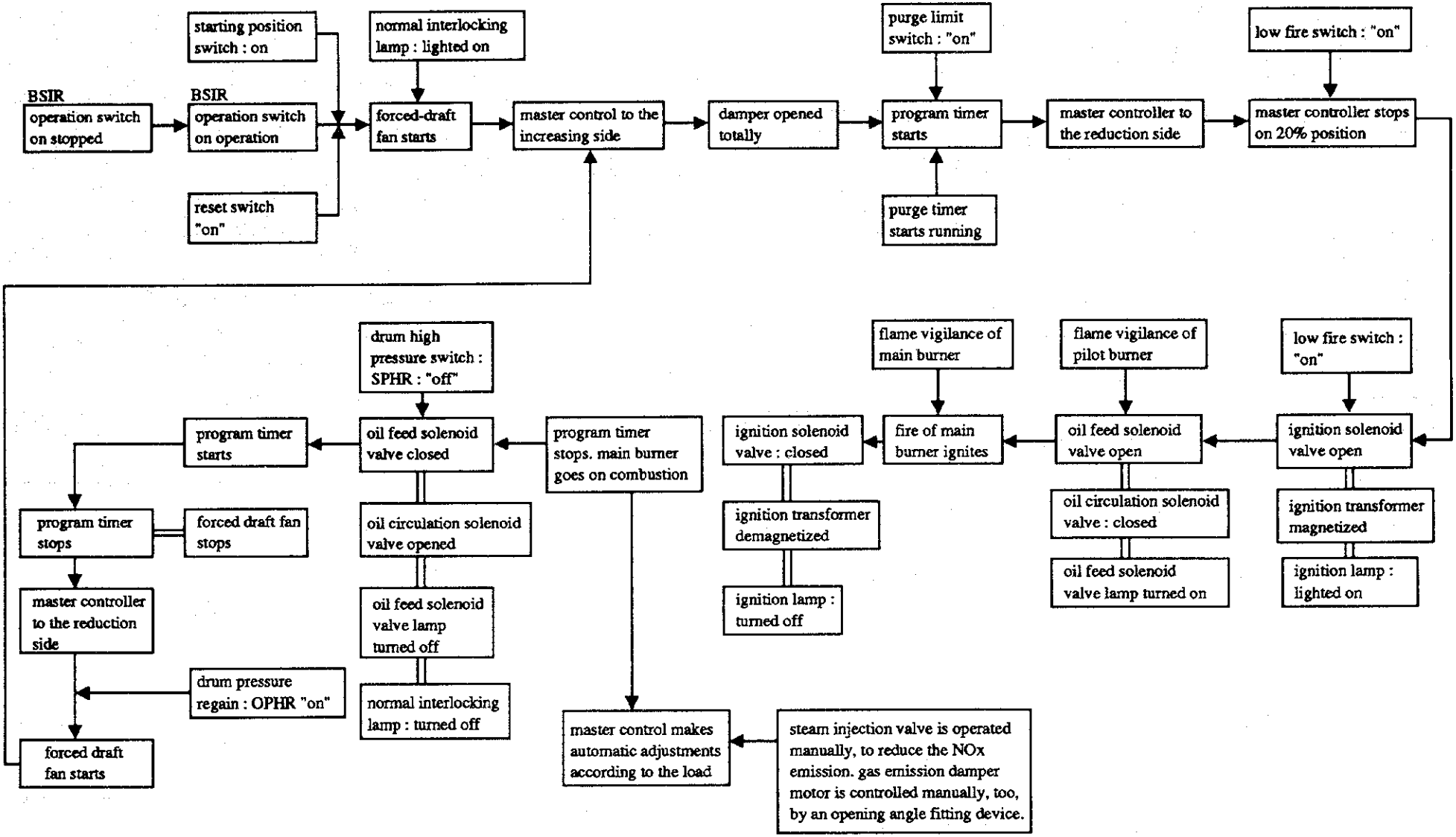
From this point on, electrical operations will be done automatically until the main burner goes on, depending on the program.

(3) Explanation of sequences of movements (with oil)

Program	Programmer position	Explanation	Signals on lamps
Starting of forced-draft fan	Stopped in the second zero	If the position of air damper is more to opened side than starting position, to close the gate on to starting position by means of master control CPM. (to avoid an excessive load in the forced-draft fan in the starting moment). In starting position, SPS should be in ON and CPM should be in stop. The forced-draft fan will start if the drum high pressure switch (SPHR) indicates normal state. * Because of the magnetism of the fan's reliever (RF), exterior contact point for starting of the forced-draft fan is set in On, and the fan begins to work.	Forced-draft fan's lamp (PL-15) is on red light.
Interlock released	Stopped on the second zero	Drum pressure normal (SPHR). Forced-draft fan's motor released (MSFM) _____ Low oil pressure (LOP) _____ Oil pressure reduction (LOP) _____ Selection of gas or another fuel (GAS) _____ Low atomization pressure (ASP) _____ Low fuel gas pressure (GPL) _____ Abnormal low water level of boiler (LWR 1) ___ Low water level of the boiler (LWR 2) _____ All these interlocking lamps turn on if they are released.	When abnormality is found. (PL-18) Lamp is off (PL-18) Lamp is off (PL-18) Lamp is off (PL-18) Lamp is off (PL-18) Lamp is off (PL-18) Lamp is off (PL-2) Lamp is on (PL-3) Lamp is on Interlock lamp (PL-18) turned on.
Pre purge	Stopped on the second zero	When the forced-draft fan starts the master control opens the damper air totally to blower, or to ventilate the furnace's interior. When the damper of air opens totally, the purge's limit switch sets in ON, and it starts the ventilation of furnace's interior, for the time defined by the purge's timer (PT).	In a normal state, the interlock lamp (PL-18) is on red light.
Program-timer starting	Stopped in the second zero	When the pre purge is finished and the interlock relay (RI) begins to function, the program starts to work.	
Low fire position	In the second 17	17 seconds after that program timer has started running, the master control rotates on to reduction' side to do the ignition of the burner on area of low combustion, and stops on the position of 20% of combustion's volume.	
Pilot burner ignites	In the second 46	Electrify the ignition's transformer (ITX). Ignition solenoid valves (VGP1,2) opend. Ignition lamp (LPG) turned on. Ignition relay (RPG) magnetized. The pilot burner ignites. Check existence of flame with the flame relay (pbs).	The ignition lamp (PL-19) is on red light.

Program	Programmer position	Explanation	Signals on lamps
Main burner ignites	In the second 54	Oil feed solenoid valves (VO 1,2) opened. Oil circulation solenoid valve (VOR) closed. Oil burner operation lamp turned on. Oil valve relay (RVO 1,2) magnetized. The main burner ignites.	Oil burner operation lamp (PL-20) is on red light.
Pilot burner extinguishes	In the second 67	The pilot burner extinguishes when the contact of program timer M2NC is set in OFF. After the pilot burner extinguishes, only the main burner goes on the combustion under vigilance of the scanner.	Pilot lamp (PL-19) is off. Oil burner operation lamp (PL-20) is on red light.
Automatic operation by master controller		The cam switch SMC cam is still on "stop"; the temperature and the boiler pressure increase gradually, because of the knob "increase-reduction" is being operated manually. The SMC switch is set on "automatic", when the ventilation phase starts. From that moment, the combustion's volume of the burner fits automatically, according to the change in drum pressure.	Oil burner operation lamp (PL-20) is on red light.
Program timer stops	In the second 83	When contact point of program timer is set in OFF, the timer running stops on the position of second 83.	Oil burner operation lamp (PL-20) is on red light.
Stable operation		Burner starts a stable operation. After the increase of pressure, the injection of atomizer steam is done to reduce the NOx emission, according to the necessity, and by manual fittings of the valve. The damper motor of emission gas (EGR) is operated manually, too, by means of the opening angle fitting device.	
Burner extinguishes	In the second zero (or 100)	The burner operation switch (BSTR) is set in "stop" position. The combustion volume is reduced at the minimum by the master control, the oil feed solenoid valves (VO 1,2) set on "closed", the oil burner operation lamp extinguishes and the burner fires out. Program timer starts to work and it returns to the initial position (in the second zero).	Normal interlocking lamp (PL-18) is off. oil burner operation lamp (PL-20) is off.
Switching off by interlocking (repetitive)	In the second zero (or 100)	Repetitive interlocking (SPHR). When the interlock detects the switching off, the normal operation lamp (PL-18) lights off, the interlock relay is demagnetized, at the same time the oil feed solenoid valve closes, and it interrupts the supply of fuel at the main burner. The program timer starts to work, and it returns at the second zero position.	

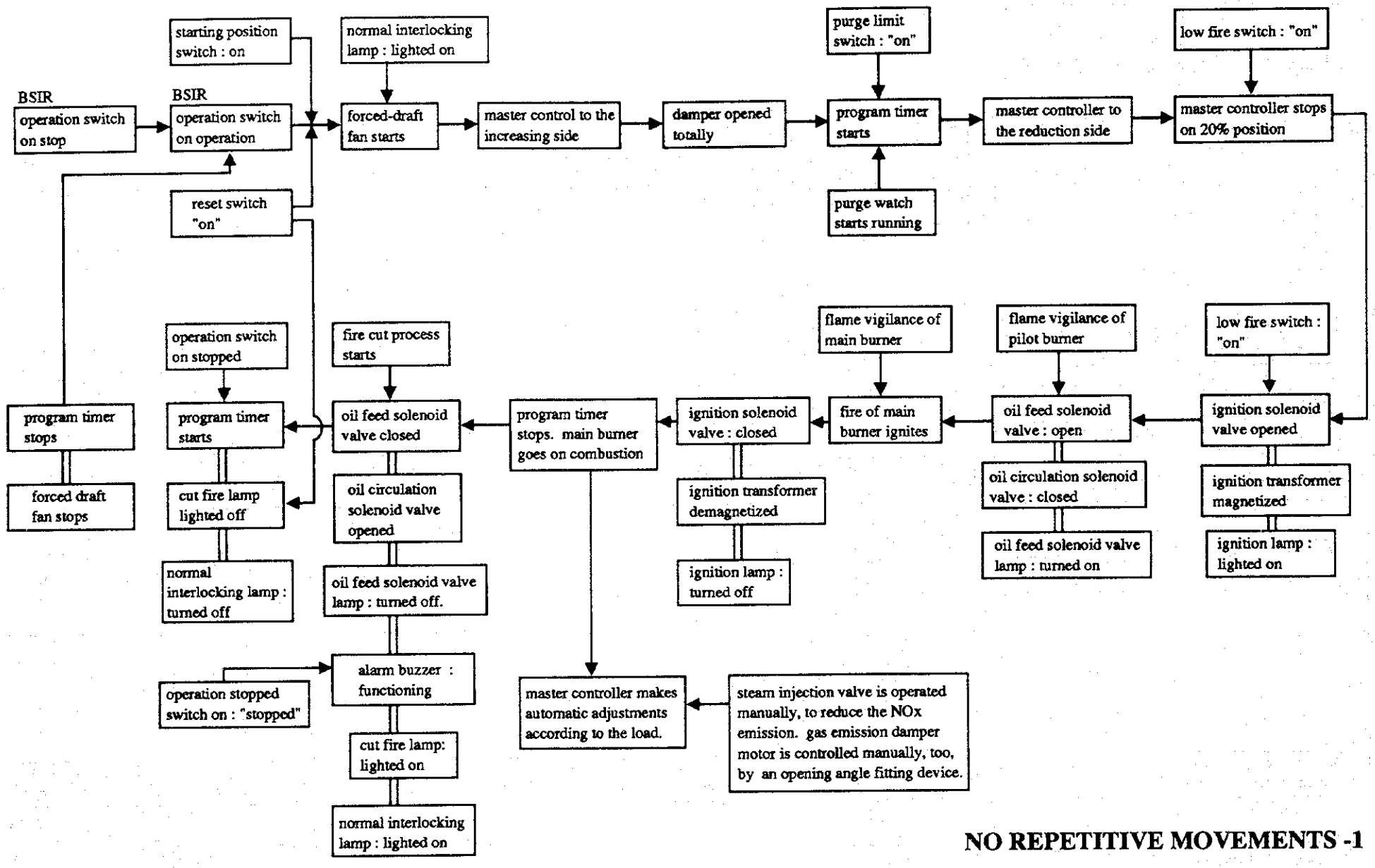
Program	Programmer position	Explanation	Signals on lamps
Switching off by interlocking (no repetitive)	In the second 83	No repetitive interlocking (MSFM) (LOP) (OIL) (GAS) (ASP) (GPH) (GPL) (LWR 1) (LWR 2). If any abnormality is detected in some of the interlocks, normal interlocking lamp (PL-18) lights off, and the interlock (RI) demagnetizes, at the same time the oil feed solenoid valve closes. The gas feed solenoid valve lamp (PL-2) lights off, and a buzzer alarm sounds (BZ). The program timer stops in the second 83. When the problem is resolved, and it's necessary to start the operation again, if the burner operation switch is non operation position, the sequence doesn't start again by pressing the reset button only. If you want to start the operation again, it is necessary to set the operation switch in "stop", to make it function.	
Flame interruption	Stopped on the second 83	Detected the interruption of burner's flame by the scanner (pbs) the operation stops. Immediately the gas feed solenoid valve closes, the flame interruption lamp (PL-30) lights on, and a buzzer alarm sounds (BZ).	



