6.2 Administration of the Plant Equipment

This chapter indicates the status and improvement plan for administration of plant equipment, such as operation administration, maintenance administration, engineering administration, inventory administration, fuel administration, and safety and health administration.

TES4 strives for maintenance, rehabilitation, efficient operation of the plant equipment, prevention of an accident before it happens and continuous stable supply of electric power, adopting the improvement plan.

6.2.1 Administration of the Operation

Operation administration involves carrying out the operation plan, operation, observation, patrol, operation record of plant equipment, report and communication of information.

The main purpose of operation administration is to prevent accidents to the plant equipment and to attain efficient operation of the plant equipment.

Combustion control is closely related to the plant efficiency.

Although various countermeasures in administration of operation are made by each section of TES4, this report proposes the improvement plan among: (1) Improvement in observation techniques of the operator, (2) Preparation and maintenance of operation support manuals, (3) Improvement of the method for taking over the next shift and means of in-house communication, (4) Improvement in keeping the operation logs, (5) Improvement in administration of repair work by the operator, and (6) coping with accidents.

(1) Improvement in observation techniques of the operator

The operator who resides at CCR is observing the working order of the plant equipment through various observing equipment, such as indicators, recorders, CRT and alarm windows.

The operator who takes charge of on-site equipment is patrolling in the field to observe the working order of the plant equipment.

Prompt action is called for, when the working order of the plant equipment deviates, or when abnormalities are discovered.

The current Status of TES4	*Improvement Plan*
(Observation item) • Since many indicators and recorders for turbine equipment and boiler No.5 to No.8 have failure parts and are difficult to observe, CRT were introduced for observation several years before aiming at intensive observation by CRT. • The control devices for boiler No.1 to No.4 have been replaced and enabled monitoring at indicators, recorders, CRT, alarm windows, etc. • Operators are recording main process data on the data sheet every hour.	• Probe the main process data, that cannot be observed and repair the faulty measuring instrument immediately. • Operators should become acquainted with the normal value of main process data. • Operators should grasp the amount of change of process data based on the difference in load band and coal characteristics. • Operators should check the recorded process data, and should act promptly when abnormalities are found.
(An alarm value and a limiting value) • Operators have insufficient understanding of the alarm values and limiting values. • Operators lack attentiveness to the alarm. • Operators do not understand the alarm. • Although the large-sized motors, such as FDF, have restricted start frequency (frequency), since this is neglected, it has led to motor damage from fire.	• Operators should become acquainted with the alarm values and its basis of set value, and should become acquainted with the alarm procedure. • Perform the device for finding abnormalities. For example, marking the normal value on the indicator. (Refer to Fig. 6.2-1.) • Operators should learn whether the machine or equipment can continue operation or not (in limiting value), when an alarm continues. (Interlock is minimum equipment for backup of the operator.)
(Patrol) • Each operation group follows a regular patrol route. • The auscultation stick (to check soundness of a rotating machine) is not used. • The environment of the field (especially boiler building) is quite dark even in daytime. • Number of flashlights is insufficient. • Patrol tools are insufficient.	• Operators should not patrol vaguely, but patrol acknowledging checkpoints of the equipment. • Patrol check items should be reviewed considering the past frequency of abnormalities. • Perform the device for finding abnormalities. For example, marking the normal value on a local gauge. (Refer to Fig. 6.2-2.) • Operators should attend to abnormalities and signs of abnormalities during a patrol. They should take care of their own health and maintain the required concentration with careful attention to the operating equipment. • At the time of finding abnormalities, the patrolling person should take a memorandum immediately and transmit the situation to operators or to a shift engineer who resides in CCR correctly. • Patrol tools should be arranged immediately from a viewpoint of safe reservation. (A standard list of patrol tools is shown in Table 6.2-1.)

Table 6.2-1 List of Patrol Tools

Patrol tools	*Purpose*
Helmet	Head protection (the name seal, blood type and qualification is stuck on a helmet)
Safety belt	Fall prevention
Working gloves	Prevention of burns, cuts, etc.
Face shield for a flame check	Protection for face eyes and during checking combustion in a boiler furnace and ashes adhesion situation
Ear plugs	Prevention of hearing impairment in an area of loud noise, such as a circumference of a turbine.
Dust protection mask	Prevention of respiratory disturbance in a place with much dust and coal dust, such as coal hopper and coal crusher.
Flashlight	Prevention of tripping and falling in a dark place
Auscultation stick	Finding abnormalities by listening to sound of the rotating machine.
Valve handle for each type	Valve opening-and-closing operation
Tester	Check of electric conduction and measurement of insulation resistance.
Thermometer	Finding abnormalities such as sheet leak, temperature rise of bearing, etc.
Machine shop tool	Slack-checks of a bolt and a nut, secondary tightening
Transceiver	For telecommunication with CCR at the time of finding abnormalities
Memo pad	For making notes at the time of finding abnormalities

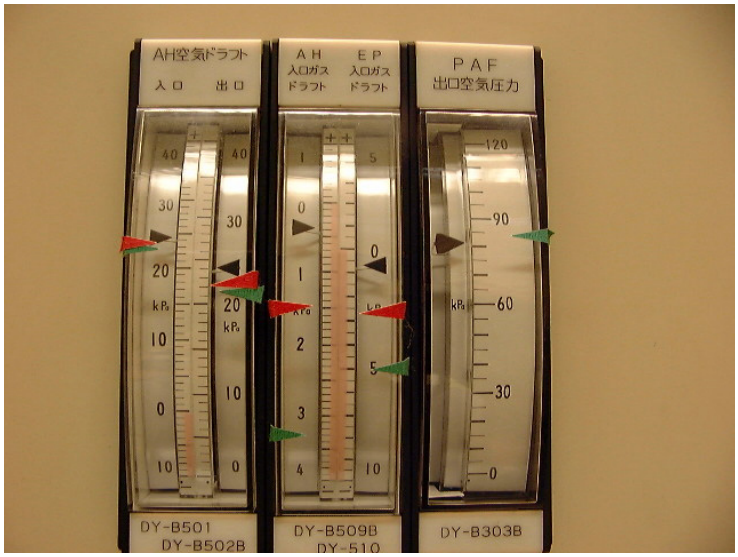


Fig. 6.2-1 Marking on a Scale of the Indicator in CCR

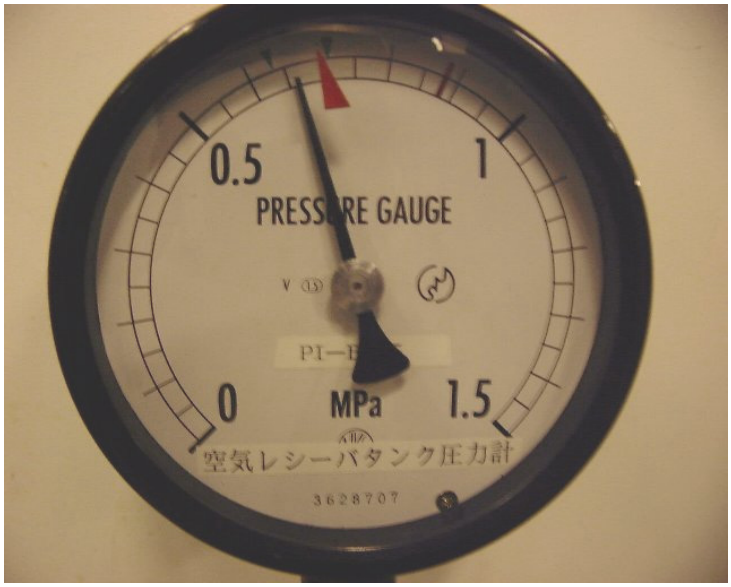


Fig. 6.2-2 Marking on a Local Gauge

(2) Preparation and maintenance of operation support manuals

An error in a schematic diagram or an operation manual causes an operating error.

