Typical Trouble	Supposed Relating Cause	Remarks
	d. Poor quality of equipment	
10. Master trip solenoid malfunction	a. Bad circumstances for those protection system-high temperature, high dust, high vibration b. Inadequate arrangement in cabling, wiring, and instrument support c. Insufficient maintenance d. Insufficient control, protection signal co-ordination between B-T-G Auxiliary systems e. Function of end detector and system itself	
11. Thrust bearing safety device test	a. Insufficient testing devices for protection system b. Bad circumstance of these existing systems c. Malfunction of testing device itself	a. Defective parts of testing system will be replaced in coming re-habilitation
12. Major trouble due to emergency D.C. power failure	a. Inadequate coordination between main machinery protection system and equipments b. Inadequate allocation (division of supply) in main protection system c. Insufficient daily protection system check d. Bad circumstance for those systems - pressure switches, signal transfer wiring, coil etc. in dirty and high temperature condition and insufficient maintenance e. Poor quality of equipment	
13. Excess turbine vibration	a. Inadequate piping and support design connected to main turbine casing b. Insufficient rotor balancing c. Inadequate alignments d. Turbine bucket failure	

Typical Trouble	Supposed Relating Cause	Remarks
14. BFP trip due to deaerator storage tank water level extremely low	a. Too large load increase rate b. Cascade drainage from HP heater to LP heater and condenser due to HP heater tube leak c. Excessive feedwater flow rate due to HP heater tube leak d. Less NPSH due to BFP-deaerator layout e. Overload of deaerator level control system (LCV, CP) due to excessively high feedwater flow rate due to the tube leak f. Mis-tripping due to actuation of level monitor by deaerator vibration	
15. HP heater and LP-3 heater tube leakage	a. Defective design and manufacturing b. Impurity in water and steam c. Drain attack due to extremely high flow rate drain into LP-3 heater due to cascade drainage from HP heater to de-aerator, LP-3 heater in case of HP heater tube leak	
16. Main transformer over excitation	a. Not stable grid operation b. Inadequate unit capacity c. Insufficient coordination power generation and distribution system	
17. Low feedwater flow/BFP minimum	a. Malfunction of BFP minimum flow control system b. Erosion of minimum flow valve c. Inadequate coordination of flow control system	a. New type of minimum flow valves already installed in S-2 and M-1
18. Turbine exhaust hood rupture diaphragm burst due to CWP trip	a. Less margin in condenser vacuum due to inadequate condenser design condition b. Insufficient circulating water system arrangement	a. In these days mechanical ejectors were not applied (recently

Typical Trouble	Supposed Relating Cause	Remarks
	and design c. Unexpected much heater drain into condenser d. Deterioration of ejector capacity due to lower working steam pressure and higher sealing water temperature, by which the vacuum pressure is restricted	applied)
19. Boiler tube leakage	a. Insufficient feedwater and steam purity b. Inadequate combustion control/feedwater control c. Inadequate spray control and defective spray stop valve d. Unexpected feedwater temperature fluctuation due to high pressure heater tube leak e. Misoperation	a. Secondary superheater tube under the most severe condition will be replaced with a material resistant to higher temperature.
20. Condenser low vacuum	a. Inadequate condenser design condition-inlet circulating water temperature, cleanness factor, etc. b. High CW inlet temperature due to recirculation of circulating water (distance of in/out, sheet pile) c. Insufficient water seal valves on the vacuum pressure line d. Excessive air leak around condenser e. Steam seal deterioration especially in vacuum gland of turbine f. Backwashing not performed due to reverse washing valve trouble	a. Deteriorated gasket and diaphragm of condenser will be replaced in coming rehabilitation b. Deteriorated gland seal element will be replaced in coming rehabilitation
21. Turbine Electro-Hydraulic Control fault	a. Bad circumstances for these electronic parts and systems-high temperature, high dust and vibration b. Insufficient ventilation and maintenance	a. Deteriorated components of EHC will be replaced in coming rehabilitation

Typical Trouble	Supposed Relating Cause	Remarks
	c. Inadequate installation of the equipments, cabling and wiring d. Reliability of EHC system, components itself under the actual site condition	
22. Fuel oil contamination of pneumatic control air	a. Inadequate instrument air system-capacity, type, dehumidifier and number of unit b. Inadequate back up system-interconnection with station air system includ-ing burner purge c. Malfunction of isolating valve d. Operator's error in valve operation during burner cut-out and purging	
23. Fire on around turbine	a. Lube and control oil leakage from the oil piping b. Insufficient maintenance to eliminate the piping leakage c. Insufficient heat-insulation on high temperature press includ-ing small drain and steam leak pipes d. Insufficient leak oil collection and drainage system e. Too many flange joints in oil piping	
24. Turbine oil leakage	a. Insufficient installation, sealing or design of lube oil piping b. Insufficient maintenance c. Misoperation of the oil centrifuge	
25. T-BFP planetary gear trouble	a. Overloading due to HP heater tube leakage - severe condition thru design condition b. Usually high vibration	

Typical Trouble	Supposed Relating Cause	Remarks
26. Main fuel oil pump trouble	a. Overloading due to deterioration of plant performance b. unstable combustion/fuel consumption c. Overloading due to insufficient auxiliary steam for fuel oil heating d. Poor quality of equipment	
27. Fire at A.H., Frequent A.H. washing	a. Unstable combustion - accumulation of carbon deposits b. Inadequate ash collecting and handling system including system design and materials	a. At this stage thermal cleaning of AH is applied insufficiently instead of washing by water. (Thermal expansion difference soot blowing)
28. Carry over	a. For B-T: Inadequate load decrease rate b. For resin carry over from CPP: Defect of resin trap c. Fluctuation in flow, pressure in condensate due to hotwell level control rangeability	
29. Boiler Casing leakage	a. Low temperature corrosion (sulphur attack) due to high sulphur contents in fuel b. Unstable combustion which leads to corrosive deposit accumulation c. Water washing which accelerates the H_2SO_4 attack d. Insufficient gas tight waterwall e. Incomplete repair during overhauling	a. counter-measures to decrease the corrosion are recommended by the QA group over-haul record
30. Shortage in make up demineralized water	a. Too many plant shut-downs and start-ups due to above troubles - much larger make up water consumption than planned in plant design stage	a. Reflecting those actual conditions, expansion for demineralized water short-

Typical Trouble	Supposed Relating Cause	Remarks
	b. Inadequate raw water supply due to receding deepwell water table	age tank is now under practice
31. Dust handling system trouble	a. Clogging of dust conveying line due to inadequate capacities of piping and hydro-vactors b. Poor design of slurry pump c. Inadequate maintenance d. Irregular operation of dust handling system	

2-1.2. FUNDAMENTAL MATTERS COMMON TO POWER PLANTS

In addition to the rehabilitation items which have been commenced already, there are insufficient matters to be improved in the early time to promote effectively the rehabilitation in general, plant system, equipment, control system, chemical management and the others.

A great part of these items are common to all plants and further improvement must be considered referring to actual condition and situation of each plant.

2-1.2.1. PLANT SYSTEM

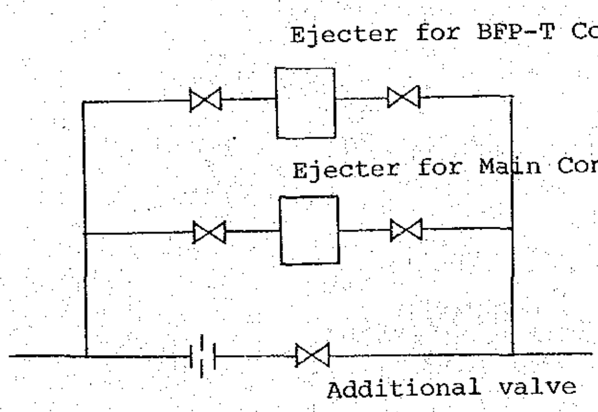
Following figures show typical and conceptional, not detailed.

1) Steam jet air ejector arrangement on condensate line. (G2, S1)

   There are experience of overheating of the ejector cooler tube.

   Existing arrangement:

   FIGURE 2-1 EJECTOR SYSTEM



Comments:

a) Working steam consumption of ejector: Normally constant even if the plant load is lower than rated output.

b) *Condensate flow: Flow rate is proportional to the* plant load.

c) The cause of the overheating would be mainly by the less cooling water (condensate) flow in comparison with necessary flow rate for the ejectors working steam at low load operation since the orifice on the main condensate line is not variable one.

For the reasons of a) and b), the orifice must have characteristics as follows:

- in high load: lower differential pressure
- in low load: higher differential pressure

and the actually installed orifice has completely opposite characteristics.

d) Recommendations:

- At least one valve must be added between the branch and confluence point for low load operation.
- In general, the ejectors shall be arranged in series on main condensate line and the condensate minimum flow line shall be led from main condensate line after the gland steam condenser and ejector cooler (before the LP-1 heater) and the minimum flow capacity must be decided on the base of the minimum flow requirement for the gland steam condenser and ejector.

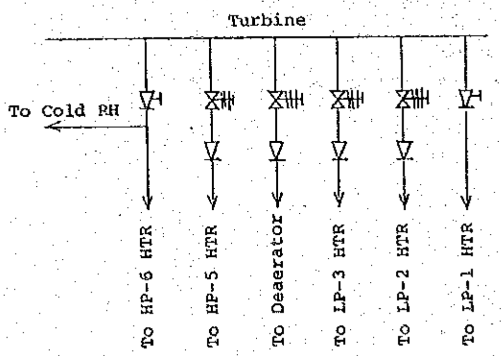
e) Regarding S2, M1: The ejectors are arranged in series on the main condensate line; however, it looks that there is not so much enough margin in its capacity.

2) Turbine bled steam line arrangement

Water induction is the most severe matter in this line.

Existing arrangement:

FIGURE 2-2 TURBINE BLED STEAM LINE



Valve Simbols:

—⊳|— : Motorized Non-return Valve

—|◁— : Non-return Valve

— : Hydraulic-open, spring-close valve (with manual handle)

—▷◁— : Isolating Valve (Manual,air motor driven or motor driven valve)

Comments:

a) The spring close valve is not able to isolate the line tightly by the spring force and the manual handwheel to close tightly the valve is not so enough large in size.

b) The valve is not so suitable for bled steam isolating valve.

