- Alarm set point

  Some alarm set points should be rechecked since the alarm is not reset although the recorder or indicator reading is under alarm set point, or recorder indicator should be re-calibrated.

- Change of alarm set point

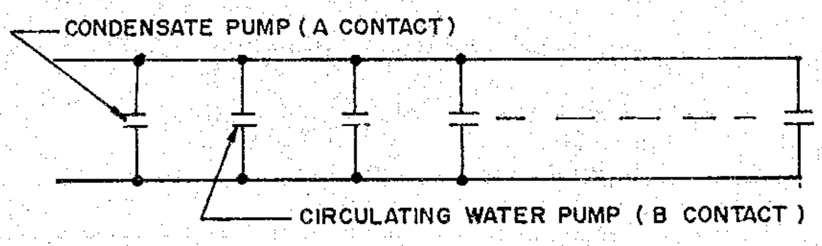
  The set points for alarms such as "4160 V motor overload" and "460 V motor overload" are set at 90% of the rated current.

  Operation of motor in the condition of 90% current is normal, and should not be treated as an alarm. These alarm set points should be set at 115% of rated current.

- Consideration of multi-points alarm

  Present alarm system for multi-points is unadequate because the system does not re-alarm repeatedly when another alarm contact is closed.

  For an example:



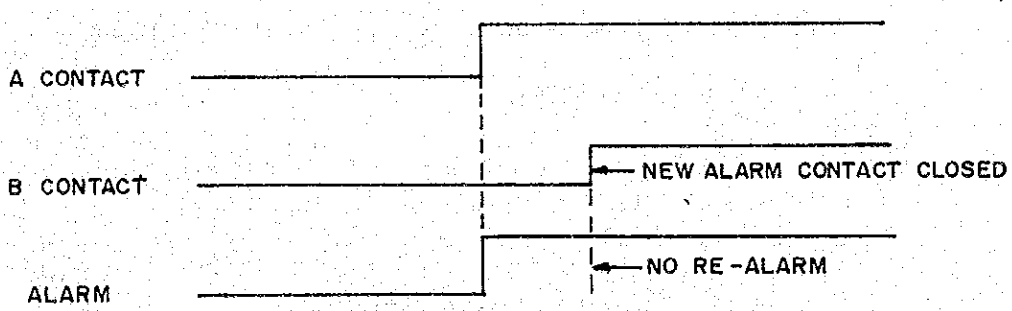


Fig. 5E-22 MULTI-POINTS ALARM

In this alarm system, operators can not acknowledge new trouble at all.

Re-alarm system should be applied to alarm having parallel contacts to let operators acknowledge new trouble occurrence immediately.

v. Fire fighting alarm system

Fire fighting alarm in Gardner/Snyder Thermal Power Station is centralized at S-1 & S-2 central control room, however, almost all the alarm are defective.

In the existing alarm system, fire fighting activities can not be performed quickly and smoothly in the event of actual fire occurrence.

Therefore, it is recommended that the overall system including fire detector and fire fighting pump start system should be rechecked, and the defective alarms should be repaired or replaced.

vi. Improvement of central control room

Under the central control room for G-1 and G-2 units there is cable marshalling room, and the wall and floor of the room are partitioned with concrete. The central control room allows relatively less dust and soot entrance from outside, and is maintained in good condition by air conditioner operating satisfactorily.

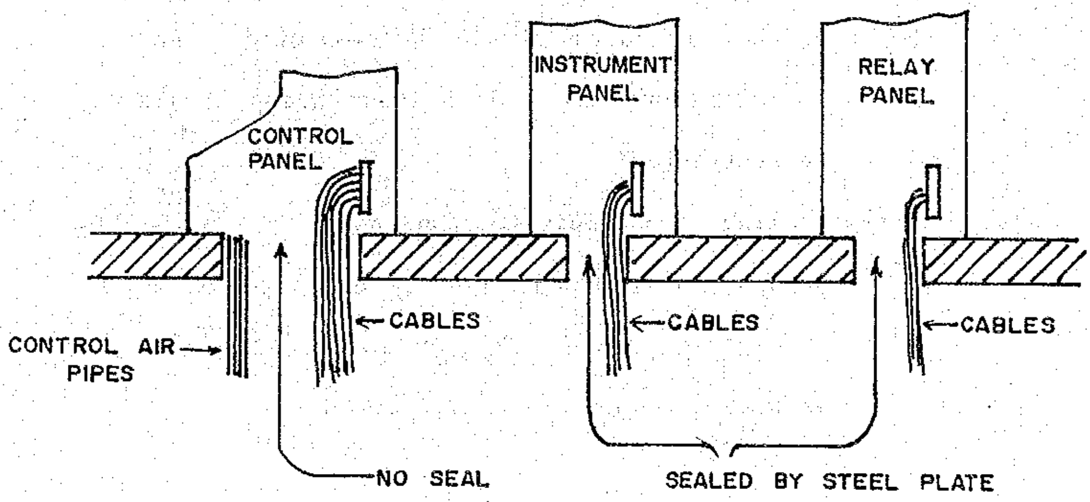
On the other hand, under the central control room and cubicle room and floor access of central control panel and relay panel in S-1 and S-2 are opened. Therefore, central control room temperature is very high because the rooms allow hot dust and soot to enter freely into the room and because two package type air conditioners installed in the room are frequently defective. Result of room temperature measurements are as follows:

Central control room for G-1 & G-2	: 76°F (24.4°C)
Central control room for S-1 & S-2	: 95°F (35°C)
Relay room for S-1 & S-2 units	: 99°F (37.2°C)

Problem on central control room temperature for S-1 and S-2 units can be considerably reduced since the additional 6 package type air conditioners are planned to be installed in the central control room and in the cubicle room.

However, there still exists important problem. It is urgently required to prevent hot gas and dust, having bad influence upon the health of operators and instrument devices, and entering into the room.

Fig. 5E-23 CENTRAL CONTROL ROOM PANELS



To improve the central control room for S-1 and S-2 units in same condition as that of G-1 and G-2 units, following measures are recommended:

Improvement of airconditioning system

In addition to the additional installation of airconditioners, fan and fresh air duct should be newly installed to introduce fresh air from outside of the boiler area because the air conditioner allows the same air recirculation in the room.

Prevention of entrance of hot dust and soot

(i) Improvement of entrance doors

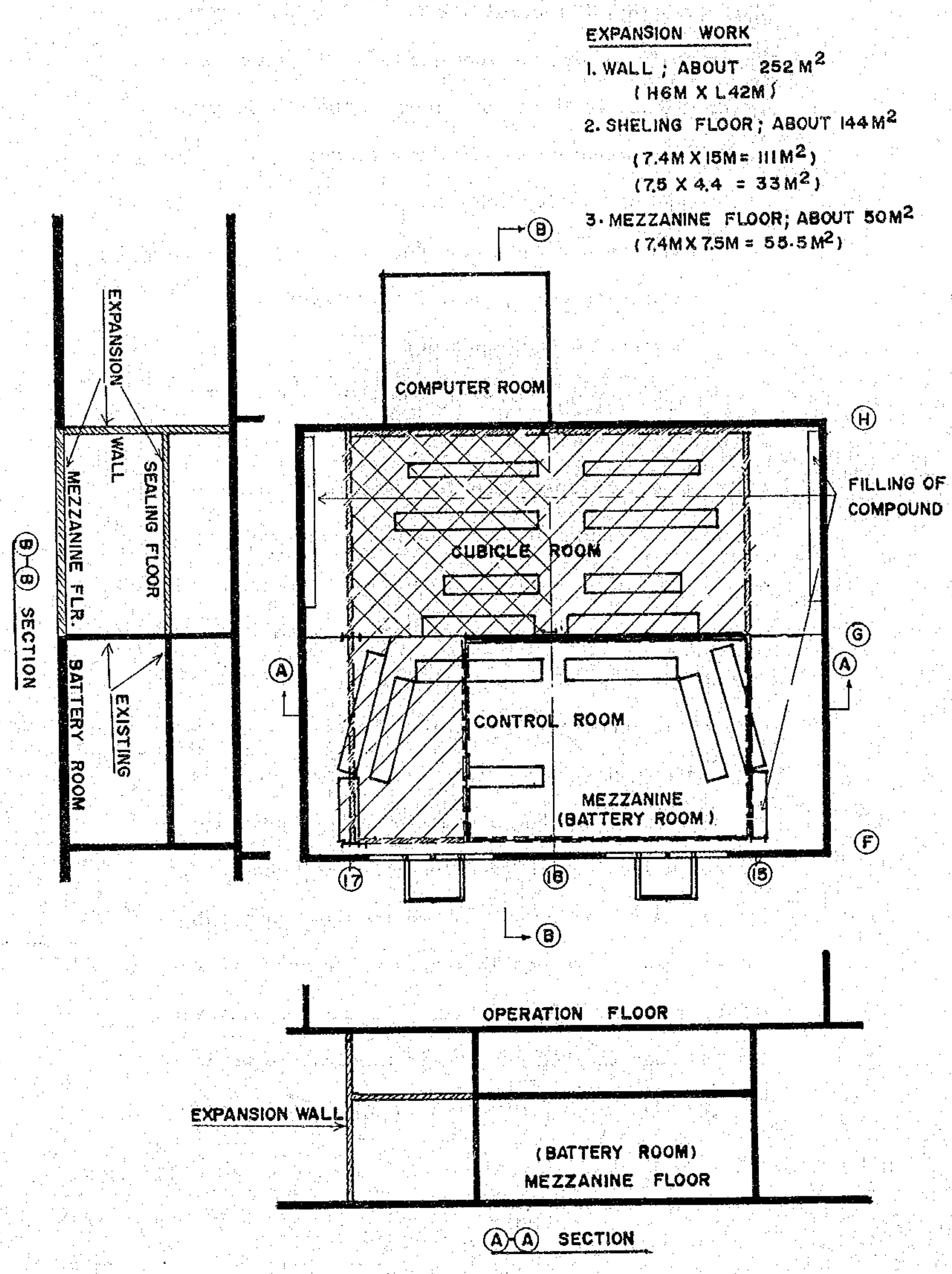
Two doors here already improved, but also another 4 doors should be improved. And entrance and exit from another doors should be restricted.

(ii) Sealing of openings for cabling

Sealing of openings only by steel plate is incomplete, and so the gap should be filled up with a compound easily treated.

Fig. 5E-24 SEALING PLAN OF CABLE HOLE IN

S-1, S-2 CONTROL ROOM



vii. Additional Supervisory Installation

At present in the central control room Gardner/Snyder Thermal Power Station some supervisory recorders inevitable to monitor the power plant are not provided. The following supervisory recorder should be provided.

- Condensate flow recorder
- Condensate vacuum recorder
- Turbine speed/cam position recorder
- Generator output recorder

In addition to the above, make-up water flow integration meter and well water integration meter should be installed for administration and consumption check of the raw water and make-up water. Boiler tube leakage can be easily uncovered by the flow rate of make-up water.

At present all the steam coil air preheater temperature control valves are defective, some of them have been already removed and some of them are defective, and the combustion air temperature are not maintained in good condition for adequate oil firing accordingly. For an example, G-1 SAH outlet temperature was increased up to only 140°F (60°C) at about 100 MW load. It can be easily assumed that the SAH outlet air temperature would be lower than 140°F at the unit start-up in the past.

These factors will considerably contribute to AH clogging. Therefore, to reduce these disadvantages the following measures should be taken into account immediately.

- To repair or replace the existing defective SAH temperature control valves.
- To use low sulfur content fuel oil as possible.

g. Associated Substation

(a) Substation

Since burnt-out trouble of lightning arresters occured two times in the past, the lightning arresters were replaced with new ones. With regards to generator breaker's trouble (three times), that is, control cable defective on 1974, malfunction on 1976, circuit breaker proper defective were all repaired during unit outages.

(b) Transformer

Troubles of lightning arrester for S-1 main transformer occured two times in 1977 and 1979, and the unit tripped due to flashover of main transformer jumper many times as follows:

Date	Troubled parts	Overhauling period
Sep. 4, 1977	S-1 Main Tr. Jumper	Feb. 7, 1977-Apr. 25, 1977
Oct. 7, 1977	S-1 Main Tr. Jumper (Phase B)	-
Jul. 25, 1978	S-1 Main Tr. Jumper (Phase A)	-
May 4, 1980	S-1 Main Tr. Jumper (Phase A)	Nov. 22, 1978-Apr. 3, 1979
Oct. 2, 1980	G-1 Main Tr. Jumper	Oct. 24, 1979-Jan 12, 1980
Dec. 29, 1980	G-2 Main Tr. Jumper (Phase A)	Aug. 6, 1980-Oct. 22, 1980

Generally when a trouble occured, same trouble tends to occur in a similar facility with high possibility.

Therefore, similar facility in which resulted from trouble once should be inspected and investigated for cause of trouble during overhauling so as not to repeat the same trouble. If the S-1 main transformer was inspected after first trouble, the unit could be avoided to repeat the same trouble three times.

(c) Circuit breaker, disconnecting switch and others

Since electrical facilities at substation (transformer, disconnecting switches and circuit breakers) have been maintained by MERALCO which has abundant experiences, trouble has been reduced recently. And from the viewpoint of preventive maintenance, the following recommendations should be applied to the facilities.

i. Periodic clean-up of insulators

Insulator contamination due to salt can be considered as less possibility, but insulation deterioration due to adhesion of dust and mist should be considered especially at seasonal change from dry season to rainy season.

ii. Countermeasures against entry of rain into the insulation oil

Especially prevention of oil circuit breakers from moisture and insulation oil quality control should be taken into consideration.

iii. Review of connecting portions of bare conductors

Method of conductor connection should be changed to compression type from clamp-bolt terminal for prevention of corrosion and overheating of conductors.

For monitoring of overheat effect, thermo-label should be provided on each contact parts and connecting parts.

iv. Countermeasures for lightning arrester

As to countermeasures for lightning arrester accident, please refer to 5.3.1 2) "230KV LIGHTNING ARRESTER FOR THE MAIN TRANSFORMER"

h. Station Electrical System

(a) Bus Transfer Interlock

Station service power failure occured twelve times in 4,160 V system and three times in 480 V system in the past. This was caused by loss of power supply due to malfunction of automatic bus transfer system.

Automatic bus transfer interlock should be checked and actual automatic bus transfer test should be carried out during overhauling. Although an emergency diesel generator (300 KW) is installed in the power station as a common facility to all units, cabling to the auxiliaries are not provided from the control center. Taking the above trouble like 480 V power supply failure into consideration, the cabling should be provided for safe plant shutdown.

(b) Emergency Diesel Generator

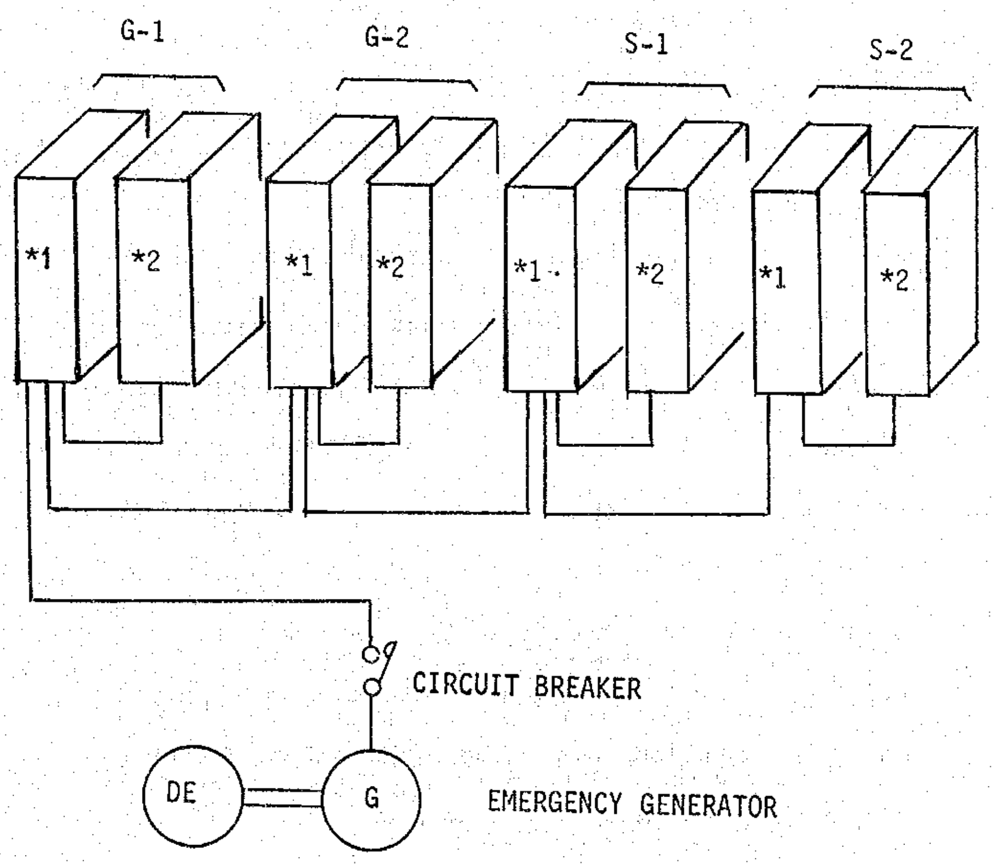
One emergency generator with a diesel engine is installed for emergency use for G-1, G-2, S-1 and S-2 units.