Drawings to be used for operation and maintenance of the plant equipment should be immediately updated after installation or refurbishment of the equipment. (An example of an accident: Since the result of system remodeling was not reflected in the drawing, water leaked causing a fatal accident when a pipe in the system was cut.)

Maintenance of operation support manuals is very important.

The operation support manuals generally prepared in the plant are shown in table 6.2-2.

Not to mention coping at the time of accidents, these operation support manuals aim at improvement in operators in the process of preparation of these documents.

Current Status of TES4	*Improvement Plan*
(**Operation manual**) • The operation group of each section is keeping the operation manual. • The operation group of each section prepared the operation manual in collaboration with the Engineering Department or the Research and Planning Department, and recognition of the Repair Department and the Operation Department has been obtained.	• The Operation Department should keep all operation manuals and make required amendments. • For improvement of operation manuals in use, operators who actually use the operation manual should take the lead, forming the working group.
(**Schematic diagram**) • The operation group of each section is keeping the schematic diagrams. • For new equipment, the operation group of each section is creating the schematic diagrams based on supplier's drawings. • The operation group of each section is reviewing drawings once a year, and if there is any deviation from the actual things, they correct the drawing after getting approval of the section chief.	• The Operation Department should keep all schematic diagrams and make required amendments. • Schematic diagrams should be re-written utilizing CAD (computer aided design), and should be corrected immediately when the necessity for amendment arises. • Amendment of schematic diagrams should also be made upon request of the Repair Department or the Engineering Department. Amendment history should be in a ledger with the amendment date and the reason for the amendment.
(**Keeping place of operation support manuals**) • The operation group of each section is managing the operation support manuals in each section chief room. • Duplication of the required part is made at every work.	• Operation support manuals should be kept in the bookshelf in CCR and ECCR so that operators who actually operate can peruse at any time. (Refer to Fig. 6.2-3.)
(**Other operation support manuals**) • The supplier's documents that are supplied by the manufacturer are important, in which not only the operation and maintenance method but also many drawings are included. The operation and maintenance manual should be developed based on these supplier's documents. However, in TES4 some drawings have already been lost and some remodeled parts are not yet reflected in the drawing.	• The operation and maintenance manual should be completed. And one complete set should be kept in the Operation Department and another in the Repair Department. • Proceeding for alarm and setting value explanatory document should be kept in the Operation Department, and be amended as required. An alarm procedure manual is shown in Table 6.2-3, and the written example of a basis of set value is shown in Table 6.2-4. • The Operation Department should issue directions for operation whenever he directs an operator to operate the plant equipment.

Table 6.2-2 Operation Support Manuals

Document Name	*Contents*
Operation manual	A manual required for operation, such as a start and stop schedule table.
Special operation procedure	The procedure of change over to another system, the procedure of isolating from failure system, etc.
Schematic diagram	Steam flow diagram, water flow diagram, electrical single line diagram, control logic diagram etc.
Instruction manuals	The procedure of operation and maintenance, drawings, etc.
Alarm procedure manual	The procedure at the time of alarm occurring
Setting value explanatory document	A normal value, an alarm value, a limiting value, and basis of determination of these values
Directions for operation	Directions different from usual operation

Fig. 6.2-3 The Picture of Operation Support Manuals in CCR

Table 6.2-3 The Example of Proceeding for Alarm

Location	(Electric room) P/C (1FL) The local panel for instrument air compressor
Device name	Over-current relay (OCR)
Setting value	160A, 1,350A, 1,800A
Normal value	120A
Name of alarm	Instrument air compressor trip
Cause	1. Electric failure (1) The instrument air compressor motor trip by the over-current relay 2. Mechanical Failure (1) The instrument air compressor trip by loss of cooling water (2) The instrument air compressor trip by lube oil pressure low
Phenomenon	The failure machine is tripped according to the above-mentioned cause, and a reserve machine starts up.
Disposal	1. Electric failure: don't start the tripped machine until the cause of failure is checked, even if the over-current relay is able to reset. 2. Mechanical failure: (1) Investigate the cause of loss of cooling water, if normal, start the machine and check whether predetermined flow is securable. (2) Investigate the cause of lube oil pressure low (plugging on a strainer, leaking from piping), if normal, start the machine and check whether predetermined pressure is securable.
Note	The reference parts in the logic diagram and the wiring diagram are indicated here.

Table 6.2-4 The Example of a Setting Value Explanatory Document

Identification number	*PIS – E 002*
Measuring point	Generator cooling gas pressure
Setting value	$\leqq 2.8 kg/cm^2 g$
Use	Generator cooling gas pressure low alarm
Note	

The basis of setting value.

When the cooling gas pressure declines from rated gas pressure ($3kg/cm^2g$), the heat capacity of hydrogen gas becomes smaller than a design value, and it decreases cooling effect.

If gas pressure decreases by $0.25kg/cm^2g$ from the rated pressure, the rated output (184MVA, 0.85PF, and 14.5kV) cannot specifically be held.

Rated gas pressure ($3kg/cm^2g$)- $0.2kg/cm^2g$= $2.8kg/cm^2g$

It considers as a setting value.

In addition, a generator capability curve is appended.

(3) Improvement of the method for taking over the next shift and means of in-house communication

In transferring the operation duty from an operation group to another, an important thing is to succeed the working order of the plant exactly.

In-house information is the basis of various judgments, and information disclosure and quick transfer are required for it.

Current Status of TES4	*Improvement Plan*
(Taking over to the next shift) • The operator of each section is taking over individually to the next shift respectively. • The shift engineer of the Operation Department has taken over the fault matter of the whole plant to the next shift collectively.	• The operator, who received taking over, holds a meeting at first and has in common with information. • Operators should strive for grasp a working order immediately after taking over. (The alarm under warning and the value of indicator should be checked at least.) • Operators should strive for grasp a fault situation and a repair situation immediately after taking over.
(**The means of in-house communication**) • The communication of information from an operation sift group to a repair group is done in the technical communication meeting of 8:00-8:10 every morning from a shift engineer. The report from the shift engineer is a working order including the fault matter. Method of repair is determined in the meeting. • In the technical communication meeting held at 15:30-16:20 every day, the problem that should be solved in the whole plant is discussed. Repair results are reported on the meeting. • The Operation Department has put up the daily working order in front of service building 1FL elevator. • Information is exchanged at the engineer meeting of all engineer participation on the 2nd Wednesdays every month.	• Perform a device not to be mannerism-zed, such as clarifying the purpose of a meeting and making a chairman into daily rotation. • The participant at a meeting should strive for making the atmosphere, which can perform free opinion exchange. • Strive for time management so that a meeting can be started on time and it can end. • Build the communication-of-information system by a station LAN so that grasp of the working order may always be possible in the office of plant. **Refer to Chapter 6.1.3 Communication.*

(4) Improvement in keeping the operation logs.