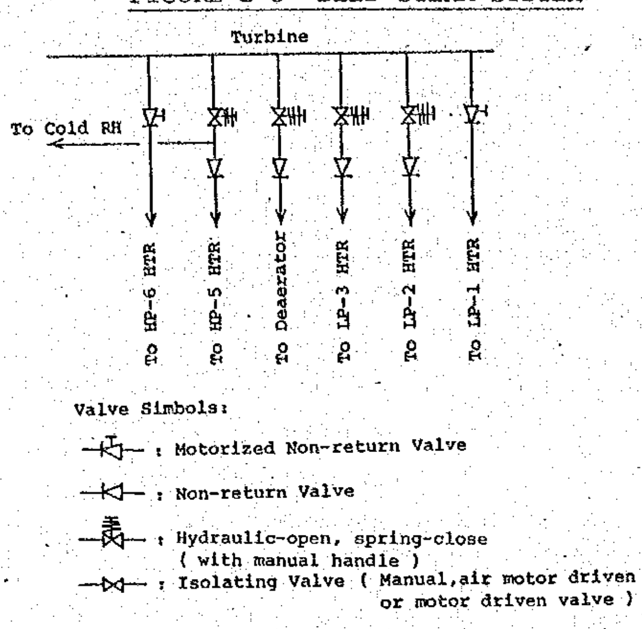
c) At least one assist non-return valve having interlock with main turbine interlock systems shall be arranged on each bled steam line.

d) For deaerator at least one non-return valve and one motorized non-return valve must be arranged since the deaerator has high possibility of water induction by its inherent property even if the bled steam is led into deaerating heater only (different from case of deaerator storage tank).

e) Preferable arrangement is generally as follows:

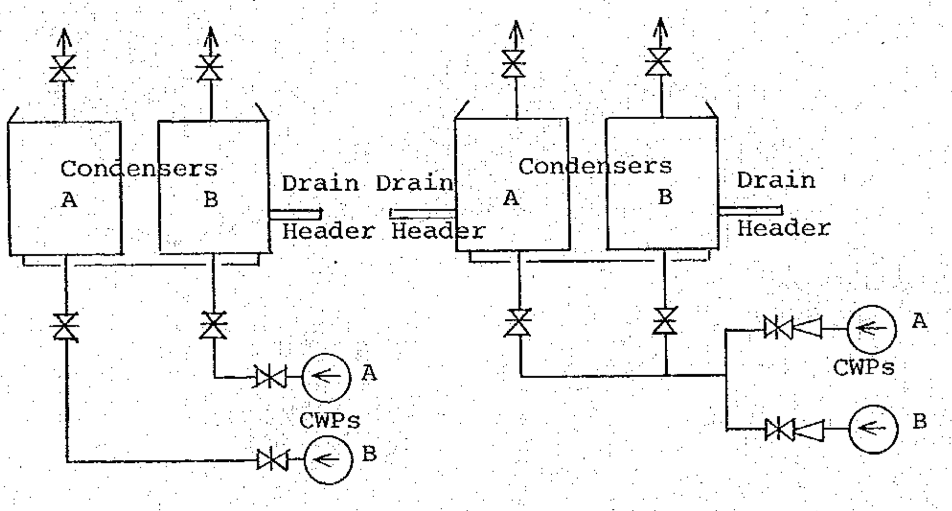
(Bled point, etc. will be changed in accordance with each system design and this sketch shows basic idea for reference.)
In case of LP-1, heater is condenser neck heater. If not neck heater, the arrangement will be the same as LP-2.

FIGURE 2-3 BLED STEAM SYSTEM



3) Circulating water system arrangement and condenser drain header arrangement

FIGURE 2-4 CIRCULATING WATER SYSTEM



Comments

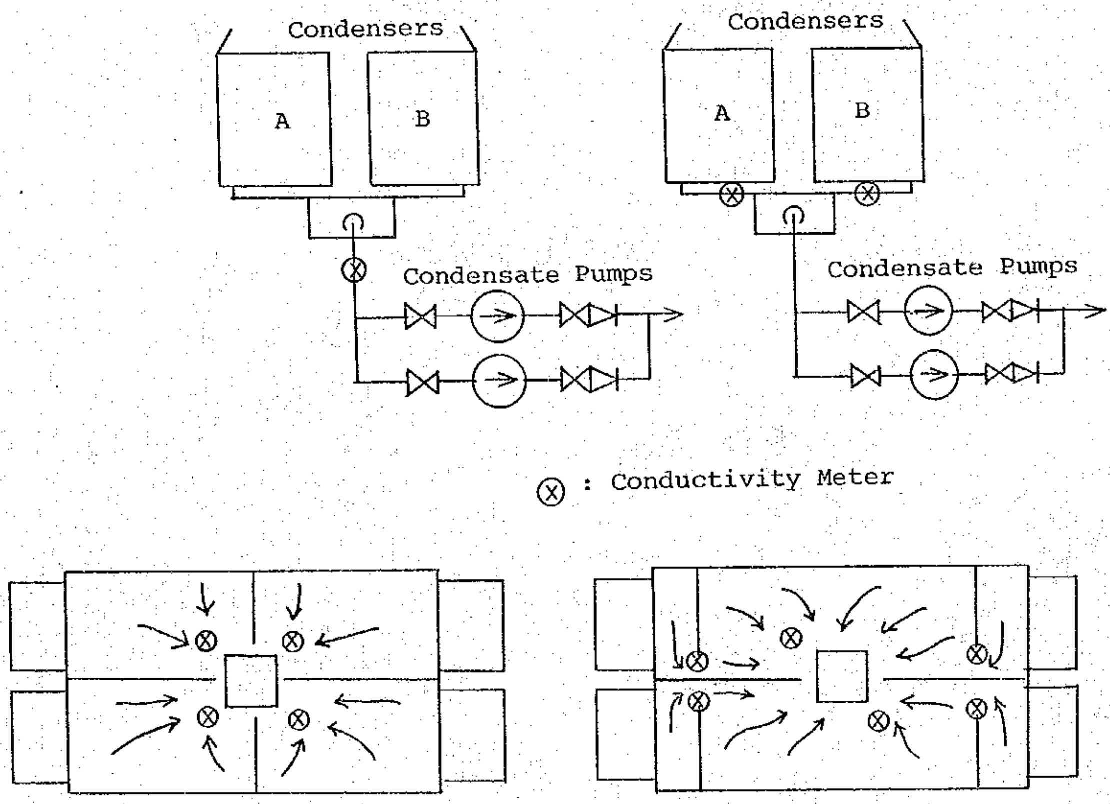
a) Above existing conceptional arrangement is not adopted to all plants; however, for instance, in case of CWP A/trip, or water box B/tube leak in the above arrangement, the plant is not able to continue its operation.

b) Preferable system:
Even if one of CWP/trip, water box/tube leak, the plant will be able to continue its operation at approximately. 50-60% load of rated output.

c) Separate drain headers divided into both sides of condenser are preferable for balance of condenser cooling.

4) Conductivity detector

FIGURE 2-5 ARRANGEMENTS OF CONDUCTIVITY DETECTORS



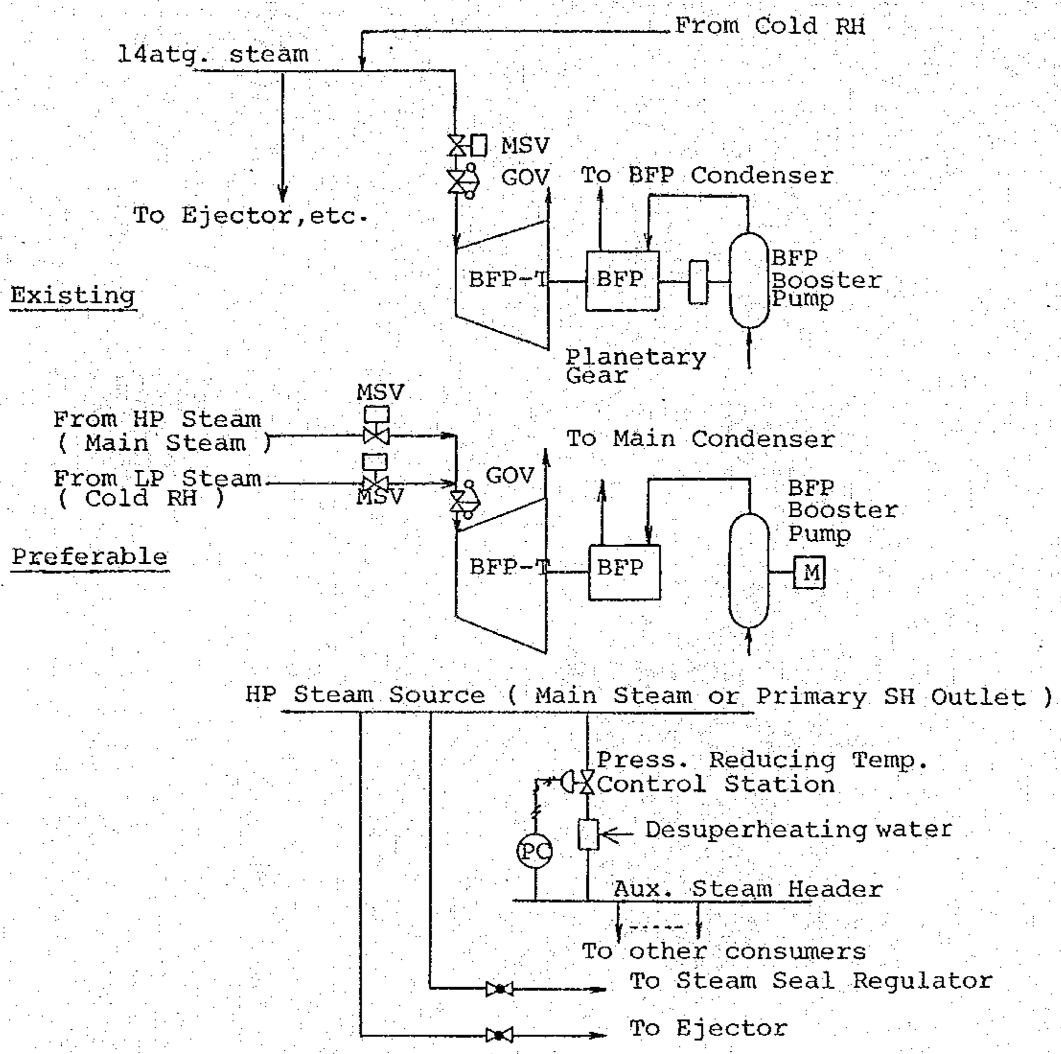
Comments:

a) By separate location of conductivity meters, in case of tube leakage occurrence, the leakage side will be identified immediately and operator will be able to put the leakage side out of service without shutdown of the plant.

b) In the preferable case, each conductivity meter can act as back up monitoring even if one or some of them are out of service.