However, the power cables to each auxiliary equipment are not completed.

These auxiliary equipment are as follows:

* Turning gear motors
* Jacking oil pump motors
* Lighting loads
* Hydrogen seal oil pump motors
* Battery chargers

In the event of emergency like black-out of power plant, when the auxiliary power source transferred to emergency transformer successfully, there arises no problem. But taking unsuccessful automatic bus transfer into consideration, emergency control center units should be additionally installed near the existing control centers and stable auxiliary power should be supplied from the unit to each equipment for the purpose of safe plant shutdown. Refer to the following sketch.



*1 shows additional emergency control centers

*2 shows the existing control centers

Fig. 5E-25 EMERGENCY POWER SUPPLY SYSTEM

(c) Station Battery System

Two station battery systems are provided for G-1 & G-2 and S-1 & S-2 units each in 1967 and in 1970 respectively. As it had passed about 15 years since installation of battery system for G-1 & G-2, battery casing cracks and flaking of electrodes are noted. Therefore, the defective existing batteries should be replaced with new ones.

In addition to the above, station battery system should be unitized for each generating unit as follows:

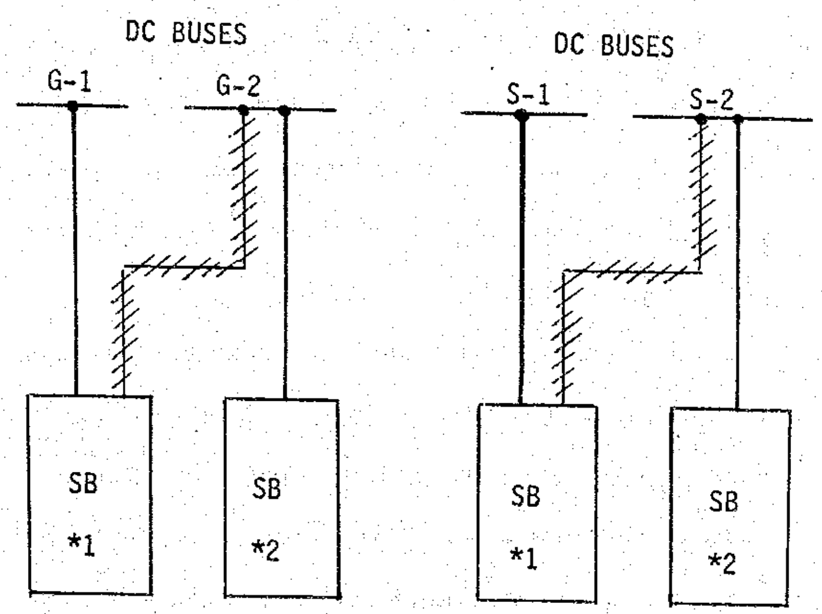


Fig. 5E-26 STATION BATTERY SYSTEM

NOTE: SB stands for Station Battery.

*1 and *2 show the existing batteries and additional batteries respectively.

(d) Metal-clad switchgear, power center and motor control center units

Common items to all units (G-1, G-2, S-1 & S-2)

i. All the metal-clad switchgears, power center units, and motor control center units except for the boiler control center units are installed on the basement floor lower level than the ground level of power plant compound. Measures to avoid flooding of basement floor especially during rainy season should be taken for safe plant operation. For future installation, installation level for metal-clad switchgears, power center units and motor control center units should be at least higher than that of power plant compound, and all the units should be installed in an electrical room ventilated satisfactorily.

ii. All the magnetic contactors and auxiliary relays in the units are of open-type. This will cause poor electrical contact due to dust on the contacting portions. Auxiliary relays should be of seal-in type, furthermore, it is recommended that the auxiliary relays should be socket-connection type even installed in the electrical room for easy maintenance.

iii. No cable and wiring identification marks

All cables and wiring incoming and outgoing to panels should be identified by cable marks and wiring marks for easy cable check.

For example, cable marks:

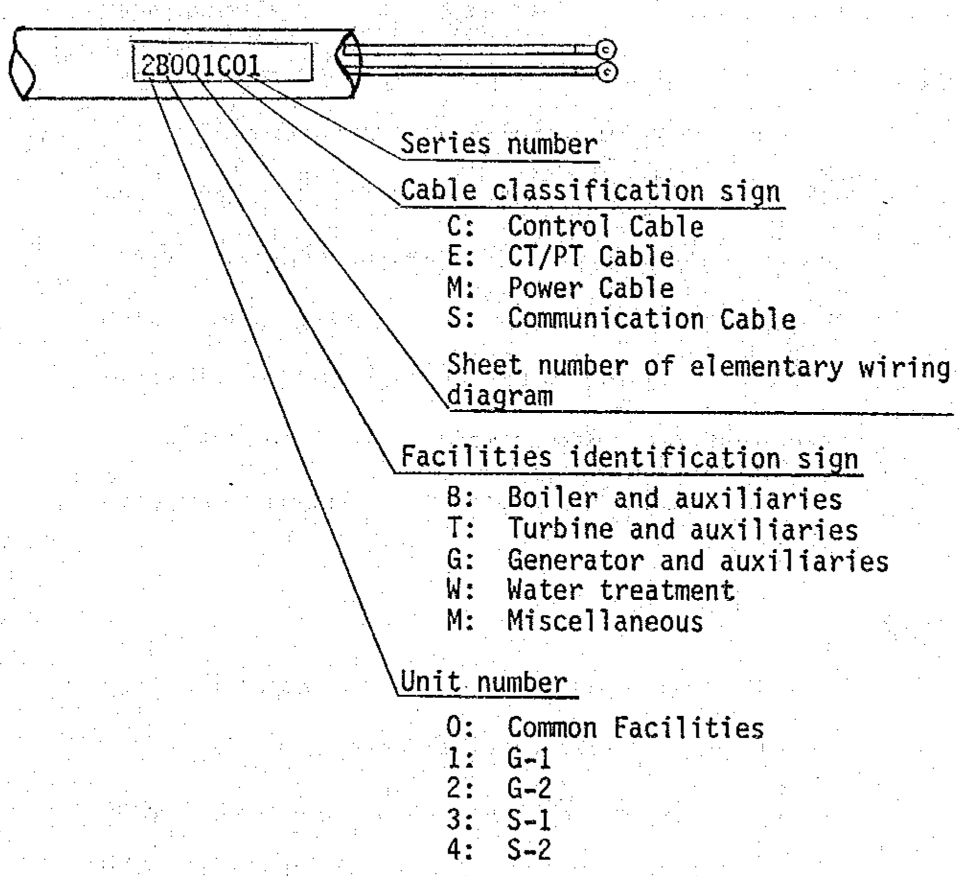


Fig. 5E-27 CABLE MARK

iv. Many pipes such as for steam, water and drain are installed on the units, and the units may get wet by steam, water and drain leakage.

Measures to avoid such leakages from the pipes should be taken so that the power plant will not be shut down due to minor trouble, and for future installation of the units should be installed in the said electrical room.

G-1

Station service control center is installed on the basement floor having a lower level than that of the power plant compound. Lake water comes out considerably from the foundation of the units. This may cause insulation breakdown due to excessive moisture for some electrical devices such as contactors, auxiliary relays and wiring especially during rainy season. It is urgently requested to take remedy. Investigate water leaking source, and stop the water leak with concrete.

G-2

Boiler control center unit is installed very closely to the boiler hot air duct, and is heated up considerably. This will cause in breakdown of cables insulation and electrical devices. The boiler hot air duct should be heat-insulated so as not to affect the control center on safe operation. For future installation the control center should be installed in the said electrical room.

v. Defective operation indicating lamps

Replace all the defective operation indicating lamps on the units, and especially fault indicating lamps should be replaced so as to identify the defective ones in the event of accident and trouble.

(e) Setting of overcurrent relay (OCR)

As a result of study on OCR setting during G-2 over hauling since some problems have been found in adjustment and setting of the OCR, JICA team would like to advise on the matters.

i. OCR for 4160 V Motor Protection

(i) Adjustment of "49" element

Adjust tap and lever setting positions taking alarm and tripping point into account.

- Select tap position corresponding to approximately 1.15 to 1.25 times of rated motor current since relay has only seven tap positions, that is 2.5, 2.8, 3.1, 3.5, 4.0, 4.5 and 5.0.
- Select appropriate lever position so as not to operate at starting rush current of a motor. Therefore, it is required to confirm starting rush current with the aid of oscilograph.

(ii) Adjustment of "50" element

Since setting of "50" element can be freely selected from the range of 20 to 80 amperes for short circuit protection, "50" element should be set at 10 times of rated current of a motor to avoid malfunction due to starting rush current (approximately 6 to 7 times of rated current).

(iii) Adjustment of "83" element

Since setting of "83" element can be freely selected from the range of 4 to 16 amperes for overload protection, "83" element should be set at 2 times of rated current of a motor. It is required to confirm that drop out point of "83" element should be 80% of pick up point so that the relay should operate at starting rush current of a motor, and open the contact at the completion of motor start.

Above-mentioned description are summarized as follows:

Element	Setting	NAPOCOR Setting	G E Instruction	Recommendation
49	$\frac{\text{Tap Current}}{\text{Rated Current}}$	0.9	1.15 1.4	1.15 1.25
50	$\frac{\text{Pick-up Current}}{\text{Rated Current}}$	-	8 to 15	10
83	$\frac{\text{Pick-up Current}}{\text{Rated Current}}$	1.7	2 to 3	2.0

ii. OCR for Station Service Transformer

(i) Adjustment of "50" element

As setting of "50" element can be selected freely from the range of 40 - 160 amperes for short circuit protection "50" element should be set at 10 to 15 times of rated current.

(ii) Adjustment of "51" element

Tap of "51" element should be selected at approximately 1.5 times of the rated current, and lever should be selected so that the "51" element does not malfunction at starting rush current of motor-driven boiler feed water pump which has maximum capacity among 4.16 KV auxiliary motors.

For an example, setting of OCR should be decided in accordance with the following result of calculation.

- OCR setting for M-BFP

  * Rated current : 582 x 5/800
    (Specification) = 3.64 A
  * Starting rush current: 4800 x 5/800
    (Measurement) = 23.75 A
  * Starting time : 10 sec.
    (Measurement)

Tap setting of "49" element 4.5 A

3.64 (1.15 to 1.25) = 4.18 to 4.55A

Lever Setting of "49" element 3.5

(More than 10 sec at 4.5A x 6)

"50" pick-up : 36.4A (3.64 x 10)

"51" pick-up : 7.3A (3.62 x 2)

- OCR setting for station service transformer

Rated current: 321 x 5/500 = 3.21 A

(Specification)

CT secondary ratio:

$$\frac{\text{Station Service Transformer Secondary}}{\text{M-BFP CT secondary}}$$

$$= \frac{18}{4.16} \times \frac{800}{500} = 6.923$$

"50" pick-up : 40A 3.25x(10 to 15)

= 32.1 to 48.15A

"51" tap : 5.0A 3.4 x 1.5 = 4.8A

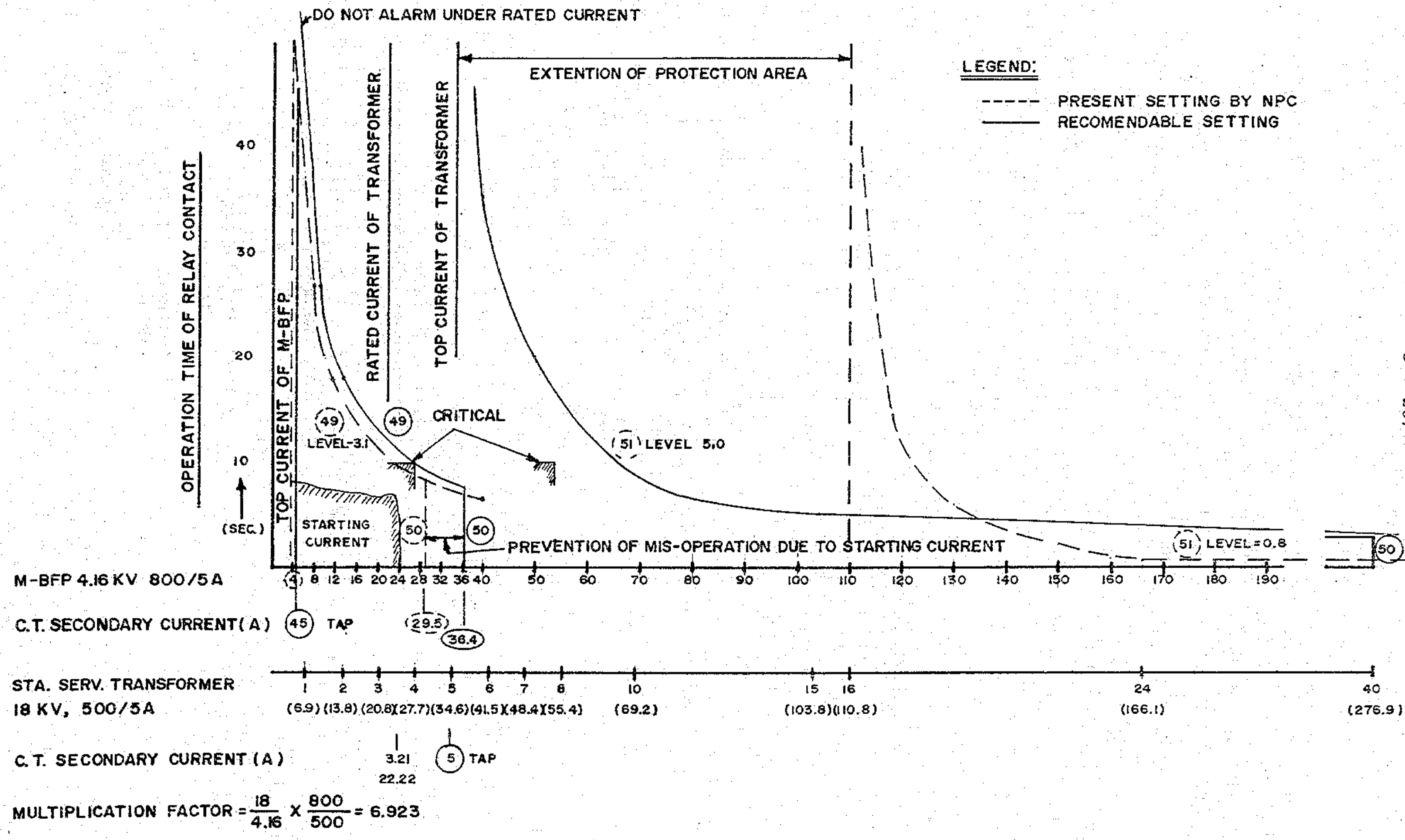
"51" lever : 6.0 8 sec. at 10A

(more than 10 sec. at 7.8A)

Fig. 5E-28 EXAMPLE OF TRIPPING TIME COOPERATION

BETWEEN 4.16 MAIN CB AND

MAXIMUM CAPACITY AUXILIARY (BFP-M)



(f) Connection of PT and CT secondary circuits for protection relays and meters

i. PT secondary circuit connection

In the existing PT secondary connection only one circuit for protective relays and metering instrument is commonly used. Connection of PT secondary for protective relays and metering is recommendable to be divided into two circuits as follows:

