PN-ABU-276
93126

UNITED STATES AGENCY FOR
INTERNATIONAL DEVELOPMENT

PRIVATE SECTOR POWER PROJECT

JAMSHORO POWER STATION

TECHNICAL DUE DILIGENCE

PERFORMED FOR

INTERNATIONAL RESOURCES GROUP, LTD.

NOVEMBER 1993

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EXECUTIVE SUMMARY

The Jamshoro Thermal Power Station (JPS) consists of four steam turbine generating units with a total installed capacity of 880 MW. These units were commissioned between 1989 and 1991.

The JPS has been the subject of evaluation as a prelude to either commercialization and/or privatization. This report includes the Technical Due Diligence analyses that have been conducted at this facility.

The initial report, entitled Equipment Condition Assessment Report was completed in November 1991. The purpose of this study was to provide an overall assessment of the major systems, components and structures necessary for the safe and reliable generation of electricity. The findings of this report are as follow:

1) The systems and components reviewed at the Jamshoro Power Station should be suitable for continued operation for the next 20 years.

2) In general, Unit No. 1 appears to be of superior quality and exhibits better overall workmanship with fewer current problems than Unit Nos 2, 3 and 4.

3) It is assumed that all equipment currently in place was designed, manufactured and installed in accordance with applicable code and standards and are of power house quality.

The second report, entitled Final Technical Due Diligence was completed in September 1992 and was conducted to update the previous study and investigate any new issues that might have arisen. The principal findings of this study are as follow:

1) Fundamentally, the major components and systems at the plant are sound and incorporate proven design concepts and technology.

2) The plant support equipment and facilities are adequate in design and number, although a few problems remain to be resolved.

3) Based on appearance, operational records and staff testimonials, it appears that Unit No. 1 is the best designed and constructed unit.

4) The units were built to currently applicable codes established in the country from which the unit was purchased.

5) The single largest area for improvement is in the area of site facilities and personnel management, a situation most likely related to the newness of the plant and the relative inexperience of the technical staff.

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In February 1993 a follow-up site visit was made by the author of the September 1992 report. The observations are included in this report. Responses from plant management to these observations are also included.

In October 1993 a third Technical Due Diligence analysis for Jamshoro was completed. Its purpose was to review the findings of the previous reports and to provide an update to their findings. This information was required to expedite the privatization of the Jamshoro Power Station. The conclusions of this report are as follow:

1) The plant was found to be in generally good condition and was operating in a normal fashion for a plant of its relative youth.

2) One area that needed attention is the recurrent plugging of steam generator components caused, in part, by the high levels of sulphur and vanadium in the furnace oil.

3) A second identified problem was the overflow of plant waste water into neighboring fields caused by the undersizing of plant settling ponds.

4) The plant staff has programs underway which are designed to alleviate each of these problem areas.

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UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PRIVATE SECTOR POWER PROJECT

TECHNICAL DUE DILIGENCE UPDATE

JAMSHORO POWER STATION

UNITS 1-4

CONTROL WORKPLAN 2.33.0

FINAL REPORT

PERFORMED FOR
INTERNATIONAL RESOURCES GROUP, LTD.

SUBMITTED BY:

DENNIS W. EVANS
JOHN T. BOYD CO.
AND
DR. J.D. GUY
I.R.G.

OCTOBER 1993

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SECTION I

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PROJECT TASK AND DESCRIPTION

The purpose of this work effort is to review the findings of the two previous Technical Due Diligence reports and to provide an update to their findings. This update is required to expedite the privatization of the Jamshoro Power Station on a fast-track as directed by the Privatization Commission of the Government of Pakistan.

A team composed of Dennis W. Evans of John T. Boyd Co. and Dr. J. D. Guy of IRG Ltd. visited the power station beginning on September 25, 1993 and lasting through September 28, 1993 to conduct the evaluation. This time was spent touring the plant facilities, holding discussions with key plant staff and reviewing and analyzing plant operating data supplied by the staff.

The team also undertook a review of previous Due Diligence reports provided by Ebasco Services, Inc. in 1991 and by John T. Boyd Co. in 1992. These two reports provided a background and a framework for the update contained in this report. For that reason some of the detailed plant descriptions are not included in this report and can be found in one or both of the other reports.

The team was able to observe the responses by plant management to the recommendations suggested by the previous reports. The team also evaluated any additional problems that may have arisen since the last previous report had been completed.

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FINDINGS

The team found the plant to be in generally good condition and operating in normal fashion for a plant of its relatively young age. There are two areas which need attention: (1) due to the high sulphur and vanadium content of the oil burned in Unit 1, and in Units 2, 3, and 4 when gas is unavailable, there is considerable plugging of many of the steam generator components in the furnace, and (2) due to the undersizing of the settling ponds, there is a discharge of waste water from the plant into surrounding fields.

Normal maintenance activities are undertaken at the plant for all four units and there does not appear to be other problems of any significance.

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PLANT OPERATING PARAMETERS AND ACTIVITIES

The table below summarizes the Jamshoro Power Station with regard to installed units and includes various relevant operating data for the past two years. The operating statistics were taken from Form E reports provided by the plant staff; however, the capacity factor information was recalculated to reflect the methods which are in more common usage in the West.

PLANT DESIGN DATA

	Unit 1	Unit 2	Unit 3	Unit 4
Design Capacity (MW)	250	210	210	210
Maximum Operating Capacity (MW)	250	200	200	200
Date Commissioned	1/90	12/89	6/90	1/91
Country of Origin	Japan	China	China	China
Fuel Type(s)	Oil	Gas/Oil	Gas/Oil	Gas/Oil
Design Heat Rate (Btu/Kwh)	9,063	10,254	10,254	10,254

PLANT OPERATING DATA (ANNUAL)

Units	1		2		3		4	
Year	91/92	92/93	91/92	92/93	91/92	92/93	91/92	92/93
Actual Heat Rate (Btu/Kwh)	9,382	10,040	9,602	9,993	9,500	10,063	9,585	9,937
Availability (%)	90.1	90.0	65.2	77.4	59.0	74.6	57.0	55.3
Capacity Factor(%)	63.7	70.1	48.8	58.9	47.6	55.5	44.4	38.0

The chart shows that all of the units at the plant are relatively new, the oldest is not yet four years old. One would expect the performance parameters shown in the

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operating data table to improve considerably as the plant staff moves up the learning curve and the normal to-be-expected new construction problems are resolved.

HEAT RATES -- The actual heat rate for Unit# 1 is on average about 7% higher than what has been described as the design heat rate while the actual heat rates for the other units are on average almost 5% less than the design values. The team was not able to review the Unit # 1 acceptance report to determine if the unit had achieved the design heat rate at the time of the test. It should be noted that the actual heat rate data are calculated using average operating data over an entire year, which will include the entire range of unit operations. However, the design heat rate would likely reflect a specific set of controlled operating conditions and may also be at a specific point of the unit's operating curve. It would be desirable that each unit be subjected to a heat rate test to determine the actual heat rates at various points on the operating curve. These data would provide a better basis for comparison to the design criteria.

AVAILABILITY -- The low availabilities of Units 2, 3 and 4 are accounted for by extended outages related to required scheduled inspections. In particular, Unit# 4 was out of service for about five months in 1992 for its first inspection. Ordinarily these inspections are of 90 day duration but in this case it was longer due to the unavailability of required replacement parts. This extended outage adversely affected the unit's availability in both the years for which data are reported.

CAPACITY FACTOR -- The capacity factor results are determined by: (1) the availability of the units to be operated and (2) the actual dispatch decisions of the system dispatcher at N.C.C. in Islamabad. The last factor is beyond the control of the Jamshoro plant management and should not be considered necessarily reflective of the plant's potential performance. The actual dispatching decisions are driven by relative unit fuel costs, overall system load requirements, and individual unit response rates.

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UNIT 1

This unit has a nominal rating of 250 MW and was designed and constructed by Tokyo Electric Power Service, Ltd. It was commissioned on January 27, 1990. The unit appears to well designed and constructed and the operating records bear this out.

The major problem associated with this unit is caused by the poor quality of the furnace oil that is burned in the boiler. This fuel contains high levels of sulphur and vanadium and the exhaust from the combustion of the fuel causes excessive plugging of the boiler components. There was no provision in the unit's design for automatic washing of these components which means that the unit must be taken out for service for an extended time for washing by hand. The plant engineers are evaluating the use of a fuel additive which should reduce the rate of pluggage of the unit. That evaluation has not been concluded at this time. It may also be possible to modify the unit by installing an automatic washing system which has been included on similar Japanese units of the same design.

It is also possible to convert the unit to burn gas if that fuel is available in sufficient quantity. This conversion would completely mitigate the plugging problem. However, an estimate provided by the constructor of the cost of conversion was approximately equal to the cost of an entire new boiler. It may be desirable to have the constructor re-evaluate this estimate.