REPETITIVE MOVEMENTS

OIL COMBUSTION

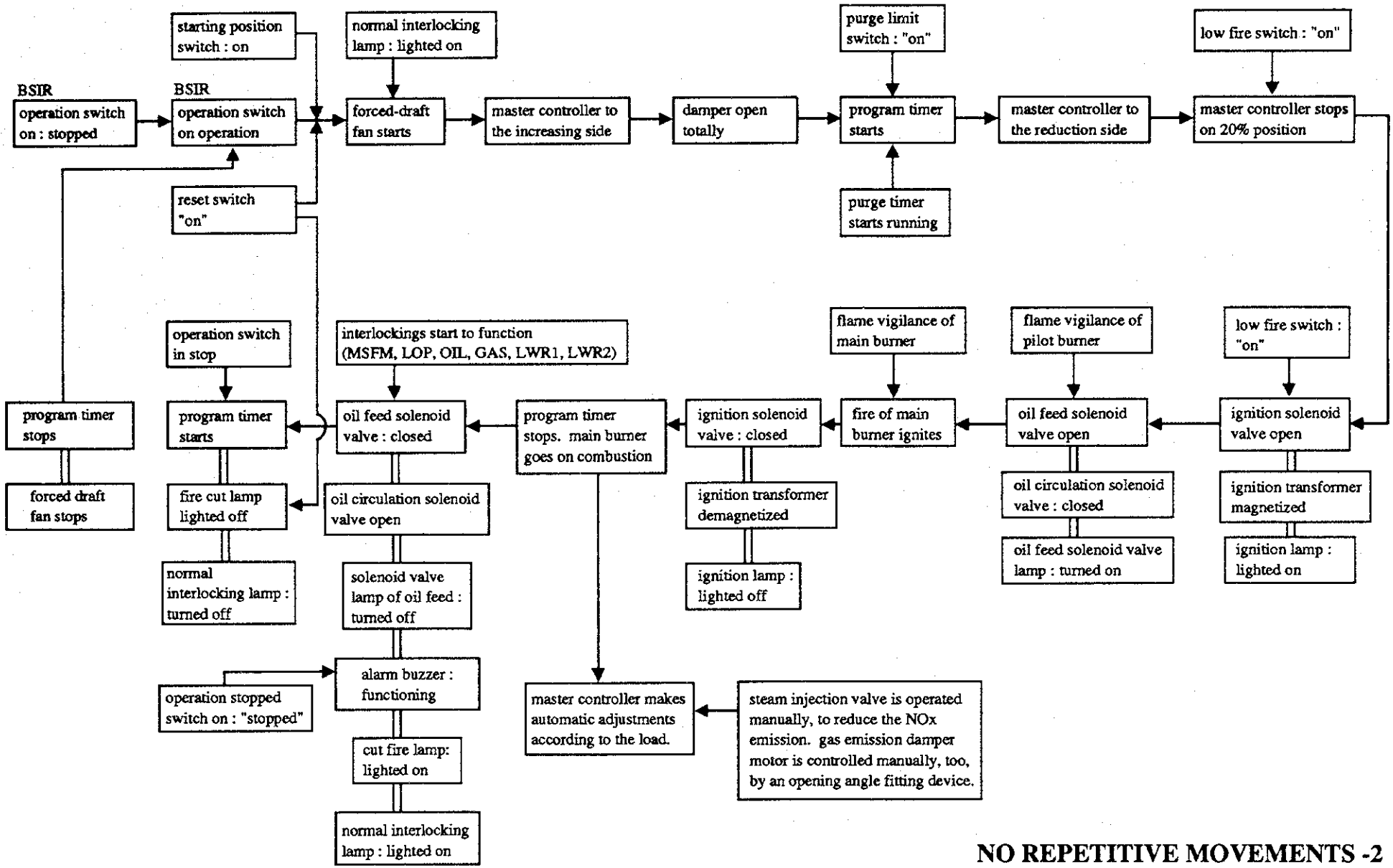
Automatic starting and stop by DRUM PRESSURE



NO REPETITIVE MOVEMENTS -1

OIL COMBUSTION

(Fire cut)



NO REPETITIVE MOVEMENTS -2

OIL COMBUSTION

(Interlocking)

2.2 Gas Combustion

(1) Preparations :

Check burner position.

Check switch positions on the control panel, if they are opened or closed, before operating the burner.

i) Nonfuse switch: [OFF]
(MCB-1, MCB-2, MCB-3, MCB-4, MCB-5. MCB-6)
(MMCB-1, MMCB-2, MMCB-3, MMCB-4)

ii) Selector switch: [STOP]
(CS-4, CS-5, CS-6, CS-7, CS-8,9, CS-10)

iii) Master controller switch (COS 1): [STOP]

iv) Boiler start/stop(CS-7): [STOP]

(2) Burner operation :

i) Nonfuse switch [ON]
(MCB-1, MCB-2, MCB-3, MCB-4, MCB-5, MCB-6)
(MMCB-1, MMCB-2, MMCB-3, MMCB-4)

ii) Selector switch [ON]
(CS-4, CS-6, CS8,9, CS-10)

iii) Master controller switch (COS-1) [STOP]

iv) Fuel selector switch (CS-5) [GAS]

v) Reset button for abnormalities (PB-1) [ON]

vi) Boiler start-stop switch (CS-7) [OPERATION]

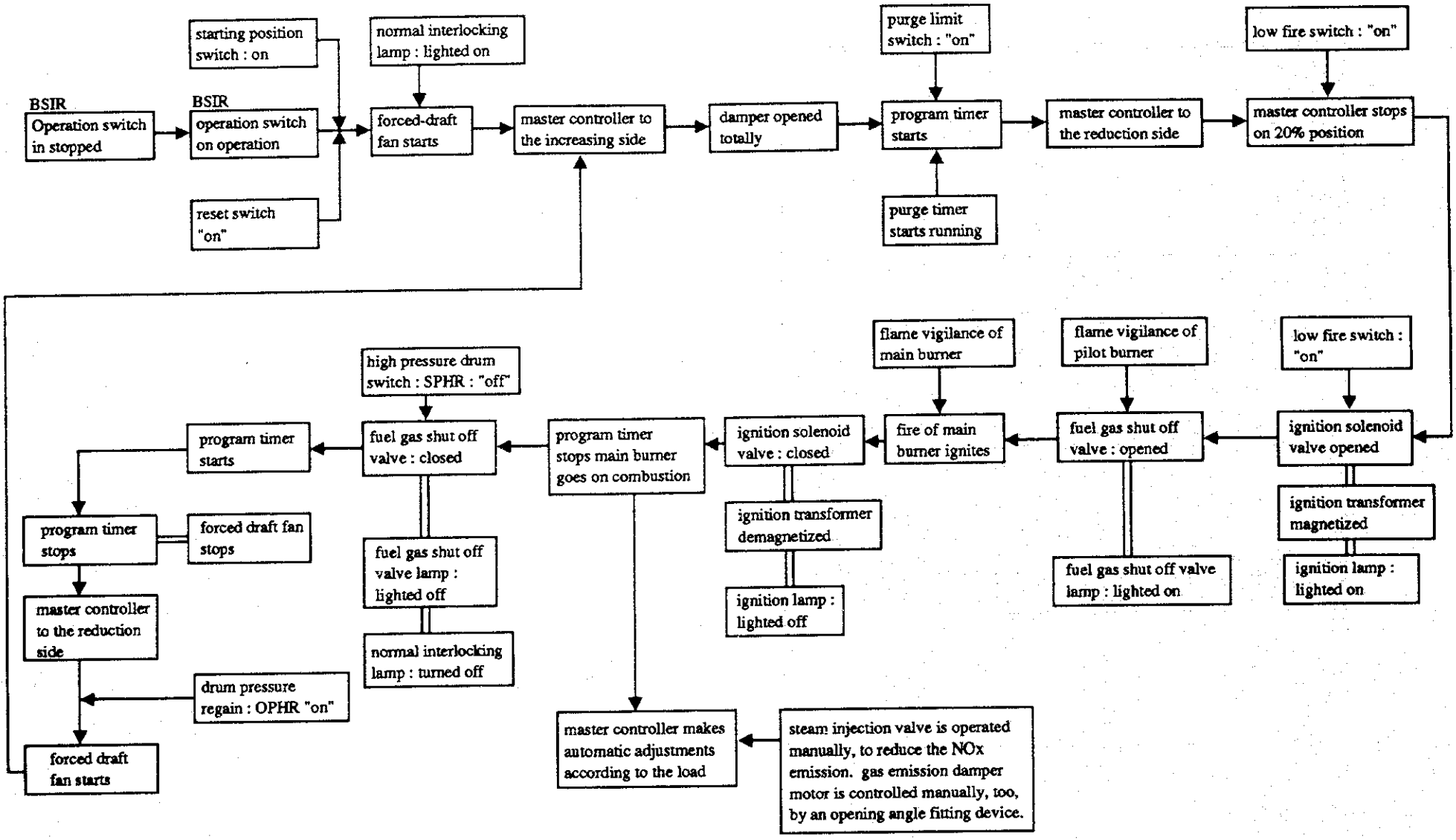
From this point on, electrical operations will be done automatically until the main burner goes on, depending on the program.

(3) Explanation of the sequence of movements (with gas)

Program	Programmer position	Explanation	Signals on lamps
Starting of forced-draft fan	Stopped in the second zero	If the position of air damper is more to the open side than starting position, the damper should be closed until starting position, by means of master controller CPM. (to avoid an excessive load on the forced-draft fan at the starting moment). In starting position, the SPS should be ON, and the CPM on STOP. The forced-draft fan will work if the high drum pressure switch (SPHR) indicates a normal state. *By magnetization of relay of the fan (RF) exterior contact point for the starting of forced-draft fan sets in ON, and the fan starts to work.	Lamp of forced-draft fan (PL-15) is on red light.
Release interlocking	Stopped in the second zero	Normal drum pressure (SPHR) Release of forced-draft fan motor (MSFM) _____ Selection of gas or another fuel (GAS) _____ High pressure of fuel gas (GHP) _____ Low pressure of fuel gas (GLP) _____ Abnormal low water level of boiler (LWR 1) _____ Low water level of the boiler (LWR 2) __ All these lamps light on if they are released.	When abnormality is discovered (PL-18) Lamp is off (PL-18) Lamp is off (PL-18) Lamp is off (PL-18) Lamp is off (PL-2) Lamp is on (PL-3) Lamp is on Interlocking lamp (PL-18) is on
Pre-purge	Stopped in the second zero	When forced-draft fan starts, the master controller opens the air damper totally, to do the ventilation in the furnace's interior. When the air dumper opens totally, the purge limit switch sets in ON, and it starts the ventilation of furnace's interior for a time defined by the purge timer (PT).	In a normal state, interlocking lamp (PL-18) is on red light.
Starting of program timer	Stopped in the second zero	The program starts to work when the purge is finished, and the interlocking relay starts to function (RI).	
Low fire position	In the second 17	17 seconds after the program timer has started its movement, the master controller rotates on to the reduction side to carry out the burner ignition, in the area of low combustion, and it stops at a position of 20% of combustion's volume.	

Program	Programmer position	Explanation	Signals on lamps
Pilot burner ignites	In the second 46	To electrify the ignition transformer (ITX). Ignition solenoid valves (VGP1, 2) open. Ignition lamp (LPG) turned on Ignition relay (RPG) magnetized The pilot burner ignites To verify the existence of flame with "Ultravision" (UV).	Ignition lamp (PL-19) is on red light.
Main burner ignites	In the second 54	Gas feed solenoid valves (VG 1,2) open. Gas burner operation lamp lighted on. Relay of fuel valve (RVG 1,2) magnetized. Main burner ignites.	Burner operation lamp (PL-21) is on red light.
Pilot burner extinguishes	In the second 67	The pilot burner extinguishes when the contact point of the program timer M2NC is settled in OFF. After pilot burner extinguishes, only the main burner goes on the combustion under vigilance of the "Ultravision".	Pilot lamp (PL-19) is off. Gas burner operation lamp (PL-21) is on red light.
Automatic operation by the master controller		Can switch SMC is on "stop" still, for this the temperature and the boiler pressure increase gradually, because of the "increase-reduction" knob is being handled manually, to set the SMC switch in "automatic" when it arrives at the ventilation phase. From this moment, the combustion volume of the burner fits automatically, according to the change in the drum pressure.	Gas burner operation lamp (PL-21) is on red light.
Program timer stops	In the second 83	When the contact point of the program timer M5NC is put in OFF, the timer stops running in second 83 position.	Gas burner operation lamp (PL-21) is on red light.
Stable operation		The burner starts an stable operation. After the pressure increases, the injection of steam is done to reduce the NOx emission, according to the necessity, and by manual fittings of the valve. The motor of emission gases damper (EGR) is operated manually, too, by means of the opening angle fitting device.	
Burner extinguishing	In the second zero (or 100)	The burner operation switch (BSTR) is set in "stop" position. The combustion's volume is reduced at the minimum by the master controller, the gas feed solenoid valves (VG 1,2) set on "closed", the gas burner operation lamp extinguishes and the burner fires out. The program timer starts to work and it returns to the second zero position.	Normal interlocking lamp (PL-18) is off. Gas burner operation lamp (PL-20) is off.

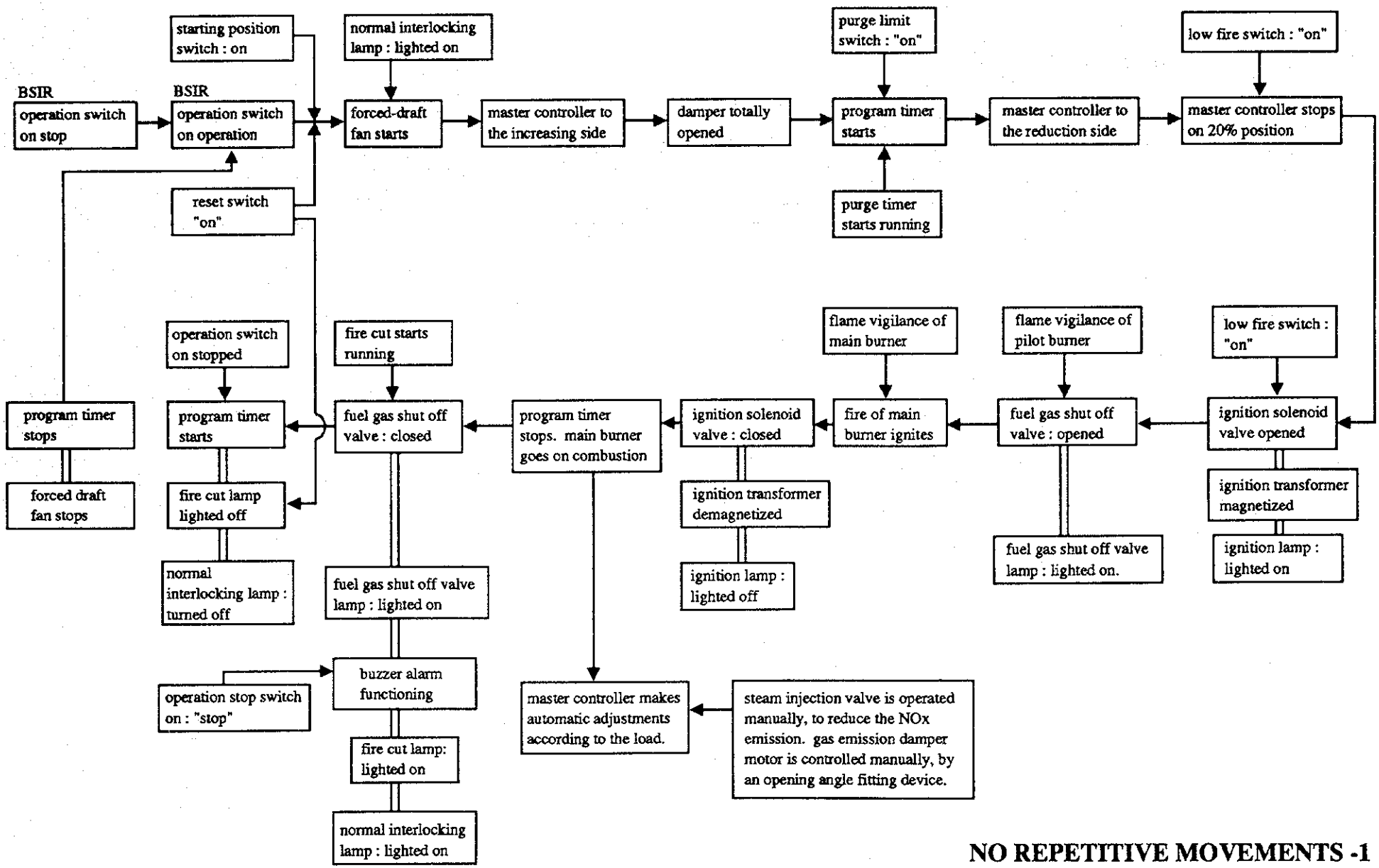
Program	Programmer position	Explanation	Signals on lamps
Switching off by interlocking (repetitive)	In the second zero (or 100)	Repetitive interlocking (SPHR). When the interlocking detects the switching off, the normal operation lamp (PL-18) lights off, the interlock relay is demagnetized; at the same time the gas feed solenoid valve closes, and it interrupts the supply of fuel at the main burner. The program timer starts to work, and it returns to second zero position.	
Switching off by interlocking (no repetitive)	Stopped in the second 83	No repetitive interlocking (MSFM) (LOP) (OIL) (GAS) (ASP) (GPH) (GPL) (LWR 1) (LWR 2). If it is detected any abnormality is some of the interlockings, the normal interlocking lamp (PL-18) lights off, and the interlocking (RI) demagnetizes, at the same time the gas feed solenoid valve closes. The lamp of the gas feed solenoid valve (PL-2) lights off, and a buzzer alarm sounds (BZ).	
Flame interruption	Stopped in the second 83	When the interruption of the burner flame is detected by the "Ultravision", the operation stops. Immediately the gas feed solenoid valve closes, the flame interruption lamp (PL-30) lights on, and a buzzer alarm sounds (BZ).	