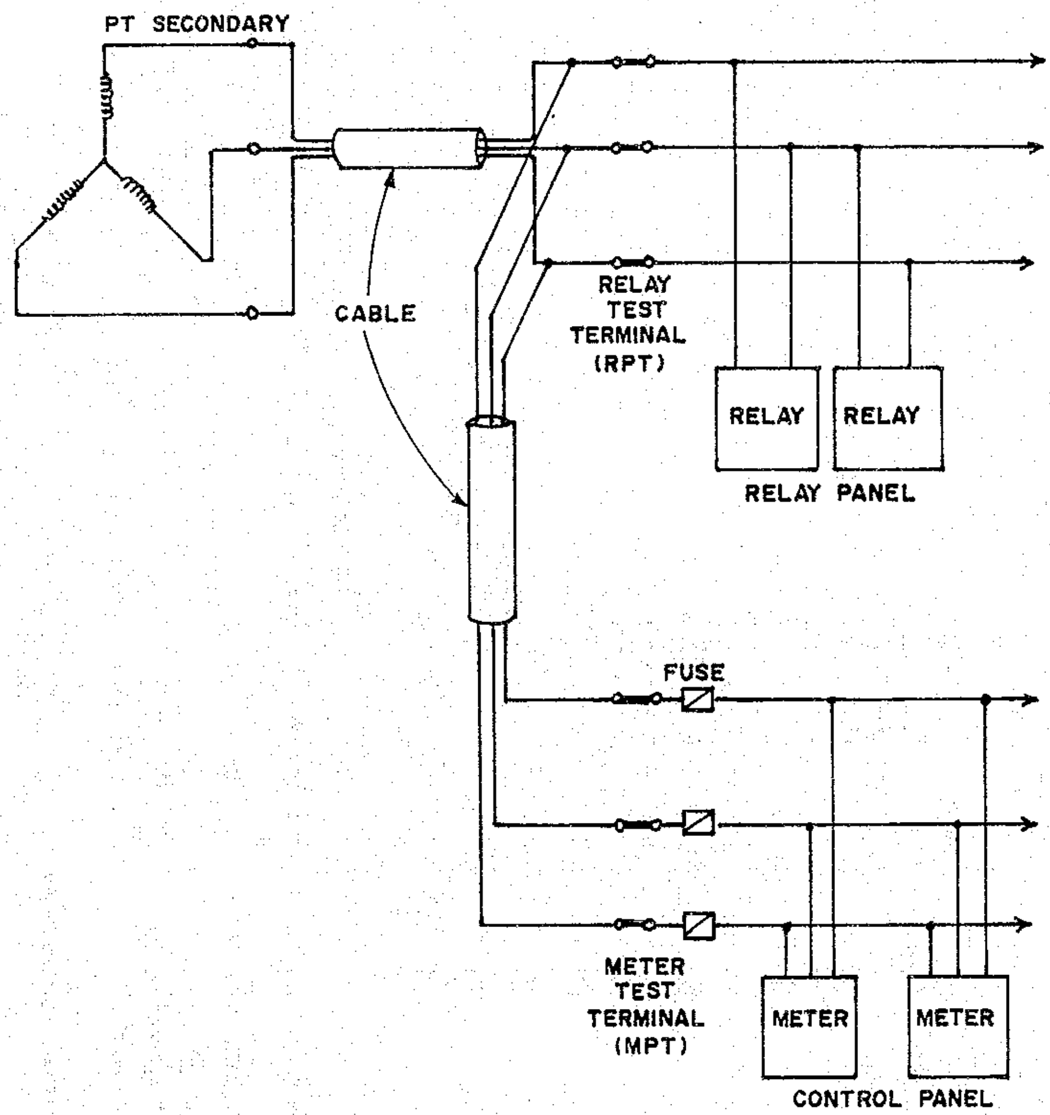


Fig. 5E-29 PT SECONDARY CIRCUIT CONNECTION

Merits of this connection are as follows:

* Inspection, repair and re-adjustment of meters can be carried out only by removal of MPT keeping protective relays placed into service under normal operation.
* In the event of short circuit accident in metering circuit, malfunction of protection relays such as under voltage relays and distance relays can be avoided.

ii. CT secondary circuit connection

It is in principle desirable to install two CTs for meters and protection relays, respectively. However, in case of one CT, following circuit should be considered for easy maintenance and safe plant operation.

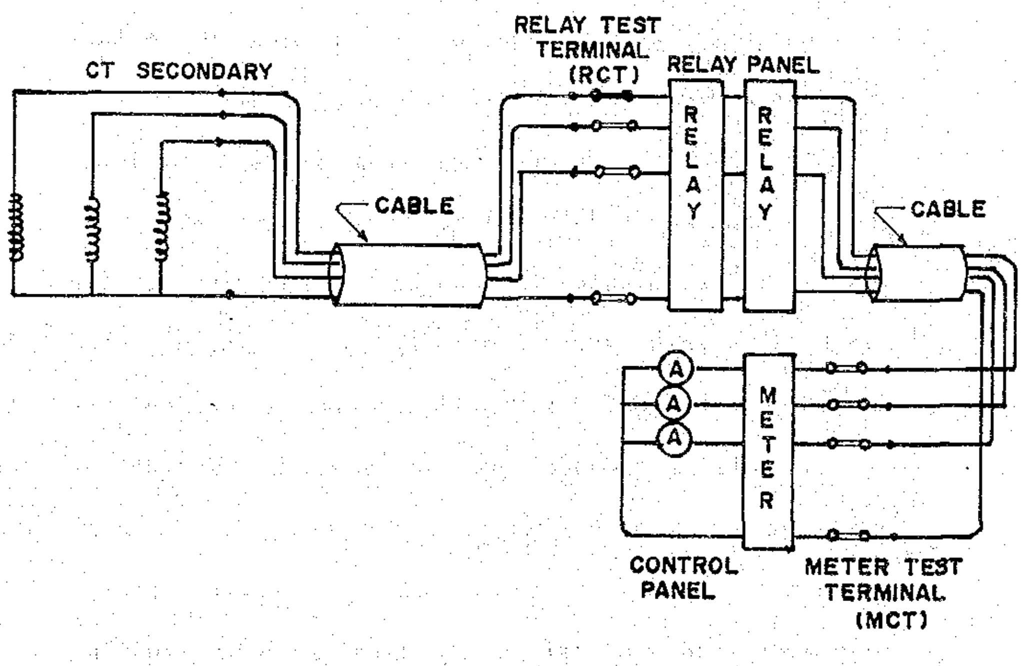


Fig. 5E-30 CT SECONDARY CIRCUIT CONNECTION

The merits of this connection are as follows:

* Inspection, repair and readjustment of meters can be carried out only by short-circuit of MCT keeping protection relays placed into service under normal operation.
* In the event of short-circuit accident in metering circuit, malfunction of protection relays (differential percentage relays) can be avoided.

(g) Lighting of Powerhouse

There found insufficient lighting and many defective fluorescent lamps in powerhouse, especially in boiler area. Additional lighting fixtures should be installed in necessary places, and defective fluorescent lamps should be replaced with new ones for easy operation and maintenance.

(h) Additional welding power outlet

Adequate outlets should be provided at various portions and/or different locations of boiler.

In case of overhauling, low voltage lighting power (about 12 or 24 V AC) is required for safety.

It is recommended that auxiliary power supply for overhauling works such as welding jobs, lighting, etc. should be taken only from auxiliary power load centers of the unit under on-going overhaul, not from other units under normal operation. Short circuited or grounding of power cables of electric welding equipment may lead to serious troubles of other running units, thus causing unit trip.

2) Malaya Thermal Power Plant

a. Boiler Proper

(a) Boiler Tubes

i. Existing Condition of M-1 Boiler

M-1 is presently operating at a reduced pressure due to the reduction in the boiler tube wall thickness in the secondary SH tubes.

The present main steam pressure is 2100 psig (the rated pressure is 2700 psig) and the safety valve setting was consequently reduce to 2111 psig. M-1 is now limited to a maximum load of 240 MW only.

This particular boiler trouble occured on February 12, 1982 and it inflicted a big damage to the boiler tubes.

According to the manufacturer's report and the Quality Assurance Group's report, the cause of this trouble is due to insufficient care and handling of the equipment.

Result of inspection:

The secondary SH-tubes had been ruptured by overheating (number of ruptured tubes is 8). The exterior dimensional check showed that fifteen (15) tubes thickness is less than TSR (necessary thickness) 5.0mm (the minimum figure is 4.1 mm) which is due to high temperature corrosion.

The superheater and primary superheater tubes did not show any thinning of less than the TSR, however, thick and black scales were found on the external surface of the tube.

The economizer tubes did not also show thinning of less than the TSR however, they were covered by soft and wet scales.

The water wall tube, showed a decrease in thickness by 1.2 mm due to bulging.

ii. Existing condition of M-2 Boiler

M-2 is operating at a reduced pressure due to weak boiler baffle wall tubes. The present boiler drum pressure is 160 kg/cm^2. M-2 is limited to a maximum load of 280 MW. These existing operating conditions has been agreed upon by the Japanese boiler manufacturer and duly concurred upon by NAPOCOR management.

This boiler trouble occured last January 24, 1982 and it inflicted a big damage to the boiler tubes.

During normal unit operation, NAPOCOR must avoid performing downcomer blowdown, since this operation poses a danger which obstructs the circulation of boiler water thereby causing boiler tube rupture due to overheating.

According to the manufacturer's report and the Quality Assurance Group's report, the boiler tubes of M-2 are corroded by hydrogen attack. This means that there are plenty of high chloride content in the M-2 boiler water system.

iii. Recommendations

NAPOCOR has already received plenty of recommendations on boiler tube problems from the manufacturers.

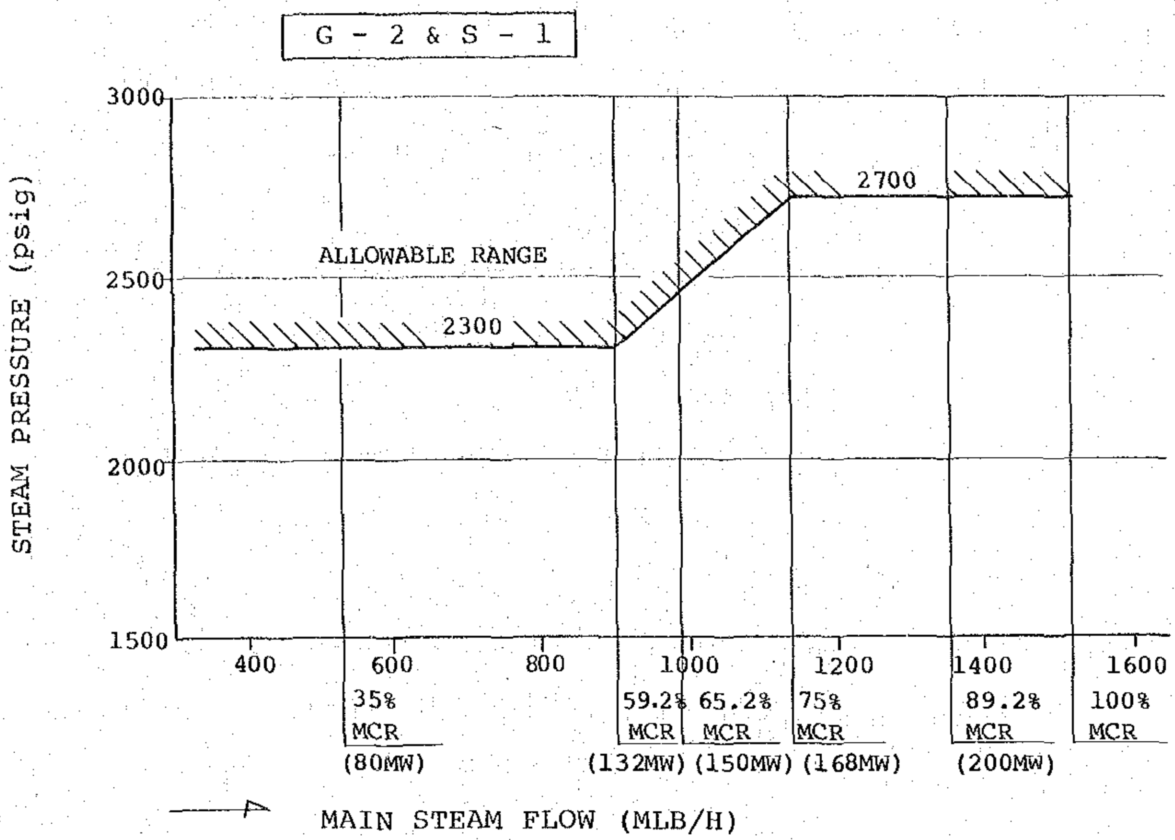
(i) JICA team strongly recommends some pointers in carrying-out the boiler reduced pressure operation.

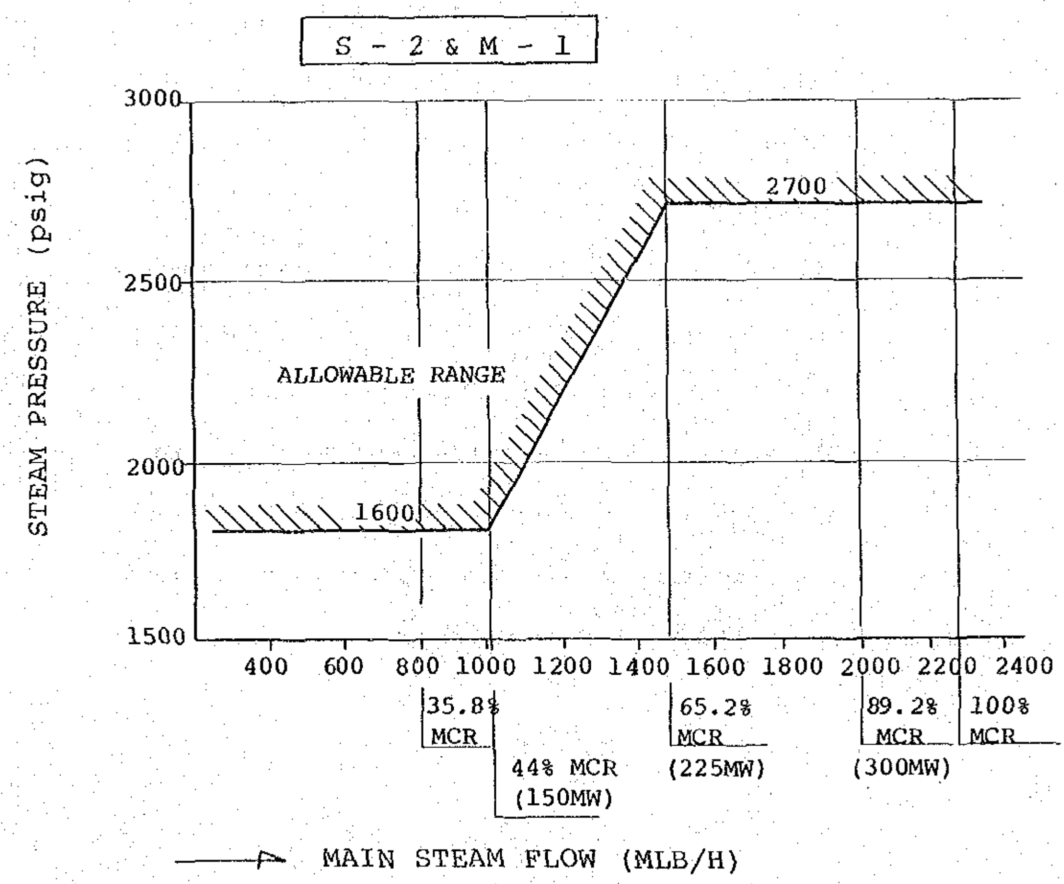
For once-through boiler, NAPOCOR should be extra careful for the flow of fluid in the boiler tubes. According to the manufacturer's report on variable pressure operation, correlation between boiler pressure and steam flow is very important. If NAPOCOR carries out a careless operation under a variable pressure operation, the boiler will suffer a serious damage.

In the case of M-1 is on variable pressure operation at 2100 psig and a maximum load of 240 MW. Under this pressure the maximum load must be kept less than 175 MW in accordance with the manufacturers recommendation.

Therefore, JICA team would like to recommend for NAPOCOR to strictly carry out and follow the recommendations for variable pressure operation by the manufacturer.

Fig. 5M-23 VARIABLE PRESSURE OPERATION





(ii) After replacement of the boiler tubes, the following conditions must be maintained.