5) BFP-T steam source, auxiliary steam, BFP booster pump

FIGURE 2-6 BOILER FEEDWATER PUMP



NPSH requirement must be confirmed with the booster pump maker in case of the rearrangement of separate or direct coupling to main BFP since the NPSH depends on the revolution speed.

Comments:

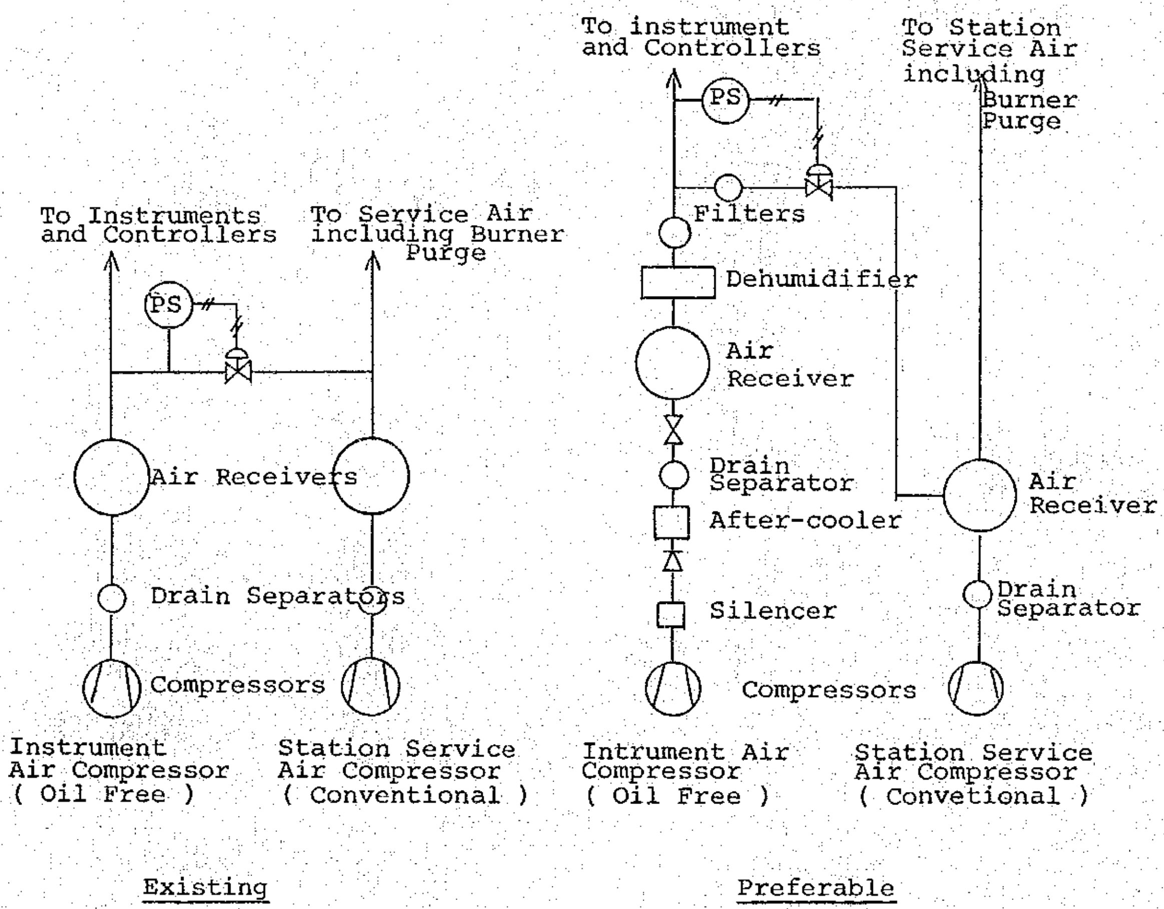
a) Back-up system for start-up should be considered.

b) Auxiliary steam for major equipment and miscellaneous equipment should be separated on the line.

c) Another motor driven booster pump will be recommendable to eliminate overloading on the planetary gear.

6) Control air and station service air

FIGURE 2-7 COMPRESSED AIR SYSTEM



Comments:

a) At least separate line from station air receiver (not piping branch) for control air back-up and at least non-return valve should be additionally installed.

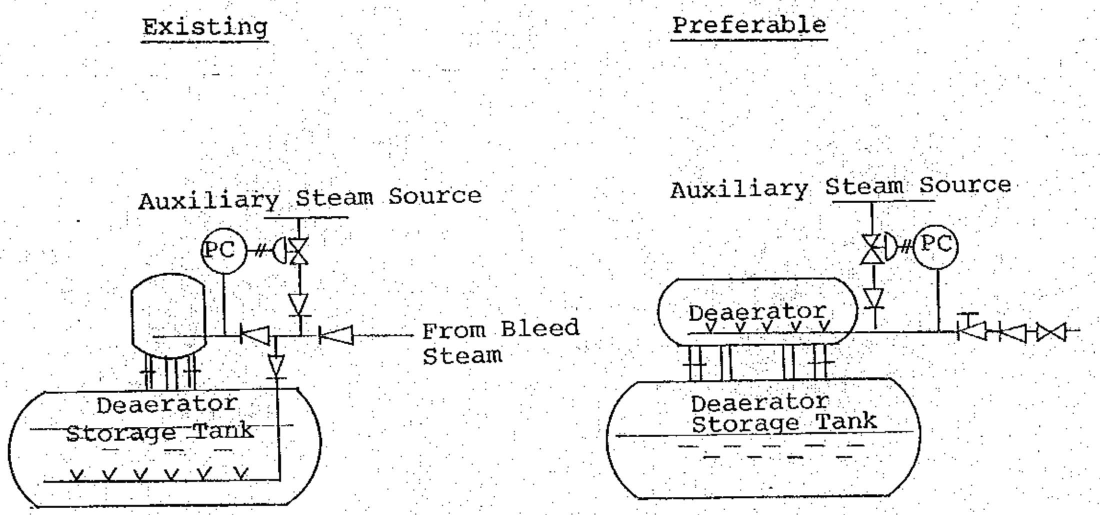
b) Control air unit back-up system will be better than air back-up system from station air source.

c) Instrument/control air compressor for standby having enough capacity is necessary.

d) In general, auxiliaries for instrument/control air system, e.g., dehumidifier, filter have not so enough capacity and function.

7) Bled steam system especially for existing deaerator

FIGURE 2-8 DEAERATING SYSTEM



Comments:

a) For existing system, at least one non-return valve on each branched pipe will be necessary to prevent water induction to the turbine.

b) In existing system, operator should take care

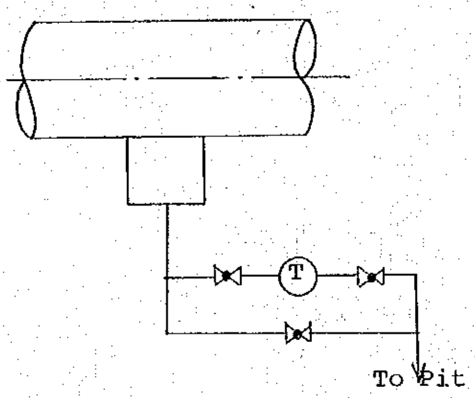
especially for the deaerator bled steam system.

c) Generally, it will be better to adopt the deaerator which does not require the storage tank deaerating and heating.

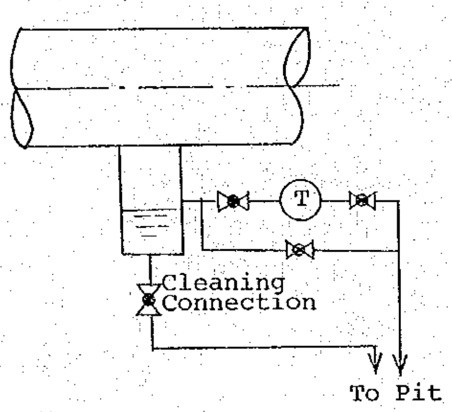
8) Major piping drainage, e.g., cold reheat

FIGURE 2-9 DRAINAGE PIPING

Existing



Preferable



Comments:

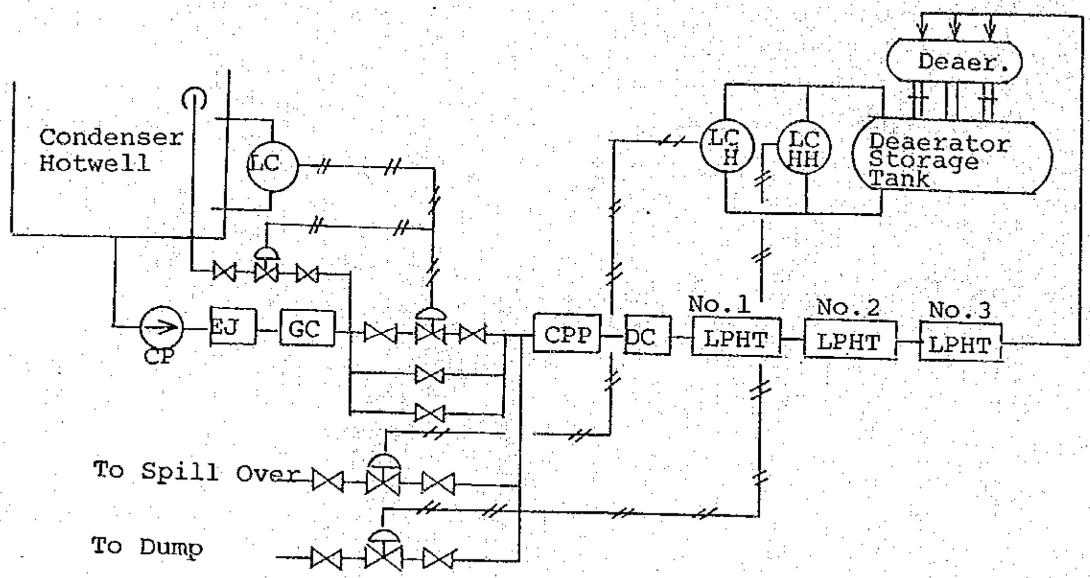
a) It will be better to provide drain pot with cleaning connection on the bottom, and the ordinary drain will be led from upper portion of the drain pot.

b) Sufficient drainage piping is indispensable for proper plant operation especially at start-up and shut-down.