REPETITIVE MOVEMENTS

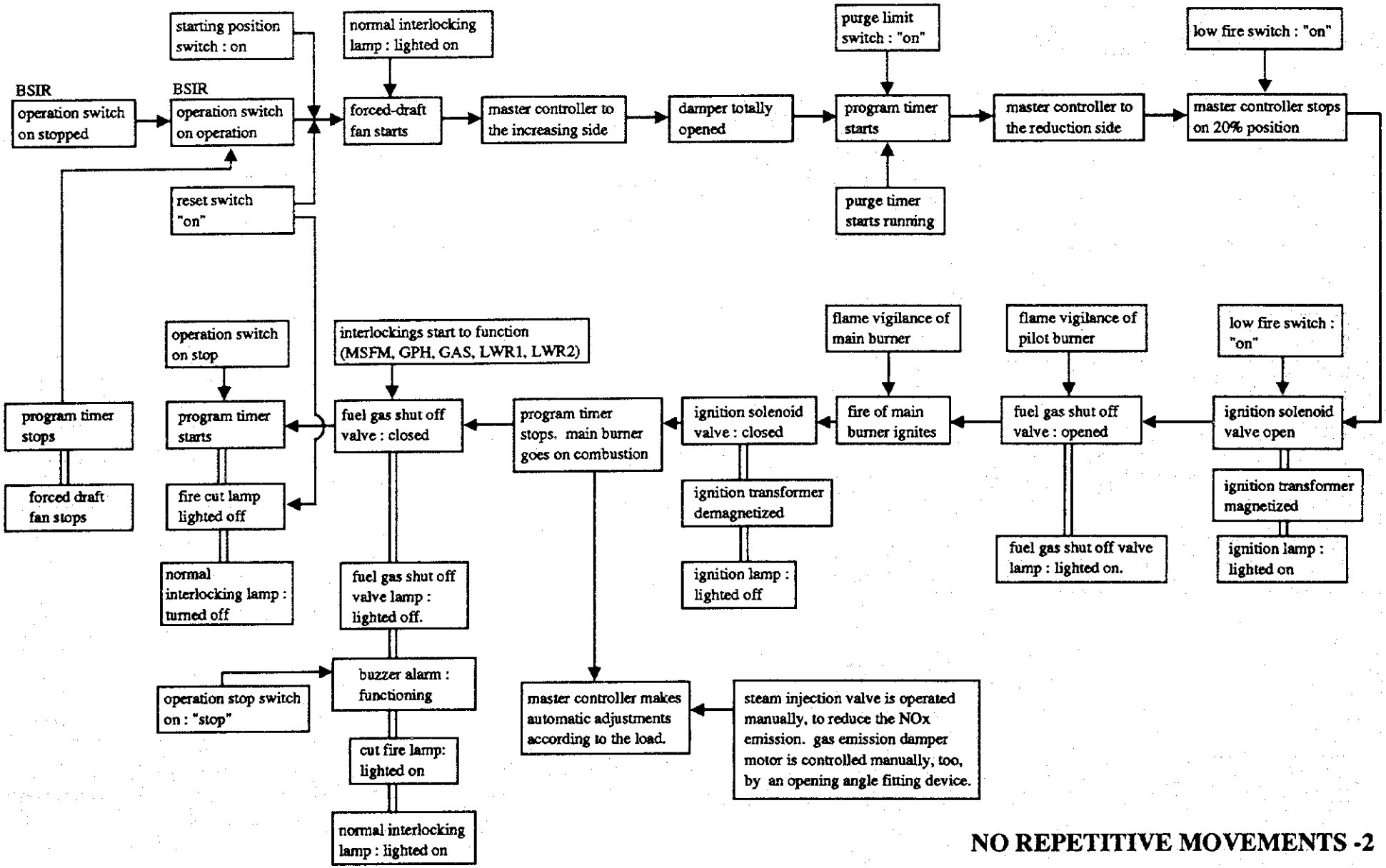
GAS COMBUSTION

Automatic starting and stop by DRUM PRESSURE



NO REPETITIVE MOVEMENTS -1

GAS COMBUSTION



NO REPETITIVE MOVEMENTS -2

GAS COMBUSTION

(Interlocking)

3. List of Interlockings

3.1 Oil Combustion

BOILER MODEL : FTN-30

No.	CONCEPT	OPERATION CONDITIONS	LAMPS	BURNER FLAME	BUZZER	CYCLE OF THE PROGRAM
1 ■ ●	SPHR (NORMAL DRUM PRESSURE SWITCH)	-Kg/cm2 OPERATION -Kg/cm2 RESUMPTION	PL-18 is OFF	FLAME CUT ▲	IT DOESN'T SOUND	
2 □	LOP (LOW OIL PRESSURE SWITCH)	It WORKS FROM -Kg/cm2 and LESS	PL-18 is OFF PL-30 is ON		It SOUNDS	REPETITIVE
3 □	OIL (OIL SELECTOR SWITCH)	SELECTION	PL-18 is OFF PL-30 is ON		▲	NO PREPETITIVE
5 □	FSG (pbs FLAME VIGILANCE DEVICE) Pr-2 for OIL	SCANNER out of the FURNACE in 4 seconds.	PL-18 is OFF PL-30 is ON			▲
7 □ ●	MSFS (FORCED DRAFT FAN RELEASE) THERMAL TRIP	THERMAL FUNCTIONING	PL-18 is OFF PL-30 is ON			
8 □ ●	ABNORMAL LOW BOILER WATER LEVEL SWITCH (LWR 1)	It WORKS FROM -- mm. AND LESS	PL-18 is OFF PL-30 is ON PL-2 is ON			
9 □ ●	BOILER WATER LOW LEVEL SWITCH (LWR 2)	It WORKS FROM -- mm. AND LESS	PL-18 is OFF PL-30 is ON PL-3 is ON			
10 □	ASP (LOW ATOMIZER STEAM PRESSURE SWITCH)	It WORKS FROM --Kg/cm2 and LESS	PL-18 is OFF PL-30 is ON			
11 □	LOT (LOW OIL TEMPERATURE SWITCH)	It WORKS FROM --Kg/cm2 and LESS	PL-18 is OFF PL-30 is ON	▼ FLAME CUT	▼ it SOUNDS	▼ NO REPETITIVE

□ ● : COMMON INTERLOCKING: for OIL and for GAS □ : INTERLOCKING USED for OIL ONLY

PL-18 : NORMAL INTERLOCKING LAMP PL-30 : FLAME CUT LAMP

PL-2 : ABNORMAL BOILER WATER LEVEL LAMP PL-3 : LOW WATER LEVEL LAMP

3.2 Gas Combustion

BOILER MODEL : FTN-30

No.	CONCEPT	OPERATION CONDITIONS	LAMPS	BURNER FLAME	BUZZER	CYCLE OF THE PROGRAM
1 □ ●	SPHR (NORMAL DRUM PRESSURE SWITCH)	-Kg/cm2 OPERATION -Kg/cm2 RESUMPTION	PL-18 is OFF	FLAME CUT	IT DOESN'T SOUND	REPETITIVE
4 □	GAS (GAS SELECTION SWITCH)	SELECTION	PL-18 is OFF PL-30 is ON		It SOUNDS	NO REPETITIVE
6 ●	FSG (UV FLAME VIGILANCE DEVICE) Pr-1 for GAS	SCANNER out of the FURNACE in 4 seconds	PL-18 is ON PL-30 is ON			
7 □ ●	MSFS (RELEASE of the FORCE DRAFT FAN MOTOR) THERMICAL TRIP	THERMAL FUNCTIONING	PL-18 is OFF PL-30 is ON			
8 □ ●	ABNORMAL LOW WATER BOILER LEVEL SWITCH (LWR 1)	It WORKS FROM -- mm. AND LESS	PL-18 is OFF PL-30 is ON PL-2 is ON			
9 □ ●	LOW BOILER WATER LEVEL SWITCH	It WORKS FROM -- mm. AND LESS	PL-18 is OFF PL-30 is ON PL-3 is ON			
12 ●	GPH (HIGH FEED GAS PRESSURE SWITCH)	It WORKS FROM --Kg/cm2 and MORE	PL-18 is OFF PL-30 is ON PL-__ is ON			
13 ●	GPHL (LOW FEED GAS PRESSURE SWITCH)	It WORKS FROM --Kg/cm2 and LESS	PL-18 is OFF PL-30 is ON PL-__ is ON	FLAME CUT	it SOUNDS	NO REPETITIVE

□ ● : COMMON INTERLOCKING: for OIL and for GAS

□ : INTERLOCKING USED for GAS ONLY

PL-18 : NORMAL INTERLOCKING LAMP

PL-30 : FLAME CUT LAMP

PL-2 : ABNORMAL BOILER WATER LEVEL LAMP

PL-3 : LOW WATER LEVEL LAMP

PL-__ : HIGH FEED GAS PRESSURE LAMP

PL-__ : HIGH FEED GAS PRESSURE LAMP

4. Desulphurization Plant and Treatment and Recirculation of Residual Water of Desulphurization

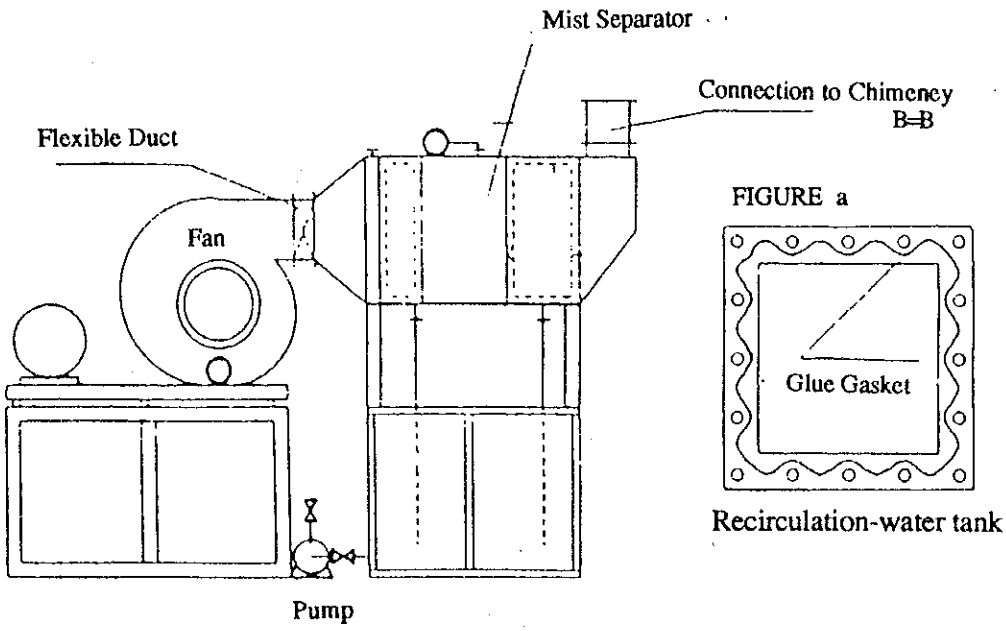
4.1 Assembly of Desulphurization Plant

(1) Level the fan and mist separator :

Assemble, joining A to A. (A = A) (16 pairs of nuts / bolts).

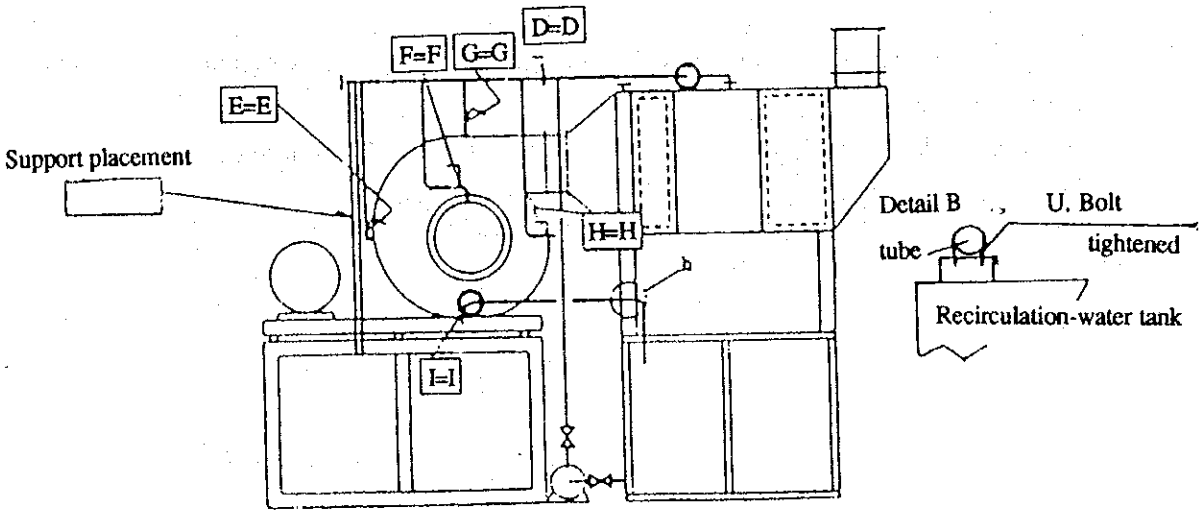
Note 1: Glue gasket using an adhesive agent inside the hole prepared for the bolt (See Figure a).
To cut the gasket, use a knife. (The gasket is of the soft bead sealing type).

Note 2: Level the fan and mist separator precisely.



(2) Pipe distribution and installation :

Assembly by joining the letters. Distribution and installation of pipes for the fan : D=D, E=E, G=G, H=H, I=I.



1) The support is fixed tightening the two sets of nuts/bolts from the inside. By fixed pipe, is fixed with the U bolts.