* Keep each boiler tube temperature within the limited value and keep the annunciator system of the boiler metal temperature in good condition.

* Keep the burner combustion in good condition. (Refer to recommendation for combustion control in item b-(c)-iii)

* Keep the boiler water quality within the limited value.

* Carry out boiler tube washing by water jet every year.

* Record and check the steam pressure with load from economizer to turbine inlet every month. If the differential pressure between economizer and turbine inlet increases more than its limited value, chemical cleaning of the boiler is necessary.

* Use M.F.T. (Main Fuel Trip) interlock at all times without exception.

If NAPOCOR will operate the boiler without following the said recommendations, the same problems on the boiler will be encountered.

(b) Boiler Casing

i. Existing Condition

M-1 has excessive flue gas leakage thru the different parts of the boiler casing at the following points:

(i) Corner of the boiler casing (primary SH, and economizer areas)

(ii) Boiler bottom part connection of GRF duct has bigger leakage.

The boiler exhaust roof vent fans are not in a good condition. Only two (2) out of six (6) are operating. This condition accumulates the flue gas in the boiler house and hastens corrosion of metal exposed to the atmosphere. Operators are likewise hampered in checking abnormal equipment conditions.

M-2 has excessive flue gas leakage thru the different parts of the AH casing and the rack type sootblowers.

When it rains, roof leakage abounds in the area such that equipment gets corroded thru sulfation of rain-water. JICA team analyzed the sulfation of rain water and found its pH to be 3.6. This value is enough to corrode materials.

ii. Recommendations:

(i) Conduct early maintenance/repair job to the leaky boiler casing (M-1).

(ii) Conduct early maintenance/repair job of all boiler roof vent fans.

(iii) To provide individually all Operations and Maintenance personnel with the following tools:

* Appropriate gas mask
* Flash-lights
* Safety gloves when working or patrolling the area.

(iv) Conduct and carry out all maintenance/repair jobs soon.

(v) Conduct training of Operations and maintenance personnel to improve their knowledge on corrosion control.

(vi) Conduct early maintenance/repair of leaky AH casing (M-2).

(vii) Conduct early maintenance/repair of leaky main powerhouse building roof.

(c) Burners and Boiler Combustion

i. Existing Condition

The boiler combustion of M-1 is found in a good condition, however, M-2 is operating poorly.

The fuel oil system of M-2 is operating without the CDFOP (Constant Differential Fuel Oil Pump). Moreover the fuel oil temperature control system is operated manually, hence the inlet fuel oil temperature to burners could not be kept constant.

Operators conduct a good cleaning job of burner tips, however, these operators are not provided with ample data on the thickness and diameter of the sprayer plates and tips. Those exceeding the maximum allowable limits will cause poor atomizing of oil in the burner. Sometimes, these sprayer plates and tips have some cracks, bruises or defects are still being used.

ii. Recommendations:

(i) Repair/replace M-2 CDFOP at once and place it in service.

(ii) Set M-1 fuel oil heater steam supply control valve on automatic control to prevent temperature hunting.

(iii) Repair M-2 fuel oil heater steam supply control system immediately.

(iv) Record thickness of sprayer plates and diamter of tips.

(v) Replace sprayer plates or tips which has some cracks, bruises or defects.

(d) M-1 Start-up By-Pass System

i. Existing condition:

During start-up condition, there are plenty of valves for start-up by-pass system that is being used on remote manual operation. For once through boilers the actual change over operation from the start-up by-pass system to the normal operating condition is very difficult.

If there is a poor changeover operation, some trouble may occur, such as: bigger hunting of SH temperature, over-heating of boiler tubes caused by excessive combustion, etc.

There is no malfunction of valves of the start-up by-pass system but its valve body and instruments, are corroded by flue gas.

ii. Recommendations

(i) Repair automatic system of the start-up by-pass as soon as possible.

(ii) Service by routine preventive maintenance all valves of the start-up by-pass system and its related instruments.

b. Auxiliary Equipment of Boiler

(a) Forced Draft Fan (FDF)

i. Existing condition

M-1

Motor bearing temperatures are high. B-side has a high temperature at the inboard motor bearing as per temperature recorder in the control room, the temperature is 72.5°C, but actual temperature by thermometer at site is more than 76°C. The FDF area is very dirty with flue gas all around.

M-2

Vibrations of fan bearing inboard is excessively high on A and B.

A-side; H-2.3, V-1.14 A-0.7 MILS

B-side; H-5.5, V-1.1 A-1.7 MILS

Unit load - 180MW: 9/3/82

ii. Recommendations

(i) To check B-side motor inboard bearing temperature by the use of a thermometer at the site. (M-1)

(ii) To calibrate temperature reconrder of 1-B motor inboard. (M-1)

(iii) To inspect fan inboard bearing for A and B at the nearest opportunity. (M-2)

(iv) To clean area around FDF every time. (M-1 & M-2)

(b) Gas Recirculation Fan (GRF)

i. Existing Condition

M-1

There is no ladder and platform for the inspection of fan bearings and motors. The GRF area is very dirty with flue gas all around.

M-2

There is some vibration in the inboard fan bearing. There are plenty of scattered insulation materials in the area.

ii. Recommendations

(i) To provide platform and ladder on M-1 GRF area so that the operations personnel could patrol more effectively.

(ii) To conduct inspection of fan blades at the nearest opportunity to check for any unbalance. (M-2)

(iii) To always maintain the area free from any debris or scattered insulation materials. (M-2)

(c) Air Preheater

M1 and M2 has a very big air preheater corrosion problem. Most especially M-2 which is in a very critical condition as shown in Fig. 5M-24.

i. Analysis of Figure 5M-24

(i) Air Preheater Differential Draft (Gas Side)

Before commercial operation the differential draft of the AH was kept between 100 and 120mm H_2O at 350 MW. This differential draft increased from Oct. 1979 and reached its peak in December 1979. AH washing was conducted and this reduced the differential draft to less than 120 mm H_2O. AH washing was again carried out at least three (3) times before the annual overhaul of the unit. During this period before overhauling, the unit was able to carry its rated load of 350 MW.

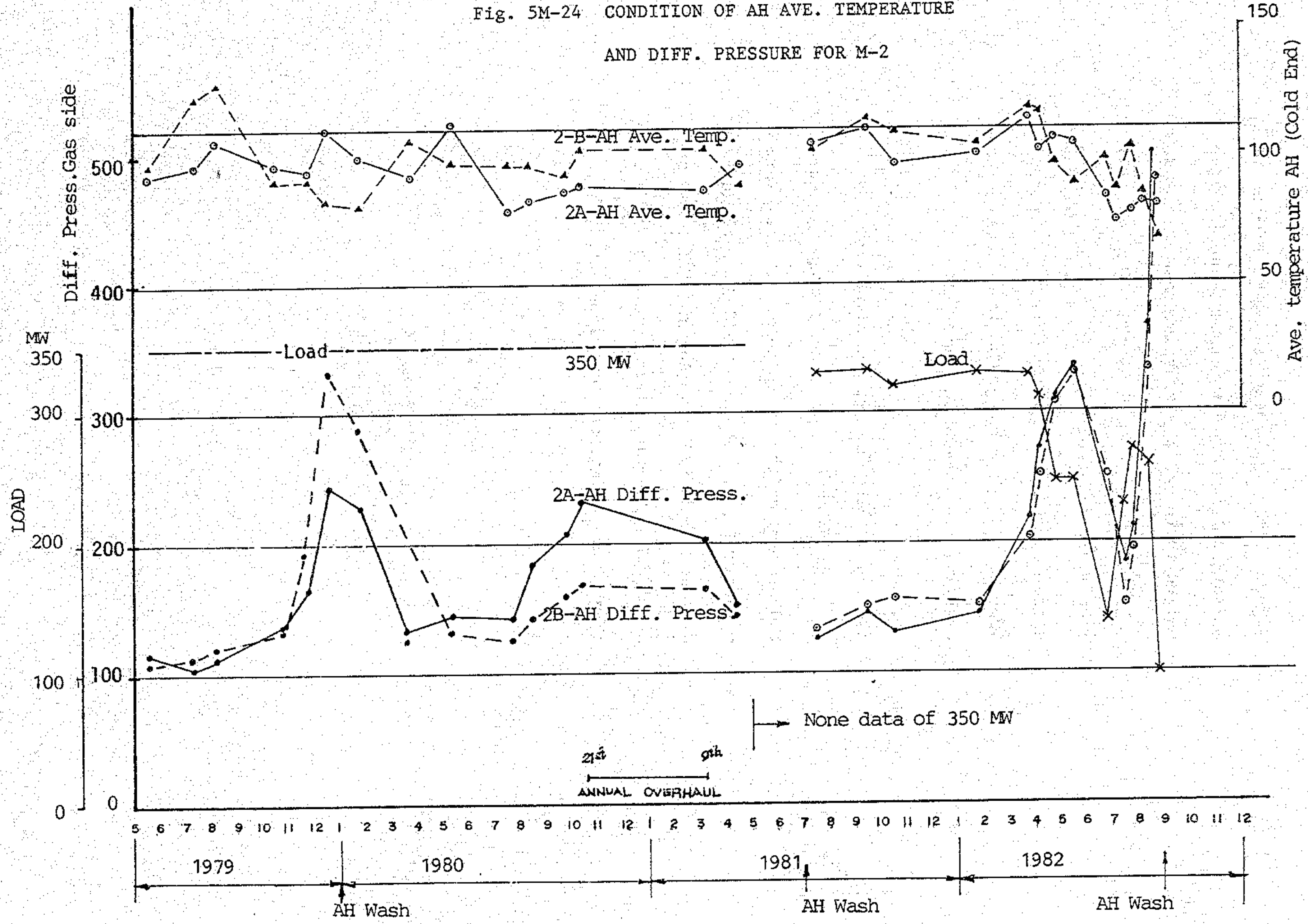
After the annual overhaul, AH washing was not carried out between July 1981 and

August 1982, according to the "RECORD OF OUTAGES AND TURBOSET SHUTDOWN". During this period there was a steady increase of the AH differential draft and consequently the unit load started decreasing. The steady rise in differential draft continued until it reached 500 mm H_2O with the unit load capable of carrying only 100 MW in August 1982.

(ii) Average Gas-Air Temperature of AH Cold End

The period where the average gas-air temperature of the AH cold-end elements were maintained to more than 110°C is very short between May 1979 to August 1982. Most especially 2A-side which operated at low temperature condition for a long period.

Fig. 5M-24 CONDITION OF AH AVE. TEMPERATURE AND DIFF. PRESSURE FOR M-2



ii. Cause of AH Element Corrosion:

For Malay-2 the process of AH element corrosion is shown as follows:

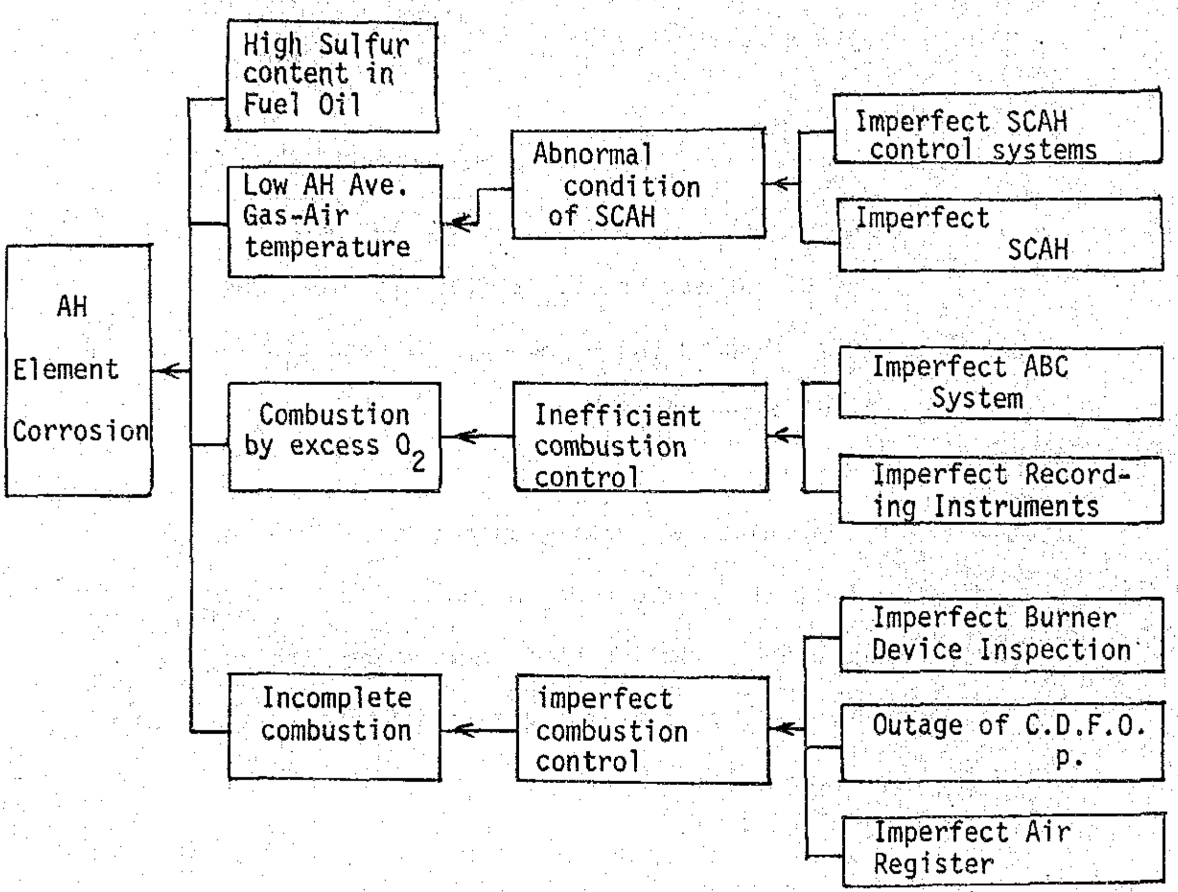


Fig. 5M-25 CAUSE OF AH CORROSION

iii. Recommendations for Combustion Control

(i) To perfectly clean the burners on a routine basis and to provide ample data as to the diameter and thickness of the sprayer plates. This way, all worn-out parts could be replaced with a new set.

(ii) To repair the automatic combustion control system to be able to operate the air flow control automatically. Boiler operators must always observe the O_2 meter, the condition of burner combustion, etc.

(iii) To immediately repair/replace the CDFOP of M-2. If combustion without the CDFOP continues, the boiler equipment (boiler tubes, air preheaters, gas ducts, etc.) will receive a death blow.

(iv) To inspect/adjust air registers during annual overhauling. To obtain perfect combustion, the condition of the air registers of each burner is very important.

(v) To train boiler operators who can ascertain the situation of combustion.

iv. Countermeasure for Air-Preheater cold end Corrosion by Low O_2 Combustion

At present M-1 and M-2 has a very serious problem in air-preheater cold end corrosion. Against these existing conditions, NAPOCOR has adopted the use of enamel coating in the cold end AH elements. However, these measure is insufficient if control system is inefficient. The steam coil air heaters (SCAH) of M-1 and M-2 are not in good operating condition. Here are the existing conditions of the SCAH during the study:

Table 5M-1 ACTUAL CONDITIONS OF SCAHs

SCAH	Heating Elements	Control System	Air Temp. In	Air Temp. Out	(To - ti) t
M-1A	Complete	Bad	99°F	167°F	68°F
M-1B	Complete	Bad	100°F	150°F	50°F
M-2A	4 Elements Leaking(out)	Bad	42°C	42°C	0°C
M-2B	Complete	Bad	43°C	48°C	5°C

* NOTE: Actual Conditions Taken During the Study.

JICA team would like to recommend that boiler combustion should be operated in low Oxygen (O_2) content condition. According to Japanese experience AH-cold end corrosion is also evident when the following conditions are experienced:

0.4% Sulfur content and 10% O_2 excess air,

4.0% Sulfur content and 1.5% O_2 excess air.

The existing condition of the fuel oil has a very high sulfur content hence the only way to improve combustion is to lower the percentage of O_2 content to 1%. This way the concentration of H_2SO_4 will be minimized, improving the life service of the Air-Heater Elements:

Minimize SO_3 content + H_2O content in vapor form $\longrightarrow$ lesser concentration of H_2SO_4

However, there may be problems which could arise when operating at a low percentage of O_2 concentration. The following conditions must be met:

(i) To maintain the fuel oil system in good operating conditions. This includes the control system which must be operated in Auto Position.

