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REMODELING FOR UNINHABITED OPERATION AT NIGHTTIME OF STEAM SUPPLY EQUIPMENT

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ABSTRACT

The steam supply equipment (Nittetsu Kagoshima Geothermal Co., Ltd.) of the Ogiri power plant was designed assuming a 24-hour watch. On the other hand, the power generation equipment (Kyushu Electric Power Co., Ltd.) was designed assuming a centralized, remote watch of two or more power plants, and plant start up is done remotely. Therefore, the steam supply equipment was remodeled in the regular repair period in May, 1997 for the automated operation at nighttime.
The components of the main steam supply control equipment are as follows.

- The LCV controls the water level in the hot water tank at a constant level.
- The BDV opens automatically when the water level in the tank rises abnormally.
- To prevent silica scaling in piping, the pressure downstream of the LCV is controlled at a constant value, higher than flash pressure, with the water balance control valve of the re-injection well.
- The PCV controls the steam pressure of the turbine inlet.
- The BDV opens automatically at turbine trip, and blows off the whole quantity of steam into atmosphere. This BDV has the function of a PCV.

In manned operation, the operator sees changes in equipment immediately and the action of switching to an alternative control valve etc. can be taken.
The problem in an unmanned operation is that the equilibrium of the hot water system is lost if these control valves fail and the hot water overflows from the hot water pit into the surroundings.
Therefore, the following remodeling was executed.

- Automatic change into the alternative well in the case of a water balance control valve breakdown or the re-injection capacity decrease of the well being used for balance control.
- Prevention of complete shut down when the water balance control valve breaks down.
- Automatic change into the alternative LCV when the LCV for the hot water tank level breaks down.
- To prevent the hot water tank level rising, the injection capacity was increased to more than the quantity of produced water by automatically making the PCV of the re-injection well full open.
- Installation of radio link alarms.

As a result, the number of operators could be reduced substantially, from 6 to 2. Moreover, there has been no major trouble and high equipment availability has been maintained in over a year since this remodeling.

1. INTRODUCTION

The Ogiri power plant steam supply equipment is superintended by Nittetsu Kagoshima Geothermal Co., Ltd. The watch and control systems of this equipment involve an operator watching plant systems via CRT. Therefore, the operator observes well changes, abnormal equipment behavior, or abnormal re-injection balance, etc. with CRT. In abnormal circumstances, the operator assesses the situation, establishes the cause and an appropriate fix and requests the mobilization of the corresponding worker if necessary. Therefore, manned nighttime operation was chosen. In general, for small and medium-sized thermal and hydro power plant, unmanned operation at nighttime is done by remotely observing two or more power plants from a control center. The Ogiri power plant power generation equipment is superintended of Kyushu Electric Power Co., Ltd. by remote watch from Sendai power plant about 60 km away: unmanned operation at nighttime was performed from the beginning. Therefore, the steam supply equipment was remodeled for automated operation during the regular repair period in May, 1997 to reduce the number of nighttime operators.

2. ABOUT THE AUTOMATIC CONTROL SYSTEM

Figure 1 shows the steam supply equipment flow sheet of Ogiri power plant.
The automatic control system set up in the steam supply equipment from the beginning is as follows.

2.1 Water level Control of the hot water tank in the production base

Two phase fluid from production wells is separated to steam and hot water in the separator. Steam is sent to the power plant via steam pipeline. The hot water is sent to re-injection wells via a tank and hot water pipeline. The water level in the separator is kept at the height of the weir in the hot water tank. As a result, the separation efficiency is maintained constantly. The water level of the other side of the weir is constantly controlled automatically with the level control valve (LCV) set up in the hot water pipeline. Two LCV systems, including a reserve, are set up because of the importance of the hot water level control.
When the water level rises due to the LCV breakdown, the BDV (Blow down valve) of the tank opens automatically, and the hot water in the tank is drained to the hot water pit.
Nevertheless, when the water level rises abnormally, the turbine trip signal is given for the turbine protection.