Keeping of operation log is important for the check of the working order of plant, grasp of a long-term deterioration, or planning of the rehabilitation schedule.

The operation log generally kept in power plant is shown in Table 6.2-5.

The check of operation log is carried out by both an operation sift group and the Operation Department. It is desirable to feed back the check result of the Operation Department to the operation sift group.

Table 6.2-5 Example of Operation log

Record name	*Contents*
Log sheet and daily report	A list of plant main data
Record chart	The data printed in chart
Long-term deterioration	Operation log of each equipment for comparison at the time of abnormalities
Monthly efficiency report	The efficiency record (actual result value over a target value), and comments on them.

Current Status of TES4	*Improvement Plan*
(**Log sheet**) • Since the operation log of the past, such as a log sheet, is kept in the data room after checking by the Operation Department, the past operation log cannot be referred to in CCR.	• Keep log sheets in a binder where the engineer of the Operation Department can be perused at any time. • The log sheet should be kept in the Operation Department for four years, and will be kept in a data room after that (same as the cycle of major overhauls).
(Chart) • Many recorders are not working because of failure or shortage of recording paper. • The recorded charts are kept in a data room.	• Broken recorders should be repaired immediately. • Recording paper should be refilled on the fixed day of each month. • Carry out required quantity purchase of the articles of consumption, such as record paper and ink, and prevent data shortage of consumed articles. • Set the preservation period of a chart to four years (it is the same as the cycle of major overhauls). It should be kept in a place where the engineer of the Operation Department can peruse.
(Long-term deterioration record) • Although the operator is recording main process data on the log for every hour, it is useless as a long-term deterioration record. • Even when an unusually process value is noticed, the past data for reference cannot be found.	• Post main data among indicators in CCR and local gauges once per month at the time of plant stability operation, and keep them in the CCR. • When abnormalities are acknowledged in the plant, and going back and investigating the time when the signs of abnormalities occurred, long-term deterioration records are greatly consulted.
(Monthly efficiency report) • The data kept by the Operation Department is shown in Table 6.2-6. • The calculation group of the Operation Department is computing the efficiency parameter based on the data that the operators recorded every day. (Manual calculation) • Efficiency calculation is performed every 10 days and the working order over an operation target value is checked.	• The efficiency calculation should be executed by the computer to save computation . • Shift the calculation group from the Operation Department to the Engineering Department. (Refer to Chapter 6.2.3 “Administration of the engineering.”) • The monthly efficiency report should be kept in a place where the engineers of the Operation Department can peruse it at any time.

Current Status of TES4	*Improvement Plan*
• Once every month, the calculation group describes the results of computation and his comments in a monthly efficiency report, and this is reported to the Operation Department manager. • The amount of specific fuel consumption for generated heat and electricity is reported to the president, the Planning Department, ERA, and a chief engineer. The cause is investigated when it exceeds the target.	• The monthly efficiency report should also be kept in CCR so that operators can be perused it and to raise the consciousness to efficient operation of the plant.

Table 6.2-6 Managing Items by the Operation Department

Item	*Unit*	*Contents*
Generated electric energy	MWh	Transmitted power to the external network + consumed power in the plant (calculation value)
Supplied electric energy	MWh	Transmitted power to the external network (watt-hour meter reading value)
Supplied heat	Gcal	Supplied hot water flow, temperature of supply water, temperature of return water
Auxiliary power ratio	%	Amount of consumed power in the plant is summed value of all the watt-hour meters.
Specific fuel consumption for generated electricity	g/kWh	Amount of consumed coal for electric generation ÷ Generated electric power
Specific fuel consumption for generated heat	kg/Gcal	(Total amount of consumed coal－Amount of consumed coal for electric generation) ÷ Generated heat
Fuel consumption (heavy oil)	kt	Amount of the fuel used per burner, number of burner, operating hours of fuel oil burner
Fuel consumption (coal)	kt	Amount of supplied coal, boiler average load
The amount of fuel consumption compared with target (excess)	t	Steam flow, boiler efficiency, calorific value of standard coal (7000kcal/kg)
The amount of fuel consumption compared with target (saving)	t	Same as the above
Loss of water and steam	%	(Amount of treated water for boiler- Amount of steam supplied for industry) ÷ Amount of boiler feed water
A difference with a load dispatching (heat supply)	Gcal	A load dispatching instruction－Supplied heat (result value)
A difference with a load dispatching (electric power supply)	MWh	A load dispatching instruction－Supplied electric power (result value)
Main steam pressure	ata	Operation parameter
Main steam temperature	°C	Operation parameter
Boiler feed water temperature	°C	Operation parameter
Condenser vacuum	%	Operation parameter
Number of times of start-up (hot start)	Times	Operation actual result
Number of times of start-up (cold start)	Times	Operation actual result
Number of times of start-up (total)	Times	Operation actual result
Availability factor of turbine (electric power)	%	Turbine rated output, Operation hours
Availability factor of turbine (heat)	%	Turbine rated output, Operation hours
Availability factor of boiler	%	Operation hours
Availability factor of boiler (design ratio)	%	A boiler rated output, Heat output
Use time of design capability (electric power)	hr	Operation actual result
Use time of design capability (heat)	hr	Operation actual result
Average of heat output	t/h	Heat output, Operation hours
Average of electric energy	kW/h	Amount of generated electric power, operation hours

Number of times of stop	Times	Operation actual result

(5) Improvement in administration of repair work by the operator

In order to stop the failure equipment and to repair them safely, while supervising the states of switch gear, valves and dampers in a ledger, the name of the person in charge, the reason for operation, and terms should be displayed on the stopped apparatus. Accordingly, accidents by the others operating it without permission, such as electric shock, will be prevented.

The work procedure ledger used in many power plants is shown in Table 6.2-7.

Table 6.2-7 Work Procedure Ledger

Ledger name	*Contents*
Work procedure slip	Failure equipment and its repair situation are recorded.
Switchgear Procedure ledger	Record of switchgears under repairing work etc.
Valves and dampers procedure ledger	Record of valves, dampers etc. locked for repairing work.