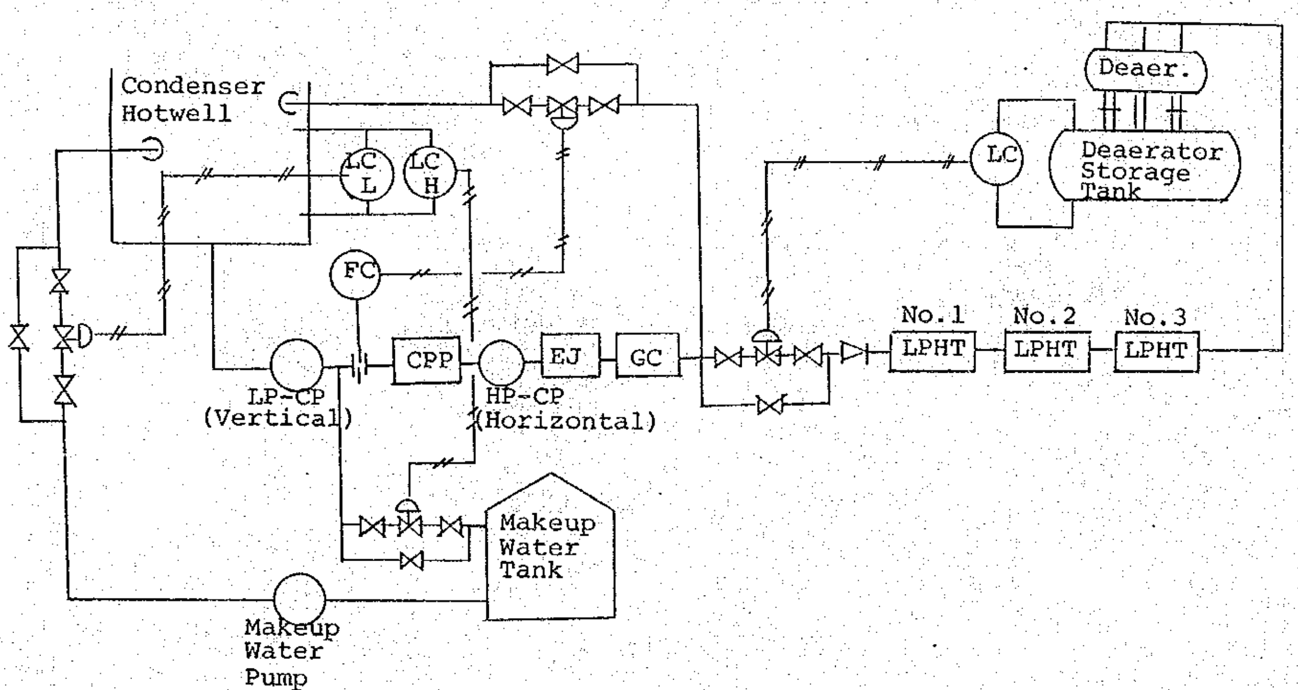
9) Condenser hotwell level control, HP-LP condensate pump

FIGURE 2-10 CONDENSATE SYSTEM

Existing



Preferable



Comments:

a) In existing system, the hotwell level control valve looks too big in size; however, every control valve has inherent rangeability, therefore, valve sizing (rangeability should be re-checked) must be re-considered.

Smaller size level control valve may be required for low load operation; however, this arrangement will depend on actual plant loading and the rangeability of existing control valve.

b) In that case, cascade control for two control valves will be applicable to the system.

10) Start-up/shut-down drainage system around main turbine

A combined drainage device operated by one motor/one arm for several drain valves is applied to the drainage system. This looks very convenient for start-up and shut-down by operating one motor.

Comments:

a) It is difficult to close the all relating drain valves tightly in same condition.

b) Accordingly, separate operation of each drain valve will be recommendable to prevent excess leakage under normal operation.

11) Non-return valve just before Economizer inlet

To prevent back flow into HP feedwater heaters, it will be recommendable to install non-return valve on the feedwater line between Economizer and final HP feedwater heater. This improvement work is now under practice.

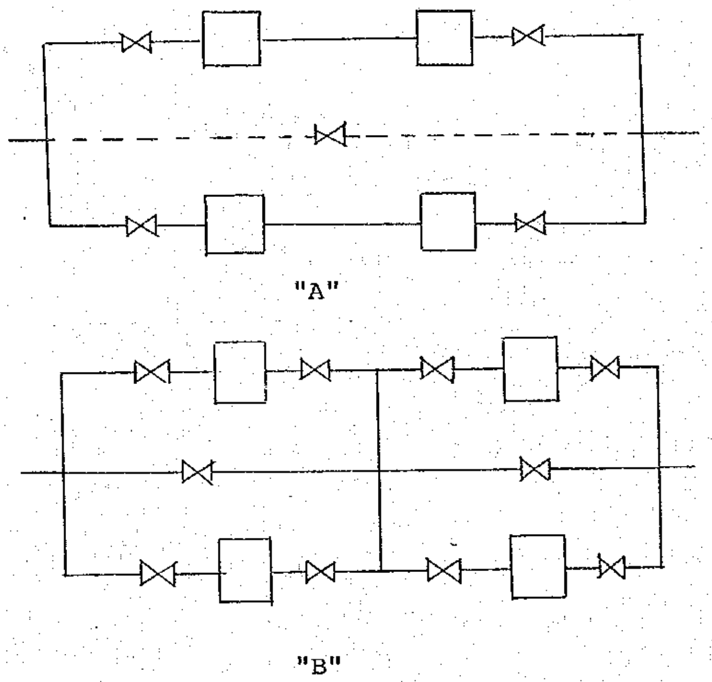
12) HP Heater drain system to LP-3 Heater

HP heater emergency drainage system into LP-3 heater is installed in parallel with HP heater emergency drainage system into condenser. More heat recovery may be possible at the emergency situation in this arrangement,

however, it will not be so good arrangement considering excessive drain attack of LP-3 heater in comparison with less heat recovery. The simple drainage into condenser for emergency case having larger capacity is recommendable.

13) HP heater bypass system
Before the HP heater bypass system has not been provided even if many heater tube leakage troubles occurred.

FIGURE 2-11 HP HEATER BYPASS SYSTEM



The heater bypass system is under consideration or installation.
To prevent water induction from heaters, and to achieve heat recovery (at maximum possible feedwater temperature) in feedwater, arrangement "B" having quick action valves will be more recommendable; however, the kinds of valves will depend on the possibility and tendency of heater tube leak.
All these valves will be very difficult to be operated by manual (big size, high pressure) and air motor or

electric motor driven valve will be recommendable.

14) Steam blowing out

After the overhauling, for instance, replacement of superheater and reheater, it will be better to apply adequate steam blowing out to prevent attack of foreign matters to turbine since the MSV strainer is normal use one not for initial steam admission.

The steam blowing effect will be calculated by following formula.

a) Critical condition of Nozzle Throat (In case of steam blowing out, the smallest pipe in the blowing system is critical and this internal diameter of the pipe will be understood as the Nozzle Throat).

(1) Critical Pressure

$Pc/P_1 = 0.5457$ (for superheated steam)

$= 0.5774$ (for dry saturated steam)

Pc : Critical pressure

P_1 : Nozzle inlet primary pressure

(2) Sonic velocity and maximum critical flow

$$V_s = \sqrt{g.k.R.Tc} \qquad (m/s)$$

$$Tc = T_1 . \left(\frac{Pc}{P_1}\right)^{\frac{K-1}{K}} \qquad (^{o}K)$$

$$Gc = \frac{A\ Vs}{\bar{V}c} \qquad (Kg/s)$$

Tc : Critical temperature ^{o}K = tc (°c) + 273

T_1 : Nozzle inlet temperature $^{o}K = t_1$(°c) + 273

$\bar{V}c$: Specific volume referred to tc, Pc

g : Acceleration of gravity = 9.8 m/s²

K : Adiabatic index :

Superheated steam = 1.30

Dry saturated steam = 1.135

A : Sectional area of throat (pipe) m²

(3) Required steam flow rate for blowing out
Force acting on foreign matters, e.g., welding slags and spatters is

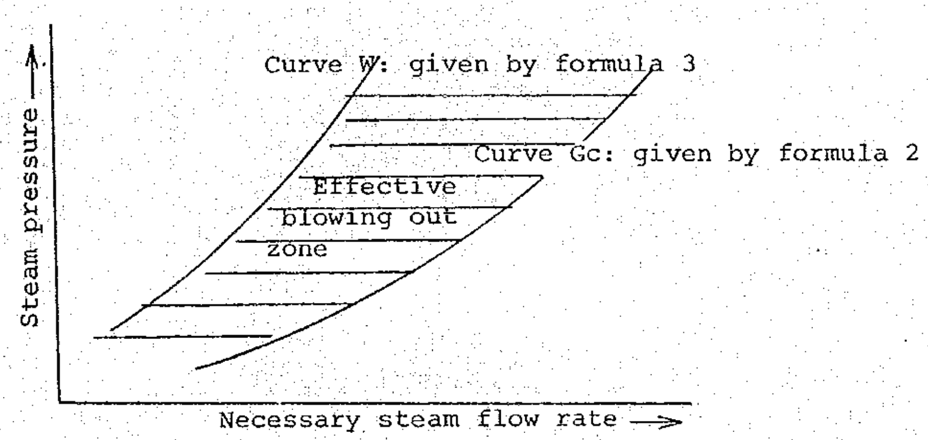
$$F = \frac{r}{2g}.a.V^2 = \frac{8a}{g.\pi^2.D^4}.W^2.\bar{V}$$

where, A, π , g and D are constant (independent) and the force acting on the foreign matters will be compared with by "W^2.V".

$\bar{V}$: Specific weight of steam Kg/m^3
g : 9.8 m/s^2
a : Sectional area of foreign matter against flow direction m^2
V : Steam velocity m/s
W : Steam flow rate Kg/s
$\bar{v}$: Specific volume m^3/Kg
D : Internal diameter of pipe m

(4) Determination of the effect of blowing out

FIGURE 2-12 EFFECT OF BLOWING OUT



15) T-BFP capacity and arrangement
100% x 1 unit T-BFP will not have enough flexibility for normal operation, therefore, at least 50% x 2 unit T-BFP will have the flexibility.
T-BFP located on ground floor will be recommendable for

general arrangement including deaerator and HP feedwater heater (generally, arrangement at lower elevation has less tendency of water induction to turbine having enough NPSH available for the BFP).

16) Stress corrosion crack on turbine last stage bucket
There are many experiences of the trouble on leading edge hardened turbine bucket.
In general, the condenser vacuum is not so good level in actual operation and it will be better to do re-heat treatment on the buckets (annealing) to avoid the stress corrosion crack since the erosion by water particle will be less due to the condenser low vacuum.
However, the last stage bucket with Stellite will be preferable which has lower residual stress in the bucket and has good anti-erosion property.

17) Stack
One common stack is applied for two units (not divided into two internally) for Gardner and Snyder T.P/P.
However, there are some disadvantages in the common stack, that is:
Disadvantage for maintenance and proper design for combustion control, draughting equipment and its control in parallel running of two units.
Accordingly, when Electrostatic Precipitator is applied in future to prevent ash pollution, it will be recommendable to apply individual stack for each unit.