2.2 Pressure control downstream of the LCV

The hot water from each production base is sent by hot water pipeline to a separate LCV, the individual lines are joined downstream of the LCVs. When the pressure of the confluence point is higher than the pressure of base C2, which is at the lowest elevation, the hot water flows backward to the tank of base C2. On the other hand, when it is lower than the

separation pressure, the hot water flashes and silica scale adheres in the piping downstream of the LCV. Therefore, the pressure downstream of the LCV is automatically controlled at a constant value by one of the water balance control valves set up upstream of each re-injection well. The operator selects which re-injection control valve is to be used. The re-injection well used for water balance control is used within a smaller flow range than the re-injection capacity, as the control with the valve is effective enough. Other re-injection wells are used at full capacity, with control valve wide open.

2.3 Steam pressure control of the turbine inlet

Steam pressure at the turbine inlet is controlled at a constant value by the PS-PCV (power station pressure control valve) set up in the branch line to the silencer in the power station.
The PS-BDV (power station blow down valve) is set up in the silencer branch line too. When the main stop valve at the turbine inlet closes rapidly at turbine trip, the PS-BDV opens automatically and blows off the whole quantity of steam to atmosphere. This BDV has the function of a PCV.

2.4 Steam pressure control in a production base

The steam pressure control valve is set up in each production base as the backup in case of PS-PCV or PS-BDV break down.

2.5 Power supply for emergencies

Though the driving power for the steam supply equipment is supplied from the power generation side, in preparation for the case of black out, an uninterruptable power supply (UPS) is set up in the steam supply side. The UPS supplies each control valve and the watch controller. The power supply capacity is about 30 minutes.

3. COMPONENTS OF REMODELING FOR UNMANNED OPERATION AT NIGHTTIME

3.1 Installation of warning sending device in wireless telephone

In the manned operation, the operator sees changes in equipment immediately and the action of switching to an alternative control valve etc. can be taken. So that warnings can be sent to the remote control station when equipment trouble occurs at nighttime, radio link alarms were installed. As a result, the operators rush to the power plant, and the situation can be prevented from deteriorating.
A combination chart of alarms was provided so that the operators might judge the emergency level of each alarm.

The problem in an unmanned operation is that the equilibrium of the hot water system is lost if control valves fail, then hot water begins to overflow from the hot water pit into surroundings, before operators arrive at the power plant and deal with the equipment trouble.
To prevent such situations, the following countermeasures are taken.

3.2 Automatic switching into the alternative re-injection well

When the water balance control valve breaks down or the re-injection ability decreases under use, the water level of the hot water tank rises, and the BDV of tanks open. When this state is prolonged, the hot water begins to overflow from the hot water pit.
To prevent this, the software was remodeled so that the water balance control can be automatically switched to one of the other alternative re-injection wells if the control valve under use breaks down or the wellhead pressure rises higher than a set value (higher than separation pressure in the separator).

3.3 Prevention from complete closure of the water balance control valve

A water balance control valve at the re-injection well might break down and close completely. In this case, the water balance control valve switches to the alternative well mentioned above. However, when the re-injection capability of the alternative well is less than that of the well that has failed, the water balance control is no longer effective.
To maintain the total re-injection capability, remodeling was executed so the control valve could not close below a set lower limit even if it broke down.

3.4 Automatic switching to the alternative LCV when the hot water tank LCV breaks down

The water level of the hot water tank in each production base is controlled automatically by the LCV attached to each hot water line. Water balance is lost if the LCV breaks down; the BDV is opened by the water level rise in the hot water tank and the hot water overflows from the hot water pit. To prevent this, the software was changed so that the control can be switched into an alternative LCV automatically by a breakdown signal from the LCV in use.

3.5 Automatic full opening of the water balance control valve of re-injection well

Water balance collapses if the LCV in production base A or production base B opens due to breakdown and hot water flows backward to the hot water tank in the production base C2, where the altitude is lower. As a result, the water level of the hot water tank of the base C2 rises, the C2 BDV opens and hot water is discharged into the pit. When this discharge time is long, the gross volume of the discharged hot water exceeds the capacity of the hot water pit and hot water begins to overflow to the surroundings.
To prevent this, the software was changed so that the total re-injection capacity is increased to more than the quantity of produced water, by automatically fully opening the water balance control valve under use. This is done when the LCV of production base A or B breaks down, the pressure of the hot water confluence point is abnormally high, or the water level of the hot water tank in base C2 is abnormally high.