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UNITS 2, 3 & 4

These units, all 210 MW each, were designed and constructed by North East Electric Power Design Institute, Ministry of Water Resources and Electric Power, Changchu-Peoples Republic of China and were commissioned on December 9, 1989, January 27, 1990 and January 21, 1991, respectively. These units to not appear to be as well designed and constructed as Unit # 1 and the operating data bear this out, at least in the first years of operation. These units also require frequent shutdowns to manually wash the boilers when burning furnace oil.

These units are highly labor intensive since they are currently incapable of operating in a completely automated mode because of the unreliable instrumentation. The operation and maintenance manuals supplied by the constructor are not as complete as those provided for Unit 1 and staff training has suffered due to communication difficulties. Similarly, maintenance activities have been made more difficult due to the lack of as-built drawings.

Many of the deficiencies noted in the previous due diligence reports are still prevalent and will contribute to higher maintenance costs in the future unless corrected. Some of these, such as open cable trays and exposed wiring on instrumentation, could be ameliorated with expanded efforts during planned overhauls.

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PLANT COMMON FACILITIES

WAREHOUSES AND STORES -- The warehouse for Unit 1 contains an adequate supply of most required spare parts which were supplied by the constructor. Some of the large items, such as intake water pumps, have yet to be delivered. The spares for the other units are located in a second warehouse and appear to marginal at best. No one seemed to know if additional spare parts are scheduled for delivery. All inventory accounting is currently done manually; however, when the Maintenance Management System is installed at Jamshoro, the inventory will be maintained on a computer based system. That process is already underway and is scheduled for completion within the next two years.

WATER HANDLING -- As discussed in previous reports each unit at Jamshoro has adequate capacity to supply its demineralized water requirements. Additionally, the water chemistry and control systems appear to be in line with generally accepted practices.

However, as mentioned earlier, there is a major problem in the handling of waste water from the plant. This effluent, arising principally from boiler and cooling tower blowdowns, is ordinarily pumped to settling ponds for evaporation. However, the ponds are undersized and are insufficient to handle the effluent flow. Consequently, the overflow from the ponds drain onto local fields adjacent to the plant. The solution proposed by the plant engineers is to construct an open channel from the ponds directly to the Indus River.

WORKSHOP -- In the last Due Diligence Report (10/92) it was noted that there existed a large workshop building but that it was not equipped with any tools. Since that time, the workshop has been equipped with a large complement of Chinese-made heavy duty workshop machines. There is, however, still the problem of an insufficient number of trained equipment operators but this situation should be eased as the workshop staff gains more experience with the equipment.

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MAINTENANCE PRACTICES

All of the units at Jamshoro have undergone at least one 90-day inspection outage since commissioning. The recommended scheduled interval between major inspections and overhauls is between 30,000 and 35,000 hours of operation. The next major overhaul for any unit at the plant should not occur for at least three years unless some unusual circumstance arises. The table below shows for each unit the number of operating hours since the last major overhaul.

Routine maintenance is conducted by plant staff on a regular time frame if the maintenance items can be accomplished without bringing the unit off line. A list of maintenance items which do require a unit shut-down are accumulated until the shut-down can be scheduled without adversely affecting WAPDA system reliability. When the unit is available for maintenance, the list of items is prioritized so that the most important items are accomplished during the relatively short outage time, typically 10-12 days. The station submits a proposed schedule for these short-term maintenance items in June of each year and expects to have them completed by November of that year. Except for planned major overhauls and unexpected forced outages, the plant is expected to be available throughout the remainder of the year.

Unit	Total running hours since last overhaul.*
1	4076
2	3884
3	5370
4	4721

* Through June 30, 1993

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STAFFING

From discussions with the senior management at the plant it became clear that one of the most serious problems faced at Jamshoro is the lack of a sufficient number of trained staff. Those who are assigned to the plant are required to work excessively long hours to keep the units available for operation. There is a major risk of employee burnout unless this problem is alleviated.

Additionally, in the areas of craft labor, there is a serious shortage of qualified welders at the plant; there are only two assigned there at this time. The WAPDA pay scales for these positions are insufficient to attract welders away from privately owned establishments.

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FOLLOW UP VISIT TO JAMSHORO POWER PLANT

On February 3, 1993 with the help of USAID Karachi, a follow up to the August Technical Due Diligence assessment was done.

Met with Mr. M.M. Chandio, Resident Engineer Mechanical and Mr. Abdu Adil, Senior Resident Engineer Operations.

Prior to the visit a list of questions was sent to the station concerning outages and is attached as part of this report.

Things have not changed, plant is still in a crisis management type of operation. Was told that WAPDA will not authorize additional expenditures as this will be privatized.

There has recently been two criminal law suits filed by property owners and the highway department. Was not able to obtain copies but have informed Hunton & Williams so they can pursue from their end.

To date they are still running without adequate spare parts, colony is not staffed, shortage of vehicles, no maintenance shop and staff is not adequate to run in this mode of operation.

The Senior Engineers and Junior Engineers are required to live in the Colony and during any emergencies have to report to the plant, most of them are averaging twelve to fourteen hour days as they can't get in touch with the personnel who live in Hyderabad.

In addition new areas of concern have been identified and will add to the indemnification that WAPDA will have to make to the new Co.

A list of these items will be part of this report.

Dennis W. Evans
Advisor, WPPO

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ITEMS NEEDING CORRECTIONS AT JAMSHORO POWER PLANT

Maintenance shop, no equipment, tools todate.

Air basket #1 unit 1 month outage to replace or clean.

Units 2, 3 and 4 hot spots need to replace insulation.

Unit # 2 main steam stop valve will not close very dangerous, drifts close after machine has cooled down.

Units 1, 2, 3 and 4 experiencing, short circuiting during rainey seasons.

Waste water evaporation pond, original size too small, line to Indus river plugged overflow's into farm fields.

Unit # 1 coagulator design not right as identified in original report, can't get parts needed to make tie to units 2, 3 and 4.

Instrument air dryers on units 2, 3 and 4 need to be replaced.

Air pre heater motors modification needed to remove for maintenance without having to shut unit down.

Units 2, 3 and 4 thrust bearings and pilot valves need replacing.

Units 2, 3 and 4 all pumps need to have grease fittings added.

Units 2, 3 and 4 main turbine lube oil system needs a complete filter redesign.

H_2 compressor sealed units have to be replaced.

Units 2, 3 and 4 24" supply line from Indus river made out of cast iron they are experiencing lots of damage this could be a big cost item if whole line has to be replaced.

Direct road from colony to station for easier access.

Need to replace underground 6.6 KV line to river pumping station with overhead, lots of failures.

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To,

Mr. Dennis W. Evans
International Resources Group Ltd.
Private Sector Power Project,
2nd floor, PIA Tower,
Egerton Road,Lahore
Phone: 6368790-93

From:- M.M. Chandio R.E. (M)
TPS,Jamshoro

Abu Adil R.E. (O)
TPS,Jamshoro

Reference: Your fax of dated 10.09.1993.

Our comments on the items needing correction at Jamshoro power plant are attached herewith.

Thank you.

(ABU ADIL
RESIDENT ENGINEER (O)
TPS, JAMSHORO

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01. **MAINTENANCE SHOP, NO EQUIPMENT, TOOLS TODATE**

Comments: Maintenance shop is now fully equipped with equipments and tools, but it is not equipped with required staff.

02. **AIR BASKET @ 1 UNIT 1 MONTH OUTAGE TO REPLACE OR CLEAN**

Comments: Water washing facilities are available which can be done in 5 days shutdown. Cold end Air Preheater elements can be replaced in 15 days shutdown. However Intermediate and hot end elements replacement require more time may be one month.

03. **UNITS-2,3 & 4 HOT SPOTS NEED TO REPLACE INSULATION**

Comments: Some of the hot spots are still without insulation but would be done in the shutdowns w.e.f.20.11.1993 to 20.01.1993.

04. **UNIT @ 2 MAIN STEAM STOP VALVE WILL NOT CLOSE VERY DANGEROUS,DRIFTS CLOSE AFTER MACHINE HAS COOLED DOWN.**

Comments: No such problem now

05. **UNITS-1,2,3 & 4 EXPERIENCING, SHORT CIRCUITING DURING RAINY SEASONS.**

Comments: Unit-1 has no such problem. However Units-2,3 & 4 have the problem specially on boiler for which necessary works of providing shades and sealing are in progress.

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06. **WASTE WATER EVAPORATION POND,ORIGINAL SIZE TO SMALL LINE TO INDUS RIVER PLUGGED OVERFLOW'S INTO FARM FIELDS**

Comments: The waste water line is not plugged fully. However to overcome this problem a case study of providing open channel from waste water pond to river is being done by the consultant. If it is found workable, the work will be started.