18) Monitoring of conductivity
At this stage, most of conductivity meters are out of service actually and the monitoring of conductivity is done with manual sampling and analysis in the laboratory.
And it takes longer time to find out actual conductivity than continuous monitoring, and it will be recommendable to trip the unit with limitation of "conductivity high" in around 0.3 .
Anyway, the conductivity must be monitored by permanent conductivity meter continuously.

19) Miscellaneous but fundamental matter

Item	Influence	Improvement Way
1. No identification mark/flow direction on pipe	a. Misoperation b. Harmful accident for operators	a. Clear mark up on piping
2. No nameplate on valves	- ditto -	- ditto -
3. No flexible tube for instrument wiring around turbine	a. Deterioration of wiring b. Malfunction c. Wire cutting	a. The wire must be installed in conduit and flexible tube. b. Instrument parts must be supported adequately.
4. No conduit or flexible tube for waterbox cathodic protection system	a. Deterioration of cables b. Cable cutting	a. The cable must be installed in conduit and flexible tube
5. No instrumentation piping support	a. Damage or cutting of the piping b. Lead to cause of serious trouble	a. Adequate support of the piping must be added.
6. SW gears, AVR, electrical panels in high temperature and dusty area	a. Malfunction b. Shorter life	a. Building ventilation must be improved. b. For future plant the layout must be altered.
7. Local indicators different unit (e.g. KP/cm^2, PSIG)	a. Misreading	a. Same unit instrument will be applied.
8. Defective heat insulation especially around high temperature (turbine) area	a. Possibility of fire b. Harmful accident for operators c. Lower efficiency	a. Repair and correct heat insulation

Item	Influence	Improvement Way
9. Not enough floor drain pit and trench sump pump	a. Undesirable accident due to water and oil, e.g., dirty water leakage into condenser	a. Addition of sump pump. b. Installation of drain collecting pipe c. For future plant, enough drainage arrangement must be considered.
10. Not cladded level gauge, e.g., condenser hotwell level	a. Glass break results in vacuum break, thus finally resulting in unit trip.	a. Replace into cladded one.
11. Central control room: hot temperature and dusty	a. Malfunction of instruments and constollers b. Shorter life of instruments c. Noise	a. Double wall, double window/door

20) Sizing of control valves

1. Cv value and Kv value

"Cv value" (Capacity coefficient) by F.C.I. (Fluid Control Institute) U.S.A. is applied generally as specification of valve capacity, and in Germany "Kv value" is applied for same purpose.

Cv value - shows flow rate in U.S. gal/mn. of fresh water under the conditions of 60°F (15.6°C) and differential pressure in the valve (in/outlet pressure difference) as 1 Psi. (0.07 kg/cm^2).

Kv value - shows flow rate in m^3/mn. of fresh water under the conditions of 5 - 30°C and differential pressure in the valve (in/outlet pressure difference) as 1 kg/cm^2.

2. Arrangement of "Cv value" calculation

(1) Review of fluid specification

* Differential pressure in the valve of fully open:

In case of adopting a control valve in long piping line or piping system including heat exchangers etc., more than around 0.4 is applied as the rate of "Valve full open differential pressure"/"Total pressure drop of the system".

The maximum flow rate will be determined considering the following points.

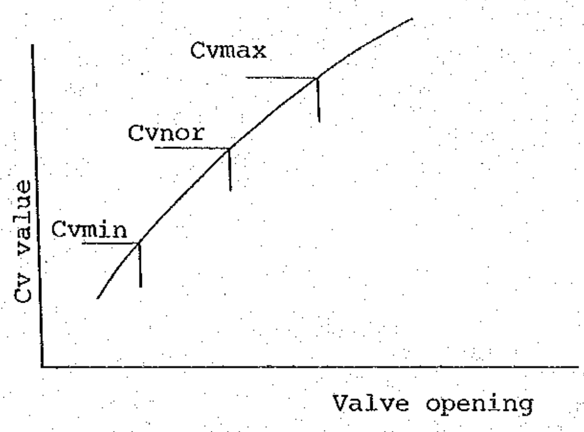
a. As appropriate valve opening for normal operating range, around 60-75% opening will be adopted considering sufficient controllability.
   Accordingly, if the maximum flow rate is set up too much, valve opening under normal operation condition becomes too small.

b. Review of rangeability of the valve
   As mentioned above, too big maximum flow rate for the valve comes to the results of insufficient control under low flow rate range in actual oepration, and the minimum limitation of the valve rangeability must be reviewed.

c. The maximum flow rate must cover the load fluctuation and anticipated overloading, however, there is a restriction of the rangeability on the other hand as mentioned in a. and b., and two valves in parallel arrangement will also be considered if necessary.

(2) Calculate the required "Cv Value" by following formula
    In this calculation, Cv max., Cv nor., Cv min. will be calculated for maximum, normal and minimum flow respectively.

(3) The control valve selection suitable for the "Cv Value" and checking of the valve opening



(4) Confirmation of the valve rangeability
"Cv of the valve"/"Cv min." must be within the rangeability, and if this rate is not within the rangeability, two valves of a big capacity and a small capaCITY WILL BE APPLIED IN PARALLEL LINE. The rangeability will be around 50 in general, however, for the rangeabilty of the valve, review of (3) and review of (4), data of goods of control valve maker will be required.

3. Formula of "Cv value" calculation

(Unit: Meter system)

Fluid	Differential Pressure Conditions: $P_2 > \frac{P_1}{2},\ h < \frac{P_1}{2}$	Differential Pressure Conditions: $P_2 < \frac{P_1}{2},\ h > \frac{P_1}{2}$
Liquid		
General	$Cv = 1.17Q_\ell\sqrt{\frac{G_\ell}{h}}$	Same as the left.
High viscosity (More than 20 CS)	$Cv - 1.17Q_\ell.Fv\sqrt{\frac{G_\ell}{h}}$	Same as the left.
Gas		
Normal temperature	$Cv = \frac{Qg}{24}\sqrt{\frac{Gg}{h.Pm}}$	$Cv = \frac{Qg}{14.7P_1}\sqrt{Gg}$
High temperature	$Cv = \frac{Qg}{404}\sqrt{\frac{Gg(273 + t)}{h.Pm}}$	$Cv = \frac{Qg}{248P_{1Y}}\sqrt{Gg(273 + 6t)}$
Saturated	$Cv = \frac{Qs}{Y\sqrt{Pm.h}}$	$Cv = \frac{1.63Qs}{Y.P_1}$
Superheated vapour	$Cv = \frac{Qs}{19.4\ Pm.h}(1 + 0.0013.ts)$	$Cv = 0.084\frac{Qs}{P_1}(1 = 0.0013.ts)$
Wet vapour	$Cv = \frac{Qs.X}{19.4\sqrt{Pm.h}}$	$Cv = 0.084\frac{Qs.X}{P_1}$

Y: (Meter system)

Steam	19.4	Freon 14	78
Freon 11	68.5	Freon 114	77
Freon 12	65.5	NH_3	25

Q_ℓ[m³/h] :	Flow rate of liquid	h[kg/cm²] :	Differential pressure $= P_1 - P_2$
Qg[m³/h] :	Flow rate of gas under under 15°C 760 mmHg	t[°C] :	Temperature of fluid
Qs[kg/h] :	Flow rate of vapour	G_ℓ - :	Specific weight of liquid (water = 1)

P_1[kg/cm².a]: Primary absolute pressure

P_2[kg/cm².a]: Secondary absolute pressure

Pm[kg/cm².a]: Mean absolute $= \frac{P_1 + P_2}{2}$

Fv - : Viscosity correction coefficient

Gg - : Specific weight of gas (air = 1)

ts[°C] : Degree of superheat of vapour

X - : Dryness fraction of vapour (Dry saturated vapour X = 1)

4. Cavitation factor

In relation to control valves for water use, the allowable differential pressure per one control valve also depends on the flow direction and following value is applied in general to check the maximum allowable differential pressure.

$\Delta P = Kc.(P_1 - Pv)$

Kc: Cavitation factor

Flow open:

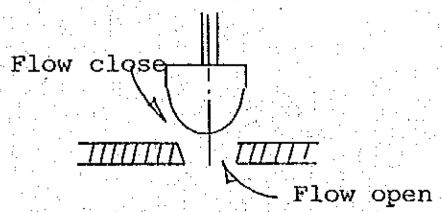
Kc = 0.65

Flow close:

Kc = 0.20

P_1[kg/cm².a]: Valve inlet pressure

Pv[kg/cm².a]: Saturated pressure corresponding to the valve inlet water temperature



21) Fuel oil system typical comparison

Various fuel oil system typical comparison is shown in the next table.

The most widely applied system at this stage is steam (air) atomizing pre-mixing type for stable operation, control and easy maintenance, however, stable auxiliary steam system is indispensable to apply the steam atomizing system.