In case of M-2, the Constant Differential Fuel Oil Pump (CDFOP) must be serviceable. Without this pump NAPOCOR will not attain a perfect combustion in the burners.

(ii) To maintain the burners in good condition and attain perfect combustion.

(iii) To stabilize the temperature of the fuel-oil flowing into the burners.

(iv) To maintain the Automatic Boiler Control (ABC) system in auto position and have an Air-rich system.

(v) To have a very good O_2 analyzer.

(d) Steam Coil Air Heater (S.C.A.H.)

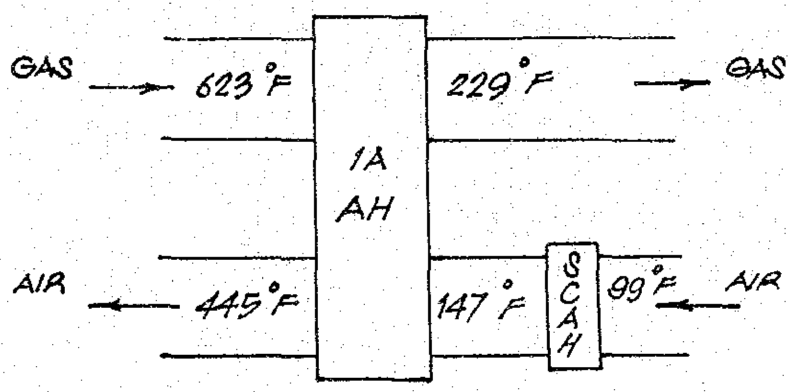
i. Existing Condition of M-1

The Steam Coil Air Heater (SCAH) is a very important equipment. This protects the low temperature part (cold end) of the air-preheater elements.

Therefore this equipment must always be maintained in good operating condition. If the SCAH lose its function, the Air Preheater (AH) cold-end elements will be corroded by H_2SO_4.

To clarify the description, an example is given for M-1.

Fig. 5M-26 AIR AND GAS TEMPERATURE OF M-1



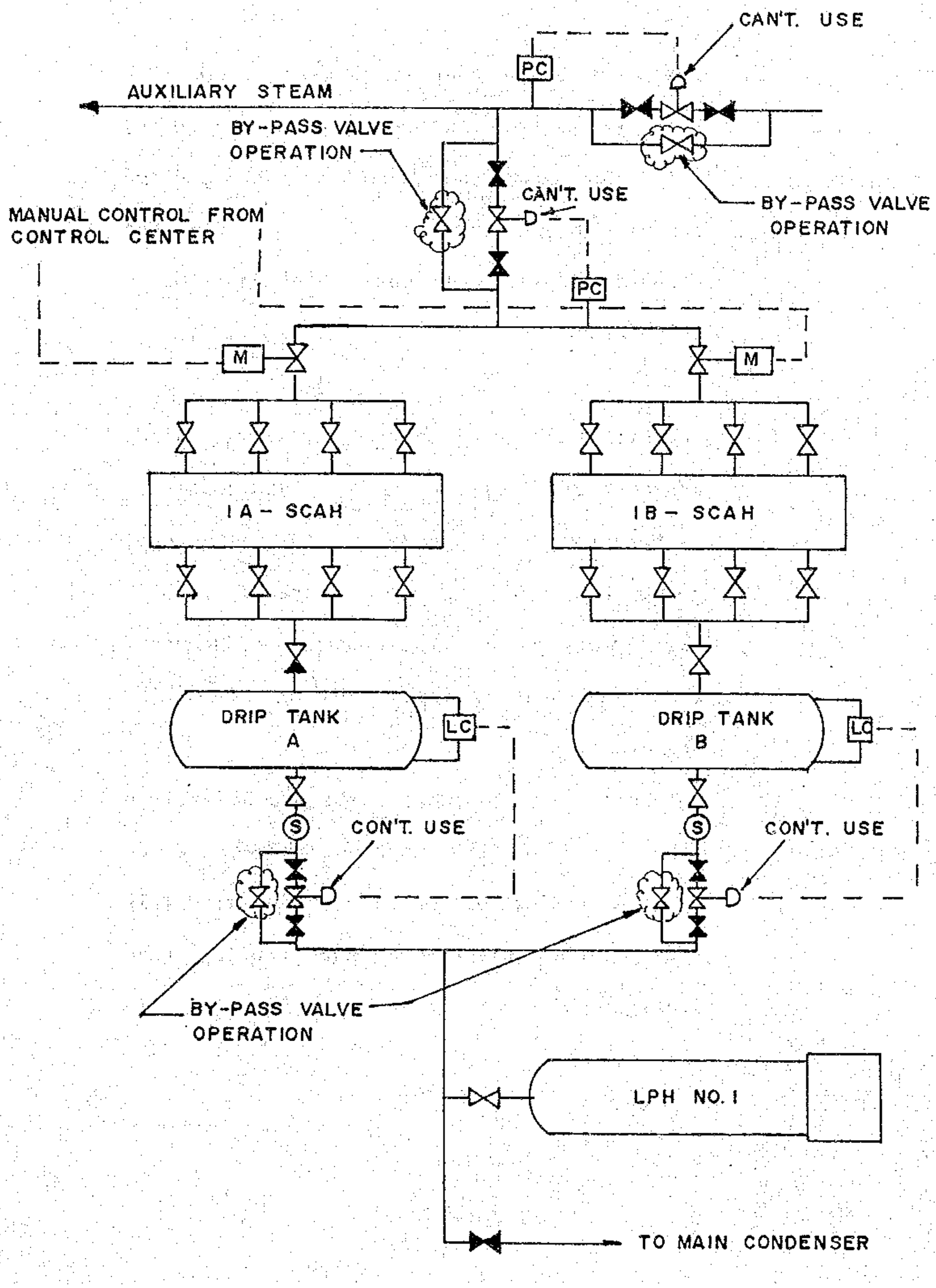
Gas-Air Average Temperature $\frac{229 + 147}{2} = 188°F$

The AH cold-end elements need an average Gas-Air temperature of more than 240°F to prevent sulfur corrosion attack.

To clarify the description, here is the existing condition of the M-1 SCAH.

The existing operation of M-1 SCAH is shown by the figure below.

Fig. 5M-27 EXISTING M-1 SCAH OPERATION



ii. Existing State of M-1 SCAH

(i) Two pressure control valves, of the auxiliary steam supply to SCAH, are both isolated from the system. Hence, the auxiliary steam supply pressure is not controlled automatically.

(ii) The temperature control valves of A&B SCAH are not on full automatic control. Hence, M-1 SCAH could not maintain the average gas-air temperature of the AH cold end element constant and more than the limited temperature.

(iii) The drip tank level control valves A & B are not controlled automatically. This condition is very dangerous because if the drain level go up, the outlet air temperature of the SCAH will drop and no heat-exchange will occur since the heating steam will be blocked by the drain.

On the other hand, if the drain level go down, the SCAH will experience hammering due to the mixing of steam and water. This effect will damage the SCAH causing tube leakage.

iii. Actual countermeasure for the existing state of M-1 SCAH

(i) Immediately repair/replace the defective control system for the auxiliary steam supply of the SCAH.

(ii) Immediately repair/replace the temperature control system of the SCAH and always use it on automatic operation.

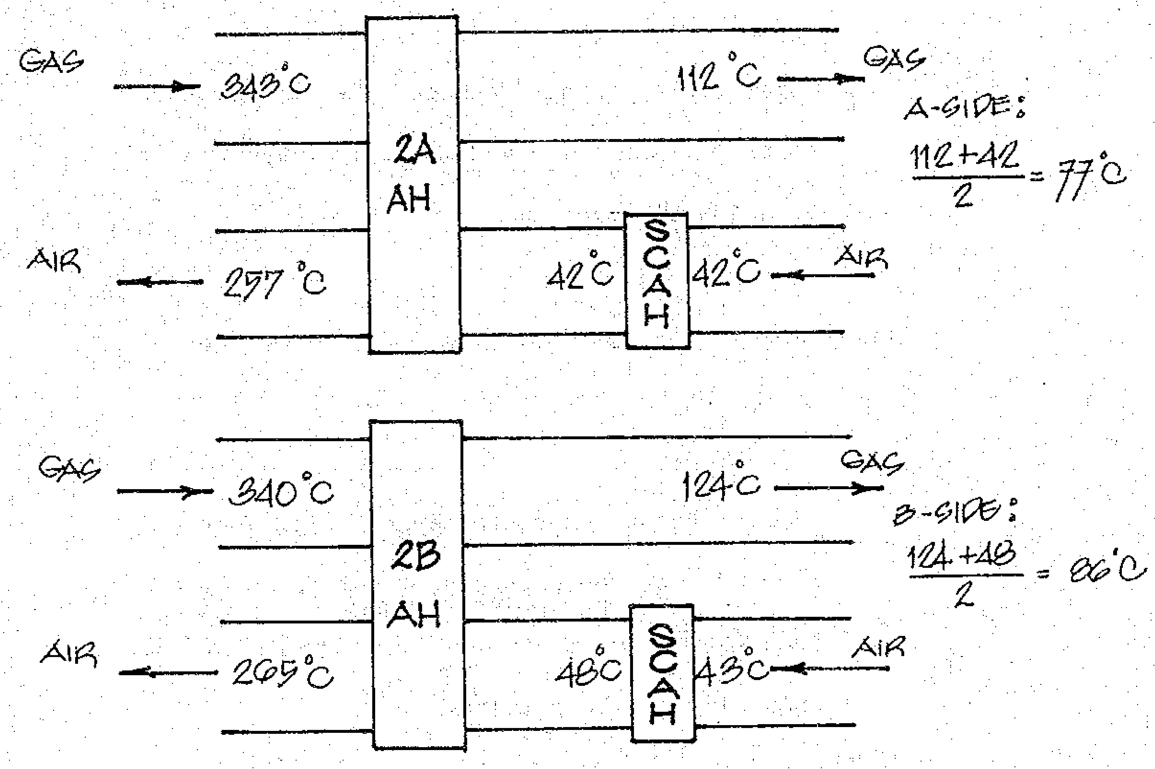
(iii) Immediately repair/replace the level control system of the drip tanks A & B.

If these countermeasures will not be carried out, the problems of corrosion of the AH cold-end elements and the damage on the SCAH will not be settled.

iv. Existing condition of M-2

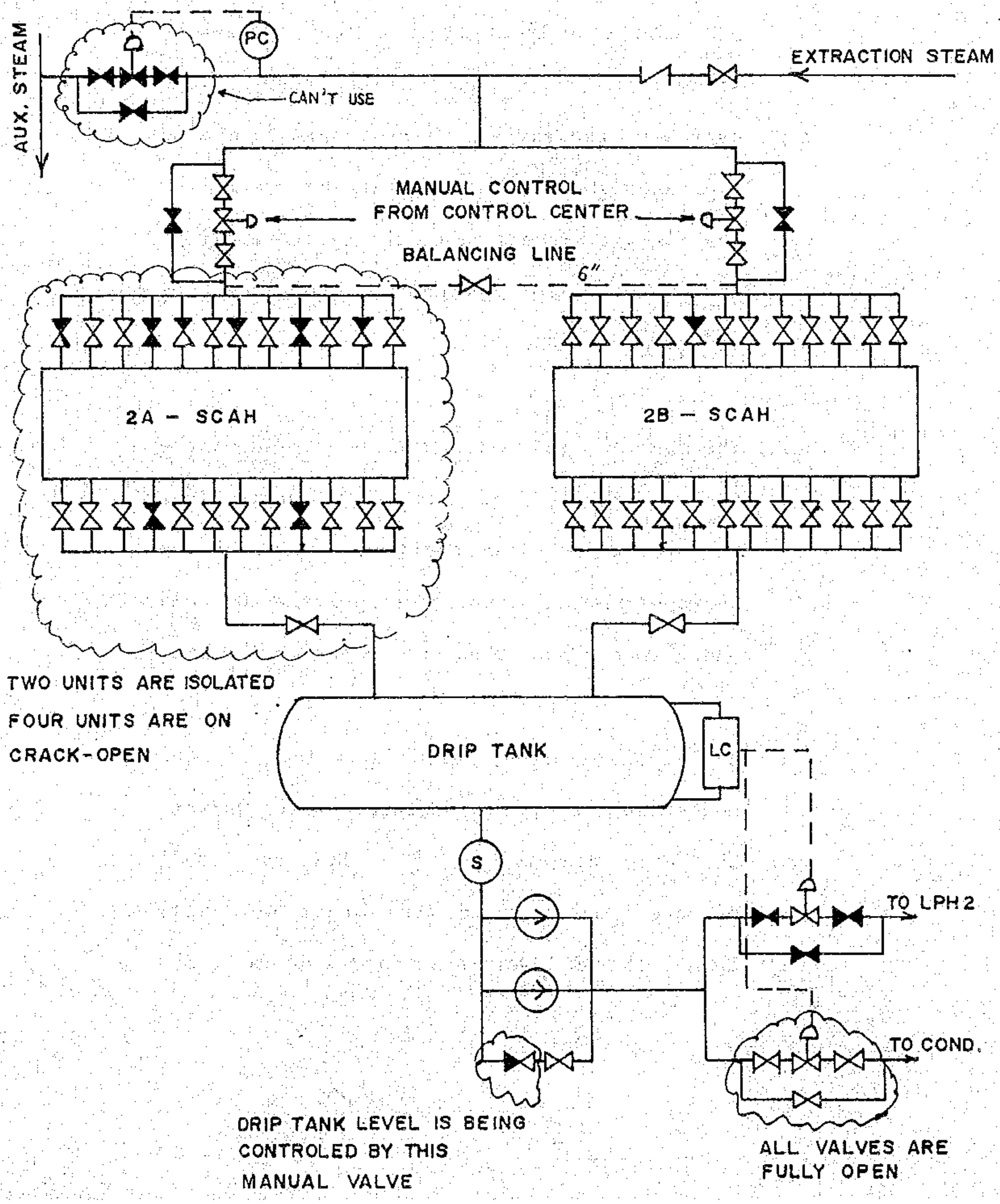
To clarify the description, an example is given for M-2.

Fig. 5M-28 AIR AND GAS TEMPERATURE OF M-2



The AH cold-end elements, need an average gas-air temperature of more than 110°C to prevent sulfur corrosion attack. To clarify the description, an example is given on the existing state of the SCAH of M-2. The present operation of M-2 SCAH is shown on the figure:

Fig. 5M-29 EXISTING M-2 SCAH OPERATION



v. Existing state of M-2 SCAH for Consideration

(i) The SCAH of M-2 has two heating sources. One is from the extraction steam (from turbine) and the other is from the auxiliary steam (boiler). However, the auxiliary steam line is isolated due to its defective pressure control system. Hence, the heating source of M-2 SCAH is only supplied by the extraction steam from the turbine. If the turbine load decrease, the extraction steam pressure also decreases and without the back-up steam from the auxiliary steam line, the steam supply to the SCAH also decreases, reducing the efficiency of the SCAH.

(ii) The temperature control valves, A & B of the SCAH are not automatically controlled. Therefore, M-2 SCAH could not maintain the average gas-air temperature of the AH cold end elements more than the temperature limit.

(iii) A balancing line, was installed at the downstream of the temperature control valves. The pipe diameter is 6". But even this balance line is used, the steam flow will change in the lower resistance side (A or B).

(iv) 2A-SCAH has two (2) isolated heating coils and four (4) crack-open heating coils out of a total of twelve (12) heating coils. 2B-SCAH has only one (1) crack-open heating coils out of twelve (12). Therefore, the heating steam of 2A-SCAH will go to 2B-SCAH through the balancing line. As a consequence, 2A-SCAH will not have an effective heat exchange to the combustion air.

(v) M-2 SCAH has a common drip tank. In this case, an unbalance condition could exist between A & B when there are some damaged coil in either side.

(vi) M-2 SCAH has two (2) drain line pumps but they are inoperable.

(vii) The SCAH drain is directed to the condenser but the level control system of the drip tank is not on automatic control. This is being carried-out by manipulating the drain pump by-pass valve manually.