07. **UNIT # 1 COAGULATOR DESIGN NOT RIGHT AS IDENTIFIED IN ORIGINAL REPORT, CANNOT GET PARTS NEEDED TO MAKE TIE TO UNITS-2,3 & 4.**

Comments: Interconnection of River intake water has been made among Units-1,2,3 & 4. As regards co-agulators, silt is accumulated and is to be removed manually.

08. **INSTRUMENT AIR DRYERS ON UNITS-2,3 & 4 NEED TO BE REPLACED.**

Comments: Case for procurement of Refrigerant type drier is in process.

09. **AIR PRE HEATER MOTORS MODIFICATION NEEDED TO REMOVE FOR MAINTENANCE WITHOUT HAVING TO SHUT UNIT DONW.**

Comments: Already modified.

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10. **UNITS-2,3 & 4 THRUST BEARINGS AND PILOT VALVES NEED REPLACING.**

Comments: Main oil pumps thrust bearings get damage after operation of about one year which results malfunction of governing system due to increase in the gap between pilot valve and governor buffle plate. Some lubrication problem is there for which Chinese are carrying out modification on their own units. After successful result, the same will be done at Jamshoro.

11. **UNITS-2,3 & 4 ALL PUMPS NEED TO HAVE GREASE FITTINGS ADDED**

Comments: Which pumps not clear. However grease nipples not provided properly on some of the pumps.

12. **UNITS-2,3 & 4 MAIN TURBINE LUBE OIL SYSTEM NEEDS A COMPLETE FILTER REDESIGN.**

Comments: Additional centrifuges have been installed on Units-2 & 3. For Unit-4 it is under procurement. Chinese purification plant on each unit is also in service. With these measures the problem has been reduced to satisfactory level.

13. **H2 COMPRESSOR SEALED UNITS WHOLE UNIT HAS TO BE REPLACED**

Comments: Yes

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14. **Units-2,3 & 4 24" SUPPLY LINE FROM INDUS RIVER MADE OUT OF CAST IRON THEY ARE EXPERIENCING LOTS OF DAMAGE THIS COULD BE A BIG COST ITEM IF WHOLE LINE HAS TO BE REPLACED.**

Comments: The frequency of damage has reduced and interconnections of all the four units have been made which may not affect the operation of the unit.The damage pipe length is being replaced with M.S.pipes.

15. **DIRECT ROAD FROM COLONY TO STATION FOR EASIER ACESS.**

Comments: Already under construction

16. **NEED TO REPLACE UNDERGROUND 6.6 KV LINE TO RIVER PUMPING STATION WITH OVERHEAD, LOTS OF FAILURES.**

Comments: The scheme is under consideration, but has not been finalized.

17. **SUB-WAY TO BE PROVIDED BETWEEN POWER STATION & PRETREATMENT PLANT TO CONTROL WHOLE POWER STATION**

Comments: Not initiated

ABU ADIL
R.E.(O)
TPS,JAMSHORO

M.M. CHANDIO
R.E. (M)
TPS,JAMSHORO

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U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
PRIVATE SECTOR POWER PROJECT

JAMSHORO POWER STATION
UNITS 1, 2, 3 AND 4
FINAL TECHNICAL DUE DILIGENCE

CONTROL WORK PLAN 1.38.0
FINAL REPORT

SUBMITTED BY:

DENNIS W. EVANS, JOHN T. BOYD COMPANY
AND
FRED A. STONE, ESI ENERGY/FPL GROUP

SEPTEMBER, 1992

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SECTION II

Date: July 25, 1992

Reply to: PSPP, Chief of Party, Ronald H. Leasburg

Subject: Control Work Plan - CWP 1.38.0

Reference: Contract # 391-0494 C-00 0540-00

To: Mr. Shahid Ahmad, Program Manager

[illegible] CWP will perform the final technical due diligence required for the corporatization of the Jamshoro Power Plant. [illegible] will update the existing study (approx. 10 months old) [illegible] Power Station Units 1, 2, 3, & 4 Performance Condition Assessment Report" prepared under Paragraph C of [illegible] CWP will focus on plant operations and maintenance. [illegible] investigating any new issues that [illegible] from subsequent actions involved in the corporatization process of the Jamshoro Power Station.

Special attention will be given to ensure [illegible] have occurred to those observed in the existing study (see above). Specifically, the Team will review [illegible] against design criteria, conformance with recommended operating and maintenance procedures and programs, as well as ensuring that procurement and construction activities have met specified codes and standards. If necessary, the Team will make recommendations to improve substandard conditions. Additionally, if [illegible] possible for certain existing conditions, the team may recommend the Jamshoro Power Corporation (JPC) receive appropriate indemnification from WAPDA or have the plant's purchase price reduced.

1. Control Identification number - CWP 1.38.0

2. Name of Responsible Advisor - Chief of Party, Ronald H. Leasburg and Robert E. Grimshaw, Resident Advisor, WPPO

3. Name of Short Term Consultants - ESI Energy, Fred A. Stone, John T. Boyd Co., Dennis W. Evans (Team).

4. Name of Firm providing services - ESI, Energy and John T. Boyd Co.

5. Estimated period of performance commencing about August 1, 1992 and completing about September 1, 1992.

6. Scope of Work:

   (a) Examine the existing study and compare its observations and conclusions with present plant conditions, codes and construction documents.

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(b) Examine ongoing, scheduled, and preventive maintenance records. Examine proposed long term repair program

(c) Evaluate plant systems to verify performance is in compliance with design specifications. Evaluate the potential adverse impact on both financial requirements and plant operation of any non standard conditions observed.

(d) Review and evaluate plant operations, availability, heat rates, fuel consumption, water chemistry and control and instrument activities

(e) Identify conditions needing correction p[illegible] to corporatization. Also, identify those c[illegible]tions that, in the Teams opinion should result in a [illegible]ction in purchase price of the [illegible], or requ[illegible] indemnifi[illegible] by WAPDA [illegible] the JPC [illegible] should give special thought to any conditions [illegible]ed that, in their opinion, will require the JPC [illegible]ntain a level of financial reserves greater than [illegible]ally expected

, Relationship between effort [illegible] in Cu[illegible] the effort contained in the contract [illegible] This task relates [illegible]ectly to Contract Article III.C. <u>Policy analysis and Special Studies.</u>

Approvals

Submitted by
Chief of Party (A)
Private Sector Power Project
Robert E. Grimshaw

Concurred
Managing Director
WPPO
Malik Muhamm[illegible] Ashraf

Approved by
Program Manager
USAID O/PEN
Mian Shahid

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SECTION III

OVERALL CONCLUSIONS

The purpose of this CWP is to perform the final technical due diligence required for the corporatization and privatization process of the Jamshoro Power Station. A short term team comprised of Mr. Dennis W. Evans, John T. Boyd Co. and Mr. Fred A. Stone, ESI Energy was assigned the task.

In summary, the Plant is a good selection for privatization. Unit 1 is a 250 MW oil fired unit provided by the Japanese, and Units 2, 3 and 4 are 210 MW oil and gas fired units provided by the Chinese. Fundamentally, all units major components and systems are very sound, and they incorporate proven design concepts and technology. They were commissioned between December, 1989 and January, 1991 and are therefore essentially new units.

Unit 1 appears to be the best unit, based on construction appearance, plant operational records and testimonials of plant employees. Units 2, 3 and 4 are still going through some start-up problems, all of which can be solved with the proper focus in a relatively short time frame. The plant support equipment and facilities are very adequate in design and number, although a few problems remain to be resolved. Again, there appears to be no insurmountable situations.

The single largest area for improvement at the Plant is in the arena of site facilities, equipment and personnel management. This situation is most likely caused by the newness of the plant, focus on commissioning deadlines, and the fact the plant is owned and operated by WAPDA. Many plant employees are fresh, and are not yet properly trained or seasoned. Valid operational documents are scarce in some areas. Privatization and time will go a long way towards resolution of these issues.

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SECTION IV

APPROACH TO TASK

The approach to task taken by team was to meet with Mr. Grimshaw, RA, WAPDA, Mr. Anis A. Zaidi, G.M., WPPO and Mr. Malik M. Ashraf, M.D., WPPO for an overview and additional direction concerning the assignment. The team then travelled to the Plant site with Mr. Grimshaw for a meeting with the Plant Management team and an extensive two-day plant equipment tour with questions and answers from plant operating personnel. The team then reviewed the report from Ebasco Services Inc., prepared in response to CWP 1.23.0 in order to verify plant equipment and systems.

As the Ebasco report was 11 months ago, the team used it as a guide for description of plant equipment and systems. The discrepancies noted at that time were explored in great detail to determine which had been corrected since that study. Also, a thorough review of plant records, observation of operation and maintenance practices, personnel interviews and plant walkdowns were made to determine if any new conditions or problems had evolved. The combined experience of the team represent more than 55 years in virtually all phases of operating power plants. This background proved helpful in efforts to understand the root cause of many conditions observed.