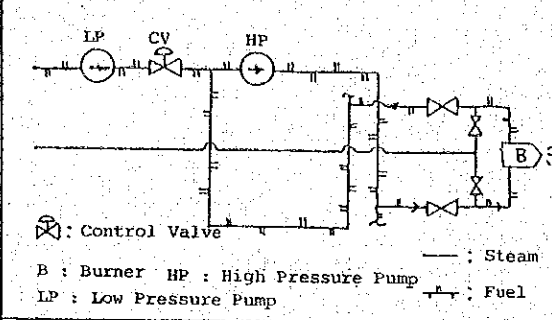
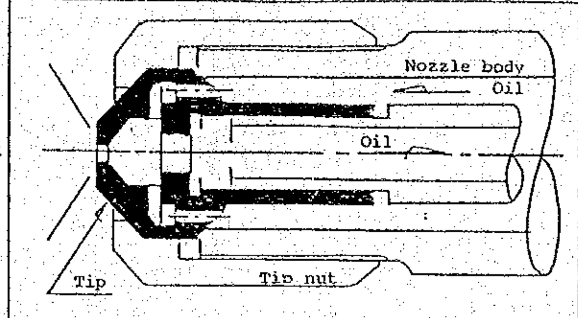
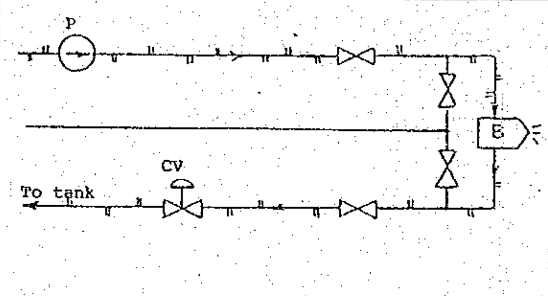
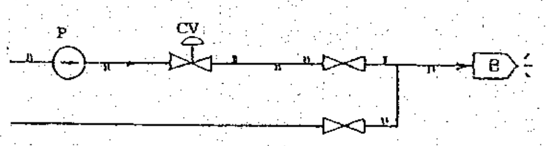
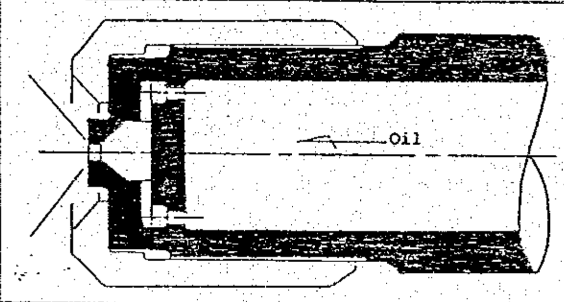
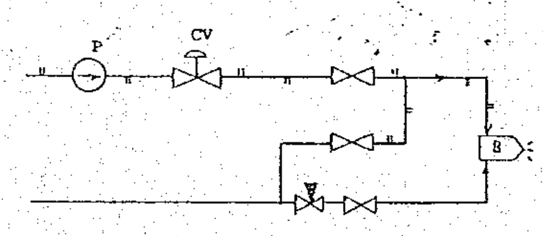
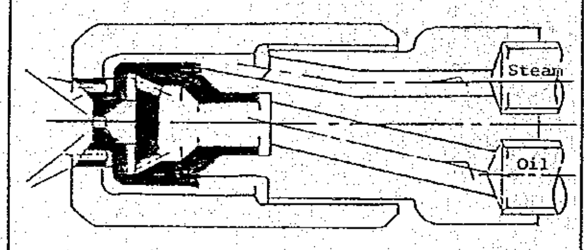
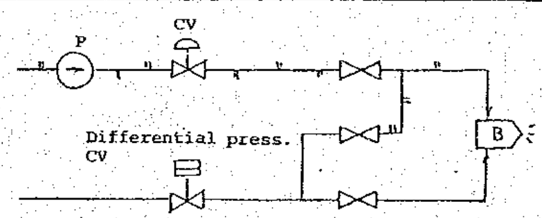
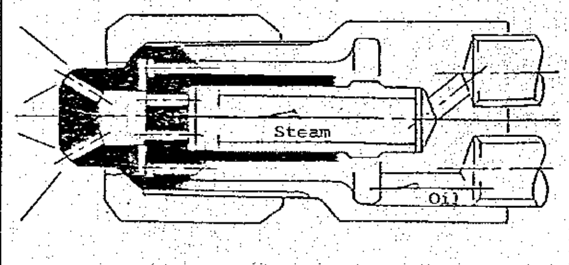
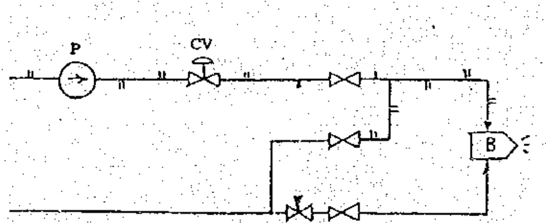
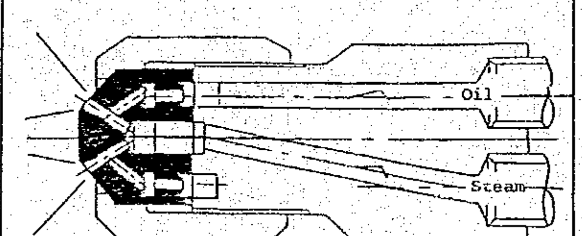
TYPE of ATOMIZING		METHOD of FUEL ATOMIZING	CHARACTERISTICS: COMBUSTION and ATOMIZING PROPERTY	CHARACTERISTICS: METHOD of ATOMIZED FUEL CONTROL	CHARACTERISTICS: PROPERTY of FUEL OIL	CHARACTERISTICS: MAINTENANCE	CHARACTERISTICS: ECONOMIC FEATURES	CHARACTERISTICS: EQUIPMENT and OTHERS	FUEL OIL SYSTEM	TYPICAL EXAMPLE OF ATOMIZER
PRESSURE ATOMIZING	CONSTANT DIFFERENTIAL PRESSURE TYPE	Revolving force is given by the pressure acts on the fuel, and atomizing is achieved mechanically by the centrifugal force.	1. Atomizing property is constant due to constant pressure drop at the burner tip in full atomizing range. (around 21 atg) And it is possible to control the atomized fuel quantity in wide range. 2. For high viscosity fuel, sufficient atomizing and combustion are not achieved by pressure atomizing.	1. Controlled by the control valve installed between the low and high pressure oil pumps. 2. Pressure difference between supply and return line is constant.	1. The fuel oil will be heated to keep its Red Wood viscosity less than around 150 sec. 2. In comparison with steam atomizing, lower grade fuel oil is not suited for fuel due to wearing of burner tip and atomizing effect.	1. Rather troublesome due to high pressure and complicated facilities.	1. Capital cost is rather high due to necessity of both low and high pressure oil pumps.	1. Both low and high pressure oil pumps are necessary. 2. Rather complicated system. 3. High pressure equipment are necessary.		
	CONSTANT SUPPLY PRESSURE TYPE	Ditto	1. Atomizing property is changed by the burner load since the fuel supply pressure is constant and the return fuel pressure is controlled in response to burner load. 2. Ditto	1. Return fuel oil quantity is controlled by pressure control valve installed on the return fuel oil line. 2. Fuel oil pressure is constant.	Ditto	1. Nearly same as straight atomizing type.	1. Nearly same as straight atomizing type.	1. Return fuel oil line is necessary. 2. High pressure equipment are necessary.		DITTO
	STRAIGHT PRESSURE ATOMIZING TYPE	Ditto	1. Sufficient atomizing property is not achieved in case of the low fuel oil pressure. 2. Ditto	1. Controlled by changing the fuel oil pressure.	Ditto	1. Operation and manipulation are simple, however maintenance for leakage is necessary due to high pressure.	1. Higher piping cost due to higher atomizing pressure, however, lower cost for others due to simple system.	1. Necessary equipment are not so many due to simple system however, the pressure is high.		
	STEAM SUPPORT PRESSURE ATOMIZING TYPE	Mixed type of pressure atomizing and steam atomizing. When the fuel atomizing pressure is high, the atomizing is achieved by pressure atomizing, and when the pressure is low, the atomizing is supported by expansion of steam.	1. Similar to steam atomizing type when the fuel pressure is low. 2. Same flame as pressure atomizing when the fuel oil pressure is high. 3. Sufficient atomizing is achieved even if the fuel oil pressure is low due to steam support.	Same as straight pressure atomizing type. 1. The pressure of auxiliary steam is constant.	Nearly same as the above.	Same as straight atomizing type.	1. Nearly same as straight pressure atomizing, however, less quantity of atomizing steam is necessary in comparison with steam atomizing type.	1. Same as straight atomizing type in principle, however lower fuel oil pressure is applicable due to wider turndown ratio.		
STEAM (AIR) ATOMIZING	INTERNAL MIXING TYPE	The fuel is mixed with the steam (air), and the atomizing is achieved by expansion of steam(air).	1. Soft and long flame with less soot and less brilliance due to reaction as C + H2O → CO + H2. 2. Stable atomizing is achieved. 3. Combustion noise is considerably high.	1. Controlled by changing the fuel oil pressure keeping the constant pressure difference between fuel oil and the atomizing steam pressure.	1. The fuel will be heated to keep its Red Wood viscosity less than around 250 sec. 2. Lower quality fuel is also applicable.	1. Rather easy maintenance due to low pressure, however, operation and manipulation are complicated due to using atomizing steam.	1. Lower capital cost due to lower atomizing pressure, however the atomizing steam is necessary during operation.	1. Atomizing steam is necessary. 2. Lower pressure equipment can be applicable due to lower fuel oil pressure comparing with pressure atomizing type.		
	PRE-MIXING TYPE	Ditto	Similar to steam atomizing internal mixing type.	1. Controlled by changing the fuel oil pressure keeping atomizing steam pressure constant.	Ditto	Ditto	1. Less steam consumption in comparison with internal mixing type.	Ditto		

FIGURE 2-13 COMPARISON TABLE OF ATOMIZING METHODS

2-1.2.2 OPERATION, INSTRUMENTATION AND CONTROL SYSTEM

1) Actual operating conditions for Gardner/Snyder and Malaya Thermal Power Stations

According to the list of actual operation conditions in 1981 for Gardner/Snyder and Malaya Thermal Power Stations, all the units cannot output the rated ones. The total output loss is 455 MW which is larger than the rated output of Malaya 2.

The total number of operating hours lost was 14,187 hours or an average of 2364.5 hours (98.5 days) per units last year. All units has been operated with efficiency lower than the original design value. This means that NAPOCOR's oil consumption was higher by about 28% based on weighted mean calculation.

According to the list, NAPOCOR's plants have low reliability and availability.

Actual operating conditions of Gardner/Snyder and Malaya Thermal Power Stations last year are shown in Figure 2-14.

FIGURE 2-14
ACTUAL OPERATING CONDITION OF GARDNER/SNYDER, MALAYA THERMAL POWER PLANTS (during May 11 - May 21)

D = Design
Dp = Design BE-0.89 /81
A = Actual (A) = /81
EM = Emergency /81
S = Scheduled /81
Ec = Economy /81

	Rated Output / Actual Output	Period of Plant Stop	C A U S E	Countermeasure	Effeciency and Stopping Hours
G-1	D 150 (MW) A 117 (MW) MW = 33 %MW = 78%	May 13	Fuel oil Fluctuation Drum level extra low	Nothing	D = 7,964 (BTU/KWH) Dp= 8948 (BTU/KWH) A = 10,721 (BTU/KWH)
					Em = 599 (Hr.) S = - (Hr.) Ec = - (Hr.)
G-2	D 200 (MW) A 130 (MW) MW = 70 %MW = 65%	May 12 - May 15	86GB (Back up Ry), CB Open or FW low not clear	Nothing	D = 7,760 (BTU/KWH) Dp = 8719 (BTU/KWH) A = 11,462 (BTU/KWH)
		May 20 - May 22	Feedwater Flow Low	Nothing	Em = 2835 (Hr) S = - (Hr) Ec = 125 (Hr)
S-1	D 200 (MW) A 134 (MW) MW = 66 %MW = 67%	May 17 - May 19	Valve broken at condensate pump	Peapir	D = 7,960 (BTU/KWH) Dp = 8944 (BTU/KWH A = 12,704 (BTU/KWH)
		May 20 -	Condenser vacuum low by G-2 trip	Nothing	Em = 2835 (Hr.) S = - (Hr.) Ec = 38 (Hr.)
S-2	D 300 (MW) (A)139 (MW) MW = 161 %MW = 46.3%	May 13 - May 17	HP 6 HTR Leak	Reapir	D = 7,710.4 (BTU/KWH) Dp = 8663 (BTU/KWH) A = 12,940 (BTU/KWH)
		May 21 - May 26	Boiler Tube Failure	Repair	Em = 2385 (Hr.) S = 4226 (Hr.) Ec = - (Hr.)
M-1	D 300 (MW) A 190 (MW) MW = 110 %MW = 63.3%	May 19 - May 20	Lightning Arrester broken	Repair	D = 7,710.4 (BTU/KWH) Dp = 8663 (BTU/KWH) A = 10,392 (BTU/KWH)
					Em = 1040 (Hr.) S = - (Hr.) Ec = - (Hr.)
M-2	D 350 (MW) A 335 (MW) MW = 15 %MW = 95.7%				D = 7,842 (BTU/KWH) Dp = 8811 (BTU/KWH) A = 9,917 (BTU/KWH)
					Em = 275 (Hr.) S = 1279 (Hr.) Ec = 17 (Hr.)