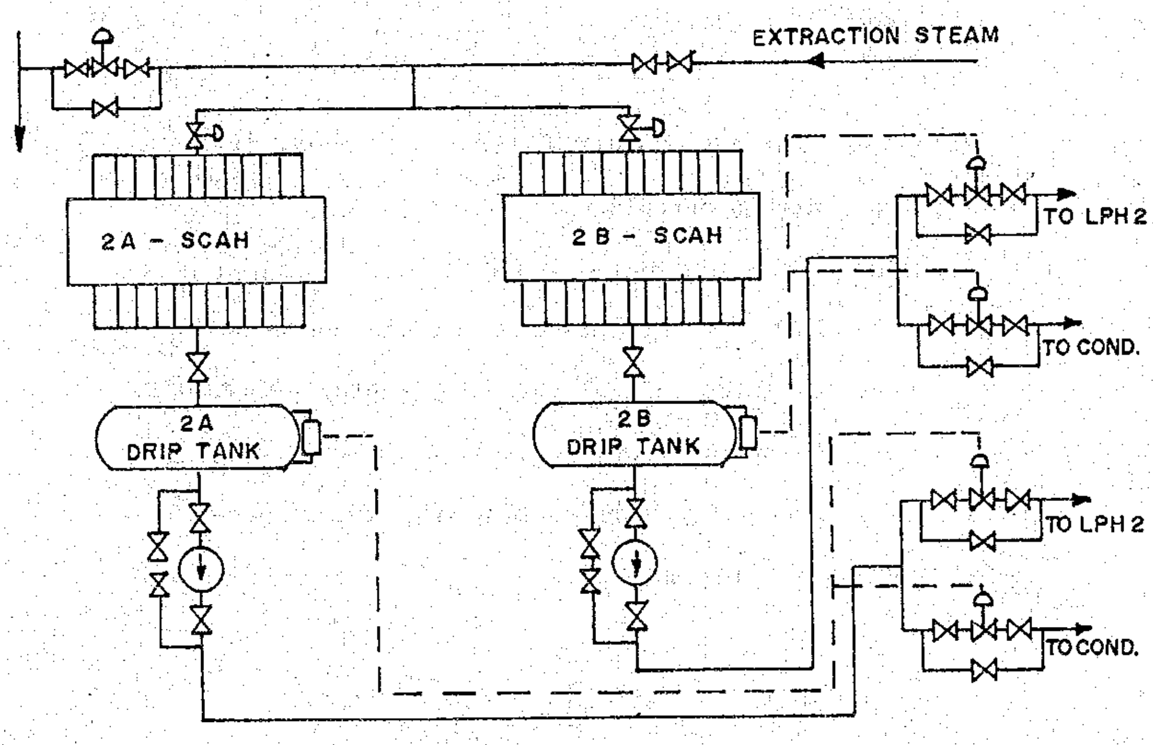
vi. Actual countermeasure for the existing state of M-2 SCAH

(i) Immediately repair/replace all defective control system of M-2 SCAH as to heating steam pressure control, temperature control, level control, etc.

(ii) Immediately repair drain pumps and to use them automatically.

(iii) To improve the drip tank by this improvement:

Fig. 5M-30 PREFERABLE SCAH SYSTEM



(iv) To close the valve of the balancing line.

(e) Fuel Oil Pumps

i. Existing Condition

M-1

M.F.O.P (Main Fuel Oil Pump) and FOH (Fuel Oil Heater) area for M-1 and M-2 are dirty. Some pressure indicators (gages) are broken.

M-2

CDFOP (Constant Differencial Fuel Oil Pump) is out of service.

ii. Recommendations

(i) To clean M.F.O.P. and F.O.H. area to prevent any untoward accident to occur. (M-1 & M-2)

(ii) To repair/replace broken pressure indicators as soon as possible. (M-1 & M-2)

(iii) To repair/replace CDFOP for M-2 at once.

(f) Auxiliary Steam System

i. Existing Condition

M-1 and M-2

There is no automatic pressure control valve which is in good working condition. Therefore, M-1 and M-2 are not able to fully get auxiliary steam for these necessary equipments. There are plenty of auxiliary steam leakage in the plants.

ii. Recommendations

(i) To repair all pressure control system for auxiliary steam line at once.

(ii) To repair all leakages along the auxiliary steam line.

(g) Compressors

i. Existing condition

M-1

There is some vibration and unusual noise in M-1 A-SAC (Station Air Compressor), and this compressor was found continuously loading at around 82 psig.

M-1 B-CAC (Control Air Compressor) found in service and continuously loading at 86 psig. The back-up air control valve was found fully open, and its isolating valves were both fully closed.

M-2

M-2 A- and M-2 B-CAC (Control Air Compressor) were on service. Both compressors are continuously loading at $6kg/cm^2g$.

The back-up air control valve was also found fully open, but its isolating valves were both fully closed. One of these compressors has unusual noise inside the cylinder.

ii. Recommendations

(i) To inspect M-1 A-SAC for internal wear at the nearest opportunity. (M-1)

(ii) To inspect the back-up air control valves (M-1 & M-2)

(iii) To search for the leaking place of control air and repair at once (M-1& M-2)

(iv) To always drain the air receiver of control air and station air at least once every shift.

(v) To provide identification marks on M-2 compressors and its auxiliaries

(h) Fuel oil storage tank

i. Existing condition

There are plenty of tall grass in the area hampering inspection and patrolling by the operation personnel, of all equipment in the area. Pipes, valves and instrument equipment are corroded.

Suction heater control system of fuel oil storage tank No.2 has been broken.

ii. Recommendations

(i) Fuel oil storage tank area must be regularly clean to provide accessibility to the equipment by the operations personnel.

(ii) A periodic preventive maintenance should be made to improve the existing condition in the fuel oil tank storage area. Patrolling by operations personnel will also improve. JICA team recommend chemical weed control system to prevent grass growth.

(i) Ash Handling

i. Existing Condition

The ash handling system of M-1 and M-2 are badly damaged due to corrosion by sulfurous attack.

NAPOCOR is implementing a rehabilitation scheme for these ash handling system.

ii. Recommendations

(i) To repair the ash handling system of M-1 and M-2 as soon as possible.

(ii) To maintain auxiliary and accessory equipments for ash handling in good condition.

(iii) To upgrade the condition of the auxiliary steam or electric power source which will be used by ash handling system.

If you detect some flue gas leakage, you should repair it at once.

(iv) To always clean floor or devices of the ash handling system. If ash handling system is surrounded by flue gas, it will be corroded.

(j) Soot Blowers

i. Existing condition

M-1 and M-2 are continuously using AH soot blowers resulting in clean AH elements. However, RACK-TYPE soot blowers are not being used for SH and RH tubes, and there are plenty of defective RACK-TYPE soot blowers.

ii. Recommendations

(i) It is undesirable to use the AH soot blower continuously, under the bad condition such as a lower gas-air average temperature at the AH cold-end.

(ii) To use rack-type soot blower for SH and RH tubes.

(iii) To repair all defective rack-type soot blower.

(k) Burner Enclosure

i. Existing Condition

In M-1 there are plenty of flue gas leakage.

In M-2 there are plently of oil spillage.

ii. Recommendations

(i) To improve ventilating system in the area of M-1 burner enclosure. (M-1)

(ii) To initiate a weekly cleaning schedule of the burner enclosure under a good supervisor. (M-1 & M-2)

(iii) To provide trash cans and drip pans in the burner area. (M-1 & M-2)

c. Turbine

(a) Turbine Proper

i. Existing Condition

M - 1

On November 29, 1980, this turbine generator unit was shut down by increased vibrations. In accordance with manufacturer's report, the cause of this trouble is due to a fracture of blade in the LP-1 turbine.

At present, this LP - 1 turbine has been provisionally remedied by the manufacturer.

This measure was carried out by cutting-off LP moving blades.

The other troubles of M-1 turbine. The stationary blade carrier and inner casings of the HP and IP turbines are erroded by solid particles. The seal strips are damaged by poor quality of steam. The compensator-type expansion joints of turbine are ruptured by the compensator corrugations, stress corrosion cracking and vibration. The LP blades mainly take the form of stress corrosion cracking caused by high residual stress in the steam region.

Gland steam seal leaks on LP2-generator end. Excessive gland steam seal leaks between LP1 and LP2 bearing No. 5.

Gland steam seal pressure control valve fully opens on manual position, because when this is placed on auto position, the condenser vacuum drops. The set point of the controller is at 1.1 kg/cm^2g (15.61 psig) and this set pressure is enough under normal conditions, maybe some labyrinth packings are wornout.

Found one FRONT-STANDARD jacking bolt (FRONT-RIGHT SIDE) bent.

ELECTRO-HYDRAULIC CONTROL PANEL is very dirty, pressure swtiches in the area are also very dirty.

Gratings are found in dis-array and not installed properly.

Miscellaneous pipes below the FRONT STANDARD of the HP-turbine has no insulation, caused by pipe vibration or pipe hammering.

<u>M-2</u>

On October 9, 1980, M-2 tripped at 350 MW load. After unit tripped, there was no emergency power supply due to the breaker also tripped.

In accordance with manufacturer's report, the damages were as follows;

No. 1 to No. 8 bearings were melted out by lubricating oil failure. Front side pad of thrusts bearing was melted by lubricating oil failures.

This trouble was resorted by replacement of each metal.

M-2 MAIN STOP VALVE (Right side) has a tempoerary countermeasures for MSV testing system. The valve stem of the pilot valve was found sheared. This was just welded.

ii. <u>Recommendations</u>

(i) To carry out automatic start test for A.O.P., T.G.O.P. and E.O.P. by testing device. (M-1 & M-2) This test should be carried out once a week and pumps running condition should be confirmed by operator.

(ii) To inspect/repair turbine equipments which are recommended by manufacturer at next overhauling (M-1).

(iii) To replace provisionally remedied LP moving blades at the overhauling (M-1).

(iv) To inspect labyrinth packing during overhaul, and prepare materials inventory of labyrinth packings before overhauling and to replace all packings if possible.

After overhauling, check the condition of the gland steam pressure controller. This must be fully operational on auto-position during start-up. (M-1)

(v) To replace bent, FRONT STANDARD JACKING BOLT, with a new one. (M-1)

(vi) During shut-down, thoroughly clean the area of the FRONT-STANDARD and THE ELECTRO-HYDRAULIC-CONTROL PANEL. (M-1)

(vii) To arrange and properly install all gratings.

(viii) To repair as soon as possible all damaged pipe insulation. (M-1)

(ix) To replace as soon as possible with a new original valve stem of the pilot valve. (M-2) The practice of testing the valve is three times a day. Since a temporary remedial measure was made on the valve, it is highly recommended that the testing of this valve be made only once a day. The standard practice of valve testing is once a day in accordance with the manufacturer's instruction.

(b) Turbine Floor

i. Existing Condition

The whole turbine floor area is being used as spare parts storage area. Overhauling tools and jigs are being stored also in the area.

This problem hinders the cleaning of the turbine floor area. At the M-2 area, storage of heavy parts causes the steel floor plates to bend. This is very dangerous.

ii. Recommendations

(i) To preserve the original condition of spare parts, transfer these parts in a warehouse. If the warehouse is already full, it is recommended to construct an additional bodega or warehouse construction as soon as possible. But there seems to be some spares after arranging existing warehouses.

d. Auxiliary Equipment of Turbine

(a) Main Condenser Area

i. Existing Condition

M - 1

The main condenser area at M-1 is very dirty. Plenty of pipes are corroded due to contact with dirty water, for example drain pipe of CRH line. If this pipe leaks due to corrosion dirty water will contaminate the system.

M - 2

Main condenser's chloride detector sampling line pump was scrapped and pulled-out of commission, due to the condition when it was submerged in the dirty water.

ii. Recommendations

(i) To replace chlorine detector system with new one. (M-2)

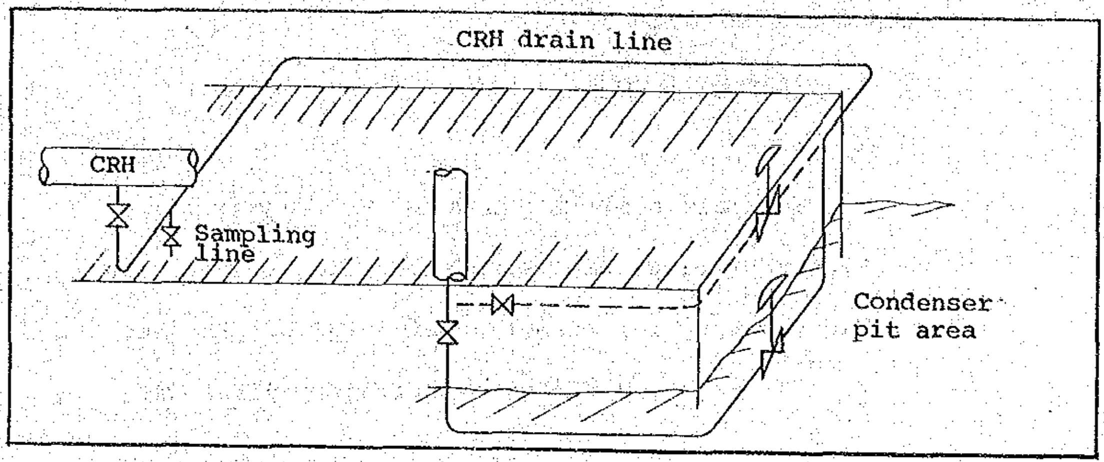
(ii) To always keep the condenser pump pit clean (M-1 & M-2)

(iii) To carry out routine preventive maintenance for condenser sump pumps. (M-1 & M-2)

(iv) To install chloride detector system on M-1 hotwell tank.

(v) To improve the condition of the CRH drain line by adopting the following; (M-1)

Fig. 5M-31 CRH DRAIN LINE



---- PROPOSED LINE

This proposal will eliminate corrosion of the CRH drain line with contaminated water in the condenser gets too high.

(b) Main Condenser

JICA team has conducted a study of the M-1 and M-2 tube leakage in the main condenser. The result of the study is shown on Fig. 5M-32 and Fig. 5M-33.

i. Analysis of M-1 Main Condenser (Fig. 5M-32)

(i) There were quite a few number of plugged-tubes on M-1 A & B side as of August, 1978.

(ii) The number of plugged-condenser tubes of the A side increased abruptly in August, 1978 to December, 1978. During this period, B side was normal. JICA team could only imagine that the A side condenser tube had other external damage such a turbine blade failure. JICA team could not conduct a more thorough study on the cause of excessive tube leakage on A side.

(iii) Tube plugging of the main condenser was not carried out during the period December, 1978 to December, 1980 (2 years) but the rate of condenser tube failure could increase due to age. Moreover chlorine injection to the condenser has been abolished.

(iv) There was an increase in the rate of the number of plugged tubes between January, 1981 and January, 1982 on both sides.

(v) Still during the period between January, 1982 to July, 1982 the rate of condenser tube failure rised more abruptly. This means that M-1 condenser is in an alarming condition now.

(vi) As of August, 1982 the nbumber of plugged condenser tube is as follows:

A side - 531 (3.05%)

B side - 517 (3.005%)

Evaluation of the analysis showed that the number of plugged condenser tubes are few, however, M-1 will encounter a big problem in the near future as shown in Figure 5M-32.

ii. Analysis of M-2 Main Condenser (Fig. 5M-33)

(i) As of June, 1982, the A side condenser tubes experienced plugging only twice since its commercial operation. In June, 1982 there was a total no. of 3177 pcs. of plugged tube (31.52%)

This phenomenon is abnormal and surprising as this means that the condensate water in the hotwell gets contaminated with dirty water due to condenser tube leakage between January, 1981 to June 1982. It is relatively impossible for 2847 pieces of condenser tubes to leak in one day.

Therefore, it is imperative that the analytical system of the condensate water be strengthened. If the conductivity detector were in good oprating condition the condenser tube leakage could be detected at once. However, this detector is damaged due to a submerged pump.

(ii) As of August, 1982, the B side condenser tubes experienced plugging four (4) times since its commercial operation. In February, 1982, a total of 133 tubes (1.32%) were plugged. However, in June, 1982, a total of 1229 tubes (12.19%) were plugged.