During the 12 day plant visit, Units 1, 2 and 3 were operating, and Unit 4 was out of service for the first annual inspection of components by CMEC personnel. While the team was on site, they observed a forced outage when Unit 2 tripped from 180 MW due to low vacuum caused by a failed turbine drain line. The team was able to observe the operator response, maintenance activities and return to service process. These observations helped to verify findings from plant record reviews.

The team also went beyond the scope of equipment technical due diligence and made findings in other plant areas. A thorough review of the employee colony was made. Observations on plant facilities, tooling, rolling stock, personnel issues and practices were also gathered. The remainder of this report will serve to document the team's findings and recommendations on the technical due diligence in response to CWP 1.38.0. Included as attachments are general comments relating to the ancillary issues.

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SECTION V

FINDINGS, CWP 6(a)

6.a) Examine the existing study and compare its observations and conclusions with present plant conditions, codes and construction documents

Areas identified in the Ebasco report as problem areas were again revised and brought up to date. We were able to confirm all units were built to code established either in China or Japan. All high pressure welds were x-rayed, but proof apparently was taken by contractor when they left the site. When asked about welder qualification again could not establish proof but were told anytime the Pakistani welders were brought in they do have qualification. Appendix A is documentation typical for Units 2, 3 and 4

WAPDA is using this plant to control frequency which accounts for the low capacity factor, and there is no incentive to run at maximum output. Plant is being maintained by emergency maintenance only, no preventive or predictive maintenance being done. The staff is relatively inexperienced and most of the training is on the job training only.

Presently there is no maintenance shop equipped and very little testing equipment available to I&C or electrical personnel. We also found no proof of acceptance testing on any of the units. Observed Units 1, 2 and 3 in operation, with all controls in automatic.

The tables following present the findings of all areas of discrepancies noted in the Ebasco report.

BEST AVAILABLE DOCUMENT

UNIT NO. 1	
ORIGINAL EBASCO ASSEMENT	PRESENT ASSEMENT
Boiler Feed Pump Mechanical Seal problems	All seals were replaced and have performed satisfactorily
Condenser Scaling	Addition of Hydrochloric acid has corrected the problem recent inspection indicate no scaling
Coagulation Units Flat bottoms and flushing system not designed properly	Still experiencing same problem due to design. Presently are tying all units together and indicate units 2-3 and 4 are sufficient to make up water for entire plant
Tube Leak in Economizer Section	No new ones since original assement

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UNIT NO. 2	
ORIGINAL ASSEMENT	PRESENT ASSEMENT
Acceptance Testing Reports are not Available	Was told it was not done, unable to verify.
Oil spills around No. 2 Burner Decks and on Windbox Casing	Indications are there but they have not been burning oil, so couldn't verify. Management indicated they have worked on the problem.
Oil Burner Guns do not retract without some Manual Assist.	Interviews with operations indicate they work and only hang up now and then. Appears there is no preventive maintenance on this system
Pneumatic Tilt drive for corners B, C and D out of service.	They are operable but need help on occasions. Preventive maintenance should correct this problem.
Three way valves On/Off/Purge motors burn up on Fuel Oil Gun Hydraulic Actuators.	This has been corrected, was told new/different motor application installed.
Auto operation of Unit No. 2 Combustion Controls.	Verified unit will operate in auto mode.
Exciter Carbon brushes have overheating problem.	Increased cleaning and precision grinding of slide ring has alleviated this problem.

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UNIT NO. 2, 3 AND 4	
ORIGINAL ASSEMENT	PRESENT ASSEMENT
Aux Boiler will not operate in Auto.	Interviews with Operation department verified they still can't operate this unit in auto. No plans to correct problem.
Boiler Feed Water Pumps Trip	As near as we can tell this problem has been corrected. They are still experiencing some grounds on 4 KV Electrical system that haven't been identified to date.
Instrument Air Compressors do not have Intra-Unit ties, and have caused Unit Trips	The management have identified this system as one needing a upgrade. Also it has a single failure criteria in the cooling water system that needs immediate attention.
Boiler Water Chemical Feed System won't operate in auto.	This problem has been corrected, and all systems are capable of auto operation.
Coagulation Sedimentation Control (Manual Operation).	Still running in manual.
Water Treatment Systems (Manual Control) on Demmeralizer Regeneration Cycle.	Was told they will operate in auto, but no preventive maintenance or control tune-ups have been performed.
Diesel Generators 2, 3 and 4	Will not perform in auto and they indicated they have a hard time getting them on the line in manual.
6.6 KV Switchgear Tagging and Training	Tagging is there but done in marker pen only and is wearing off. They are tagging with permanent tags when they can. No training has been provided to date.
Cooling Tower Fans and Intake Pump motors do not have adequate overload protection.	Still a problem area. Original recommendation to perform an engineering study remains.
Uninterruptable Power Supply Documention and Training.	Systems works, still no training, however some prints in English.

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UNIT NO. 2, 3 AND 4	
ORIGINAL ASSEMENT	PRESENT ASSEMENT
Oil seepage 220 KV Cables to 2, 3 and 4 Main Transformers	Still a problem area no effort made to correct to date.
Single Phase Grounding No. 2 Unit 6.6 KV feeder to Intake Water 400 Volt Power Supply	Haven't been able to isolate problem Also they are experiencing same problem with .4 KV Emerg Section .4 KV unit section on all the Chinese units.
D.C. Batteries Units 2, 3 and 4.	Positive side scaling on all batteries
Auto Operation does not work on Combustion Control, Feed-water Controls and Steam Temperature Controls.	Observed auto operation of Units 2 and 3, Unit No. 4 down for 1st year inspection Plant Management assured that unit will run in Auto.
Aux Boiler will not Operate in Auto.	Still having same problem no effort to correct to date.
No. 2 Vibration Recorder out of Service. No. 2 Generator Temp Scanner out of Service.	In Service now In Service now.
No. 3 Unit Eccentricity Indication, IP Cyl Metal Temp, Turbine Digital speed and Condenser vac protection. O.O.S.	All in Service.
EHC and CCS System do not function properly.	Malfunction corrected and systems work as designed.
Hydrogen Valves no auto operation.	Not designed to operate in automatic.
Unit 3 Cooling Tower Cell damaged by fan failure.	Repairs have been made to damaged cell structure.
All Fire Base Cabinets do not have Fire Hoses.	Still the case. Hoses are available at the fire station.
Power Cables, instrument cables and lighting cables all in same cable trays and ducts.	Still the same. No apparent problems yet, but should be addressed long term.

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UNIT NO. 2, 3 AND 4	
ORIGINAL ASSEMENT	PRESENT ASSEMENT
400 V breakers and cables at RO unloading facility are full of oil, dust, dirt and corrosion.	Condition still exists, may even be worse. Better housekeeping required in this area

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SECTION VI

FINDINGS, CWP 6(b)

6.b) The ongoing, scheduled, and preventive maintenance records and procedures were reviewed, with the following findings:

Ongoing (routine) Maintenance

As a fault or equipment defect is observed by operations personnel, they prepare a Trouble Report. This report is reviewed and verified by the shift supervisor, who then decides if the work can be accomplished with the unit running, and whether or not a Permit to Work clearance form is required. If the work is non-outage type, the shift supervisor then issues a permit to work clearance and the trouble report to the appropriate maintenance discipline department head. The maintenance department then assigns a crew to work the job, and upon completion cancels the PTW clearance.

This system seems to be a logical one by design, but the execution was observed to be seriously flawed. First, there was no system of priorities in place, only verbal recommendations of what should be done next. Second, there was no planning involved to determine what parts and materials would be required. Third, there were no written maintenance procedures available for the workers to use, fourth, the type and number of tools required were discovered while the job was in progress. And finally, there was no attempt to determine if the repair work was effective in correcting the original fault. These conditions can only result in ineffective and inefficient maintenance over the long run.

Preventive Maintenance

There is little or no preventive maintenance on the equipment at this time. Although many people appear to understand the requirement for a formalized program, the main focus is still on working trouble maintenance jobs.

Long Term Repair Program

At present each of the units have undergone an inspection by the manufacturer after one year in service. This was part of the contract to construct the units. A request to make a scheduled outage on Unit 1 for 30 days and Units 2 and 3 for 15 days each has been made to WAPDA. The time for these outages, if approved, is October and November, 1992. A detailed plan of work to be done and verification of spare parts availability has not been made. No plans were evident beyond 1992.

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SECTION VII

FINDINGS, CWP 6(c)

6.c) Evaluate Plant Systems to verify performance is in compliance with design specifications. Evaluate the potential adverse impact on both financial requirements and plant operation of any non-standard conditions observed.

With the exception of Unit No. 4 which was down for first year inspection, observed units 1, 2 and 3 in operation at varying loads. Unit No. 1 is limited to 230 MW due to air heater plugage. Units 2 and 3 were at loads from 70 MW to 200 MW. Feed water pumps were running as designed two on the line one in standby. This also applied to condensate pumps, air compressor, heater drain pumps and ID and FD fans on the units in service.