3.6 Sending a turbine trip signal when the UPS battery voltage drops

When the power supply from the power generation side fails, the control power supply on the steam supply side is supplied by the UPS battery for about 30 minutes. However, after that, all the controls, including the water balance control, cannot be maintained. As the water level of the hot water tank cannot be controlled, even if the water level of the hot water tank rises, the BDV of the hot water tank does not open. Even if the water level rises higher and turbine trip signal is sent, the PS-BDV

does not open.
To prevent this, the software was remodeled so that a turbine trip signal is sent, via a timer, to open the PS-BDV when a decrease of the voltage of the battery driving the inverter in the UPS is detected.

3.7 Automatic full opening of the water balance control valve and LCV of hot water tanks due to decrease of UPS battery voltage

Though turbine damage can be prevented by the above mentioned measures, the danger cannot be avoided that two phase fluid, from the production wells, is dammed up because the water level in the hot water tank and the separator becomes higher than the height of the separator inlet and the production wells stop.
To prevent this, the software was remodeled so that the water balance control valve and LCV of the hot water tank under use fully open automatically before the turbine trip signal, above-mentioned in 3.6, is sent. Thus the water level of the hot water tank does not rise, and re-injection will be steady.

4. CONCLUSION

The equipment breakdown situation after remodeling is shown in Table 1.
15 main equipment breakdowns occurred after remodeling as of July, 1999. Six occurred during unmanned nighttime operation and of these, five resulted in the remodeling sequence of the valve of the automatic switch etc. operating.
Excluding an unexpected accident which is caused directly by the control system (such as a design mistake in the sequence remodeling or the installation mistake when the DCS communication parts are replaced) the occurrence of a serious accident during unmanned nighttime operation is prevented by automatic switching of control valves and simultaneous alerting of operators by alarms sent by the wireless telephone.

Table 1. Main equipment breakdown situation after remodeling

No.	date	Time zone	Contents of breakdown	Actions
1	8/10/1997	Uninhabited	Shift to single operation in place (power transmission interruption by lightning)	Automatic steam pressure control change PS-PCV into PS-BDV
2	9/16/1997	Manned	Power supply for control distribution panel interception of re-injection base D	Power supply turning on by person after treatment
3	10/29/1997	Manned	C-LCV power supply interruption	Automatic change into preliminary LCV
4	1/25/1998	Uninhabited	abnormally high water level warning by water level meter of hot water tank freezing (miss-display)	Released by worker
5	1/29/1998	Manned	Power supply trip of heater for hot water tank level gauge frozen prevention	Action by worker
6	1/30/1998	Manned	A-PCV opening by miss-operation adjusting steam pressure detector and power output decrease due to decrease of turbine steam flow rate	Valve control by worker
7	1/30/1998	Uninhabited	C-LCV Torque abnormality warning	Automatic switching to preliminary LCV
8	2/4/1998	Manned	C-LCV Torque abnormality warning	Automatic switching to preliminary LCV
9	4/15/1998	Manned	Disconnection of internal wiring of C-LCV actuator	Automatic switching to preliminary LCV
10	4/17/1999	Manned	Failure by overheating of CTD (condenser trip device) for VCB (vacuum circuit breaker) (during regular repair work)	Action by worker
11	4/20/1999	Uninhabited	High steam pressure warning by stopped up of silencer in base C2 (during regular repair work)	Action by worker
12	5/13/1999	Uninhabited	Opening condition deflection warning of C2-FCV (Well head flow control valve)	Action by worker
13	5/27/1999	Manned	Malfunction of control system by an installation mistake when the DCS communication parts were replaced.	Action by worker
14	5/31/1999	Uninhabited	Wellhead high pressure warning by decrease of re-injection ability for water balance control	Automatic switching to preliminary re-injection well
15	7/2/1999	Uninhabited	Shift to single operation in place and turbine trip (power transmission interruption by lightning)	Automatic steam pressure control switched PS-PCV into PS-BDV