2) Ends are connected with flanges D=D and I=I.

3) Ends E=E, F=F, G=G and H=H are connected by tightening the joints.

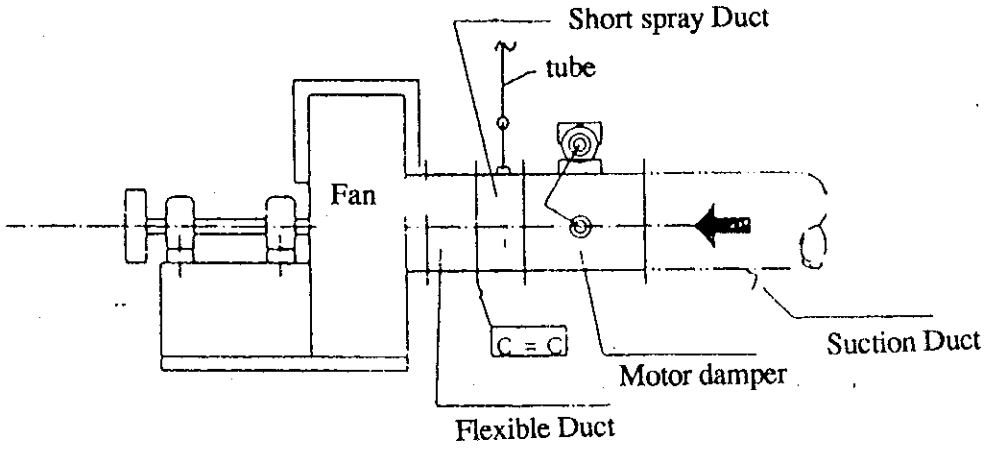
Note : After the full assembly tighten nuts and bolts. At the joints and flanges, be sure to place the gaskets. If (1) is not fitted correctly, pipings may not meet.

(3) Duct installation. Installation of C=C (16 sets of nuts / bolts).

1) Place the short side of the spray duct next to the fan.

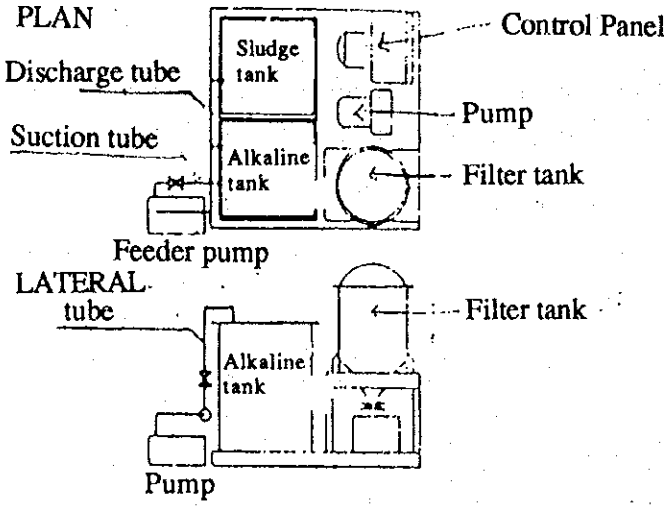
2) Set the gasket inside the bolt hole, just as for (1).

Note : Install the suction duct at the height and at the suction level of the fan, place a support, so there is no excessive weight for the flexible duct.



4.2 Treatment and Recirculation Plant for Residual Water of Desulphurization

(1) Installation of the feeder motor :

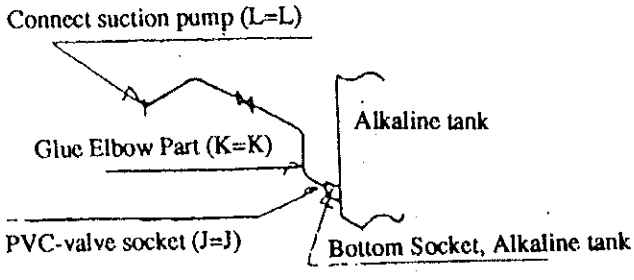


(2) Installation of suction tube :

1) Screw the PVC valve socket to the alkaline tank stainless steel socket, (J=J), (requires sealant material).

2) Glue PVC elbow (K=K)

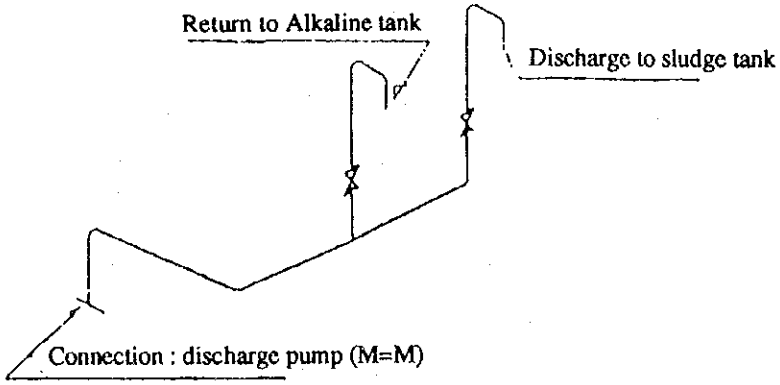
3) Place suction - pump flange (L=L)



(3) Installation of discharge tube

1) Place the pump discharge tube (M=M)

2) Place supports (4 points)

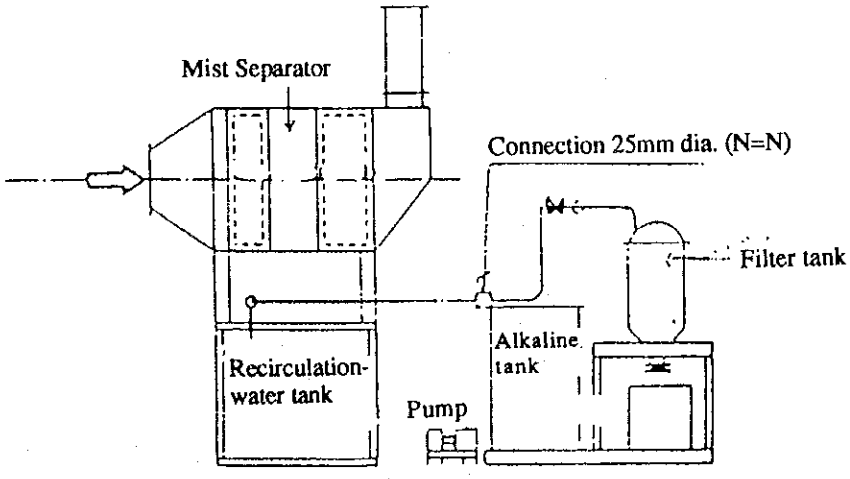


4.3 Pipe Installation for the Desulphurization Plant and the Residual Water Treatment and Recirculation Plant

(1) Pipe assembly for treated and filtered water.

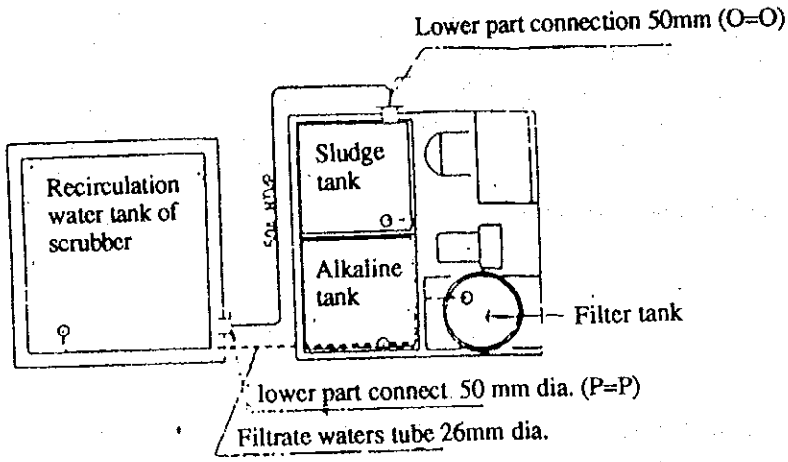
(1) Join connection N=N (Use gasket)

(2) The pipes are SGP and have 25 mm. diameter.



(2) Assemble connecting tubes between the recirculation - water tank of the scrubber and the sludge tank of the filter system.

1) Connect the recirculation - water tank of the scrubber and the sludge tank as below, with 50 mm. diameter flanges (thighten bolts carefully).



4.4 Placement of pH Electrode and Chemical-feed Pump Cables

(1) Place and method of pH electrode installation:

l) Place the metal hook in the pH electrode holder. Insert the holder into the sludge tank of the filter system, and hook it onto the tank edge. The hook should be put in a suitable height, in so that the electrode has no contact with the bottom of the tank.

2) (Attention) The tip of the electrode is covered with a black vinyl cap. This cap shouldn't be removed until the plant starts operating (until water is placed in the tank). After removing the cap, it should be kept, since when the plant operation is suspended for an extended time (when the tank is without water), it should be used again. In these cases, water should be put in the cap, and the electrode protected by the cap.

3) The electrode should be placed near to the filtrate suction pump, inside the sludge tank of the filtrate system (See Figure X, as reference).

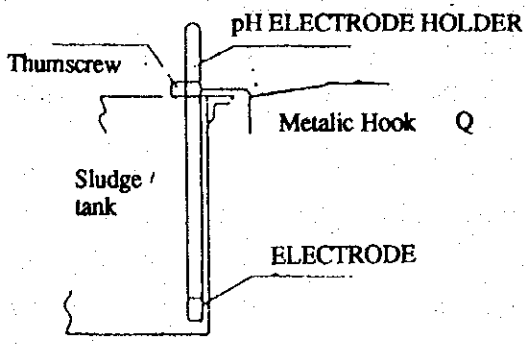
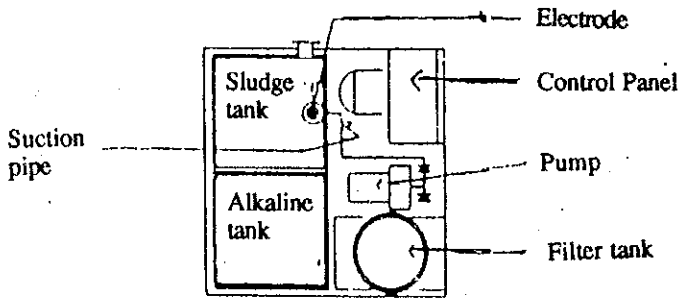
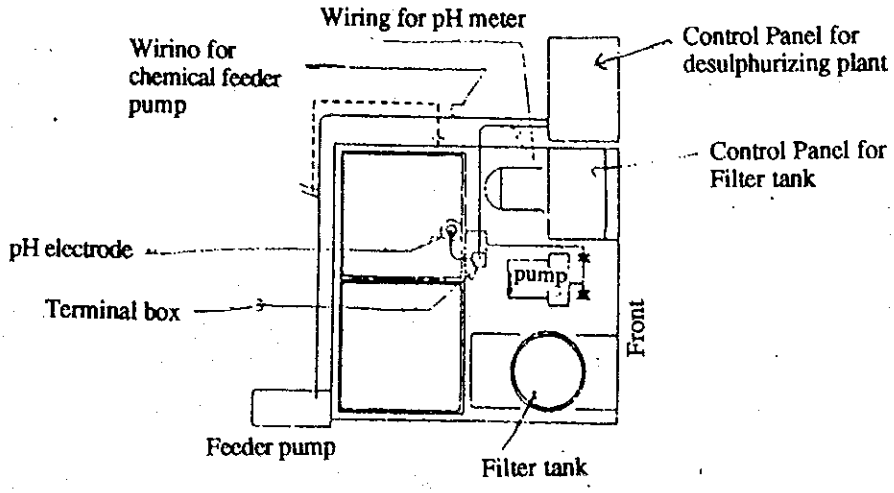

pH ELECTRODE HOLDER
Thumscrew
Metalic Hook Q
Sludge tank
ELECTRODE

Figure X


Electrode
Control Panel
Sludge tank
Suction pipe
Pump
Alkaline tank
Filter tank

(2) Wiring for the pH electrode and the chemical feeder pump



1) The pH meter and chemical-feeder pump are connected to the control panel of **the desulphurizing plant** by cabling.

2) The pH is connected by pH - electrode cable (5 meters are included in the equipment) with the terminal box (provided with desiccant, to protect against water) and then, with the special cable for the pH system, directly to the pH indicater - calibrator located on the control panel. The terminal box should be installed on a steel pipe or a steel angle close-by. [For the pH meter cabling, see the manufacturer's manual (Model : electrode SP 3311, indicator SH/62/2). Carefully cover (electrostatic shielding) the guide cable to terminal G of the special cable for the pH system. A poor coating can cause the meter to malfunction].

Reference: It is possible to connect the pH meter directly to the pH indicator on the control panel, with the electrode cable. In this case, the connection should be made so the electrode holder can be removed from the tank. (The special cable for the pH system is found on one side of the control panel).

3) The pH system cabling should be done in a separate tube, not in a multiple use tube

4.5 Others

l) Preferably, the connection between positioner EE (N-660) and the control motor (CM-300 P) should be done with armored cable, directly, without passing through the terminals. Cabling must be done independently of the wiring for the motive force.

2) For the cabling of positioner EE and the control motor, consult the manufacturer's manual (standard of connection diagram, Figure 6-1, 6-2, cable connections, etc).

3) Before operating the control motor, check if the damper opens and closes using the handwheel on the side of the motor, and make the necessary adjustments, such as tightening nuts and bolts.

4) Others

* Letters A=A ~ P=P are clearly indicated on the parts to be connected.

* Consult the operating manual, before starting up plant.

* With this, all connections are completed.

PART II MAINTENANCE MANUAL

1. Boiler

1.1 Body

(1) Cleaning

After a long and continuous operation, the boiler must be cleaned on its flue and water sides. Soot and fly ash adhered to the flue passages and heat absorbing surfaces will act as insulators retarding the transfer of heat, and sludge and scale accumulated in the water side will cause loss of heat transfer and corrosion as well. Be sure to clean boiler regularly.

(2) How to Cool Boiler After Operation

A complete blow-off of water for inspection and cleaning should be done in the following manner.

1) Leave the boiler for natural cooling off while keeping the damper fully open for cool air ventilation.
2) To expedite cooling for a need, repeat blow-off and water feed for several times while controlling the water level to stay within the range of the water gauge glass.
3) Do not attempt to drop boiler pressure rapidly by opening the steam valve fully in the beginning.
4) Keep the air vent valve open while blowing off. It is best to blow off after boiler pressure has completely dropped and the heat in the combustion chamber has gone.

(3) Soot and Fly Ash Cleaning

The FT Boilers are designed to speed up the flue passing for better combustion efficiency thus causing less soot adherence on the flue passages when compared with other conventional smoke tube boilers. Needless to say, soot adherence will greatly reduce boiler efficiency. Therefore, clean soot regularly after a course of operation. The cleaning interval, though it depends upon daily operating hours and boiler load, should be at least once every two or three weeks. Cleaning procedures are as follows.