Example; Switchgear Procedure Ledger

Name	*Identification*	*Period/Person*	*Period/Person*	*Period/Person*
IDF	P/C-12	2.5-2.10/B.Yamada	2.8-2.10/T.Sato	
IDF damper	C/C-14	2.5-2.10/B.Yamada		
……				
……				

Current Status of TES4	*Improvement Plan*
(**Work procedure)** • The repair engineer who belongs to the Operation Department does repair work. • When repair work cannot be performed by the repair engineer (repair which requires part exchange, or it takes a long time), the maintenance plan is discussed and determined in the technical communication meeting. • On the failure record document, the record number, the contents of failure, and date of failure are recorded by the Operation Department. • On the maintenance record document, the dates of commencement and completion of the repair work, the cause of failure, the repair record, the material name and kind that were used for the repair are recorded by the Repair Department. • Repair Department manages the major overhaul.	• The Repair Department should perform all repair work. (The Operation Department should not perform any repair work.) • The Operation Department should make a "work procedure slip" for the Repair Department, when abnormality or a failed part are discovered. • During complicated times such as Major Overhauls involving many contractors and a great deal of construction work, the Repair Department assembles all contractors before commencement of the work, and checks notes on the contents of construction, the construction time schedule, and safety procedures. • When the safety of work cannot be assured, the operator should not permit the work.

Current Status of TES4	*Improvement Plan*
(Supervising states of switchgear, valves and dampers in a ledger) • Except for the Chemical Section, no section is supervising states of valves and dampers in a ledger. • Since supervising states of switchgear is not carried out at all, many electric shocks have occurred.	• Since it leads that supervising states of switch gear, valves and dampers in a ledger is inadequate to serious accidents, such as electric shock, when work becomes complicated, define the "switchgear procedure" and "valves and dampers procedure", and strictly supervise the maintenance. • Switchgear procedure slip is shown in Fig. 6.2-4, and valves and dampers slip is shown in Fig. 6.2-5.

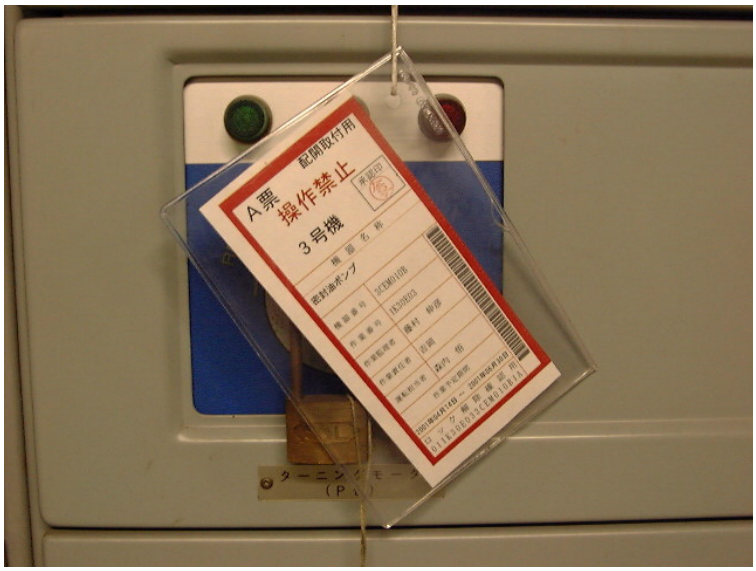


Fig. 6.2-4 Switchgear Procedure Slip

Fig. 6.2-5 Valves and Dampers Procedure Slip

(6) Coping with accidents

The operation shift group should cope with accidents quickly and safely after grasping the situation. In addition, they should relate what happened to the relevant departments and sections, and should collect data required for cause investigation.

Current Status of TES4	*Improvement Plan*
(Shift engineer) • The shift engineer usually resides in another room different from CCR and ECCR. • Therefore, the shift engineer cannot always grasp the working order, and cannot make a judgment at the time accident. • Although the repair group is coping with the repair work in almost all cases, the responsibility for coping with accidents about operation is ambiguous. • A shift engineer does not have command / connection responsibility at the time accident. • When accidents occur, the urgent correspondence department is collecting information gradually through a central monitoring system.	• The shift engineer should always reside in CCR where he can grasp the working order and the contents of operation of operators. • In an accident, a shift engineer should return to CCR immediately, when he is out of CCR, and he should strive to outline the accident and grasp the cause. • If the cause of accident and the situation of equipment are clear, the shift engineer should judge quickly whether operation should be continued or not and should direct operators with all responsibility for coping with the accident. • The shift engineer should report the accident situation, cause, the coping, prospect of restoration, etc. to the Operation Department, the Repair Department, the Engineering Department, and the other related Department promptly, and request aid if needed. • The shift engineer should create and reexamine of an emergency communication organization. • Order evacuation when operator's lives are at risk.
(Preparation of operation procedures in case of accidents) • Operation procedure at the time of accidents is not provided.	• Although accidents are of infinite variety and it is impossible to prescribe a detailed operation procedure uniformly, operation procedures for typical accidents should be made.
(Training of operators) • Operators are trained using a plant simulator to a minimum extent in order to learn the adequate judgment and the operation procedure at the time of accidents. • Communication system between an operator and another part operator is not arranged.	• The operators should be trained to be skillful in equipment operation, and well versed in the function and principle of equipment, and have sufficient skill to react to many kinds of accidents. • In some accidents, reaction is needed not only by an operator of one section but also by another operator of another section. When such an accident occurs, the operator should quickly follow procedure in close cooperation with the other operator and try hard to limit the damage to the minimum. • In an accident, the operator should check accident time, alarm items, etc., and report the failure equipment and the extent to a shift engineer. • When it is judged that it should stop, the operator should perform stop operation immediately to prevent a secondary accident or a fatal accident. • Re-start operation of failed equipment should be done under the direction of a shift engineer. Re-start operation should be prohibited before the cause of accident is clarified.

6.2.2 Administration of the Maintenance

Maintenance administration implies check, inspect, repair and improvement of equipment so that the power generation equipment can continue operation safely and smoothly.
In this chapter, 6 items of the status and improvement plan for the maintenance administration of TES4 is described:

(1) Improvement in administration of the maintenance organization,
(2) Planning and implementation of repair work,
(3) Preparation of repair manual, and improvement in repair skills,
(4) Observance of repair manuals and judgment for repair work results
(5) Preparation of replacement parts and materials, and maintenance of repair and testing tools,
(6) Improvement of workplace environment.

(1) Improvement in administration of the maintenance organization

The maintenance administration organization of TES4 is divided into 2 repair groups. One is the Repair Department that manages the major overhaul (performed in every 4 years) and the middle overhaul (performed biyearly in principle). The other is the repair group of each section who performs daily repair work.

The responsibility for failure of equipment is ambiguous.

Current Status of TES4	*Improvement Plan*
(Daily repair work) • There is a repair group in the Boiler Section, the Turbine Section, the Electric Section, the Instrumentation Section, the Chemical Section, and the Fuel Section, respectively. Most daily repair work is done by these repair groups. • The repair group of each section operates a 2-shift service. When there is a failure that cannot be rectified within his service hours (The case where part exchange is required, or when a longer time is required), the repair plan is determined in the technical communication meeting. (The Repair Department does not involve in this daily repair work.) • There is periodic maintenance carried out according to a monthly preventive maintenance plan.	• The Repair Department should manage and perform all repair work including daily repair work. (See Chapter 6.1.1 "reexamination of an organization.") • The contents of the periodic maintenance plan should be improved from the viewpoint of preventive maintenance (to prevent a failure before it occurs). • The measuring instruments in CCR and in the field should be checked periodically so that the correct value is always shown.