The calculated average heat rates for each unit was used as a basis for evaluation, as performance tests are not run on the units. From annual Form E data, the heat rates in KCAL/KWh for the period July 1991 to June 1992.

UNIT NO.	DESIGN HEAT RATE	AVERAGE HEAT RATE	DIFFERENCE (DES - AVG)
1	2284	2363	-79
2	2584	2418	+166
3	2584	2392	+192
4	2584	2414	+170

This data would indicate Unit 1 is operating slightly worse than design, and Units 2, 3 and 4 are operating better than design. However, the conditions for design are unknown (such as load, fuel type, ambient conditions, etc.), therefore it is difficult to draw any meaningful conclusions. The team would recommend each unit undergo a periodic performance test at design conditions. When this is completed, an estimate of financial impact can be better calculated.

Unit No. 1 has a six cell double flow cooling tower and Units 2, 3 and 4 have 12 cell double flow cooling towers, temperature was greater than 100°F when observation was made and circulating water temperature were running 73°F inlet and 76°F outlet.

The control systems on the units running were observed to be operating in the automatic mode, interviews with operation staff confirmed (EHC) electrical hydraulic control and the (CCS) coordinated control system are working properly. Units 2 and 3 were on gas

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so couldn't observe oil fire operation. Staff indicated they have burned oil successfully. Only enough gas available for two units at full load.

Emerg diesel generators on Units 2, 3 and 4 will not start and load in auto and staff indicates this problem is being addressed by the manufacturer.

Aux boilers for Units 2, 3 and 4 will not operate in automatic. Interviews indicate it's not a priority item at this point.

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SECTION VIII

FINDINGS, CWP 6(d)

6 d) Plant operations, availability, performance, water chemistry and control and Instrument activities were reviewed with the following findings:

Plant operations does not appear to have any goals beyond making electricity. Unit efficiency is not a major concern, and no performance testing is performed on the units or on the equipment Heat rate (gross) numbers are calculated from summaries of daily log sheets on a monthly basis, and reported on annual "E" form Any discrepancies from design are not explored for root caused and subsequent correction.

Unit availability does not appear to be of high concern to plant. During our visit, unit 2 tripped on low turbine vacuum due to a ruptured drain line from the turbine to the condenser. The rupture was in a 6" carbon steel elbow. The elbow was replaced, and the unit returned to service six days later. The actual time to cut out the damaged pipe section and weld in a new piece was about eight hours. The remainder of the time was spent on performing other maintenance as identified by previous Trouble Reports. Had availability been a concern, the total outage time should have been less than 24 hours, resulting in improved availability. Availability numbers are calculated and reported only, with no attempts to improve.

Fuel consumption is also an area that has concern only to the extent the storage tanks don't run dry. There appears to be no effort to focus on reduction of fuel usage. This area is one with a very high potential for improvements, as wise usage of fuel translates directly to improve heat rates, resulting in a better financial picture overall

Water chemistry and control appears to be adequate. The pretreatment systems all function per design, with some labor-intensive processes in place. The result is an adequate supply of silt-free filtered water to meet the needs of the demineralizers, cooling towers, plant service water, and colony consumption.

Each unit has its own two-drain demineralizer, with more than adequate capacity to meet operational needs. Water sampling is continuous for make-up water, condensate, feedwater, boiler water and steam. In addition, manual samples are taken every four hours and analyzed in the laboratory. The boiler water chemistry is controlled to a coordinated Ph-Phosphate scheme, with automatic chemical injection systems with variable feed rates adjusted as required based on laboratory water analysis. In general, the water chemistry and control appears to be in line with prudent practices, designed to prevent boiler pressure parts from early failure, as well as protecting the turbine from early stage solid particle erosion or later stage efficiency-robbing deposits.

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The instrumentation problems all appear to be on Units 2, 3 and 4. All of the problems appear to be solvable and well within today's technology. It will take some time, money and focus to bring the instrumentation and controls systems to a desirable level that would be considered acceptable for continued reliable operation. The problems can be broken down into five main areas: (1) Design, (2) Documentation, (3) Construction, (4) Personnel and (5) Training.

- Design

  The overall control philosophy for combustion control, steam temperature controls, drum level and feed water controls and turbine controls is sound, and keeping with current technology. The components appear to be a cheap imitation of Baily controls equipment, and are very difficult to calibrate, adjust and operate. Calibration drift is a very common problem, and is not checked with any frequency.

- Documentation

  Documentation on components, as well on systems and control loops is very poor. Drawings are hard to read, not properly translated and not made available. Only some systems have correct drawings, and these are hard to find.

- Construction

  Instrument air lines are carbon steel and have rust and plugging problems. Some systems have been changed to stainless steel tubing. Boiler instrumentation is installed in the field in enclosures that are not water proof. Very few instrument wiring terminals are labeled properly and permanently. Instrumentation cables are not shielded, and are run in the same cable trays as power cables.

- Personnel

  Adequate trained staffing appears to be a problem. Only a very few engineers understand controls and how to troubleshoot and they are spread very thin. It is not uncommon for on engineer to work 24 hours at a time. The bulk of the personnel in the instrument shop are fitters, and can only calibrate gages and do other menial tasks. Due to the excessive hours worked, no one is available for call-outs.

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SECTION X

FINDINGS, CWP 6(e)

6.e) The team has identified a numb[illegible] onditi[illegible]s that should be addressed during the corporatization stages of privat[illegible] These items are listed in the following pages There are recommended actions for e[illegible] condition identified with cost estimates totalling $677,000. Many of these issues are already being addressed by WAPDA, as shown in Appendix B

The team was not able to identify any significant problem areas that should result in a reduction in the purchase price of the facility. There were a number of areas that should receive an initial level of maintenance attention for one-time resolution Examples of these are:

- Improve lighting on all boilers and equipment rooms on mezzanine and basement levels.
- Return all elevators to service, and keep on a maintenance program.
- Continue program of marking wiring terminations behind BTG board and in cabinets.
- Repair sheet metal lagging on No. 2 boiler flue gas duct work. Reinforce pop-rivets elsewhere
- Replace broken glass in windows in turbine deck and in auxiliary buildings.
- Repair boiler casing cracks causing gas leaks and hot spots on No. 2, 3 and 4 boilers.
- Investigate boiler slag build-up on Unit one superheater elements and formulate plans to desensitize the effect.
- Perform survey to ensure adequate spare parts are available to support maintenance program.
- Continue efforts to provide as-built drawings and documents on all equipment.

The team also feels, in their opinion, there is no significant expected condition that would require JPC to maintain a level of financial reserves greater than normally expected.

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CONDITIONS NEEDING CORRECTION PRIOR TO CORPORATIZATION

CONDITION	RECOMMENDATION FOR CORRECTION	$ (APPROX)
Units 2, 3 and 4 have major control problems on combustion control, steam temp controls and feedwater/drum level controls	• Replace iron instrument air lines with stainless steel • Purchase and install weather-proof enclosures for all outside instrumentation • Replace/upgrade deficient components with new design • Establish preventive maintenance and calibration program with procedures and training • Provide shielded cable in separate conduit for all instrument signals	120,000 65,000 33,000 0 56,000
Units 2, 3 and 4 have cooling tower make-up pumps to supply cooling water for instrument air compressors. These pumps are outside, and occasionally under water.	Provide separate pumps for instrument air compressor cooling water. Pumps with a back-up scheme and separate piping arrangement interconnected with sister units would be recommended	48,000
All units have stand-alone vital systems of water, air, hydrogen etc. This reduces operational flexibility, and adversely effects unit reliability	Provide interconnection between all units for the following plant support systems: • Instrument air • Pre-treated water • Demineralized water • Hydrogen gas • Emergency diesel bus • Service air	 35,000 35,000 35,000 35,000 35,000 35,000
Units 2, 3 and 4 do not have automatic generator hydrogen pressure control. Manual pressure controls dependent on operator alert.	Provide automatic generator hydrogen gas pressure controls, with regulator valve, sensing element and manual bypass valves	15,000

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CONDITION	RECOMMENDATION FOR CORRECTION	$ (APPROX)
No formal maintenance program beyond trouble response	Install Computerized Maintenance Management System (CMMS) equipment to include: • PM schedules and work orders • Planning/Scheduling functions • Long term maintenance plans • Spare parts inventory control • Cost accounting (per Unit) • Maintenance record keeping • Reporting capability (multi format) Train plant population on CMMS	80,000 for installation and training only. Assumption that hardware and software have been procured and are available.
No focus on unit or plant availability, efficiency, or long-term reliability.	Establish positions of reliability engineer and performance test engineer. Positions should be separate from line maintenance responsibilities, and be authorized to recommend courses of action.	No additional cost, as positions will replace existing posts.
Units 2, 3 and 4 turbine high pressure control oil piping welds have failed, and QC documents are not available	Provide 100% NDE inspection of all High Pressure hydraulic oil welds. Repair/replace defective areas with certified welds.	50,200
	Total Approx	677,000

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ATTACHMENT I

PLANT COLONY

The plant colony is adjacent to the power station, located north of the RO unloading facilities. The purpose of the colony is to provide adequate housing and living requirements for the plant employees. The concept includes all necessities; however many facilities are under construction or not yet staffed

The plant colony is about 25-30% occupied as of this date, largely due to the poor facilities available The majority of current residents are plant management and supervision, as these employees are given strong urging to live there The rest of the employees live in Hyderabad City, or nearby villages.