1) Open the front access fully and brush off the soot in every flue tube thoroughly using soot brush.
2) Sweep off the soot on the tube plate and front smoke access with broom.
3) Open the rear access and rear side clean-outs and clean the soot on the tube plate and rear access.

4) Get into the furnace from the rear access to inspect the condition of the masonry and remove the carbon, if already adhered. Sweep off the soot on the corrugated furnace once every ninety to one hundred twenty days.

(4) Boiler Interior Cleaning

1) Cleaning interval

Scale and sludge must be cleaned to eliminate the loss of heat transfer, corrosion and damage by overheating. The maximum allowable interval for the interior cleaning will be that of the inspection by the local authorities who might require this cleaning for inspection. It is, however, necessary to clean boiler interior more frequently depending upon other factors such as feed water cleanliness, presence of water treatment equipment and steam consumption. It is advisable to inspect the interior within thirty or sixty days after starting operation in order to determine the appropriate interval for the future cleaning and to check if the present water treatment is acceptable.

2) Cautions when entering the water side of a boiler

Be sure to confirm there has been no pressure or vacuum pressure existing in the boiler before opening the manhole. Steam and water back flow from the pipelines to the empty boiler is very dangerous. Make certain, therefore, to shut steam and water pipelines by locking valves and cocks before entering. Do not enter boiler without checking the existence of fresh air ventilating and the lack of inflammable and toxic vapors in the boiler. Do not use ordinary breakable electric lamp. Be sure to use well insulated cable to avoid short circuit and leak.

3) Manual cleaning

Wire brush, scraper, chipping hammer, etc. are practical for manual cleaning. Be careful not to damage boiler, when descaling, by using tools that are too sharp or giving strong hammering shock. As scale is usually hardened when dried, it is wise to descale it while draining slowly. At this time, all the boiler accessories and pipings should be inspected and cleaned. If necessary, valves and valve seats may be scoured for a better fit.

4) Chemical cleaning

Chemical cleaning surpasses manual cleaning in efficiency and complete descaling. It has been remarkably developed in the recent years and will remove scale completely in a short time without giving any damage to the boiler when properly

applied. As to individual application, comply with the instructions prepared by the boiler compound maker.

a) Analyze scale sampled from boiler and determine type of chemicals and hours necessary for cleaning prior to application.
b) Dismantle unnecessary boiler accessories and blind some openings to prevent leak of chemicals.
c) Minimize the difference of temperature of chemicals and boiler water.
d) Provide some means to exhaust carbon dioxide and hydrogen which may be generated from boiler to outdoor where no danger exists.
e) Fresh water cleaning and neutralization treatment should be done after chemical cleaning has been finished.
f) Pay special attention, when chemical cleaning is being proceeded, to handling of chemicals, opening and closing of steam and water supplies, and fresh air ventilation into boiler and boiler room.
g) Inspect boiler interior thoroughly and pay extra care on the corroded part, if any, that has been found at the previous inspection.

5) Procedures after cleaning

Any findings by the inspection after cleaning should be recorded for the future operation.

a) Be sure to remove tools and other materials used for cleaning.
b) Clean the sealing surface of manhole, clean-out and inspection holes and their covers, and apply graphite on the packings and threads of bolts and nuts before closing.
c) Other procedures are according to the starting procedures.

(5) Preservation Procedure

It is important to prevent a boiler from rust and corrosion during a long operation suspension period. There are two methods of preserving boilers, and in either method, wet soot and fly ash must be cleaned from the furnace and flue passages when the suspension period is expected to be beyond sixty days.

1) Dry preservation

This method is applicable usually for a long suspension which may be continued over sixty or ninety days. Drain boiler water completely and clean the exterior and interior. Close water and steam supply pipelines and wipe off water drops in the boiler. Fire charcoal extremely low to dry the boiler interior. Then, place suitable desiccating agent in the boiler. When using calcium oxide as the desiccant, figure

out its weight at the rate of 0.3 kg lime to a cubic meter volume of the boiler interior(In case of calcium chloride, 0.1 kg to the same volume.) Desiccant should be served on trays. After this, seal boiler completely for preservation. It is recommended to examine the desiccant in the boiler at ninety days interval for replacement. Keep the flue passages dry with the fan and draft damper closed. In a long suspension, the furnace and flue passages may get moistened, and, therefore, it may be necessary to fire charcoal slowly occasionally. Apply some protective coating on the boiler exterior for a preservation of more than one year.

2) Wet preservation

This is applicable for a short suspension of less than sixty or ninety days, or for a long suspension where and when the other method is considered impractical. This method is to fill the boiler interior with alkalified water(to approx. 300 ppm) and leave it filled with all openings sealed. To alkalify water, use 0.7 kg sodium carbonate to a cubic meter water, or 1 kg sodium phosphate to the same. Clean the boiler interior and check up the boiler fittings completely. Fill the boiler with alkalified water and heat it adequately to let air and carbon dioxide melted in the water escape. When the water become cool, add water to fill the boiler. The water will splash out from the air vent valve when filled. Seal the boiler completely. The water must be kept cool to slacken corrosion because, when the water temperature stays between 60 and 80 Degrees Celsius, it will give the best spur to expedite corrosion. Do not use this method when and where the water is feared to be frozen. In this method, it may dew on the furnace and flue passages in the summer season and slow charcoal burning may be needed to keep boiler exterior dry.

3) Preservation for other boiler equipment

Give dry air spray to the interior of the main control cabinet to remove dust and moisture. Wrap integral parts of the control with oil paper. Give the burner a complete cleaning and apply rust preventive vaseline or grease on the main parts. Be sure to wrap it with oil paper. Apply grease or other rust proof coating on the metal surface of equipment where rusting is feared. Before restarting, be sure to check all the boiler equipment for defects and damage. Examine carefully the electrical equipment and see if all are kept well insulated. Manually rotate or move them, if possible, and give lubricant when necessary.

1.2 Chemical Feeder

An unforeseen accident might happen under maintenance work when you loosen or remove delivery side hose and pipe. Be careful to check the power source or if valves are open or

closed. When you treat the powerful chemicals or poisons, you should wear rubber gloves and protection mask.

(1) Daily inspection

1) Check for chemical tank level, and add chemical if short(Make sure to bleed air if the liquid level went down and the pump suck up air).
2) Check for leak at joints. If so, tighten the hose nut gradually. Too much tightening might damage the pump head and joint unit itself.

(2) Replacement of diaphragm

1) Diaphragm should be replaced when it is damaged. Broken diaphragm let the liquid leak and drip through the bottom hole of sub-ring. Generally a diaphragm last for 5,000 hours use.
2) How to replace
Remove 4 head bolts, then pump head. Turn the diaphragm counterclockwise and put off. For assembling, reverse the steps.

(3) Leaving idle for long periods

1) If the pump will not be used for long periods, take out the foot valve from chemical tank and immerse it into water. Then drive the pump for 30 minutes or so to wash the pump head and joints with water.
2) After leaving pump idle for long periods, the check balls often adhere to ball seats, that is, pump does not suck up the liquid. In this case, remove the joints and wash both check balls and ball seats.

(4) Others

1) If diluent is pumped, be sure to install a heater, since the diluent may freeze in the pump in cold weather causing damage to pump or tank.
2) Wash the inner sides of tank and foot valve every 3 months.

1.3 Mini-Blow

(1) Precautions

The following precautions must be strictly adhered to for correct operation of your Mini-Blow. As the precautions are useful in preventing accidents, strict adherence to them is definitely requested.

1) Operational precautions

a) Do not operate the Mini-Blow at a pressure higher than the maximum operation pressure.

b) Do not install a valve in the instantaneous flowmeter outlet pipe and apply pressure.

c) Do not set the relief valve at a pressure higher than the specified value.

d) Do not operate the Mini-Blow with the blow outlet water temperature exceeding 100°C.

e) Do not leave the blow water outlet master valve open during an extended stopping of the boiler.

f) Do not cause water to flow into the heat exchanger in the opposite direction of the inlet-outlet.

g) For commissioning, do not use high-temperature and high-pressure blow water for flushing of the pipes.

2) Maintenance and servicing precautions

a) Do not remove and install the lid of the body during a blow operation. Do not remove the sensor, thermometer or valves, nor clean the strainer during a blow operation.

b) Do not allow the equipment to freeze.

c) Do not leave the equipment during an extended stopping without applying a corrosion-preventive treatment.

(2) Maintenance and Servicing

1) Inspection and cleaning of heat exchanger interior

a) Close the blow water inlet valve to positively separate the boiler and Mini-Blow pipes.

b) Close the water supply outlet valve, and positively shut down the pipes to Mini-Blow.

c) Remove the water supply inlet and outlet pipes of Mini-Blow.

d) Loosen the flange bolts under the Mini-Blow body, remove the body and separate the body from the legs.

e) Check and clean the heat transfer tubes. The tubes cannot be removed.

f) Assemble the unit in the reverse procedure.

(3) Instantaneous Flowmeter

Periodically check and clean the indicator. Check cage tube and packings for damage and leakage. To replace the cage, remove the through bolts of the top and bottom flanges. Tighten the bolts evenly and slowly.

(4) Other Valves

Check other valves for leakage at normal operating conditions. Check them periodically and when a damaged valve seat is found, polish and repair it or replace it.

(5) Strainer

Periodically clean the metal strainer with the plug removed.

1.4 Forced Draft Fan

(1) Cautions on Resuming after Suspended Operation

An accident has often occurred when the operation was resumed without careful repairs made immediately after the suspended operation of the ventilator or without a check being made before its resumed operation on a mere presumption of its good condition before the suspension of operation and only a short-term stop of operation. The possible causes of any accident happening upon resumption of operation are listed as follows.

1) In case much dust sticking to the impeller gets moist, it tends to come off partially. The dust, limited in quantity, causes the impeller to be corroded partially, especially on the part of the impeller during the suspended operation.
2) The grease or oil in the bearings tends to deteriorate by weathering, and thus the bearings tend to be pitted. The grease loses its lubricating effect.
3) If the damper work is not checked or repaired before resuming the operation, excessive power, the breakage of the damper, etc. will occur at the re-start of the ventilator.
4) Partial changes tend to arise in various sections during a comparatively long stop of operation. Be sure to make a careful check on all the sections after suspending the operation and before resuming it. Check the ventilator carefully to keep its condition similar to or better than that before its suspended operation.

(2) Regular Check

Check the impeller and its interior once a month

1) The dust sticking to the impeller, if growing, causes the impeller to vibrate. Clean the impeller before the dust increases too much.

a) Cautions in operating the blower in a dusty place

i) The impeller of the blower installed in a dusty place may gradually or rapidly get unbalanced and increasingly vibrate when the dust sticking to it increases, and thus a large accident may occur. Be sure, therefore, to keep a regular record of the vibration of the blower installed in a dusty place and remove the dust completely from the impeller at the regular inspection thereon.

ii) Dust removing method and cautions

Remove the dust sticking to all the gas-contacting faces of the impeller completely with a wire brush, pallet, etc. The dust tends to stick on the rear faces of the plates and impeller blades, etc. on the rear faces of the plates and the impeller blades, etc. on the inlet side and accumulates more in the inlet(suction) side than the outlet side. The dust sticking to the said plates and blades is very difficult to remove. Clean the dust completely with full care to the abovementioned points.

iii) Check and inspection after cleaning

The dust may not be removed completely from the abovementioned places which are difficult to see and clean. Make a check on them with special care. Check whether any dust has been left on the impeller. Turn it gently by hand to check whether it stops naturally at an optional position(whether its static balance is good). Then check whether the dust falling into the casing has been completely removed and be sure the drain pipe is not clogged.

2) Check whether the runner blades and the main plate may partially or wholly be worn or corroded.

(3) General Cautions

1) Lubricating oil for bearing

Use the lubricating oil of specially fine quality. The following greases are used in the blowers at the delivery of them.

a) Oil for Ball Bearings and Cylindrical Roller Bearings: Unit Power FM68 (Esso product)

b) Grease for general use: Albania No.2(Shell product)

Use the equivalents to the abovementioned lubricating oils in case they are not available. Be sure to replace the grease completely. Never mix it with other manufacture's grease because the mixed greases may cause a chemical change.

2) Cautions on replacing lubricating oils

a) Oils

i) Replacing interval

Replace the oil initially poured in at the delivery completely with new oil 700-1,400 hours (1-2 months) after the start of operation.

ii) Oil supply

An oil gauge is attached to the bearing case. The middle between the upper and lower limit lines of the oil supply indicates the optimum oil supply. The oil may leak from the shaft section when it comes over the upper limit line, resulting in overheating the shaft. When the oil falls below the lower limit line, the oil shortage may cause the seizure of the shaft. Pay full attention to the oil level in the gauge.

b) Greases

The grease replacing interval depends on the operating condition at various plants. When the overhauling interval of the equipment is longer than the grease replacing interval, supply grease at appropriate intervals. Pay attention to the following points.

i) If the oil is supplied in quantities at one time and the number of times of oil supply is reduced, the bearings are overheated or continuously heated at a high temperature and, as a result, the grease replacing interval is shorted.

ii) The failure in supplying oil periodically may cause bad bearing sound, abnormal wear, burning of bearing and other dangers. Conduct good maintenance and control of the equipment.

iii) An overheating or long continuous heating of bearings may occur after the grease has been supplied. This is due mainly to the excessive supply of grease at one time or the grease discharging port being clogged with the old grease. In this case, remove the grease clogging the grease discharge port to enable the unnecessary grease to be discharged. Incidentally, the trouble as mentioned above may occur when grease is supplied during the stop of operation.

1.5 Water Softener

(1) Main Body

It is advisable to open the manhole or top end cover at least once a year and take out the ion exchange resin so as to inspect closely the inside and to find out if any coating there has come off. Inspect, at the same time, the equipment inside to see if any damage has been done to them, including damages and clogging of the BD strainer. Any damage could cause a leakage of the hardness constituents into the treated water or the ion exchange resin flow out. Accordingly, a very close inspection is required. Detached coating and damages to the equipment inside should be repaired as thoroughly as possible.

(2) Ion Exchange Resin

The water softening capacity of ion exchange resin becomes deteriorated by the following three causes.

1) Crushing of the resin

Ion exchange resin becomes crushed after an extended period of time. At the time of backwash process, such crushed resin gathers on the surface of the resin tank, not only increasing the pressure losses during the water collection, but clogging the internal device. Accordingly, such crushed resin must be removed. In this case, scoop up and take away the crushed resin on the surface of the resin layer and replenish the ion exchange resin.

2) Oxidation by an oxidizing substance

If raw water contains oxidizing substances such as free chlorine, ion exchange resin is oxidized and becomes swollen. In a worse condition, it is impossible to use the resin(Pay particular attention to water supply). In the case of such raw water it is necessary to have pre-treatment equipment.

3) Defective ion exchange by contaminant

If raw water contains contaminant, it deposits on the surface, or in the grains of ion exchange resin, blocking the ion exchanging action. In this case, it is necessary to wash the ion exchange resin.

4) In a normal case, about 5 to 10 % of ion exchange resin is replenished annually. If ion exchange resin was used for an extended period of time, the capacity is reduced. It is more advantageous to have the entire resin replaced.