Current Status of TES4	*Improvement Plan*
(Major overhaul) • The Repair Department plans time scheduling and supervises the major overhaul. Overhaul of the auxiliary machines except for turbine auxiliaries are executed by the repair group engineer of each operation section under the supervision of the Repair Department. • Overhaul of the boiler and turbine is ordered for a contractor after bidding. • Repair is often postponed due to financial deficit or late arrival of repair parts. It has led to degradation of equipment and decline in availability of the power plant. • The Marketing Department is carrying out bid of construction contractor determination, and schedule adjustment.	• The Repair Department should take all the responsibility for planning, time scheduling, supervising and execution of the major overhaul. (See Chapter 6.1.1 "reexamination of an organization.") • Time scheduling of the major overhaul should be well arranged including connection between repair work and material procurement. (Cautions are especially required for other repair work at the same site.) • Secure the cost of construction required for the major overhaul so that the overhaul can be carried out as planned.
(Middle overhaul) • In addition to the major overhaul and daily repair work, repair which cannot be carried out unless stopping operation of a unit is carried out as a middle overhaul biyearly. • Planning, time scheduling and supervising of the middle overhaul is performed by the Repair Department like the major overhaul. • Overhaul of the auxiliary machines except for turbine auxiliaries are executed by the repair group engineer of each section under the supervision of the Repair Department like the major overhaul.	• The Repair Department should take all the responsibility for planning, time scheduling, supervising and execution of the middle overhaul. (See Chapter 6.1.1 "reexamination of an organization.") • Time scheduling of the middle overhaul should be well arranged including connection between repair work and material procurement. (Cautions are especially required for other repair work at the same site.) • Secure the cost of construction required for the middle overhaul so that overhaul can be carried out as planned.

(2) Planning and implementation of repair work

The major issue in Maintenance administration in TES4 is that planning and implementation of the necessary repair are not fully made. Consequently, repair did not catch up with failure but has led to increase of repair cost.

Current Status of TES4	*Improvement Plan*
(Planning of repair work) • Planning of daily repair work is determined at the Operation Department meeting. • Each operation section that takes charge of the daily repair work omits required sufficient repair just because he gives top priority to continuation of operation. Consequently, the life of equipment is shortened or it has become a failure factor of other equipment. (Temporary repairs are carried out instead of permanent repairs.) • The Engineering Department drafts an original plan of the middle overhaul based on information from the Operation Department who has managed operation every day. The	• There are two kind of repair work: one is a temporary repair which is performed immediately after the accident and the other is a permanent repair which is a countermeasure aiming at recurrence prevention after investigating the cause of accidents. Even the daily repair work should consider recurrence. • A preventive maintenance is to consider remaining life assessment. Repair of equipment based on the result of remaining life assessment will improve reliability of the plant equipment and repair cost curtailment. (The approach method to repair expense curtailment is shown in Table 6.2-8.)

Current Status of TES4	*Improvement Plan*
Repair Department states his opinion on the original plan at the meeting from a viewpoint of repair implementation. • Analysis of the cause of the failure and repair work for the damaged equipment is inadequate, and the same failure occurs repeatedly.	• The Repair Department should take full responsibility for all repair work including daily repair work. • The Repair Department should make an effective plan of the repair work including material procurement and implement the plan. • In making the repair plan, the results of the past repair work should be considered to avoid repeating the same failure. • Repair work should be commenced after examining status of the equipment to be repaired and repair conditions (permitted hours for the repair work, isolated equipment from the system in operation). • The periodic maintenance should be planned and implemented following the maintenance manual of each equipment. (Observance of a repair interval)

Table 6.2-8 The Approach to Repair Cost Curtailment

• Curtailment of cost for daily repair work - Improvement in the repair concept (temporary repair => permanent repair) - Improvement in repair skills - Uplift of consciousness of preventive maintenance • Curtailment of cost for the major overhaul - Observance of maintenance interval for each equipment - Reexamination of the contents of the major overhaul and repair interval of each equipment (Preventive maintenance) - Improvement in repair skills • Curtailment of cost for the middle overhaul - Implementation of permanent repair in daily repair work - Observance of maintenance interval for each equipment • Rehabilitation of equipment - Arrangement of a repair history and a check result, failure cause analysis - Remodeling for improvement in performance or for prolongation of life of equipment

(3) Preparation of repair manual and improvement in repair skills

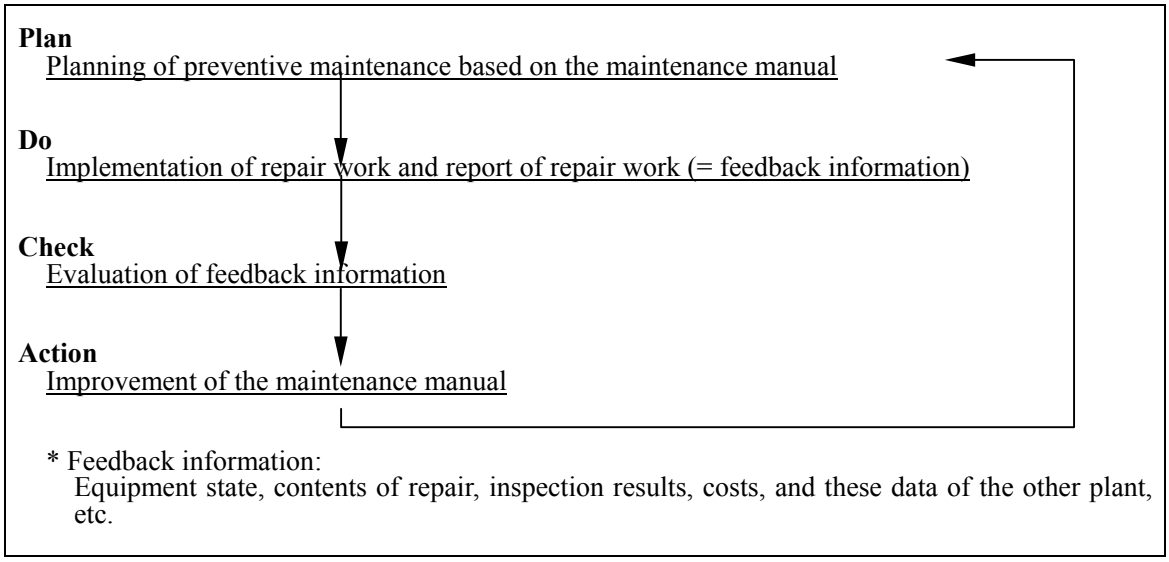
Current Status of TES4	*Improvement Plan*
(Preparation of repair manual) • When new equipment is installed, the repair manual is arranged based on supplier's equipment instruction manual. • An operation manual and a repair manual are intermingled and are kept. • Generally, there are many old drawings and there are many parts that do not match the present status due to equipment reconstruction etc.	• In accordance with restructuring of the organization, the operation manual should be kept by the Operation Department and the repair manual by the Repair Department. • Equipment repair intervals, testing tools, parts, materials, and repair procedures that are required for daily maintenance, should be indicated in the maintenance manual. The daily repair work and arrangements of parts and materials should strictly follow those instructions. • In assembly and disassembly work, dimension control is essential for the performance of the equipment. Dimensions and clearances to be kept and measuring methods should be indicated in the maintenance manual.