Fig. 5M-32 CONDITION OF PLUGGED CONDENSER TUBES FOR M-1

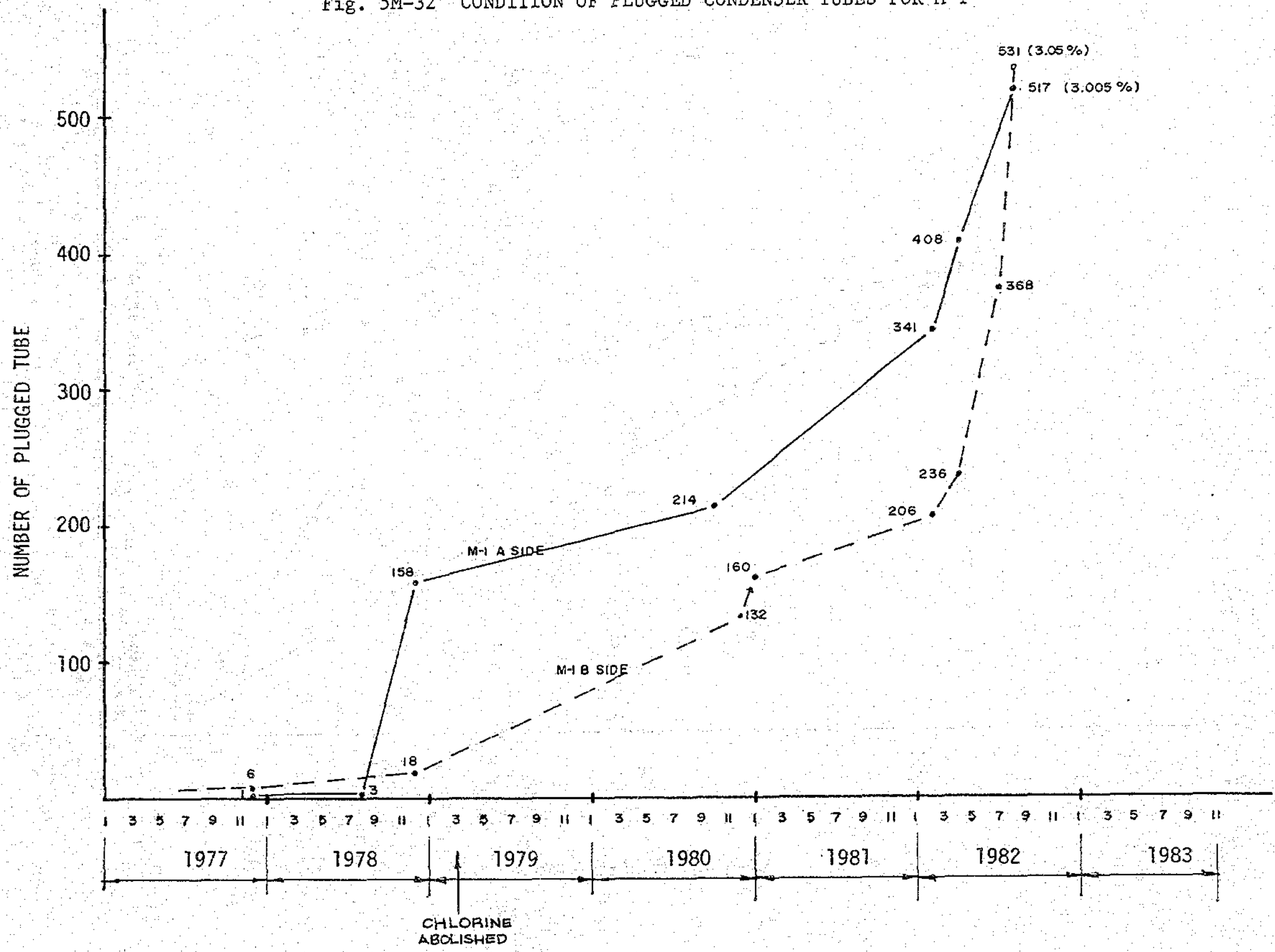
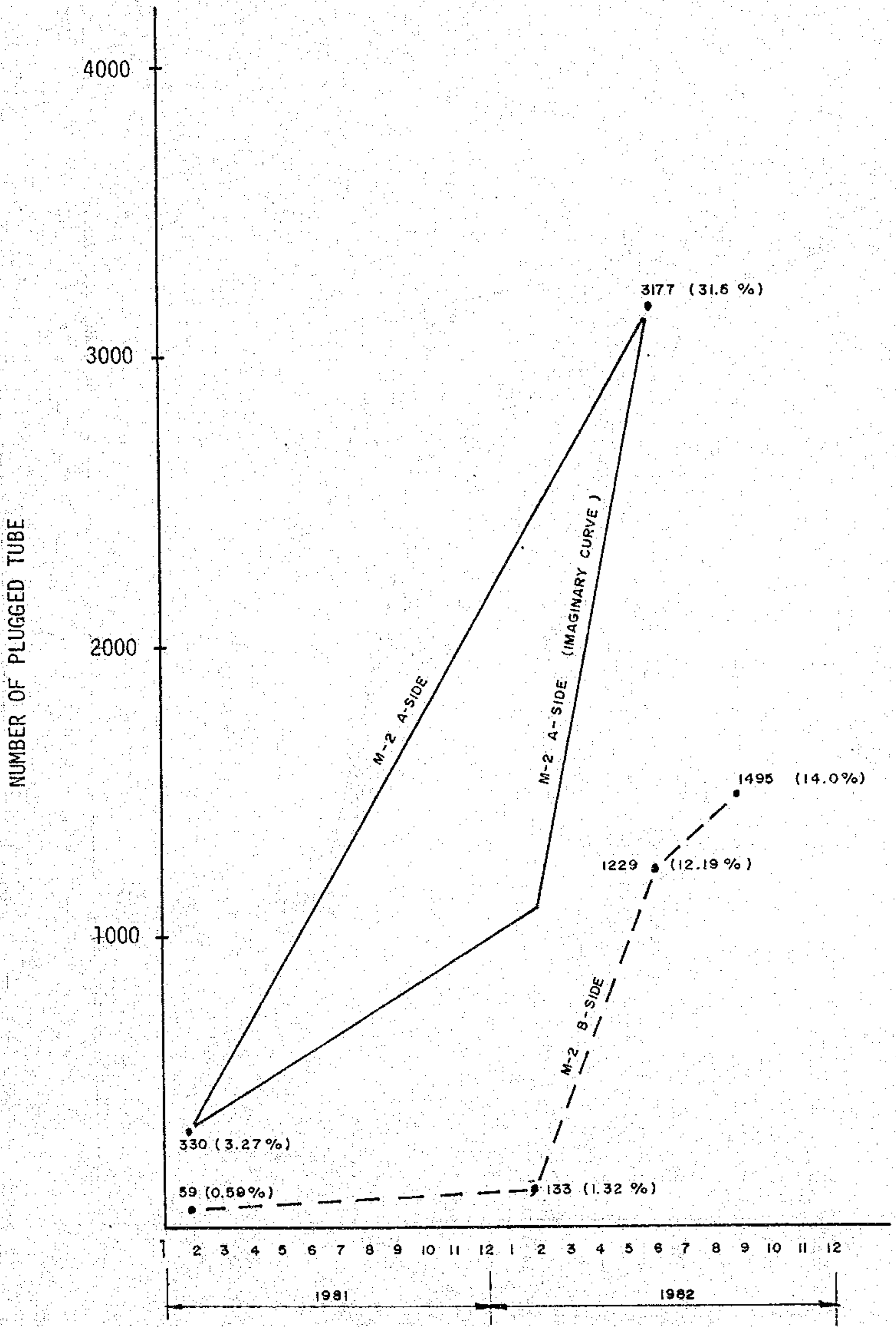


Fig. 5M-33 CONDITION OF CONDENSER TUBES FOR M-2



(iii) The rate of plugged tubes on the B side has abruptly increased between February and June, 1982. This means that M-2 has an alarming condition now.

We will presume that M-2 will encounter a big problem in the near future due to condenser tube leakage as shown in Figure 5M-33. To this problem, NAPOCOR planned to re-tube all condenser tubes to aluminum alloy tubes.

JICA team would like to recommend that planning of a preventive maintenance for the new tubes to be carried out.

iii. Countermeasure for the Corrosion of the Main Condenser

In Japan, the main causes of condenser tube leakage are inlet attack and deposit attack.

Condenser tube damage is increased by inlet attack. This is caused by galvanic corrosion and/or the separation of the tube surface protective coating by excess velocity of the circulating water inside the tubes coupled with the intermingling of air bubbles and the change of water current direction.

Corrosion of condenser tube may also be caused by deposit attack. This is caused by galvanic corrosion and/or eddy current effect when shells, woods and foreign matters are deposited in the condenser tubes. When foreign matters adhere in the condenser tubes, an eddy current effect may occur destroying the protective film coating of the tube. This will eventually lead to failure of the condenser tube.

It is therefore suggested that the following countermeasures be carried out to improve the service life of main condenser tubes.

(i) Prevent the itnermixing of foreign matters into the condenser.

(ii) Form a protective coating inside the surface of the tubes.

(iii) Maintain the cathodic protection system in good operating condition.

iv. Active Method

(i) Chroline Injection (reference)

Chlorine injection is a more-effective method against preventive biological corrosion, antisticking of slime on the inner surface of the condenser tube, and bacterial corrosion by vitriol disinfection, etc.

Quantity of chlorine injection is important for the condenser. However, due to accelerated corrosion of condenser tube material, it is undesirable to inject chlorine at a concentration of more than 0.5 ppm. The correct dosage of chlorine injection must be determined in accordance with the present condition of the condenser tubes.

For Malaya-1, chlorine injection of 0.2 ppm, has been a practice until it was stopped in March, 1979. This dosage is just right.

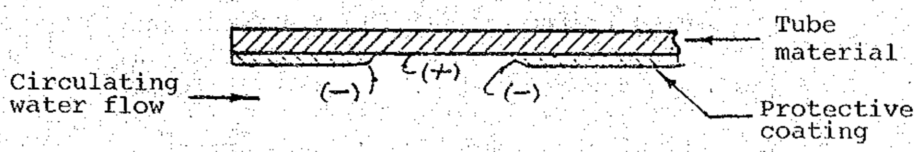
According to the data on plugged tubes for M-1 main condenser (Figure 5M-32) the total number of plugged condenser tubes started increasing since March, 1979 when Malaya Thermal Plant stopped its chlorine injection.

Moreover, Malaya-2 had not experienced chlorine injection eversince start-up. The number of plugged tubes for M-2 have started increasing inspite of the fact that the condenser tube material is stainless steel.

Therefore, JICA team recommends the rehabilitation of the chlorine injection system and the operation of the chlorine injection to M-1 and M-2 main condenser depending on the result of analysis for damaged tubes.

(ii) Injection of Ferrous Sulfate to the Condenser (Reference)

Abrasion in the condenser tubes is a very important problem. The protective coating on the inner surface of the condenser tube gets easily damage by the flow of circulating water. As a result, the condenser tubes will be prone to corrosion attack through galvanic attack by electric potential between the exposed portion of the condenser tube (+ anode) and the remaining protective coating (- cathode).



A new protective coating could be formed on the inner surface of the condenser tubes by the injection of Ferrous-Sulfate. The injection method is as follows:

(A) For initial injection.

Lasting 3 months, Ferrous-Sulfate content is 1.0 ppm Injection time - interval - 1 hour per day.

(B) After 3 months:

Ferrous-Sulfate content is 1.0 ppm. Injection Time-Interval - 1 hour per week or 1 hour per 10 days in accordance with the unit condition.

Note: The injection time-interval will be determined by the actual condition of the protective coating being formed by the injection of the ferrous-sulfate. This could only be determined by actual condenser tube inspection.

Herewith is the proposed ferrous-sulfate injection scheme:

Fig. 5M-34 FERROUS-SULFATE INJECTION SCHEME FOR M-1

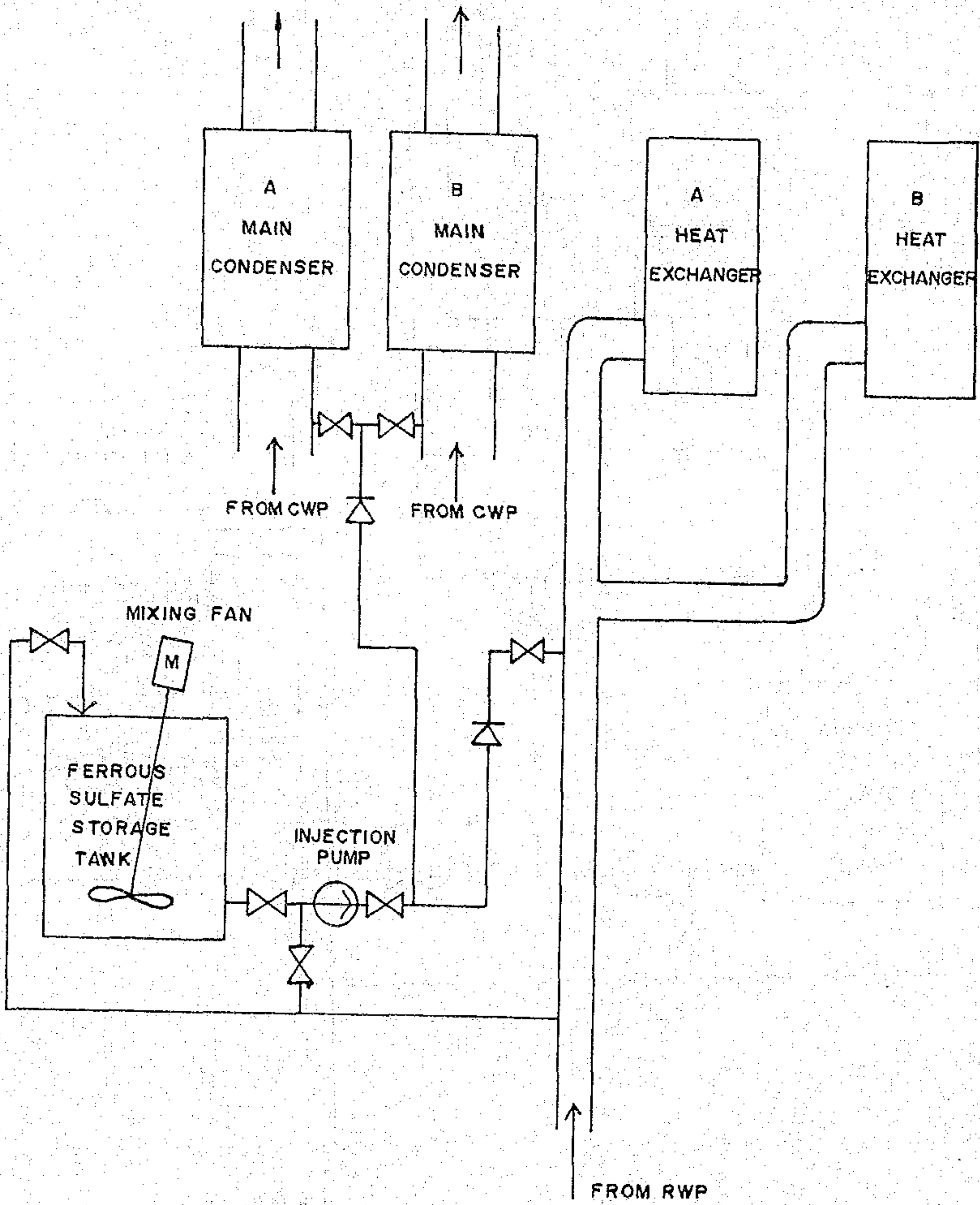
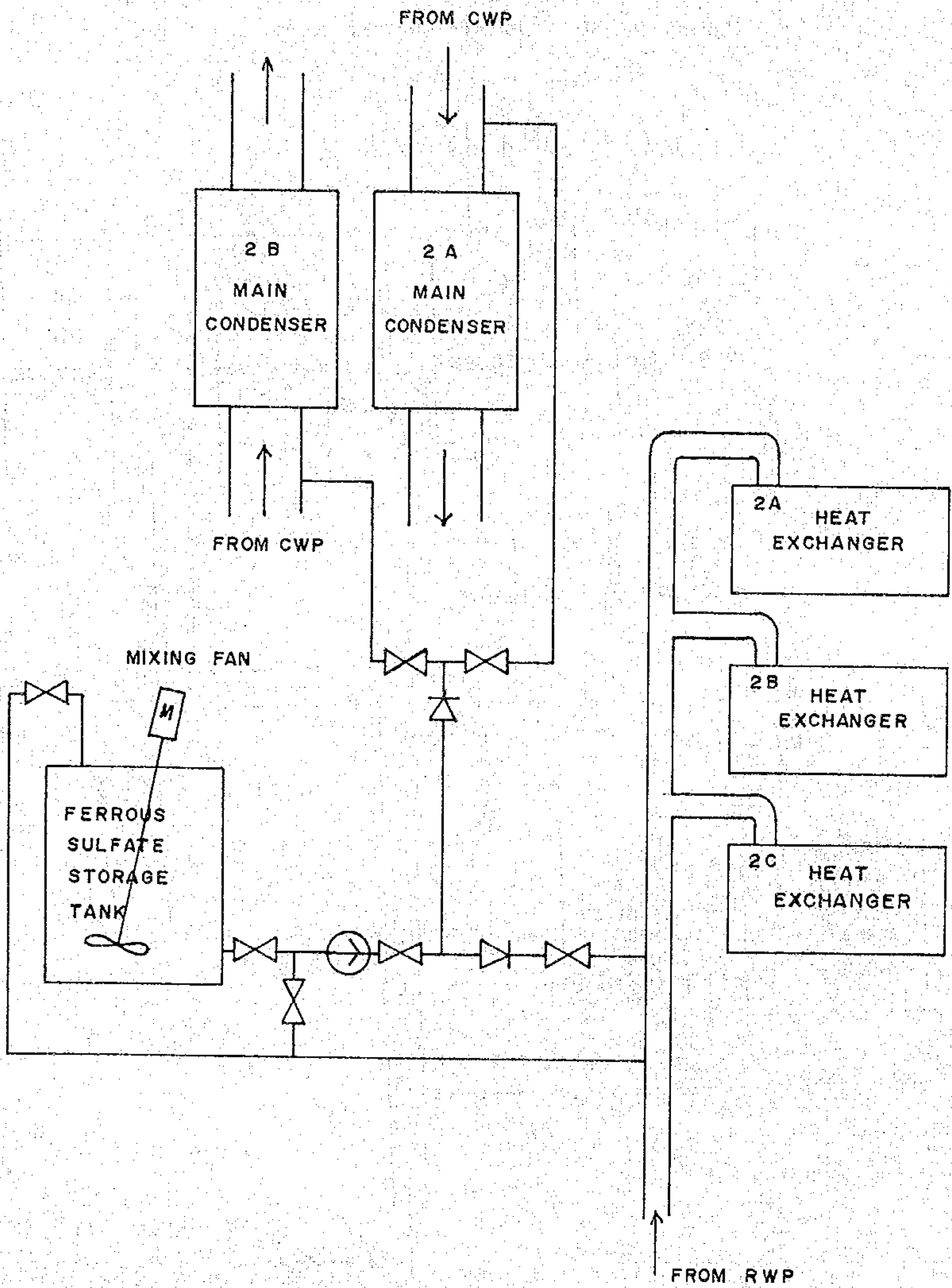