(3) Acid Cleaning of Ion Exchange Resin

If ion exchange resin is contaminated as mentioned above, acid cleaning should be carried out in the following manner.

1) Take out the ion exchange resin in an acid-proof container, immerse the whole resin in 5-10 % HCl solution, and, after stirring well, leave it standing for more than 24 hours.

2) Drain the HCl solution and, after neutralizing the resin with 5 % NaOH solution, wash it with water.

3) After washing, put the resin in the ion exchanging tower, backwash it and regenerate it with twice the prescribed amount of salt water. After completing the regeneration process, collect the soft water.

4) If raw water contains iron or organic matter, it is necessary to have a separate treatment.

(4) Raw Water Quality

If raw water contains more than the prescribed amount of hardness constituents, the amount of collected water is decreased or quality of the soft water is declined. It is necessary, in this case, to consider increasing the amount of resin as well as the amount of regenerating chemicals.

(5) Ejector

Due to the following causes, the ejector could not have a regular suction force. It is necessary to take an appropriate measure against each case.

1) Insufficient water drive pressure

The minimum driving pressure of the ejector used in the water softener is 1.5 kg/cm^2. Insufficient raw water pressure cannot provide adequate suction force to the ejector. It is necessary to check the raw water pressure with the pressure gauge.

2) Clogging of the ejector and strainer

In dissolving the salt, foreign substances may sometimes enter, clogging the nozzle of the ejector as well as slits of the strainer. Avoid such clogging, but if it occurs, thoroughly clean the clogged part.

3) Air suction

If air is sucked during salt water injection, the operation will not proceed smoothly. Check for any cause of air suction along the suction line. Specifically, examine the suction cock.

(6) Single Control Valve(SCV)

The structure of single control valve is so simple that no regular handling causes trouble. But mishandling could inflict damage to it. Accordingly, pay attention to the following points in handling.

1) Always set the pointer to one of the processes. Do not leave the pointer at midway between the 2 processes.

2) Always observe the direction of arrow in turning the handle of the SCV. Turn the handle only after checking with the pressure gauge that the pressure inside the water softener has dropped(If the handle is turned with force under the pressure, the rotary plate and shaft inside the SCV may be damaged, causing trouble. Attention must be paid to this point.).

(7) Moving of a Water Softener

A water softener should be moved as it normally stands. Do not place the water softener on its side or suspend it upside down, as it may damage or cause trouble in the inside devices and other parts.

(8) Allowable Raw Water Qualities and Pretreatment Methods

Constituent	Allowable limit	Pretreatment method
Turbidity	2 degree or less	Filtration
Iron	0.3 ppm or less	Removal of iron
Manganese	0.3 ppm or less	Removal of manganese
Potassium permanganate consumption	10 ppm or less	Actuated carbon filtration
Free chlorine	0.3 ppm or less	Actuated carbon filtration

1.6 Economizer

(1) Cleaning inside of glass tube

Periodically check the inside of each heat resisting glass tube at intervals of six months, and give a cleaning if necessary.

1) Cleaning of slime or algae
   a) Cleaning chemical : Hydrogen peroxide(H_2O_2)
   b) Concentration : More than 6 %
   c) Volume : One and half times as much as total volume of economizer
   d) Cleaning hour : Half an hour
   e) Temperature : Normal temperature

2) Cleaning of synthesis scale such as iron oxide and calcium carbonate
   a) Cleaning chemical : Acid cleaning with hydrochloric acid
   b) Concentration : 5 %. It is advisable to add 0.3 % inhibitor to prevent header and tube from corrosion.
   c) Volume : One and half times as much as total volume of economizer
   d) Cleaning hour : One hour with the solution heated at 60°C 2 hours at normal temperature

3) Note
   a) After the cleaning, the glass tube should be sufficiently flushed and washed. Or otherwise, remaining impurities may be mixed in the feed water to the boiler, thus causing corrosion or giving damages such as on or to the boiler's water tubes.
   b) The volume of water contained in any glass tube is 1.5 ℓ/m. The total volume is determined from the tube length and the number of tubes.

1.7 Compressor

(1) Maintenance and Inspection

For the effective and extensive use of the compressor, routine servicing is essential. Based on the operation time counter, conduct the routine servicing complying with the list shown in next page.

Check items	Procedures/measures	Check/shakedown time				Remarks
		Daily	Every 250 hrs 1-month	Every 3000 hrs 1-year	Every 6000 hrs 2-years	
Draining	After completion of a daily job, drain the air tank.	○				
Confirm operation of checking pressure gauge solenoid valve and safety valves	Check operation status.	○				
Abnormal vibration noise	In the event of any abnormality, check compressor for installation method.	○				
Loose bolt, screw, nut.	Tighten them standard wrench or screwdriver.		○			
Slack or frayed belt	Replace frayed belt, and sidle the motor for slack belt.		○			
Stained or clogged suction and crank case filter element	Clean and blast with blush and so on, both inner and outer of the filter.		○			
Anti-vibration rubber	Check installed height of anti-vibration rubber.			○	●	◎
Air valve leakage	After leaving compressor under the maximum pressure for 30 minuets, make sure that the pressure drops within 20%.			○	●	◎
Piston ring	Check the air tank for charging time and the piston ring for radial thickness.			○	●	◎
Rider ring	Check the rider ring for a decrease in radial thickness due to abrasion.			○	●	◎
Ball bearing	Check the ball bearing for rotating condition and for grease leakage.			○	●	◎
Needle roller bearing	Check the needle roller bearing for rotating condition and for grease leakage.			○	●	◎
Unlodar piston	Check attrition at engaging part and grease deterioration.			○	●	◎

Note) 1. ○ indicates the hours after a start-up or replacement and ● the time to replace parts.
2. Inspection/maintenance cycles specified in table above apply when the compressor is operated under standard conditions(in terms of temperature, humidity and the like.) and may vary on a case-by-case basis. Under severer working conditions, shorten the inspection/maintenance cycles accordingly.
3. ◎ for inspection/maintenance, entrust supplier service station nearest.
4. If the installed height of anti-vibration rubber is 32-34 mm, they shall be replaced by new.

(2) Precaution for Maintenance and Inspection

1) Piston ring and rider ring check(every 3,000 hrs.)
   a) When checking these rings, even if one of them is found worn out, they should be replaced by new.
   b) When thickness of piston ring and rider ring is checked and measured, result of the measurement should be recorded in check and servicing record chart as a referential standard for subsequent replacement.
   c) Replacement interval shall be 6,000 hrs. under normal use, and should not exceed 8,000 hrs. in any case.

2) Bearing check
   a) For all bearings, a sealed type bearing, sealed with heat resistant grease, is used. When frictional rotation or unusual amount of grease leak is discovered, the bearing should be repaired.
   b) bearing and oil seals should be replaced every 6,000 hrs. under normal use, and this limit should not be exceeded at all events.

3) Check if belt tension is adequate, if not, adjust the tension.

4) Check if any deviation or offset from the contour or V groove of both compressor and motor pulleys is discovered.

5) If the tension of V-belt is too much, the life may decline, prevent it from tightening too much.

6) Since accretion of foreign matters such as oil, chip to V-belt may decline the service life, particular attention should be paid to this point.

7) When operation of unloader piston is frequent, checking and servicing interval should be shortened.

8) Retrofitting such as direct welding of angle joint to air tank is strictly prohibited.

9) When the compressor is not operated for an extended period, grease life may decline because of moisture. To avoid this, the compressor should be idled for 30 min. once a month. In addition, the following items should be observed to prevent the compressor from becoming inactive resulting from corrosive effect.
   a) Operate the compressor every 6 months under the conditions.
      i) No-load running for 10 min
      ii) Check control pressure by boosting compression.

iii) Then, operate another 10 min. without load, and stop operation.

b) The compressor should be stored in a place where humidity is low and it is protected against dirt and dust.

1.8 Burner

(1) Precautions

A person in charge of oil combustion shall operate paying full attention to the above-mentioned. Otherwise, he will cause a grave accident such as the explosion fire. The items for a person in charge to pay attention to are as follows.

1) He must be well acquainted not only with the entire equipment but also the condition of piping.

2) If an oil leak is discovered, apply a saucer or a can immediately and report to the responsible person without delay for repair.

3) Always pay attention to the oil strainer, change it over from time and fully clean it.

4) When extinguishing the burner, never fail to close the oil valve at the burner inlet, steam valve and main valve.

5) When igniting the burner, always feed steam first to fully eliminate drain, then, ignite the pilot burner and check that it is fully burning.

6) Periodically feed oil to the air fuel ratio arm and to the moving portion of the air damper bearing.

7) If the fixed screw at the air fuel ratio arm joint is loosened, it will make not only the air fuel ratio arm disordered but also the control impossible, thus, it is necessary to periodically inspect whether the screw are loosened or dropped.

8) When the combustion condition of the burner is bad, extinguish it at once, look for the causes and perform re-ignition after the improvement thereof.

9) Never leave combustibles near the boiler or the oil tank.

10) After the extinguishment, since the burner end is heated, soak it in such as treated oil for a while to reduce the temperature, then, perform the disassembly and cleaning.

11) Before igniting, exhaust the gas the furnace, and if the ignition is not successful, extinguish it first, then, after fully removing the gas inside the furnace, perform the re-ignition.

12) If the light receiving surface of the flame eye is dirty, it will cause the malfunction, therefore, inspect it periodically.

13) When drain is mixed with the steam for atomization, the atomizer will become extremely bad at low combustion, which not only has a great influence on combustion but also cause combustion to loose stabilization, resulting in mis-ignition.

14) When the burner is extinguished, there is residual oil in the piping from the supply side solenoid valve to the inside of the sprayer, which will cause oil dripping and make the swirler dirty, the oil dripping in the furnace burning and likely to generate gas. Therefore, never fail to drain oil.

15) In order to continue proper operation of the combustion equipment, check and measure in a fixed interval whether it is operated at a specified pressure and temperature.

16) Since the dirty atomizer end will make atomization defective and cause accidents, observe the combustion condition periodically. When an abnormality is recognized, immediately replace it with a clean one.

Further, check for an abnormality of combustion condition, observing the inside of the furnace and the neighborhood of the fire hole in a fixed interval.

(2) Maintenance

1) Replacement method of the sprayer

a) The sprayer can easily be removed by loosening the yoke mounted on the carrier and the clamp screw of the clamp.
b) The atomizer and the cap nut shall always be serviced together with the sprayer to be ready for replacement at any time.
c) The atomizer shall be incorporated into the sprayer in a correct way and fully be tightened.
d) The sprayer mounted with the proper atomizer and the cap nut shall always be kept handy to be ready for replacement at any time.

e) The sprayer shall be removed from the burner carrier, immediately be turned upside down and be pulled out of the housing tube, preventing the oil from dripping down.

f) The check housing installed will close the hole when the sprayer is removed, preventing the gas from blowing out.

g) It shall be checked whether there is anything abnormal with the burner carrier packing, and whether the contact surface is clean and free from flaws. It shall be so equipped that the burner carrier packing and the sprayer will well conform each other.

h) The sprayer shall be at the specified position, and the yoke and the clamp screw of the clamp shall not be fixed until after checking that the contact surface is well fitted so as to prevent the oil from leaking from the joint.

2) Replacement of the atomizer and the cleaning method

a) Usually, the atomizer shall be cleaned once in 2 weeks even if nothing abnormal is recognized in the combustion. Combustion condition and the related measuring instruments shall periodically be checked, and should anything abnormal be recognized in the combustion, first, the atomizer shall be disassembled, inspected and cleaned. Further, when removing the atomizer from the sprayer, the disassembly tools delivered shall be used.

b) When inspecting and cleaning the burner, the burner cap shall be loosened by the wrench provided, paying careful attention not to drop or damage the atomizer.

c) It will be sufficient to wash the atomizer and cap nut in paraffin oil. The fixed carbon cannot be removed as it is, nor even soaked in paraffin oil for a long time, but can be removed by means of a bristle brush. Never use sandpaper, steel wire, scraper. etc.

d) The sliding surface of the sprayer and the atomizer shall be cleaned. It is not necessary to apply undue force when the cap nut is screwed in. On the occasion of this work, it shall be checked that the atomizer is correctly equipped in the cap nut.

e) During the initial operation after the boiler is newly installed or the piping is revamped, dirt and the other objects in the newly installed equipment or the piping are often carried up to the atomizer to clog it. Therefore, it is necessary to pay special attention to the combustion condition and to perform the frequent cleaning.

2. Exhaust Gas Treatment Facility

2.1 Blower and Fan

(1) Impeller

1) If the vibration of impeller increases more than installation, it is necessary to adjust the balance, especially at high speed rotating (more than 3,000 r.p.m).

2) If something foreign material adheres on the impeller, it should be thoroughly removed and cleaned also on the mount of small impeller.

3) Since such abnormality that small impeller wears out and corrodes, welding of the mount corrodes, tack loosens and head of tack wears out, can cause accident, check and repair them.

(2) Lubricating Oil for Bearing

Oil and grease must be replaced at degradation, and the quality and quantity must be also kept properly.

(3) Others

1) Since joint of bearing such as leather or rubber wears down, the abrasion state must be checked.

2) The new V-belt gets loosen, especially after it is replaced. The new V-belt must be adjusted after one month operation, and after that it should be checked regularly.

2.2 Pump

(1) General Suggestions

1) Check to see if the pump is running smoothly with no abnormal vibration.

2) Check the water level of the suction basin and the pressure at the suction inlet.

3) Compare the actual values of the discharge pressure and current during operation with those specified on the name plates of the pump and the motor, and check the operation load of the pump.

4) Be sure that the indication on the pressure gauge is proportional to the specific gravity of the liquid to be handled.

5) The gauge cock for a pressure gauge or vacuum gauge should be opened only when it is used for measuring, and closed after the measurement. If left open, the gauge may break down due to water hammer or other abnormal pressure. Measure pressure of dirty water through the medium of a water-containing U-tube (in case the pressure is lower than 1 kg/cm^{2}G (70PSIG) or by using a diaphragm type gauge).

6) Exercise particular care after changing the packing. Check for heating or leakage of the stuffing box.

7) If you have a reserve pump, trial-run it every so often to be sure of its use for emergencies.

(2) Checking of Bearings (of Oil Lubrication)

1) Check the volume of oil during the operation by means of the oil gauge. If the oil level is too low, replenish the oil. Renew the oil completely after the first 200 hours of operation. Wash the interior of the bearings and ball bearings with thinner or the like at intervals of 4,000 hours of operation thereafter and change the oil.

2) For lubrication use ISO. VG 46. turbine oil, with a viscosity of 35 CS (at 50°C)

(3) Checking of Bearings (of Grease Lubrication)

1) Intervals for grease change vary with the time of operation per day, the size of ball bearing, the number of speed. If there is no possibility that water or dust may enter the grease, changing once a year will be sufficient. To change the grease, remove the bearing cover, wash off the old grease and then fill the interior of the ball bearings with fresh grease. When a pump which has not been used for a long time, try and turn it by hand. If it turns smoothly, it will function properly. If it feels stiff or a hard sound occurs, it may be due to solidified grease. In this case, renew the grease.