Current Status of TES4	*Improvement Plan*
	• In the arrangement of the maintenance manuals, improvement in repair skills of a repair engineer is also expected.
(Improvement in repair skills) • In the Repair Department, introduction of new technology (improvement of GRF lining material, sealing material, and the high-pressure valve repair method) is tackled positively, and it is striving for substantial plant and equipment. • Repair skill, such as welding, is trained in a training center. • Accidents that damage other equipment have occurred by a part or a tool left behind inside equipment.	• Repair engineers should improve the repair skills through practice of the repair work based on a repair manual. • The repair engineer should witness and check the check items indicated in the maintenance manual after the worker completed the assembly work. • The introduction of new technology should be handled positively. • The contents of repair skills training in a training center should be enriched.

(4) Observance of a repair manuals and the judgment of repair work results

Current Status of TES4	*Improvement Plan*
(Observance of repair manuals) • Many maintenance manuals exist, but instructions in the manual are neglected in the actual repair work. • Feedback information, such as a repair result, is not put to practical use in reexamination of a repair manual.	• A repair master and a worker should observe the instructions indicated in the repair manual. • The repair manuals should be improved examining the results of the repair work (a procedure, hours, safety, etc.). • An example of PDCA (Plan-Do-Check-Action) cycle in optimization of the preventive maintenance is shown in Table 6.2-9.
(Judgment of a repair work result) • The evaluation of quality of the major and middle overhaul is made by the Inspection and Research Department. • At the end of the major and middle overhaul, an inspection record that recognizes the completion of the overhaul is issued after technical deliberations of the Repair Department. Then the Operation Department can re-start the plant. • The repair engineers and repair master draw up the record document of the overhaul. And a repair engineer keeps it. • The memos about repair work, tests, trial operation, adjustment, etc. are appended to the inspection record.	• A repair master should make an inspection record before assembly of the equipment. • A repair engineer should carry out history management (a photograph etc. is included) also including the repair result. • The record document of repair work can be useful also for the maintenance of the other equipment. • The Quality Control Department should be newly established and carry out QC (Quality Control). (Refer to 6.1.1 “Review of an organization.”)

Table 6.2-9 The Example of the PDCA Cycle in Preventive Maintenance Optimization



(5) Preparation of replacement parts and materials, and maintenance of repair and testing tools

At present, the sound equipment is badly affected by poor daily maintenance.

It is necessary to secure packing and seal material required for repair, and to prevent steam and water from leaking.

Current Status of TES4	*Improvement Plan*
(Preparation of replacement parts and materials) • In daily repair works, shortage of parts and consumables required for repair is one of the reasons why sufficient repair is not carried out. • Manufacture and processing of parts are carried out in the mechanical workshop of the plant where the Repair Department manages, everything from expensive parts to a screw. However, poor alternative material is often used since correct material is not to hand or hardening processing cannot be done in the mechanical workshop. Therefore, the life of parts is short. • The list of parts and material necessary for daily repair work and periodical overhaul is arranged considering past experience of repair and facts of fault that occurred before the repair work.	• Improvement in manufacture and processing skills of the replacement parts in the mechanical workshop is essential. • A sufficient quantity of packing and seal material should be prepared always and exchange of these old materials with new ones should be performed before a failure occurs. • Chronic shortage of spare parts and consumables should be dissolved preparing a sufficient budget. (Refer to 6.2.5 "Administration of the inventory.")
(Maintenance of repair and testing tools) • Required repair tools, such as a spanner and an oscilloscope, and testing tools are insufficient. • Although there are lathes, boring machines, sawing machines, machine hammers, cutting machines, milling machines, bending machines, etc., in the machine shop, all machines are old and maintenance for the machines is not sufficient.	• Chronic shortage of repair and testing tools should be dissolved preparing a sufficient budget. (Refer to 6.2.5 "Administration of the inventory.") • Damaged workshop machines, such as an electric furnace should be repaired as soon as possible.

(6) Improvement of workplace environment

An unsuitable workplace environment is one of the big issues of TES4. The unsuitability of the work environment has a big influence not only on a repair result but also on the safety of repair work. Accidents that damage other equipment has occurred due to parts or a tool being left inside equipment, and such accidents can be prevented by thoroughness of proper arrangement and order.

Current Status of TES4	*Improvement Plan*
(Proper arrangement and order) • The inadequacy of proper arrangement and order in the field is one of the reasons why sufficient daily repair work is not carried out. • Many machines are laid down on the floor in the field, but there is no sign to show if it is an article under repair or to be abandoned. • Arrangement of tools and power cables for work is inadequate. • The display of a working space, an opening, etc. is not provided.	• Displaying signs in the working space and proper arrangement and order of tools leads to improvement in a worker's consciousness, and improvement in the quality of repair work. • At the end of a daily work, the quantity of tool should be used to check for prevention of loss of tools. • The display of a working space, an opening, etc. is effective for prevention of an industrial accident. • The passage in the boiler and the turbine house should be lined with paint not to place materials and garbage within the passage.
(Protection of equipment) • There are many occasions when a part or a tool fell into a pipe or a tank during repair work, and some of them are discovered at a strainer after operation, and some others damaged a valve. • The quantity of tape and plastic sheeting that is necessary for covering temporarily an opening of a tank or both ends of a pipe during repair work is insufficient.	• After completion of the repair work, a repair engineer in charge should check cleanliness and no existence of oddments or repair tools inside the repaired equipment, before permitting assembly. • Tape and plastic sheeting are also necessary for the repair work as well as spare parts and consumables. Sufficient quantity of these materials should be provided.
(Cleaning) • Plant simultaneous cleaning is carried out once a year, mobilizing all the member of the plant. • The usual cleaning is not sufficient and local panels and electric terminal boxes are covered with dust. • Floor cleaning is performed by pouring water and the local panel and the motor are covered with water.	• Plant cleaning should be performed periodically by composing a cleaning staff and deciding the cleaning range and frequency. • Cleaning of upper floors should be done surely using the vacuum-cleaning machine supplied by grant aid of Japan, and cleaning with water should be strictly prohibited.

6.2.3 Administration of the Engineering

Appropriate administration leads not only to the profit of the company that the company produces electric power efficiently and supplies it stably to the consumer, but also to fulfillment of his social responsibility to cope with environmental problems, such as global warming.