Sanitation is very poor, with sewage discharged into open trenches, and no rubbish or garbage disposal area. There is no public transportation for families to travel for school, shopping or other needs. There is a hospital, college, boys school, girls school, post office, bank and market area for the employees. None of these facilities are staffed, however, and are not available for use by residents. There are plans for recreation facilities, but they have not been completed There is a bus available to transport workers to and from the plant at shift change times.

The potential for the colony is very great It should be completed and cleaned up soon. Priority needs to be put on hiring the proper staff to open existing facilities.

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ATTACHMENT 2

PLANT STORES

Not part of this CWP but requested by Resident Advisor evaluated the stores department.

The plant has four large warehouses on site, estimated to be about 3600 square feet per unit. They are in the process of setting up some control. Observe twenty large containers not opened that contained spare parts for Unit No. 1. Was told by manager they have only received approximately 20% of the spares for Units 2, 3 and 4

Appears they are handicapped by lack of trained stores personnel, no inventory control and lack of equipment needed to handel large and heavy spares

Consumables for everyday operation of a large power plant were not available, they purchase on a as need basis in Hyderabad.

Observed a large quantity of chemicals that were stored outside and probably no longer useful due to weather etc.

There is no fire protection installed in any of the warehouses.

Management feels they are well supplied for Unit No. 1 but expressed strong concerns in regards to Units 2, 3 and 4. They also indicated they are losing parts from theft.

We also tried to obtain a list of available equipment on site

- Two 25T Mobile Cranes, manufactured in Japan
- One Bedford Truck No. bov
- Five Fire pumper units, one not running
- Two Pajeros for Management use
- Two Small Fork Lifts
- One Water Tanker

Stores is responsible for fuel accountability including unloading, indication this is talking a lot of manpower.

Conclusion they have more than enough storage area, addition of an inventory control, some fire protection, equipment for transporting and training is needed to ensure plant is supplied as required.

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ATTACHMENT 3

JPC STAFFING PROPOSAL

Attached is a proposed organizational structure for Jamshoro power Company (JPC) with preliminary estimates of numbers of employees required in each functional area. As you can see, the entire complement of JPC would be about 520 employees. This estimate is based on conditions expected to exist after initial corporatization efforts have been completed. Additional contract labor may be required to perform large plant overhauls on a five year per unit basis. Also, the standing complement should be reviewed and adjusted periodically as needs change.

Some features of this proposal include:

- Plant Colony activities are separate from and are expected to complement plant operations activities;
- Procurement, inventory control and fuel supply functions are separate from normal plant operations and maintenance;
- Financial and cost control functions are also separate from plant operation, providing a check and balance system;
- A greater emphasis is placed on improving the plant performance in the areas of availability, reliability and efficiency; and
- There is a significant increase in the level of training for all employees.

Since the proposed complement is about one-third of existing complement, some time will be required to achieve these levels. The key to this transition is attrition through training. I am aware of the sensitivity that will necessarily accompany a proposal to reduce the labor force, but it will eventually be offset by improved employee net worth

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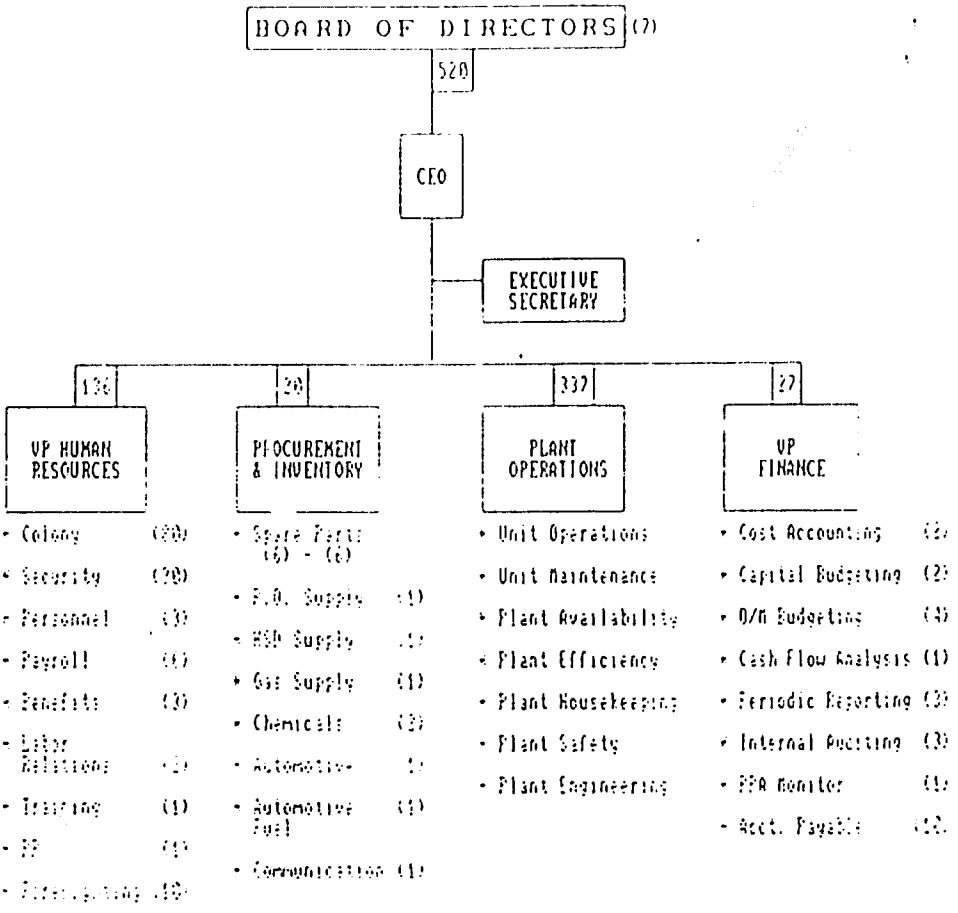
JAMSHORO POWER CORPORATION
PROPOSED CORPORATE STRUCTURE



• Functional Accountability Areas

[###] Total Permanent Employees

(##) Estimated Employees Each Function

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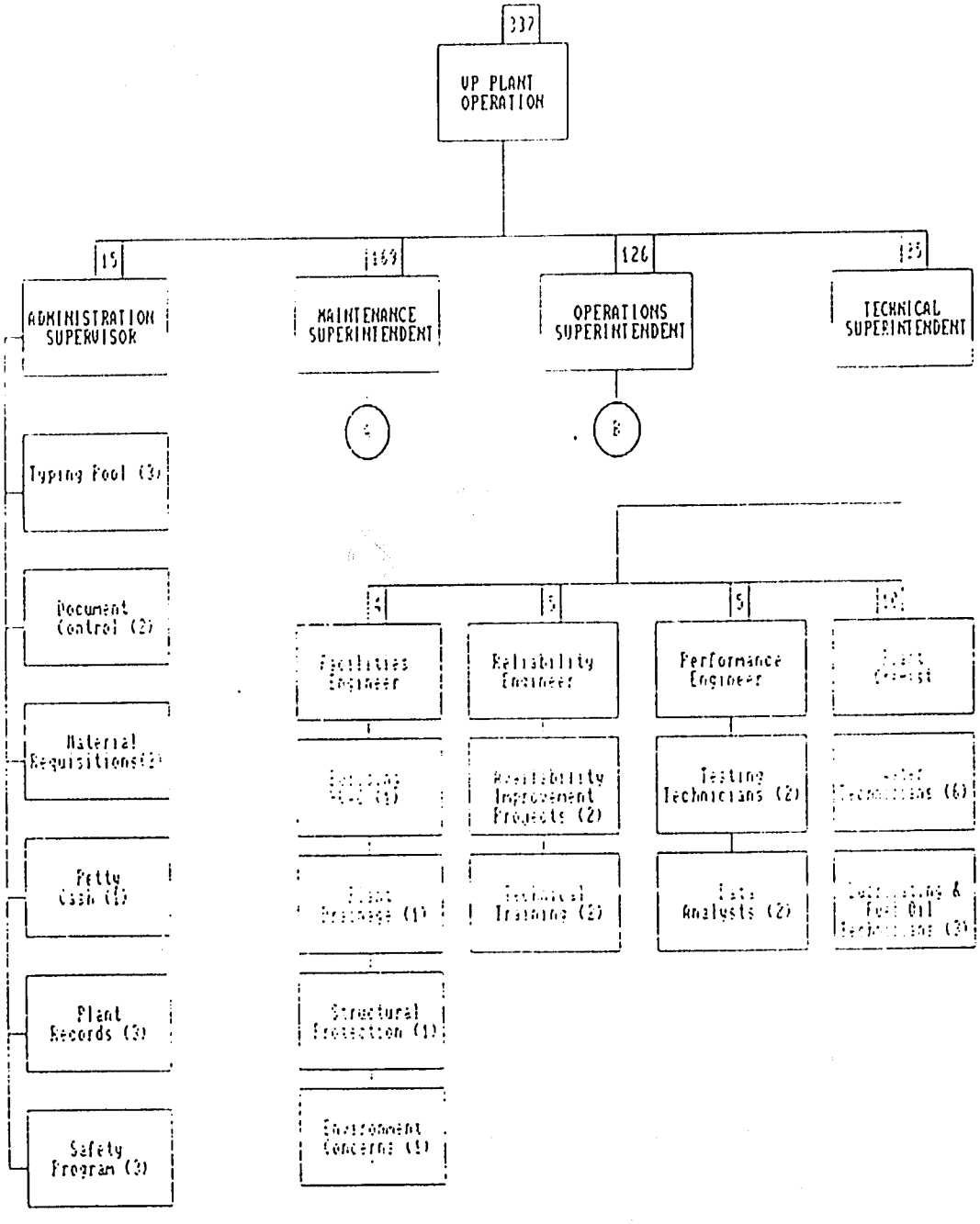