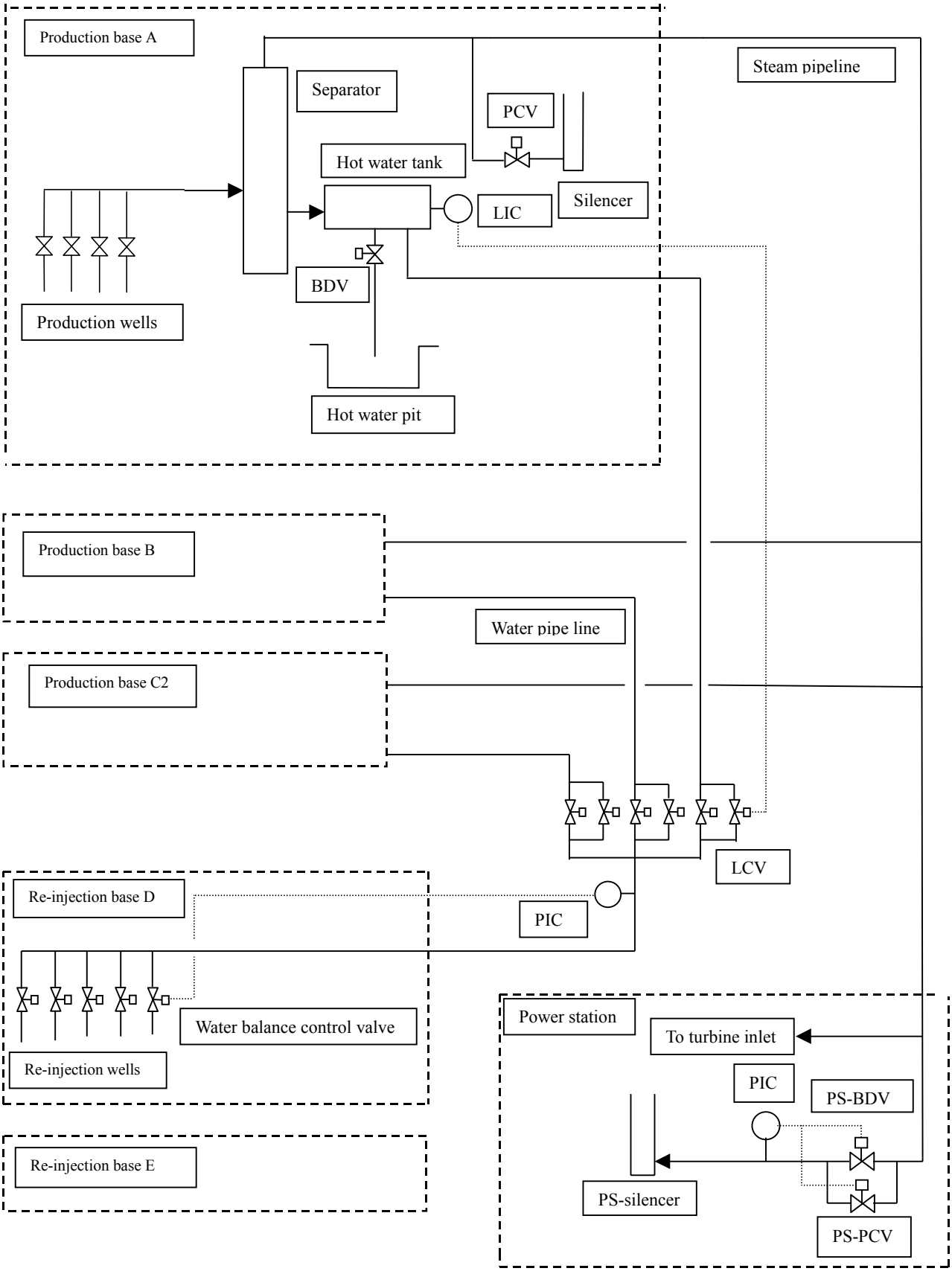

Figure 1. Steam supply equipment flow sheet of Origi power plant