The administration of the engineering comprehends various investigations, arrangement of many statistics, making of reports and technical negotiation with outsiders for improvement in the plant efficiency, environmental preservation and equipment maintenance. Analysis of coal, water etc. and, quality control of them should be included in this category.

Improvement plans are shown hereinafter for: (1) Restructuring of the organization for engineering, (2) Improvement in supervision items

(1) Restructuring of the organization for the engineering

Current Status of TES4	*Improvement Plan*
（Administration of the organization） • The supervision item closely related on operation of the plant is distributing in each section, and is not supervised efficiently. Plant efficiency control; the Operation Department The quality control of coal; the Fuel Section The quality control of plant water; the Chemical Section Boiler combustion control; the Operation Department and the Sales Department	• The Engineering Department and the Inspection and Research Department should be combined as one organization, and administration of the engineering related closely should be managed as the unitary control by the Operation Administration Section of the Engineering Department. • Calculation group of the Operation Department, who computes the plant efficiency, should be moved to the Operation Administration Section of the Engineering Department. • The group of a Chemical Section, who is performing plant water quality control, should be moved to the Operation Administration Section of the Engineering Department. • Proper control of plant efficiency is important work linking directly to the profit of the plant. The Operation Department should perform supervision (daily supervision) of the parameter related to plant efficiency, and Operation Administration Section of the Engineering Department should keep an actual result (calculation of plant efficiency and record). • When the plant efficiency goes down, the cause should be investigated by nominated engineers lead by the Operation Administration Section of the Engineering Department. Necessary countermeasures against the cause should be taken quickly. • The Engineering Section of the Engineering Department should take care of the various investigations and many statistics necessary for equipment maintenance, many reports, and technical negotiation with outsiders.

(2) Improvement in Supervision Items

There are 3 supervision items in the power plant: 1) plant efficiency control, 2) plant water quality control, and 3) boiler combustion control, and all are closely related to each other.

Current Status of TES4	*Improvement Plan*
(Plant efficiency control) • The Operation Department kept the plant efficiency calculating it manually. • Managing items for calculating the plant efficiency are shown in Table 6.2-6.	• The "efficiency control manual" that defines the basic efficiency control of the plant should be arranged to perform work smoothly and rationally. For improvement of the plant efficiency, all members concerned should serve work together. • The Operation Management Section of the Engineering Department should issue a monthly efficiency report to the Operation Department, and should investigate the cause of the plant efficiency fall together with other nominated engineers.
(The quality control of coal) • The Fuel Section analyzes coal characteristics. • Analysis of coal characteristics is done at the time of coal receipt and discharge (every 24 hours) and the analyzed data is reported to the Operation Department, but it is used only for efficiency calculation and is hardly utilized for combustion control. • The reaction about breach of contract of coal quality is ambiguous.	• The quality control of coal is an important work to keep plant efficiency in high level. • The analyzed coal data should be reported to the Operation Department, and should be utilized for combustion control operation. It is also useful when requiring coal quality of a coalmine. • Assign the engineer specializing in fuel in the Operation Administration Section of the Engineering Department, and he should check the analyzed coal data. • Price adjusting article with the difference of moisture and calorie should be specified in contracts with coalmines.
(The quality control of plant water) • The Chemical Section performs operation of the water treatment system and analysis of water. • The investigation for cause of water quality deterioration and the countermeasure against it are inadequate. • Since a continuous measuring instrument is not installed in the water treatment system, (all manual analysis), the quality control of plant water depends mainly on the measuring instruments installed at another plant system.	• Plant water quality should always be controlled. When water quality deteriorates, proper countermeasure should be taken promptly after investigation of the cause. • Assign the engineer specializing in water quality in the Operation Administration Section of the Engineering Department, and he should check the analyzed water quality. • A continuous measuring instrument should be installed in the water treatment system. • The monthly amount of chemical consumption should be added to the efficiency management item.

Current Status of TES4	*Improvement Plan*
（Boiler combustion control） • The Boiler Section performs daily operation control among boiler combustion control. • The Fuel Section carries out analysis of coal characteristics and reports the data to the Operation Department. • The engineer in charge who checks a boiler combustion state with various parameters is in the Engineering Department. • The environment engineer of the Research Department is performing supervision of flue gas (SOx, NOx, and Dust).	• Operators should observe the boiler parameters, such as boiler metal temperature, spray water flow, and unburned carbon quantity. • It is expected that a smoke regulation will be prepared in the future, and proper supervision of TES4 will be required. • The smoke observation meter, which is out of order now, should be repaired to continue observation. • The density of dust in flue gas should be measured periodically and boiler combustion state and EP efficiency determined. (Refer to 6.3 "environmental preservation.") • A TV camera that supervises flue gas should be installed for monitoring in CCR, and it is utilized for combustion control or early correspondence of the abnormalities of EP.
（Plant performance test） • Plant performance test is not carried out in TES4.	• The plant efficiency should be measured before and after the periodical overhaul, or major repair work. These data may be effective for evaluation of the results of those overhaul and repair work.

(3) The example of administration of the engineering (measure to improve the condenser vacuum)

The condenser vacuum has gradually deteriorated every year since 1994 as shown in Fig. 5.2-2.

In TES4, the recovery of condenser vacuum is hung up over an annual action plan, the working group centering on the Engineering Department is formed, and cause investigation and the countermeasure are implemented. However, since neither cause investigation nor countermeasures are sufficient, it has not resulted in recovery of the vacuum.

Since the decline of condenser vacuum leads to decline in plant efficiency, the monthly management by the Engineering Department is an indispensable management item, and immediate investigation and a countermeasure should be demanded when unusual is acknowledged.

As for reference, the causes and countermeasures for decline of condenser vacuum are shown in Table 6.2-10. (Refer to 5.2.2 "Recovery of condenser vacuum rate.")