2) There are many kinds of grease, and the life of pump will be greatly affected by the grease selected. The following kinds are recommended: cup grease, barium grease, lithium grease.

3) Fill one side of the ball bearing with grease by means of a pallet (metallic pallet) or your finger. If the bearing is filled with too much grease, the bearing temperature will rise higher than normal, which will cause bad effects. Grease should be applied to the sealed part of the shaft in order to prevent dust or foreign matters from entering the machine.

(4) Checking of Stuffing Box

1) After the renewal of packing, check the stuffing box every now and then. When the packing fits, the checking can be performed at longer intervals.

2) If no liquid leaks through the packing gland, slightly unfasten the bolts of the packing gland.

3) If the pressures in the stuffing box is placed on only one piece of packing, the shaft may wear abnormally. In this case, remove the packing and refill it more properly.

(5) Maintenance for a Long Period without Operation

1) In case the pump is to rest for a period time (even for a short period), be sure to empty the water by opening the drain cock or plug, or the pump may break due to freezing of water in a cold area.

2) When the pump is to rest for a long period, remove the packing, dry it, soak it with grease, and refill the stuffing box properly to prevent the part from rusting. Be careful to protect the bearing and finished surface of the shaft and coupling from rusting.

2.3 Digital pH Meter

(1) Calibration by standard buffer solution

Electromotive force of electrodes is calibrated with pH standard buffer solution. This operation is necessary to perform pH measurement stably and precisely. In case of installation or exchanging of electrodes, and in operation 1-4 times/month, this operation should be performed.

(2) Exchanging electrodes

When the electrode is deteriorated or damaged, exchange it for new one. Remove off the bad electrode from the holder and exchange it.

(3) Cleaning electrodes

When a dirty adhere to glass bulb, wipe out with dilute HCl solution or alcohol, etc.

(4) Exchanging the liquid junction

Erratic readings from an electrode system or malfunction of span adjustment can result from a clogged liquid junction. In case of it, remove off skirt. And then remove packing

and ceramic junction with screw-driver making much attention not to clack the glass bulb, and exchange it.

(5) Refilling internal electrolyte

1) Remove liquid junction and wash inside reference electrode.

2) Place the body in inverted position.

3) Fill electrode with about 30 mℓ of saturated KCl solution, and add KCl crystal slowly stirring and agitating with a clean inert rod (plastic, wood, silver etc.) to work entrapped air out of slurry.

4) Continue to add KCl crystal and saturated KCl solution until slurry is formed that fills tube to within one-half of the top. Removed as much entrapped.

5) Removed as much entrapped air as possible by tamping and stirring slurry and fill electrode completely.

6) Insert liquid junction into center glass tube allowing excess filling solution to spill out.

7) Remount skirt on the main body and tighten it (O-ring seal).

3. Automatic Flue Gas Monitoring Devices

3.1 Automatic NOx Analyzer

(1) Routine Maintenance and Check-up

1) Primary filter

Check every month and replace with new one when the filter is blocked by dust and mist (cleaning in not accepted).

2) Secondary filter

Check visually every week. When the contamination is heavy, replace. A Teflon filter paper is better for the NOx measurement and a glass fiber filter paper may be used for only the NO measurement. 70 ø PF020 (Teflon) GA-200 (glass fiber)

3) Sample flow rate

Check that the sample flows at about 1 ℓ/min. If it is lower than ℓ/min., set with the flow rate setting valve at the specified rate. If the gas connecting part of the flowmeter is stained, clean it.

4) Dehumidifier

Check if the lamp goes on and off. If it does, the temperature is as specified (2±1°C). Clean sometimes the filter (right side).

5) Converter temperature

Check the temperature. The precise temperature measurement is not needed as a routine check-up, but check to see that the converter is heated. The temperature measuring terminals (CN15-5,6) are provided in the converter unit. The output is DC 13.45 mV at 330°C.

6) Zero and span check

Once a week as necessary.

7) Standard gas cylinder pressure check

Replace the cylinder when the pressure is about 10 kg/cm^2. When replaced, be careful about gas leak. Be sure to check it (with soapy water, etc.).

8) Draining

Daily by opening the drain cock, once a week.

(2) Periodical Maintenance and Check-up

1) Diaphragm pump

Replace once in 6 months. Diaphragm, gasket, valve.

2) Air filter for ozone

Check the contamination once in 1~3 months, and replace. Glass filter 40 ø GA-200

3) Sampling pump

Replace once in 6 months~1 year. When the suction power dropped, first clean the diaphragm valve (or replace it). Diaphragm & valve for GA-480

4) Active carbon cylinder for zeroing

Replace once in 6 months. When replacing, clean the sponge in the active carbon tank.

5) Guard filter for ozone and sample

Clean once a year or replace. SUS316-100μ.

3.2 Automatic CO and SO_2 Analyzer

(1) Sampling System and Flow Path Control Unit

1) Primary filter and sampling tube
   a) Check the state of stain and clogging. When sample gas does not flow at above 1 ℓ/min. even if the needle valve is opened fully, clean or replace.
   b) Clean with compressed air(pressure of above 3 kg/cm^2), steam, organic solvent, acid, etc.(with the sampler and sampling tube off).

2) Drain separator

Open the valve for draining.

3) Mist catcher

Replace when the inner wall of the tubing around the mist catcher outlet is stained white.

4) Sample gas filter

Check the state of stain and dust, and replace when it is unfavorable.

5) Sample gas pump

a) The flow rate is to be above 1 ℓ/min. Replace the valve and diaphragm when sample gas does not flow at above 1 ℓ/min. even if the needle valve is opened fully.

b) Check for irregular sound. Clean the valve if the vibrating sound of the diaphragm cases at times when the sample gas filter is replaced.

c) Check if the pump stops when the flow path changeover switch of the electric control unit is set to zero or span (When zero or span gas does not flow, the flow is 0 ℓ/min.).

6) Flowmeter

Adjust to about 0.7 ℓ/min.(both zero and span gases). Adjust zero gas with the needle valve for regulating zero gas flow, and span gas with the needle valve of the pressure regulator.

7) Dehumidifier

a) Check temperature regulation. Make sure that the power lamp goes on and off at constant intervals.

b) Clean or replace the fan filter

8) Guard filter

Check the state of stain and dust. Replace when it is unfavorable.

9) Zero gas pump

The flow rate is to be above 1 ℓ/min. Clean or replace the valve and diaphragm if zero gas does not flow at above 1 ℓ/min. When the needle valve is opened fully.

10) Zero gas filter

Check the state of stain and dust. Replace when it is unfavorable.

11) Trap

Open the drain cock for draining.

(2) Analyzer

1) Constant temperature oven

Make sure that pilot lamp of the electric control unit goes on and off.

2) Zero and span calibration

a) After checking the amount of zero and span drift in accordance with "Instruction Manual", make calibration.

b) After calibration, record the values of zero and span.

3) Span gas

a) After calibration, record the gas pressure in the cylinder. When automatic calibration is not conducted, close the primary cock of the cylinder after calibration and remove any residual gas in the pressure regulator.

b) Check the piping for gas leakage in accordance with "Instruction Manual".

(3) Others

1) Recorder

a) Check if the recorder is working properly and if its record corresponds with the meter indication within 2 % of error.

b) Replenish chart paper and ink.

3.3 Automatic O_2 Analyzer

(1) Gas Flow Rate

It is necessary to check the sample gas flow rate once a day. The sample gas flow rate changes if piping is clogged or if the pressure of the sample gas changes substantially.

(2) Operation

Check, from time to time, that the "Ready" pilot lamp flickers.

(3) Calibration

Carry out calibration with the standard gas once every other month by the procedure shown in "Instruction Manual".

3.4 Automatic CO_2 Analyzer

(1) Secondary filter

Check the contamination of secondary filter visually every day. If found, replace with new one.

(2) O-ring

Check the crack and leakage of O-ring visually every month. If found, replace with new one.

(3) Exhaust vinyl tube

Check the blockage on the way every day, and repair or replace after visual check.

(4) Calibration

Read the shown value on the span gas cylinder. Carry out calibration with the standard gas once every week by the procedure shown in "Instruction Manual".

Table of Inspection of Combustion Test Plant

Place of Inspection	Cycle	Inspection Item	Procedure
Boiler			
1. Pressure of boiler	Constant At any time 1 day or 1 week At any time	1. Reading. Pointer Movement. 2. Surface temperature. Leakage. 3. Initial and stop temperatures of pressure controller. 4. Particularly take care to popping pressure at operation of the safety valves.	1. Smooth moving without catching. 3. See "Pressure restriction devices". 4. Check disorder by comparison with pressure gages of three or more.
2. Water level of boiler	Constant 1 hour At any time	1. Movement of water level of a water gage. 2. Normality of water level at start and stop of the feed water pump. 3. Special care must be taken to the working at a lower and higher level alarm.	1. A little movement of the water level is normal. If the hole is clogged, the movement becomes dull. Compare the water levels of two water gages which the height changes. 2. A detection by bellows vary with the level and the operation range by fluctuation of pressure. When the pressure goes to higher, the level goes to down and the operation range comes to wider. Check the operation level and range in an average pressure. 3. Find out the cause and take a countermeasure. (See "Water column" and "Automatic feed water adjustable device. Low level breaker. High and low water level alarm").
3. Combustion state	Constant 1 hour Constant	1. Change of burning sound 2. Shape and color of flame 3. Generation of smoke and its time	1. Take care to abnormal sound at the start of combustion and during the switching from low to high. 2. Proper flame without touch to furnace and with no rough particle. 3. Check the internal pressure of furnace, exhaust gas analysis and the quantity of air and oil. Care must be taken to long time operation under a low load.
4. Gage glass	Constant At any time 1 hour	Check of gage glass. Open a drain cock, close a steam cock and blow out water sufficiently. And then close the water cock, open the steam cock, check the steam side, then close the drain cock, open the water cock and watch forcible rising of water level.	1. Make sure the open and close condition and any leakage of each cock. Clean the inside. 2. Repair to any leakage from the end of glasses,. Check a disorder of the mounting core of the upper and lower cocks and the length of glass. 3. Clean the glass. Use a predetermined length of glass if exchanged. Take care not to tighten too much the glass. Namely, first, open the drain to warm with steam and close the drain cock. Open the water cock and open fully the steam cock. After use a little, do retightening.
5. Water column (floatless)	1 hour At any time	1. Drain water in the column and remove sludge scale. 2. Built-in water level detector. Inspect the electric wiring terminal, any contamination of the insulation of the electrode holder, contamination and crack of the electrode.	1. Make sure the open and close condition of the interconnecting line and clean the inside. 2. Check the electric wiring(heat resistance wiring). Measuring of insulation resistance-remove the wiring for the electrode holder and the resistance between the electrode and the earth shall be more than 100 MΩ. Cleaning of electrode. Clean contamination of the electrode holder, check any crack or exchange it.
Accessory of the body			
1. Automatic feed water adjustable device. Low level breaker. High and low water level alarm	1 hour 1 hour At any time At any time At any time	1. Purge scale and sludge in the interconnecting pipe. 2. Make sure the operation with lowering of the water level by blowing. 3. Check the internal mercury switch and bellows. 4. Check the electric wiring. 5. Check a wrong operation due to vibration.	1. Make sure the open and close condition of the inter-connecting line. Clean the inside (blow enough) in a condition of lower pressure if possible. 2. Make sure the operation with blowing. If impossible to blow, remove the electric wire to make sure the operation (burner cut). 3. Check a scattering of mercury and balance. Check leakage from the bellows. 4. Check damage due to heat. Rewire with a heat resistance wire. 5. Mount a stay in a change operation.

1. Automatic feed water adjustable device. Low level breaker. High and low water level alarm	At any time	6. Check contamination, crack and leakage of the electrode holder.	6. Replace the cracked and leaking insulator with a new one and clean the electrode. Insulation shall be more than 100 MΩ.
2. Flame detector	1 day or 1 week	1. Make sure fire going-out, no-ignition and burner cut.	1. Stop an ignition fuel for detection of the pilot and make sure not to transfer to the main. For detection of the main, remove the cap or the detector and make sure no ignition. A flame response delays for 2 to 4 seconds.
	At any time	2. Check the degree of fatigue of a detector.	2. Measure the current by a microammeter, test by a false flame.
	At any time	3. Detect of electric wiring. Influence of induced current of power.	3. Change to the sealed wire or a single wire.
	At any time	4. Detection of false flame. Self-discharge. Check by a protect relay, no ignition.	4. Check mistake to detect red heat refractory and change the position of installation. Inferior tube shall be replaced.
	1 day or 1 week	5. Contamination of lens and glass tube and mounting position.	5. Cleaning of contamination. Stop down it when excessive current is detected(the life be shortened).
	At any time	6. Check + or – phase of the electric wiring and loosening of connection.	6. Change the wiring and tighten it.
	At any time	7. Check the amplifier and the flame rely.	7. Replace the defective. If current is normal in measuring current by a microammeter but fire is not ignited, the amplifier or the flame relay are defective.
3. Pressure restriction device.	At any time	1. Check the operation stop pressure and the setting of differential gap.	1. Clean and check the siphon pipe, meter cock and detective part of the bellows. Change the setting of differential gap.
	At any time	2. Check leakage and concave in the bellows of the detector. Check the mounted position and orientation.	
	At any time	3. Check the two step setting valves for control of high and low-off.	
	At any time	4. Check damage of the electric wire.	4. Inspect and replacement.
4. Pressure controller	At any time	1. Check the width of proportional band.	1. Change the width of proportional band.
	At any time	2. Check the clogging of the detective part.	2. Inspect and clean
5. Oil temperature switch	At any time	1. Check the setting value.	1. Set to the proper temperature.
	At any time	2. Check the contamination and installing dimension of the heat sensitive cylinder and the detecting part.	2. Clean contamination. Investigate the length and replace. Investigate the installing location.
	At any time	3. Check the configuration of detecting part.	
6. Latch switch. Low and high interlock, damper lock and burner cut	At any time	1. Check the settings of each latch switch.	1. Check that it is set in a proper position
	At any time	2. Check the loosening of the setting of installed position.	2. Check and adjustment.
	At any time	3. Check a normal operation of the interlock.	3. Check the operation, inspect and repair.
7. Control motor	1 day or 1 week	1. Check the movement.	
8. Pilot burner	1 day or 1 week	1. Check the gas pressure.	
	At any time	2. Check the deterioration of the ignition transformer.	2. Check a spark between the electrode and the earth to be 7 to 8 mm in atmosphere.
	At any time	3. Check the deposit of carbon.	3. Clean the carbon between the nozzle and the electrode and clean the insulator.
	At any time	4. Check a backfire at the ignition.	4. Set an air-fuel ratio in a proper low combustion.
	At any time	5. Check the clearance between the nozzle and the electrode.	5. Adjust an interval suitable.
9. Electric pilot firing device	At any time	1. Check an electric spark state.	1. Blue color is normal. If reddish, cleaning is necessary. Short spark is a narrow interval.
	At any time	2. When a frequent cleaning is required, inferior electrode setting.	2. If the electrode is set within the jetting angle, the electrode is wetted with oil and don't spark. The electrode should be set to the setting value.
	At any time	3. Transformer insulation defect. Deteriorated lead.	3. Check the transformer and clean the insulator. Check any damage of the lead.