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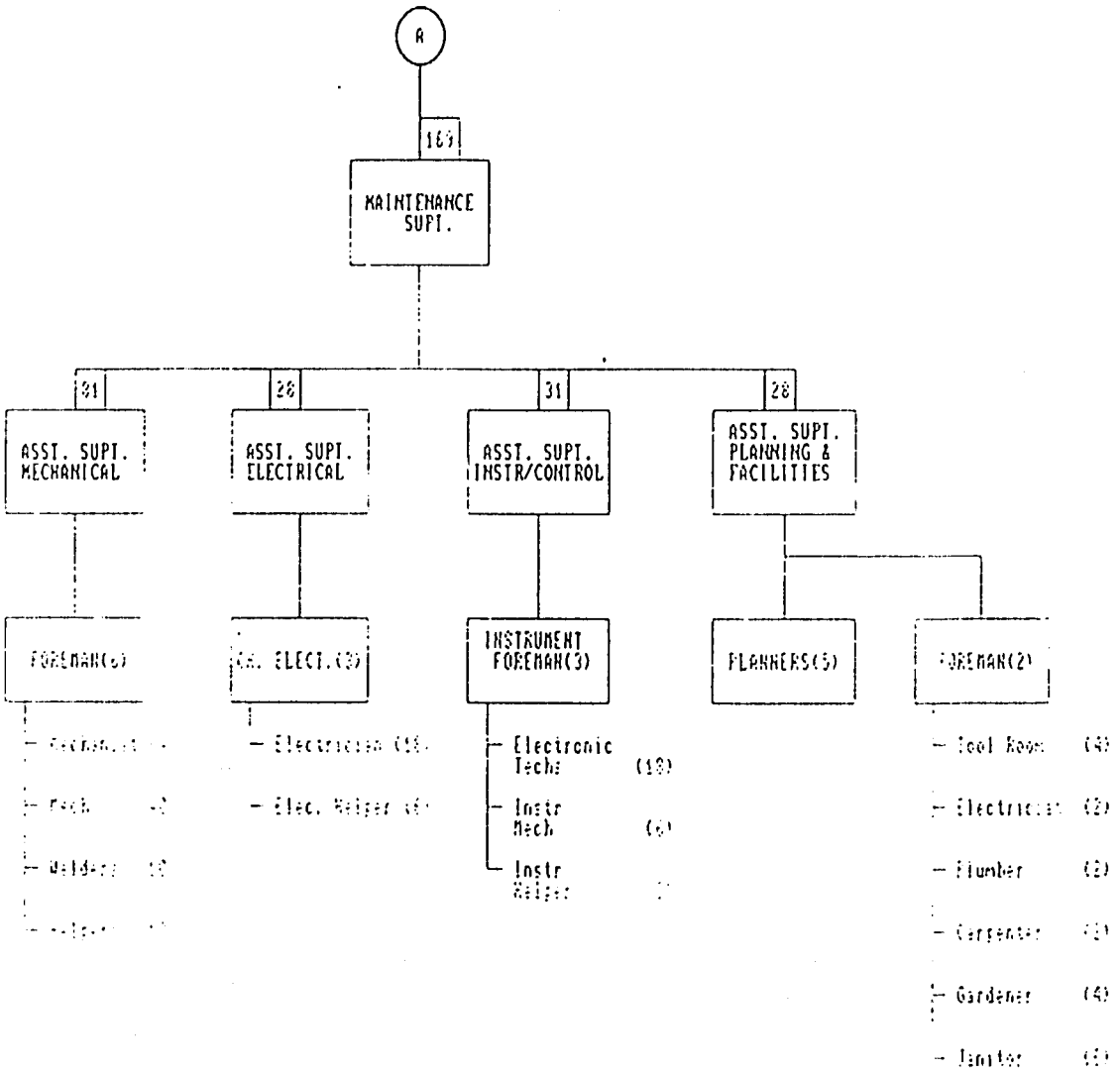

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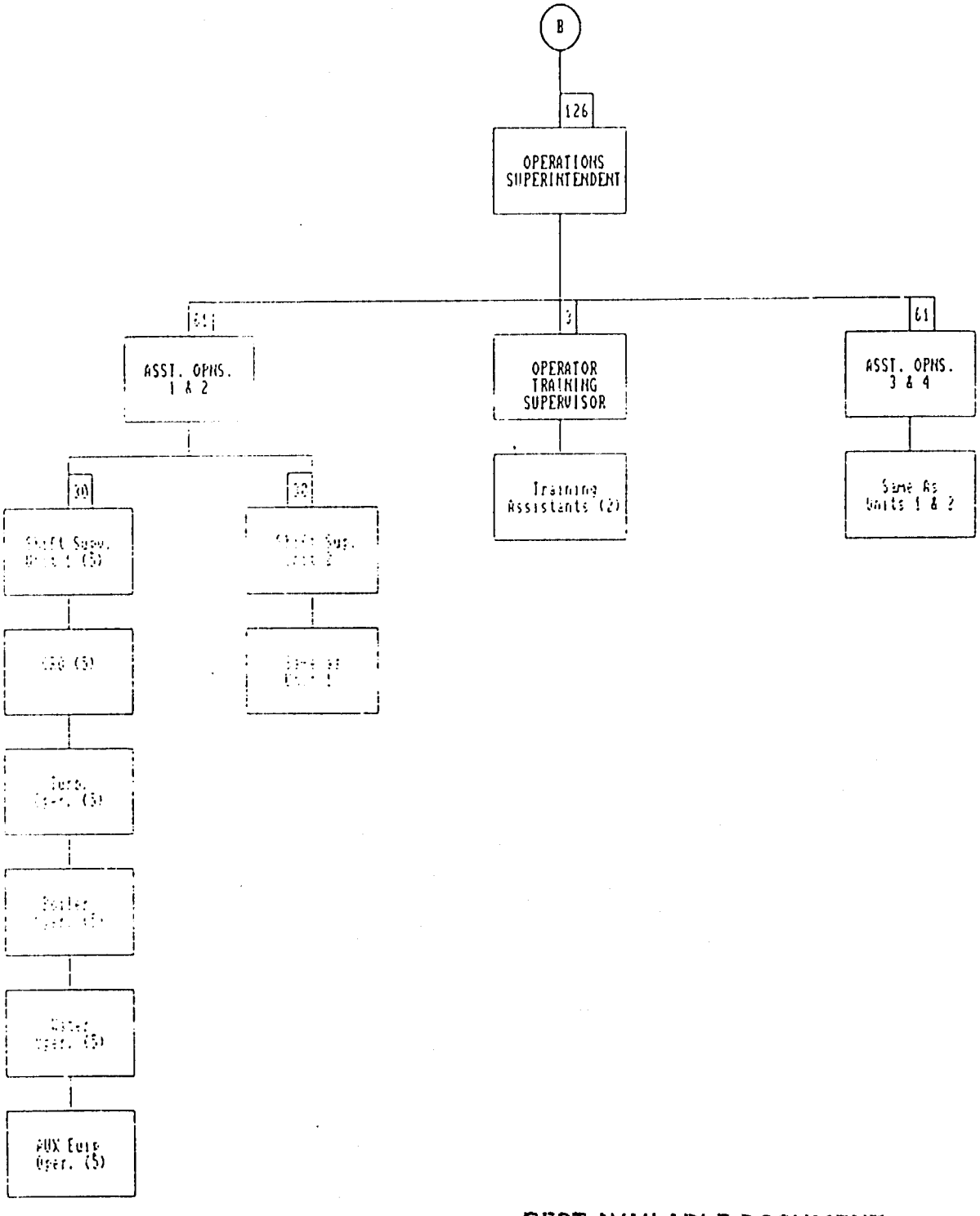