Table 6.2-10 The Cause and Countermeasures for Decline of Condenser Vacuum

The key factor of the fall of Condenser vacuum		Phenomenon	Investigation item		Results of investigation	Judgment	Measure
Condenser	1. Dirt of a condencer tube	(1) Slow decline of the vacuum	(1),(2),(3)	Inspection inside the condencer tube	The dirt is acknowledged on cooling tube at the time of open check.	×	a) Periodical inspection and cleaning of condenser tube shall be executed. Severely dirtied tubes shall be drawn off and scale shall be analyzed. b) Warm air purge for condenser is effective method and to be continued. c) Condenser tube ball cleaning system should be installed. d) measuring instrument required for investigation and the supervision of condenser vacuum should be installed.
		(2) Increase in pressure loss	(1),(2),(3)	The situation of an adhesion thing, and ingredient analysis	Since a measuring instrument has not been installed, judgment is impossible.	×	
		(3) Increase in a terminal temperature difference	(2),(3)	Time progress of pressure loss and terminal temperature difference	Since a measuring instrument has not been installed, judgment is impossible.	×	
			(1)	Calculation of actual heat transfer co-efficient or cleanliness factor and comparison with design value	Since data is insufficient, it is detailed investigation un-carrying out.	×	
	2. Insufficient cooling water flow	(1) Increase in temperature rise in the condenser	(1),(2),(3)	Flow calculation from a condenser performance curve	Shortage of cooling water flow is seen.	○	a) Water flow at inlet and outlet of each cooling tower shall be measured periodically. When difference in flow between inlet and outlet, flow adjustment shall be done. b) A screen should be installed at water outlet of cooling tower to prevent invasion of the foreign substance to Condenser. c) Check and cleaning of the cooling tower lower part and cooling water pipe shall be carried out periodically. d) Bearing cooling water shall be recovered
		(2) Increase in pressure loss in the condenser	(2)	Inspection inside the cooling tube(any clogging ?)	Clogging of a foreign substance is seen at cooling tube inlet.	○	
		(3) Decrease in pressure loss in the condenser	(3)	Check of circulating water pump performance	Circulating water pump performance was checked and deterioration in the performance is not acknowledged.	×	
		(4) Air in the water chamber	(2)	Inspection of cooling water pass (channel, screen, strainer, etc) (any clogging ?)	The blockade was not acknowledged in the cooling water pass. Sand is accumulated on the cooling tower pond.	△	
			(4)	Inspection of air bent valve, water level gauge installed on upper water chamber	Inspection is not yet carried out.	×	
	3. Cooling-water temperature and water quality change	(1) Increase in inlet cooling water temperature, cooling water quality aggravation	(1)	The check of cooling-water temperature, water quality, etc.	Cooling capability is declined since cooling tower header is clogged.	○	a) Cooling tower header shall be repaired to restore in design spray capability.
	4. Air leak	(1) Increase in an air meter	(1),(2),(3)	Inspection of the slack and damage on a turbine exhaust port, condensate pipe joint, extraction steam pipe joint, etc. (a chlorofluo carbon type detector is effective). Leak from joint of turbine casing flange is rarely	a) As a result of dismantling of insulation material for all turbine expansion joints and measuring diameter and thickness, the part where degradation and damage is remarkable is acknowledged. b) Some water seal type relief valves for condenser are broken or lack of seal the ordinary type valves are installed for the vacuum system, its sealing effect is insufficient.	○	a) Leak air flow shall be checked periodically using the air flow meter of main ejector. (It strives for the early detection of air leak) b) Damaged expansion joint shall be replaced as soon as possible. c) The valve of a vacuum system shall be replaced with water seal type valve. d) The technique of checking the sealing of condensate system shall be established and it strives for the early detection and the early measure of a failure part. e) Degraded seal and packing material for local level gauge and air vent valve shall be repaired.
		(2) Longer start-up time of the condenser	(1),(2),(3)	Inspection of slack and damage on joints of steam traps and level gauges, valve sheets, packings etc. for feedwater heaters and other equipments	Degradation is acknowledged in jute material used for seal of valves of connected with condenser. Moreover, the packing of water level gauge and air vent valve are deteriorated, and air is inhaled.	○	
		(3) Increase in vacuum break time during turbine stop operation	(1),(2),(3)	Inspection of leak from turbine gland steam system	Inspection is not yet carried out.	×	
			(1),(2),(3)	Inspection of damage on exhauster installed on turbine exhaust part	Inspection is not yet carried out.	×	
			(1),(2),(3)	Leak test filling with water	A seal check equipment for condensate system was developed (using steam of 150 degrees C or less, 0.5k). But the examination has not been carried out due to restrictions on operation.	△	
	5. Rising up of condenser water level	(1) Rising up of condenser water level	(1)	Check of condensate pump performance	Condensate pumps were replaced with another type several years ago, but the pump characteristic has not agreed to the present system.	○	a) Reexamination of the hotwell level control system including the control valve shall be executed so that the level control could be able automatically. b) Reexamination of the replaced condensate pump shall be executed, if it has unproper performance, the pump shall be replaced with a proper one. c) Hotwell level indicator, position indicator for the level control valve, and control switch, etc. that are installed in CCR shall be replaced with new ones so that operation and supervision of water level can be done at CCR.
			(1)	Check of condenser level control equipment	a) Level of hotwell is controlled by operating bypass valve with level control noise level is kept in higher level than NWL	○	
			(1)	Inspection of water level gauge (correct indication ?) and gauge pipe (leak or clogging)	Hotwell level indicator in CCR is corrected every two weeks comparing with local level gauge.	△	
			(1)	The abnormalities in suction side of condensate pump (corrosion on impeller, packing gland air leak, balance pipe blockade, etc.)	After replacement of condensate pumps, load following performance of level controller is degraded and cavitation on pump impeller and breakage of pump shaft have occurred.	○	
Steam Ejector	1. The performance decrement of steam Ejector	(1) Low steam pressure and steam flow	(1)	Check of valves, pressure gauges	Ejector operates unstably since working steam pressure fluctuates.	○	a) Inspection and repair of the steam pressure adjustment equipment for an ejector shall be carried out, and steam pressure shall be kept at constant. b) Inspection and repair of the steam ejector shall be carried out with the procedure and interval that are specified in manual. (especially replace of wear part is essential) c) Chek of wear parts (especially nozzle) and leak parts shall be performed. d) Measuring instruments (extraction air flow meter etc.) shall be installed, and the performance of ejector shall be checked.
		(2) Increase in the amount of leak air	(1),(3)	Inspection of nozzle and strainer (clogging)	Inspection is not yet carried out.	×	
		(3) Insufficient of cooling water flow	(2)	Check of change of extraction air flow with air meter.	Since measuring instrument has not been installed, judgment is impossible.	×	
		(4) lack of seal water in the 1st step stage drain pipe	(3)	Check of cooling water pressure and temperature	Since measuring instrument has not been installed, judgment is impossible.	×	
		(5) Plugging in the 2nd stage drain pipe	(3)	Inspection of control equipment for condensate recirculation	Inspection is not yet carried out.	×	
		(6) Increasing in exhaust air pressure	(4)	Check of level gauge and thermometer for U-tube of 1st stage drain pipe	Check is not yet carried out.	×	
		(7) Plugging or damage in the nozzle or in the defuser	(5)	Inspection of 2nd stage drain pipe (clogging), check of operation of steam trap	Inspection is not yet carried out.	×	
		(8) Reverse flow of air	(6)	Check of valve and pipe for exaust air	Check is not yet carried out.	×	
		(9) Dirt of a cooling pipe	(7)	Disassembling and check of nozzle and defuser	Steam ejector is overhauled once per 4 years. Performance of ejector is degraded due to wear of 3rd stage	○	
		(10) Fluctuation in working steam pressure	(8)	Inspection of separate sheet of cooler (corrosion penetration), packing (breakage)	Inspection is not yet carried out.	×	
			(8)	Check of defuser valve (closed? Any leak ?)	Check is not yet carried out.	×	
			(9)	Check of cooling tube inside, corrosion of pipe nearby water	Check is not yet carried out.	×	
			(10)	Check of drain contamination into steam (gradual agitation), check of pressure gauge	Ejector operates unstably since working steam pressure fluctuates.	○	