10. Burner	1 day or 1 week 1 day or 1 week At any time	1. Remove carbon and sludge. 2. Check the atomizing cap and the sharp of tip bleeding part. Clean contamination. 3. Check and clean the chip and strainer.	1. Check and repair of burner tile. 3. Disassembly and cleaning. Check the chip hole.
11. Fuel cutout valve (main valve)	1 day or 1 week 1 day or 1 week At any time	1. Check leakage of the cutout valve. 2. Make sure cutout due to a low level and no ignition. 3. Check the electric wiring.	1. A fire is extinguished entirely after cutout. 3. Check damage due to heat.
12. Oil pump	1 day or 1 week At any time At any time At any time	1. Check the oil pressure 2. Clean the strainer 3. Check oil leakage 4. Check over heat and overcurrent	1. Set to a proper oil pressure. 2. Drain and remove sludge. 3. Repair and remove sludge. Replace the oil seal. 4. Replace the bearing.
13. Oil preheater	1 day or 1 week At any time At any time At any time	1. Check the proper oil temperature. 2. Drain. 3. Check oil leakage. 4. Check the shieth heater.	1. Adjustment of the thermostat. Check a gasification by the air chamber. 2. Drain and remove sludge. 3. Repair the leaking place. 4. Sludge removing.
14. Oil meter	1 hour At any time	1. Check the oil meter indication record 2. Grasp the oil temperature passing through the meter.	1. Disassemble and clean the meter and replace the parts. 2. Since the efficiency calculation is based on the specific gravity at passing through the meter, the oil temperature should be roughly grasped.
15. Oil quantity controller	1 day or 1 week At any time	1. Check the link mechanism to the controller. 2. Check the oil quantity by a meter measurement (every load).	1. Adjust the link mechanism compared with the air volume, check loosening and play. 2. Check by operation and oil quantity and disassemble and clean it.
16. Oil strainer	1 day or 1 week	1. In an change type strainer, a prepared one should be always cleaned.	
17. Damper	1 day or 1 week At any time At any time	1. Check the link mechanism of the dampers. 2. Check the damper opening 3. Check the damper draft in the outlet of boiler.	1. The damper should be adjusted to be opened slowly. 2. Check distortion or loosening. 3. 0±2 mmAq in a pressurized combustion of rated operation.
18. Flue and stack	At any time At any time At any time	1. Check leakage and corrosion 2. Remove soot in the flue and stack. 3. Discharge of rain water.	1. Inspection and repairing.
Water softener	1 day or 1 week At any time At any time At any time At any time 1 year In case of necessary	1. Check of the water pressure. 2. Check of the water quality. 3. Check of hardness 4. Leakage from the perforated valve. 5. Care must be taken to leak during a stop of pump operation. 6. Check the main body. 7. Acid cleaning of ion exchange resin	1. Minimum is 1.5 kg/cm^2 2. Check of pH, conductivity and chlorine ion 3. Check in the secondary side and from 70 to 80 % in cycle. 4. Take care to leak from the fitting part of the packing. 6. Open the manhole and take out the ion exchange resin to inspect closely, and also check the coating or damage inside of the body. 7. If ion exchange resin is contaminated, acid cleaning should be carried out with 5-10% HCl solution.
Feed water tank	1 hour At any time	1. Check of the level gage. 2. Check the painting on the tank inside and corrosion. Clean the inside.	 2. Check, repair and cleaning.
Chemical feeder	1 day 1 day 1 day or 1 week 3 months 5,000 hours	1. Check the chemical tank level 2. Check the leakage at joints. 3. Check linkage to the feed water pump. 4. Wash the inside of tank and foot valve 5. Replacement of diaphragm.	1. Add chemical if short. Check contamination in the tank. 2. Tightening the hose nut. 3. Check the operation. 5. Diaphragm should be replaced when it is damaged. Broken diaphragm let the liquid leak and drip through the bottom hole of sub-ring.

Feed water pump	1 day or 1 week	1. Check overcurrent.	1. Adjust the valve.
	At any time	2. Check the performance of pump	2. Flow and pressure
	At any time	3. Check leakage from the packing ground.	3. Replace and tighten a packing
	At any time	4. Check overload unit of motor	4. Adjustment of tripping time for the overload unit.
	At any time	5. Remove and clean or replace all filters fitted to the installation.	
	At any time	6. Check the frequency of starts and stops.	6. Since the pump should not start too often, adjustment should be made to the controls to reduce the frequency of starts and stops.
	At any time	7. Check play in the coupling.	7. Repair and replacement.
	At any time	8. Check the operation of all controls.	
	At any time	9. Check the water level.	
Injector	At any time	1. Check a normal operation.	1. Impossible to feed when the steam pressure lowers, the feed water temperature rises, air is sucked, the feed water pressure is too much higher.
	At any time	2. Check the check valve. Attachment of scale.	2. Check, disassemble and clean.
Water flow meter strainer	Constant	1. Check the volume, temperature and operation.	1. Record and check.
	At any time	2. Check the clogging in the strainer.	2. Disassemble and clean.
Feed water check valve	At any time	1. Check back flow.	1. Water hammer. Hand touch feels hot to the feed water pipe. Overhaul or replacement.
Feed water internal pipe	At any time	1. Check the clogging in the internal pipe.	1. Insufficient feed water quantity. Overhaul.
	At any time	2. Inferior or falling of the gasket for installation of the internal pipe.	2. Water hammer. Replace the gasket.
Relief valve	1 day or 1 week	1. Check the leakage of steam.	1. Repair the leaked place and overhaul.
	At any time	2. Check the popping and blowdown pressure in operation.	
	At any time	3. Check the popping volume.	3. When the pressure rising in a rated combustion is 6 % or more, it is not acceptable.
Mini-blow	At any time	1. Inspection and cleaning of heat exchange interior.	1. Close the blow water inlet valve and the water supply outlet valve and remove the water supply inlet and outlet pipes of mini-blow. Loosen the flange bolts under the mini-blow body, separate the body from the legs. Check and clean the heat transfer tubes.
	At any time	2. Check instantaneous flowmeter.	2. Check cage tube and packing for damage and leakage.
	At any time	3. Check other valve.	3. Check leakage at normal operating conditions. When valve seat is damaged, polish repair it or replace it.
	At any time	4. Check the strainer.	4. Clean the metal strainer with the plug removed.
Economizer	Constant	1. Monitor the temperature of exhaust gas and supplied water.	1. Temperature of inlet and outlet of exhaust gas and supplied water.
	6 months	2. Cleaning inside of glass tube.	2. Check the inside of each heat resisting glass tube, and give a cleaning if necessary. After cleaning, the glass tube should be sufficiently flushed and washed.
Forced draft fun	Constant	1. Monitor the pressure	1. The pressure of outlet, wind box(primary and secondary) and furnace.
	1 day	2. Check bearing	2. Check the temperature, oil, abnormal noise, overcurrent and vibration. If abnormal, disassemble and clean, or replace bearing.
	At any time	3. Check foreign matter in the suction port.	3. Mount a wire gauze not to suck foreign matter.
	At any time	4. Check vibration. Check and replace the belt.	4. Loosening of installed bolts. Loosening of the runner. Remove any deposit to the runner. Replace the bearing.
	1 month	5. Check impeller.	5. The dust sticking to the impeller, if growing, causes vibration, corrosion and wear of the impeller. Clean the impeller before the dust increases too much.
	8~10 months	6. Replacing lubricating oil	6. Pay full attention the oil level gauge.

Forced draft fun	135 days	7. Grease supply	7. Keep the replacing cycle and the quantity. Maximum by grease replacement is about 23,000 hours.
Compressor	1 day	1. Draining	1. After completion of a daily job, drain the air tank.
	1 day	2. Check operation states.	2. Confirm operation of pressure gauge, solenoid valve and safety valve.
	1 day	3. Abnormal vibration and noise.	3. In any abnormality, check compressor for installation method.
	1 month	4. Loose bolt, screw and nut.	4. Tighten them standard wrench or screwdriver.
	1 month	5. Slack or frayed belt.	5. Replace frayed belt, and slide the motor for slack belt.
	1 month	6. Stained or clogged suction and crank case filter element.	6. Clean and blast with blush and so on, both inner and outer of the filter.
	1 year	7. Anti-vibration rubber.	7. Check installed height of anti-vibration rubber.
	1 year	8. Air valve leakage	8. After leaving compressor under the maximum pressure for 30 minutes, make sure that the pressure drops within 20%.
			9. Check the air tank for charging time and the piston ring for radial thickness.
	1 year	9. Piston ring	10. Check the rider ring for a decrease in radial thickness due to abrasion.
	1 year	10. Rider ring	11. Check the baring for rotating condition and for grease leakage.
	1 year	11. Ball bearing and needle roller bearing.	12. Check attrition at engaging part and grease deterioration.
	1 year	12. Unloadar piston.	
Exhaust gas treatment device			
1. Blower and fun	At any time	1. Check the impeller.	1. Check the foreign matter, balance, vibration, corrosion and wear of the impeller.
	At any time	2. Check the casing.	2. Check the dust, wear and corrosion.
	At any time	3. Check the oil and grease for bearing.	3. Keep the proper quality and quantity.
	At any time	4. Check the joint(leather or rubber) for bearing	4. If worn, it should be replaced.
	1 month	5. The adjustment of V-belt.	5. The new V-belt must be adjusted after one month operation, and after that it should be checked regularly.
2. Pump	1 day	1. The temperature of bearing	1. Touch by hand.
	1 day	2. The measurement of suction and discharge pressure.	
	1 day	3. The leakage from packing ground and mechanical seal.	3. Tighten in proportion to the wear of packing.
	1 day	4. Check the motor on.	4. Check the electric current.
	1 day	5. Check the lubricating oil for bearing.	5. The leakage from the oil seal.
	1 day	6. Check the vibration and noise.	6. Make sure if it does not change from the previous day.
	1 month	7. Check the bearing.	7. Measurement of the temperature, the volume and degradation of lubricating oil and the volume of grease.
	1 month	8. Check the connecting states of pump and motor.	8. If dislocated, check the load of piping.
	6 months	9. Disassemble of packing gland and axis sleeve.	9. If worn, it should be replaced.
	6 months	10. Check the oil seal for bearing.	10. Check the wear of axis and lip.
	6 months	11. Check the rotating parts such as axis joint, metal draining and heat radiation board.	11. If loose, tighten it.
	6 months	12. Change the lubricating oil in bearing.	12. It should be changed approximately for 2,000 hours.
	6 months	13. Disassemble and check the pump.	13. Except sealed ball bearing, it should be disassembled and washed with oil. Check the rotating parts, foot valve, check valve and sluice valve.
	1 year	14. Check and wash of air-cooled coil.	14. Flashing with pumped water.
	1 year	15. Remove or wash the fur and scale in the water-cooled chamber.	
3. Digital pH meter	2 weeks	1. Calibration by standard buffer solution.	1. Electromotive force of electrodes is calibrated with pH standard buffer solution.

3. Digital pH meter	At any time	2. Cleaning electrode	2. When a dirty adhere to glass bulb, wipe out with dilute HCl solution, alcohol, etc. When the electrode is deteriorated or damaged, exchange it for new one.
	More than 1 year	3. Refilling internal electrolyte	3. Refill if internal electrolyte KCl is less than one-third.
Automatic flue gas monitoring devices			
1. Automatic NOx analyzer	1 month	1. Check the primary filter.	1. Replace new one when the filter is blocked by dust and mist.
	1 week	2. Check the secondary filter visually.	2. When the contamination is heavy, replace.
	At any time	3. Check the sample flow rate.	3. Check that the sample flows at about 1 ℓ/min.
	At any time	4. Check on the dehumidifier	4. Check if the lamp goes on and off.
	At any time	5. Check the converter temperature.	5. Check to see that the converter is heated.
	1 week	6. Check the zero and span.	
	1 week	7. Draining	7. Drain by opening the drain cock.
	6 months	8. Check the diaphragm pump.	8. Replace diaphragm, gasket and valve.
	1~3 months	9. Check the filter for ozone.	9. If contaminated, replace.
	6 months~ 1 year	10. Check the sampling pump	
			11. When the suction power dropped, first clean the diaphragm valve(or replace it).
	6 months	12. Check the active carbon cylinder.	12. At the replacement, clean the sponge in the active carbon tank.
	1 year	13. Clean or replace the guard filter for ozone and sample.	
2. Automatic CO and SO_2 analyzer	1~6 months	1. Check the primary filter sampling tube visually.	1. Check the state of stain and clogging.
	At any time	2. Check the water level of drain.	2. Open the valve for draining.
	At any time	3. Check the mist catcher visually.	3. Check the stain of inner wall of the tubing around the mist catcher.
	2 weeks~ 1 month	4. Check the sample gas filter visually.	4. Check the state of stain and dust, and replace when it is unfavorable.
	6 months~ 1 year	5. Check the sample gas pump.	5. Check the operating condition such as the flow rate, irregular sound, etc.
	At any time	6. Check the flowmeter.	6. Both zero and span gases should be adjusted to about 0.7 ℓ/min.
	1 month	7. Check the dehumidifier.	7. Make sure that the power lamp goes on and off. Clean or replace the fan filter.
	1~3 months	8. Check the guard filter.	8. Check the state of stain and dust. Replace when it is unfavorable.
	6 months~ 1 year	9. Check the zero and pump.	9. Check the flow rate. Cleaning and replacement of the valve and diaphragm.
	At any time	10. Check the zero gas filter.	10. Check the state of stain and dust. Replace when it is unfavorable.
	At any time	11. Check the water level of trap.	11. Open the drain cock for draining.
	At any time	12. Check the constant temperature oven.	12. Make sure the pilot lump of the electric control unit goes on and off.
	1 day~1 month	13. Zero and span calibration.	13. After checking the amount of zero/span drift, make calibration.
	1 day~1 month	14. Check the cylinder of span gas.	14. After calibration, close primary cock of the cylinder and remove any residual gas in the regulator.
	1 month or at the replacement	15. Check the piping for gas leakage.	
	At any time	16. Check the recorder.	16. Check the operating condition and the error within 2 %. Replenish chart paper and ink.
3. Automatic O_2 analyzer	1 day	1. Check the sample gas flow rate.	1. The sample gas flow rate changes if piping is clogging or if the pressure of the sample gas changes substantially.
	Constant	2. Check the operation.	2. Check the "Ready" pilot lamp flickers.
	2 months	3. Calibration	3. Make calibration with standard gas.
4. Automatic CO_2 analyzer	1 day	1. Check the secondary filter visually.	1. If contaminated, replace.
	1 day	2. Check the O-ring visually.	2. Check the crack and gas leakage.
	1 day	3. Check the exhaust vinyl tube visually.	3. If blocked on the way, repair or replace.
	1 week	4. Calibration	4. Make calibration with standard gas.