2) Analysis of the trouble in the Gardner/Snyder and Malaya Power Stations.

During 11th - 21th of May, 1982, 9 times trips occurred thus resulting in the stoppage of thermal power plant in each case. In some cases, the trips could have been avoided if the control systems were operating satisfactorily. Here is the JICA team's analysis of the trips from the point of view of the control systems and their functions.

Example 1: Gardner unit No. 1:

Drum level extreme low trip was initiated as follows:

a) Fuel oil pressure fluctuation occurred; standby fuel oil pump started automatically.

b) Increase in fuel oil pressure; excessive fuel oil supply to the boiler

c) Increase in drum pressure; safety valve operated

d) Decrease in drum level; extreme low level interlock tripped boiler

During this time, the boiler automatic control system should have operated to prevent trip of the boiler. The main cause of the trip was the malfunction of the fuel oil pressure control system.

Example 2: Gardner Unit No. 2 (recurring trips)

First trip: The following devices were actuated.

a) 86 GB action

b) Generator breaker open

c) Feedwater flow low

The actual cause of the tripping could not be clarified before the unit was restarted up.

Second trip: Feedwater flow low:

The interlock for low feedwater flow was actuated in both cases, thus it was considered that the cause of the record was the same one as the first trip from the point of view of possibility. This may be repeated unless the source/defect is pinpointed and corrected.

Example 3: Snyder 1:

Condenser low vacuum trip: This was initiated by the tripping of Gardner No. 2 unit which supplied auxiliary steam to steam jet ejector of Snyder No. 1 unit. The once-through units do not have an independent source of auxiliary steam for low-load operation.

In the four cases described above, control system problems and operational system difficiencies resulted in unit trips. Half of the number of trips would not have happened if these systems had operated satisfactorily.

3) Trouble source of the control system and method of operation

a) Unclarification of analysis of the cause, and no taking measures against repeated trip

In the four trips mentioned above, there were no definite findings as to the source of trouble, hence no countermeasures were done. Thus, there is a high probability that the trouble will again occur. It is understandable that the units had to be placed into operation as early as possible due to shortage of power supply, however, it must be emphasized that tripping of the unit is a very serious matter and that efforts should be exerted to clarify the source of trouble before placing the unit into operation. Tripping derived from the same trouble source will occur again and again without fail if preventive measures are not taken.

b) Operation of the control system:

Normally, the control system in the thermal power station is designed for automatic operation. Plant stability and dependability is the main objective for the automatic control of the systems. However, many parts of the thermal power plant control systems are manually operated. Thus, if a sudden change occurs in some operating conditions, there is no immediate response to correct these unusual conditions which

often result in tripping of the unit.
During start-up, the correct ratio of the feedwater flow to the firing rate is not maintained automatically. This is unacceptable condition to the boiler thus resulting in uncontrollable conditions. In some instances, plant interlock has not been in service and this is not a good condition for safe operation of the plant.

c) Bad quality of the instruments air
It was found that there is too much drain in the control air which is carried over to the pneumatic control equipment. Dust and water mixture accumulates at the pneumatic instrument and become one of the causes of unit trips.
This problem should be corrected so as to prevent unit trips due to dirty air. Originally, dryers were installed, however, some are no longer in service at present. To achieve high reliability of equipment in the pneumatic control system, water and dust should be eliminated. Otherwise, the pneumatic equipment cannot perform its control function satisfactorily. This causes not only sticking but also impulse change which will be one of the causes of trips.

d) Problem on alarm annunciator
Normally, the alarm annunciator on panel should be, however, during visiting the plant several alarm annunciators lighted continuously. This is an abnormal conditionand shows that there are troubles on many parts of the plant.

e) Supervision and inspection of the function, and performance of the equipment
There are at present differences between therated and the actual genertor output. There seems to be no group in the plant organization responsible for analyzing changes in plant condition. The cause of the trouble is that actual values do not conform

with the design values. There are overvalues and undervalues for the actual operation of equipment. It is not clear as to who performs periodical checking of the performance of power plant.

f) Unavailability of instruments and spare parts

All instruments must be maintained in good condition at all times including the equipment and their spare parts. But now, they are not maintained in good condition. Enough indicators and recorders are not mounted on the control panel in the control room and some of these are out of service or removed. This shows that improvements should be made with regards to the supply of instruments and spare parts. There are also problems in the method of repair and maintenance. For example, the oxygen analyzer which is important for the supervision of boiler combustion is not in service. Another example is the boiler metal temperature recorder which is very important for boiler operation. These instruments have not been operated for a long time. Oxygen analyzer has been under ordering.

g) Ambient condition around the equipment

There are excessive flue gas leaks, there is too much SO_2 gas and dust inside the building accordingly. These gases and dust build up a film of oxide at the contacting point of the relays and the connector, thus resulting in poor electrical contact. The flue gas leak also causes high ambient temperature at the upper side of the building. The life of the electrical equipment is shortened.

h) Low plant efficiency and reduction in MW capacity

There is a total poer loss of 455 MW for the six units. The design capacity is 1,500 MW for Gardner/Snyder and Malaya Thermal Power Plants, but at present NAPOCOR can get only about 1,045 MW (about 60% of design capacity). This is caused by degraded operation at lower steam condition than design

condition. Shortest outage periods of scheduled shutdown and emergency shutdown is 599 hours (25 days), and longest one is 6,611 hours (277.5 days). Low reliability and inadequate administration of equipment and facilities cause in large amount of outage of the plants.

5) Recommendation and advice:

NAPOCOR has lost a total of 455 MW power output at Gardner/Snyder and Malaya Thermal Plants. This value is larger than the rated output of Malaya No. 2 by 100 MW. If these three (3) plants (Gardner/Snyder and Malaya) are improved, it is equivalent to acquiring a new 455 MW capacity plant. This means not only merely that generator output is lost, but also that the availability and reliability of power supply are reduced, and this reduced energy purchased and increasing fuel cost due to degredation of thermal efficiency.

a) Improvement of availability and reliability

(1) Investigate causes of trips and implement countermeasures to prevent their recurrence
There are many trips caused by the same source, which means that there was no detailed investigation and no countermeasures were taken. When a trip occurs, a thorough analysis should be made and countermeasures should be taken, that is, repair or replacement of defective instrument, modification of the control circuit or improving mode of operation. The same should be applied to control and protective interlock circuits.

(2) Place the control systems into automatic operation
All control systems should be operated

automatically for stability of power plant. At present, once-through boilers are operated manually through the selector stations. In some instances, the correct ratio of feedwater flow rate and firing rate is not maintained during ramping operation. Manual operation cannot achieve the same good operating condition without automatic operation. Many kinds of troubles may occur in the power plant, and finally lead to tripping of the power plant unless operator responds correctly and timely to the quick change in operating conditions.

Hence, each control system must be operated automatically all the time.

There is a plan by NAPOCOR to adopt Bailey NW 90 to the automatic by-pass control system of Snyder No. 2 unit. If all the existing ABC (Automatic Boiler Control) of once-through boilers cannot be operated automatically and could no longer be rehabilitated, it is better to change all ABC systems to the new Bailey system. For easier maintenance and repair, it is advisable that all once-through boiler control equipment be of the same type. When the new control system is installed, the ambient conditions should correspondingly be improved to eliminate adverse conditions such as boiler gas leaks.

(3) Repair all instrument air dryers

There are much quantities of water drained in the instrument air. If water in the instrument air enters into the pneumatic instrument, some troubles will be experienced. This may lead to tripping of the plant. Repair or replacement of instrument air dryers is urgently needed for the protection of the pneumatic instrument.

(4) Reset all alarm annunciators lighted on the panel
There are many alarm annunciators that are lighted during operation, which show abnormal conditions. This situation is unacceptable for the normal operation of the plant.

(5) Improve the method of maintenance, repair and supervision
The continuous supervision and analysis of each equipment condition is necessary to achieve high availability and reliability of the operation as well as to maintain the rated output and efficiency.
At present, there is not enough supervision and analysis for each equipment, thus there are low output, efficiency, reliability and availability.
Restoring the rated output of these plants is equivalent to having a new 455 MW capacity plant.
Therefore, NAPOCOR needs to rehabilitate each plant, and when they are restored to their normal condition, NAPOCOR must administrate and control operating condition of the plant and equipment.
The operating data of each equipment must be continuously compared with the design values (original) in order to check whether it is normal or abnormal. Any abnormality will be detected at an early stage so that repair or replacement can be quickly carried out before resulting in serious troubles. For the purpose of periodical and suitable administration of plant performance, organization of a group that prepares standard performance data list establishes a method of comparison and an evaluation of the performance and periodic performance test should be formed in the power plant.

(6) Maintain and repair the instruments

(a) Ambient condition

There are too much SO_2 and dust coming from flue gas leakages in the boiler. This results in problems of erosion, corrosion and high temperatures. These conditions have been existing for a long time.

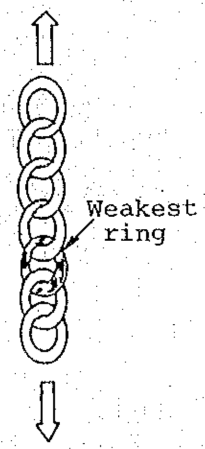
In addition to the above, since air dryers in the instrument air systems have not worked, the compressed air may contain drain mixed with sulfide. If the mixture enters into electronic control devices, contactors or connecting points are corroded by the sulfide mixture and thus resulting in serious troubles like plant trip. Therefore, repair of gas leakages from the boiler is the first and complete provision of air conditioners in central control room is the second.