Fig. 5M-35 FERROUS-SULFATE INJECTION SCHEME FOR M-2



(iii) Control of Cathodic Protection

The effective area of the cathodic protection system is very limited. This is mainly concentrated in the water box, the tube sheet, and only about 500 mm of the condenser tube from the tube sheet.

Therefore, the cathodic protection is effective against inlet attack of the condenser water box. It also prevents deposit attack by corrosion in the water box.

JICA team hereby recommends that the cathodic protection be maintained in good operating condition. A monitoring system must also be adopted to record data of the cathodic protection system. This must be incorporated in the daily log-sheet of the chemical section on a weekly basis.

(iv) Recommendations

* To expedite the order of spare condenser tubes for M-1 and replace all damaged tubes. (M-1)

* To adopt the eddy current tester for detecting cracks, corrosion and thinning of condenser tubes during annual overhauling. (M-1 & M-2)

* To maintain condition of the cathodic protection in good condition (M-1 & M-2)

* To repair ball cleaning equipment (M-2)

* It is further recommended that should one side be opened-up for leak test, the other side must also be opened for inspection and leak test. (M-1 & M-2)

* To analyze leaky tubes and to determine its countermeasure (M-1 & M-2)

(c) M-2 Main Condenser Ball Cleaning Equipment

i. Existing Condition of the Ball Cleaning Equipment

This equipment was not used in M-2 main condenser since 1980. It was able to operate only for a period of less than six months. During operation, plenty of balls were lost including the spare balls. The equipment was then damaged when the upper and lower screen motors were sub-merged in sump water.

ii. Purpose of the Ball Cleaning Equipment

This equipment has two purposes. One is to maintain the condenser vacuum in good condition and the other is to prevent condenser tube corrosion by deposit attack.

Condenser vacuum is the most improtant factor for the turbine. If the vacuum drops, the turbine will experience various troubles such as; increase in exhaust steam temprature, turbine vibration, decrease of unit load, etc.

If shells woods and other foreign matters were deposited in the condenser tubes, corrosion by deposit attack will occur.

Therefore, the ball cleaning equipment must be operated at regular intervals or when the occasion demands.

iii. Countermeasures

(i) To repair all damged devices as soon as possible.

(ii) To check the causes of decreased ball collection rate in accordance with the attached sheet. (Table 5M-2)

(iii) To always keep and maintain more than 5,000 spare balls.

(iv) To record the ball collection rate every time and if the rate decreases to less than 50% twice, inspection of the main condenser and the ball cleaning equipment must be made.

Table 5M-2 COUNTERMEASURE TO INCREASE BALL COLLECTION RATE OF BALL CLEANING EQUIPMENT OF M-2

No.	CAUSES	CONDITIONS	COUNTERMEASURES
	Abnormal condition of catching screen.	* No established set positions for the upper and lower screens. * Damaged upper or lower screens	To check the upper and lower screens. Repair/replace all parts found in abnormal condition.
	Accumulation of foreign matters on the screen.	* Balls can't be collected in the ball collector due to lodged balls on the screens caused by foreign matters.	To check and clean the upper and the lower screens. To backwash the screens before operating the ball cleaning equipment.
	Accumulation of foreign matters in the main condenser water box.	* Balls are retained in the main condenser water box because of clogged-up condenser tubes by foreign matters, hence balls can't reach the collector.	To conduct an occassional inspection and cleaning of the main condenser water box.
	Blockage of the ball collector circulating line by foreign matters.	* Balls can't smoothly circulate in the ball collector circulating line. * The circulating pump capacity is reduced by the loss of head.	To conduct an occassional inspection and cleaning of the ball collector circulating line.
	Shortage of ball inudation in the main condenser water box.	* Balls remain at the upper area in the main condenser water box.	To fully soak the balls in the water until it settles down.

(d) M-1 Feedwater Heaters

JICA team conducted a thorough study of the feedwater heaters of Malaya-1 concerning tube leakage. The result of the study is shown on Figure 5M-36.

i. Analysis of Figure 5M-36

(i) Low Pressure Feedwater Heaters:

LPH #1 has no plugged tubes.

LPH #2 has few plugged tubes at 2.66%, this is no problem.

LPH #3 has 14.9% plugged tubes as of July, 1982, inspite of the fact that it has just been replaced last July, 1980. The rate of tube failure is alarmingly high for this particular heater.

(ii) High Pressure Feedwater Heaters:

HPH #5A has an alarmingly high rate of tube failure which accelerated between February and September of 1979. After this period, the rate of tube failure has decreased between September 1979 and Dec. 1981. However, the frequency has increased such that the percentage of plugged tubes went to a high 41.92% as of January 1982. By July, 1982 the feedwater heater was completely isolated from the system.

HPH #5B experienced a steady rate of tube failure. The percentage of plugged-tubes is 22.07% as of March 1982.

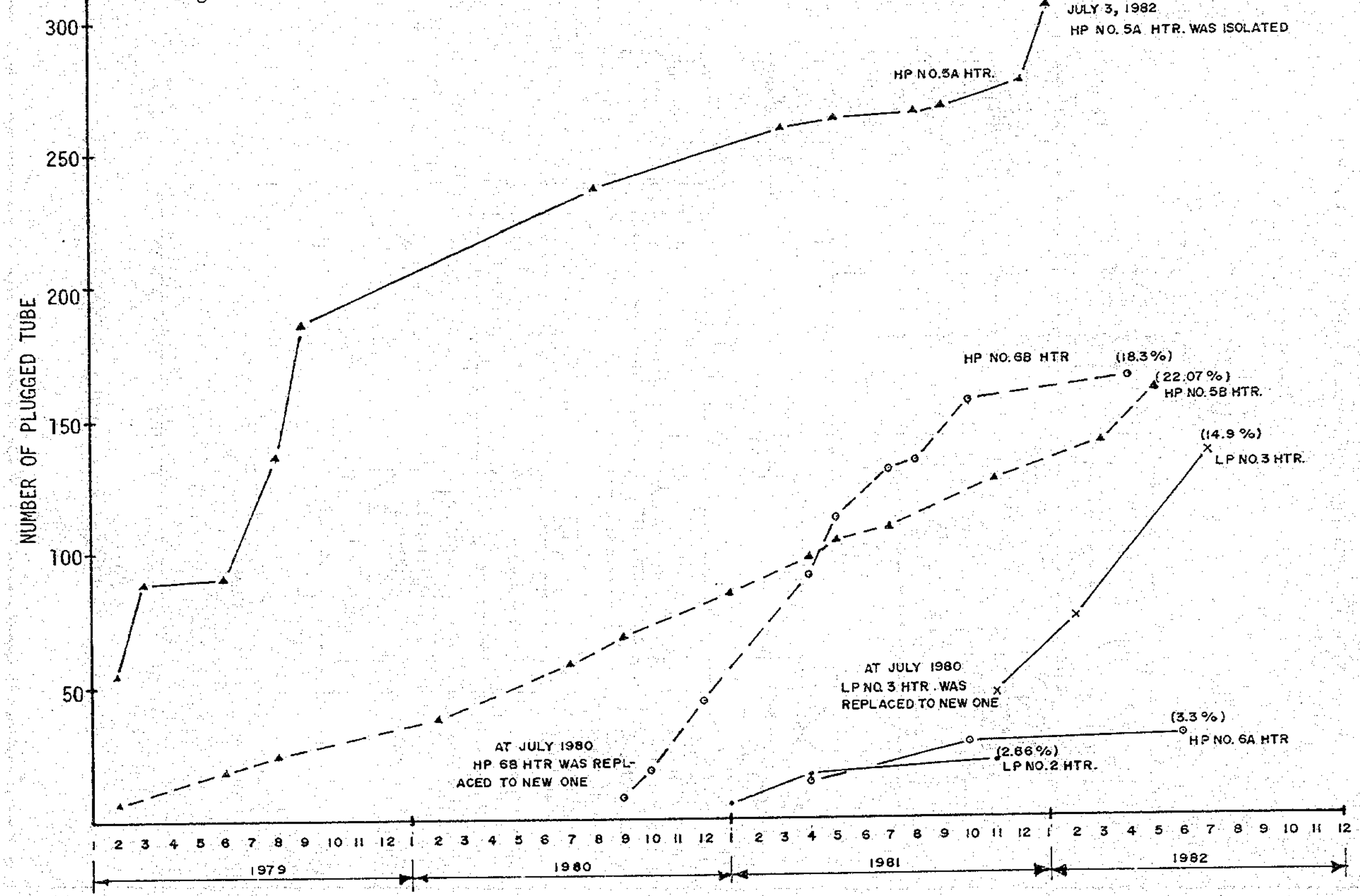
The difference of the total number of plugged tubes between HPH #5A and HPH #5B will be described in another data.

HPH #6A is comparatively in a better condition. The percentage of plugged tubes is 3.3% as of June, 1982.

HPH #6B was newly replaced only last July, 1980 but the percentage of plugged tubes is a high 13.3% as of April, 1982. This particular heater also experienced a high rate of tube failure.

The difference of the total number of plugged tube between HPH #6A and HPH #6B will be described by another data.

Fig. 5M-36 CONDITION OF PLUGGED TUBES OF FEED WATER HEATERS FOR M-1



To clarify the description, here is an example for M-1

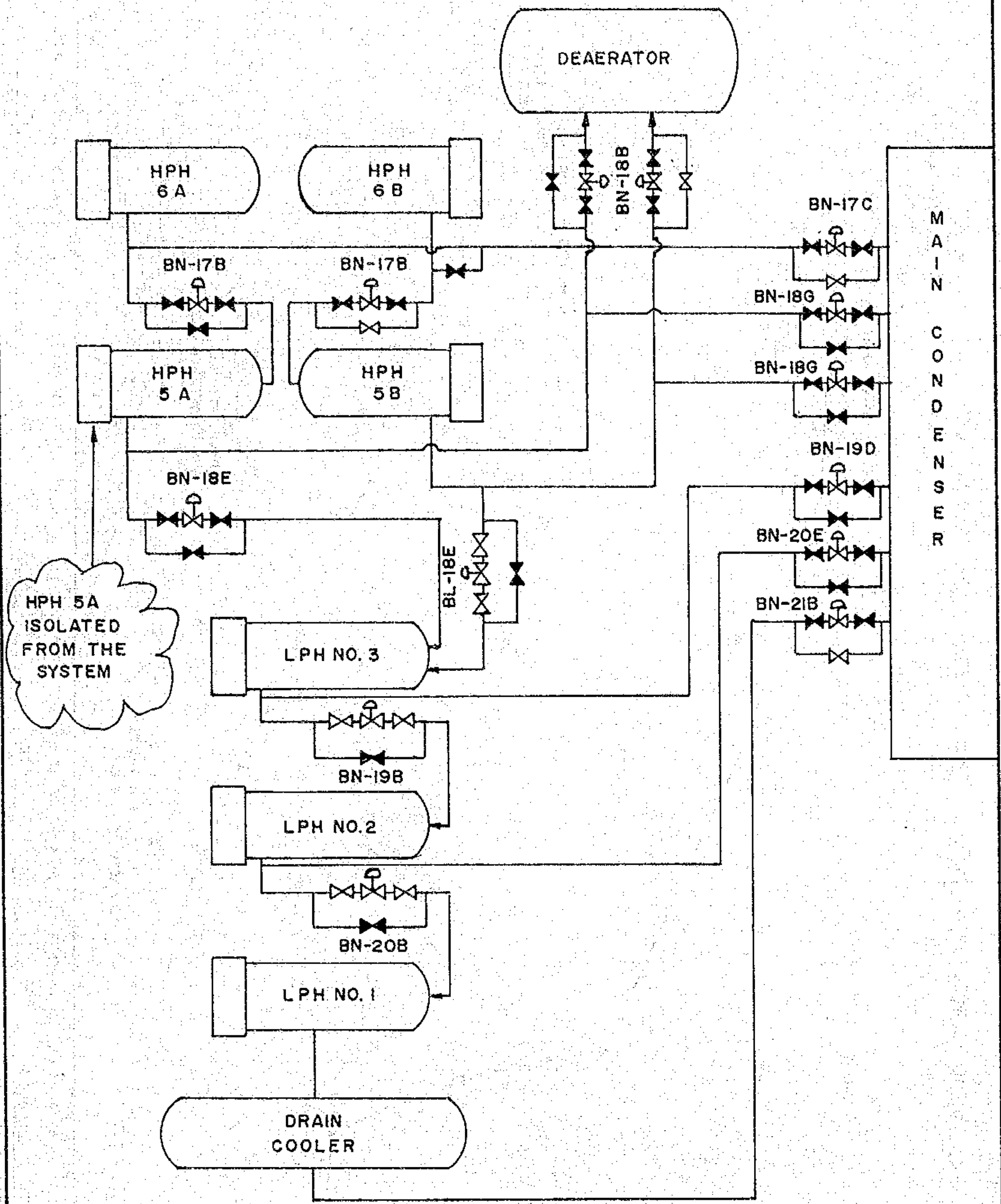


Fig. 5M-37 FEEDWATER HEATER DRAIN CONTROL SYSTEM

ii. Result of study:

Herewith is the existing condition of the feedwater heater drain control system.

(i) Low pressure feedwater heaters

LPH #1

The level control valve of LPH #1 (BN-21b; LPH #1 to condenser) is isolated by trouble. The drain level of LPH #1 is presently controlled by manual operation.

LPH #2

The LPH #2 has two (2) level control valves, BN-20B (LPH #2 to LPH #1). This is presently on automatic operation. However BN-20E (LPH #2 to condenser) is isolated by trouble.

LPH #3

The LPH #3 has two (2) level control valves, BN-19B (LPH #3 to LPH #2) and BN-19d (LPH #3 to condenser). BN-19B is on automatic control but BN-19D is isolated by trouble.

(ii) High pressure feedwater heaters

HPH #5A

This particular heater has been isolated from the system due to excessive tube failure.