(b) Periodical maintenance

It is needed to periodically replace the consumables which are parts subjected to rotation or rubbing. Stocks should also be replenished periodically. During maintenance time calibration should be performed by comparing new data with the old one for hysterises, backlash and, air or power supply conditions. The instrument is not as tough as the main equipment so that adequate supply of parts should be provided. It is needed to periodically test the performance of plant equipment.

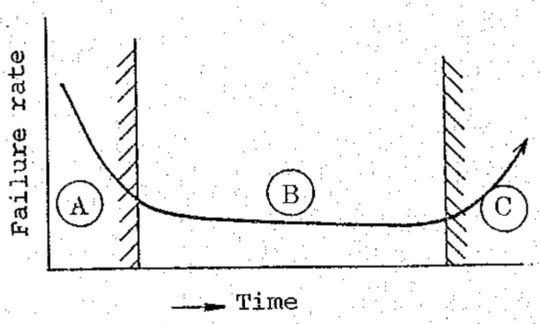
(c) Control of troubles and countermeasures for recurrence

Generally, troubles are resulted from the



same source frequently. This point is known as the weakest link. The counter-measures against trouble mean that the weak-est link must be corrected step by step.
After the first weakest link is corrected this becomes strong but the second weakest link will be the source of tripping. Thus, this must also be corrected in the same way as the first weakest link. This is the maintenance concept for high reliability and availability. It is required that thorough analysis of troubles and trips be performed each time. After trouble-shooting, the weakest link should be corrected so that the original reliability is restored.

FIGURE 2-15 BATH TUB CURVE

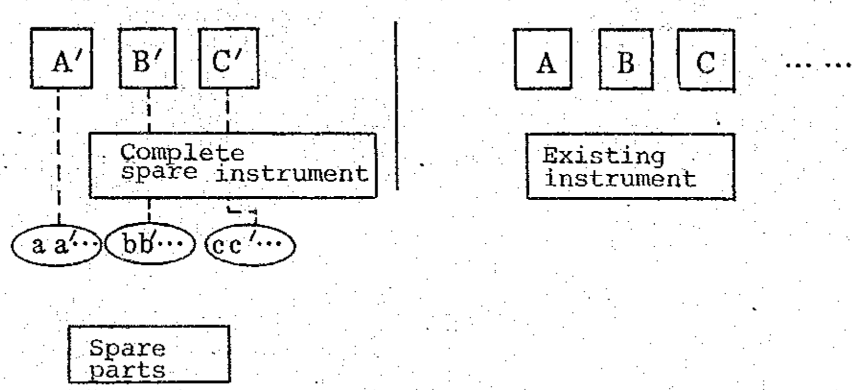


The idea of the weakest link is equivalent the area (A) in the bathtub curve shown above. The area (B) represents the period where only accidental troubles occur. This period is generally called Mean Time Between Trouble (MTBF).
The plant operation is generally stable since there are no specific source of trip. When the condition enters into area

Ⓒ, this is the wearing out period where trouble increases gradually. The indicator as to whether present situations are at the area Ⓑ or Ⓒ is obtained from the analysis of the actual trouble ratio. Records of troubles are very important accordingly.

d) Method of repairing of instruments

FIGURE 2-16 METHOD OF REPARING



A,B,C : Existing instrument

A',B',C' : Complete spare instrument

aa',bb',cc' : Spare parts for each instrument

If instrument A has some troubles, this is replaced with A', and A is then repaired at the instrument shop. This method will allow the trouble time shorter. During repair of A, defective parts will be replaced with new ones coming from aa'. The repaired instrument A can then be used as standby of A' for the future troubles. This system needs several complete assemblies as spare for each kind of instrument. This is the best way of maintaining the plant safety, availability and reliability.

(7) Scheduling for countermeasures

(a) For immediate implementation

- repair of instrument air dryer
- analysis of the source of trips and establishment of countermeasures against the trips
- complete automatic control system operation

(b) For short term

- improvement of the environmental conditions (leaking flue gas, air conditioning of instrument room, etc.)
- replacement of existing Automatic Boiler Control System

  It is better for all once-through boilers to use the same type of control device for reasons of repairs and maintenance as well as commonality of spare parts
- inspection and repair of the electro-hydraulic governor by manufacturer
- stocking of complete instrument assembly and spare parts
- Improvement of the measuring instruments

(8) Others

Start-up schedule and procedures are kept adequately based on start-up chart of schedule, check sheet, regulations and temperature increase rate of boiler metal and steam.

Operators, maintenance engineers and specialists for instruments and controls are all superior, but at present problem exists in lackness of spare parts and instrument parts.

2-1.2.3. CHEMICAL MANAGEMENT

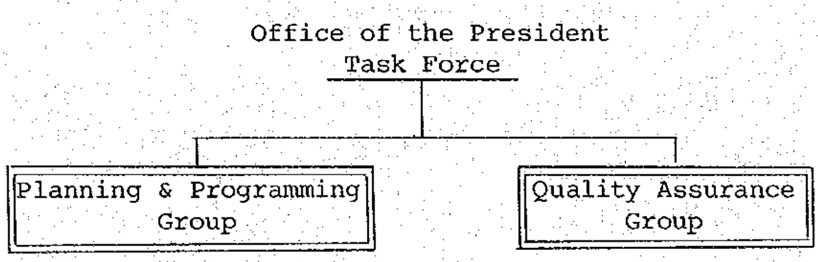
Conclusion of Survey:

1. <u>General</u>:

1) Organization of Chemical Staff

Chemical Section of Thermal Power Plant belongs to Technical Services which is almost the same system in Japan, and three (3) shift system is applied.

The upper organization consists of the following groups and these groups manage the chemical problem. Likewise, in the rehabilitation of the feedwater quality monitoring instruments, a task force was created to completely rehabilitate the said instruments, a Task Force was created to completely rehabilitate the said instruments and to maintain its proper and continuous operation. The said Task Force is part of the planning and programming group (one chemical engineer).



2) Number of Chemical Staff

The number of chemical staff is not sufficient to cope with various tasks in the chemical section. Comparing the present complement with the approved Table of Organization (73 chemical staffs), the Gardner/Snyder needs additional 10 chemical personnel, Malaya - 8 personnel, and Tegen - 2 personnel, twenty (20) personnel in total.

All the chemical staff have qualification of 2 years college education at least, particularly graduated from Chemical Engineering or Chemistry Course. about 60% of

the total has experiences more than two years, and ten (10) women chemical staffs are in charge of 3 shift duty, six (6) - Gardner/Snyder, two (2) - Malaya and two (2) - Tegen Thermal Power Plant.

3) Duties of Chemical Section

Duties of Chemical Section are as follows:

* Water quality control and analysis
* Fuel analysis
* Receipt and management of chemicals
* Operation and regeneration of demineralized water equipment and condensate polisher
* Operation of chemical injection equipment

4) Training and others

Training of chemical management is not planned and no chemical staff is sent to abroad for widening of their technical knowledge on water and fuel oil treatment.

The positional grade of chemical staff is one rank lower than that of operator. During MECO set-up, both positions were equal.

TABLE 2-1 NUMBER OF CHEMICAL STAFF

Remark: A = Actual C = A - B
B = Approved Table of Organization

	G.S.T.P.			M.T.P.			T.T.P.			TOTAL		
	A	B	C	A	B	C	A	B	C	A	B	C
Technical Service Superintendent A	1	1	0	1	1	0	1	1	0	3	3	0
Water Unit												
Principal Technical Analyst B	1	1	0	1	1	0	1	1	0	3	3	0
Sr. Technical Analyst B	2	5	-3	3	5	-2	5	5	0	10	15	05
Sr. Technical Analyst A	2	5	-3	-	-	-	-	-	-	2	5	-3
Equipment Control Technician B	8	10	-2	5	5	0	5	5	0	18	20	-2
Equipment Control Technician A	10	10	0	1	5	-4	-	-	-	11	15	-4
Fuel Unit												
Principal Technical Analyst B	1	1	0	1	1	0	1	1	0	3	3	0
Sr. Technical Analyst B	1	1	0	1	1	0	1	1	0	3	3	0
Sr. Technical Analyst A	0	1	-1	0	1	-1	0	1	-1	0	3	-3
Technical Analyst	0	1	-1	0	1	-1	0	1	-1	-	3	-3
Newly Hired Chemical Engineer	(3)									(3)		
Newly Hired Chemical Technician	(2)			(1)						(3)		
TOTAL	26 (31)	36	-10	13 (14)	21	-8	14	16	-2	53 (59)	73	-20
Number of one shift		6			3			2			-	
Length of Service												
Less than one (1) year		6			1			4			11	
One (1) to two (2) years		10			3			7			20	
Three (3) to five (5) years		3			3			1			7	
Six (6) to ten (10) years		7			7			1			15	
Eleven (11) years or over		5			0			1			6	

2. Present Situation of the Power Plants

1) Chemical laboratory

Chemical laboratory of Gardner/Snyder Thermal Power Plant is located on ground floor below the turbine hall while that of Malaya Thermal Power Plant is located on the same floor as turbine hall.

Generally, the chemical laboratory is relatively clean and the necessary instruments for chemical analysis are installed.

Just recently, part of the sample is supplied to chemical laboratory from G-2, S-1 and S-2 condensate pump discharge. Sodium analyzers were installed at the chemical laboratory for the monitoring of the condensate polishers inlet and outlet sodium concentration.

For Malaya Thermal Plant, sodium analyzers were also installed at the chemical laboratory for the analysis of condensate polishers inlet and outlet sodium concentration. With the arrival of silica analyzer, the anion effluent silica is continuously being monitored.

Installed Conditions of Instruments in Chemical Laboratory (GSTP)

Instruments	No.	Specifications
pH meter	3	Zeromatic SS-3 Beckman PH meter, Zeromatic IV PH meter, Beckman Horizon PH meter, Ecology Co. Model 5995
Conductivity meter	1	YS1 Conductivity Bridge Model 31
Colorimeter	3	Beckman Model DU^2 spectrophometer, Beckman Model 35 spectrophometer, Fisher Electrophometer II
Atomic Absorption Spectro Photo Meter	1	Perkin Elmer 360 Atomic Absorption Spectrophometer
Direct Reading Balance	2	Mettler P5N Platform Balance, Mettler Model B6 Analytical Balance
Colorimeter	1	Parr Adiabatic Colorimeter
Kinematic Viscosity Meter	1	Fisher/Tag Saybolt Viscosimeter