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APPENDIX A

CONSTRUCTION CONTROL DOCUMENTS

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电力建设施工及验收签证

ELECTRIC POWER CONSTRUCTION & [illegible]

NO. BB-025/2

Reheater 再热器	ITEM DESCRIPTION & DRAWING NO. 项目名称及图号		erection of reheater of Poloer No.2 [illegible]	
ler Construction Group 3 炉子	STARTING & COMPLETION DATE OF CONSTRUCTION 施工起止日期间	[illegible]	INSPECTION DATE 验收日期	[illegible]
ALITY SPECIFICATION 质量标准	CONSTRUCTION AND INSPECTION RECORD 施工及检验记录			QUALITY GRADE 质量等级

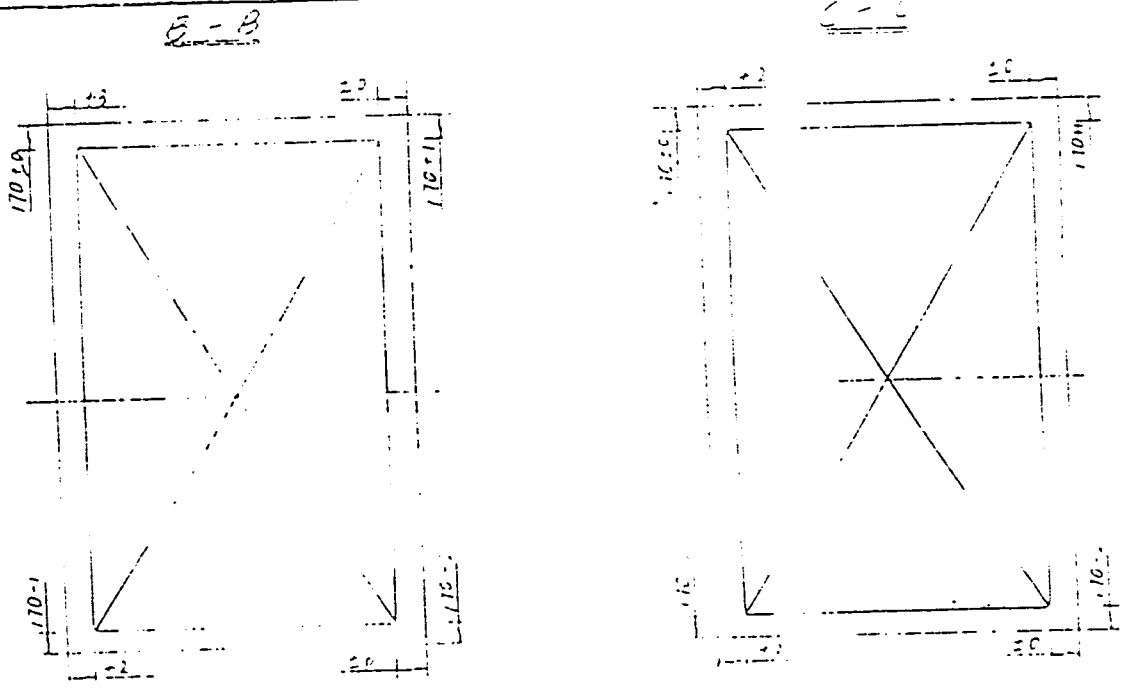
电力建设施工及验收技术规范

(锅炉机组篇)

DLJ52-81

ceptance & Technical odes of Elecric Power onstruction for Boiler art

DL55-81



PROFESSIONAL ENGINEER 专业工程师	[illegible]	PERSON IN CHARGE OF CONSTRUCTION 施工负责人	[illegible]

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电力建设施工及验收技术规范

ELECTRIC POWER CONSTRUCTION & ACCEPTANCE CARD

NO. T-030/2

ead steam piping (冷段)蒸汽管道	ITEM DESCRIPTION & DRAWING NO. 项目名称及图号		erection of cold reheat steam piping 再热(冷段)蒸汽管道安装工程	
管四班	STARTING & COMPLETION DATE OF CONSTRUCTION 施工起止日期间	Mar. 1, 1989-- Sep. 1, 1989 1989 3 1--1989 9 1	INSPECTION DATE 验收日期	Sep. 5, 1989 1989 9 5
SPECIFICATION 质量标准	CONSTRUCTION AND INSPECTION RECORDS 施工及检验记录			QUALITY GRADE 质量等级
验收标准 见设计. acceptance sta— the requirement drawing	完的时管道 瓦为34.6 kg/cm² 时 27.27 kg/cm² 过 密合后 性检查 无渗漏现象. While piping was full of clean water, all air in piping was exhausted up then pressure was increased. After pressure reached test pressure, 34.6 kg/cm²g, keeping it for 5 min. then drop it to working pressure 27.27 kg/cm²g then overall examination was made. No leakage was found.			优良 Fine
	PROFESSIONAL ENGINEER 专业工程师		PERSON IN CHARGE OF CONSTRUCTION 施工负责人	

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APPENDIX B

PLANT IMPROVEMENT PROJECTS

Thermal Power Station, Jamshoro
I&C Problems on Unit 2, 3 and 4

S.No.	Problem/Deficiency	Proposal/Recommendation	Present Status	Action by
1	Frequent problems pneumatic actuator of Boiler & Turbine controllers, causing reduction in load or tripping of the units	CMEC was to furnish a detailed report of manufacturers investigations and his recommendations for solution of the problem by 15 6 92 WAPDA Engineers and technicians would be involved in carrying out necessary remedial/repair work	The problem was investigated in detail by Specialists from CMEC & the manufacturer They are of the opinion that the sluggish operation of actuator was due to the bad quality of the air used for instrumentation and control at Jamshoro CMEC informed that by changing of the material of piping from mild steel to stainless steel and carrying out some modifications in filtration system the performance of actuators has improved appreciably Since carrying out these modifications the Combustion Control System (CCS) has so far run 687 hours on Unit-2 & for 95% of the period it worked satisfactorily on Auto mode The problem is still under investigation & CMEC confirmed that they will rectify the defect completely by Sept 1992 on all 3 units. In this regard the committee also suggested that CMEC should make the control panels of actuators dust and water proof.	CE (O&M) Jamshoro in association with CMEC must ensure completion of job by end of Sept 1992

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S.No	Problem/Deficiency	Proposal/Recommendation	Present Status	Action by
	Quality of instrument air going to actuators is not good	Necessary instrument air lines for the actuators have been replaced with stainless steel pipe lines on Unit-3 Similar replacement of Unit-4 will be made during its first inspection & those on Unit-2 will be made during any convenient shut down on it Improvement has also been made in air drier by putting additional filtering arrangement The quality of air on Unit-3 has considerably improved There are two driers with silicagel, one drier is in service while the other is on regeneration cycle The drier works on turn at 8 hrs. duty cycle The committee recommended to ensure proper working of the driers	For Unit-3&4, the changes/modifications of instrument air piping has already been completed However for Unit 2 it could not be completed due to non availability of shutdown on the unit CMEC are of the view that since Unit-2 has already been taken over by WAPDA, the material required for this modification should be supplied by WAPDA The Committee however emphasized CMEC that considering good relations between WAPDA & CMEC, they should reconsider to complete the modification work on Unit-2 by themselves including supply of material (stainless steel pipe) CE (O&M) Jamshoro may please be advised to ensure completion of the job	CE (O&M) Jamshoro in association with CMEC must ensure completion of the job by end of Sept 1992
	Defective eccentricity meters	The Committee is of the opinion that the exist meters can not be made reliable WAPDA should replace these meters with those of better make as CMEC do not agree for its replacement at their own	CE (O&M) may kindly be advised to study the modifications proposed by the Committee in association with CMEC Specialist & furnish the specification and other technical details of the instruments and recorders to be replaced to the office of GM Thermal for arrangement of their procurement	CE (O&M) Jamshoro must furnish specification of the required meters by end of Oct 92
	Unreliable turbo generator bearing Vibration recorders	The committee recommends that the existing arrangement of recording bearing vibration on 24 point recorder is unsatisfactory and of no use Therefore it should be replaced with a better made considering the safety and reliability of the units. The new recorders should have less recording points per recorder and must be of continuous pen recorder type WAPDA will purchase and install.	CE (O&M) may kindly be advised to study the modifications proposed by the Committee in associations with CMEC Specialists & furnish the specification & other technical details of the instruments & recorders to be replaced to the office of GM Thermal for arrangement of their procurement The Committee also proposed that till such time the Vibration recorders are replaced with better quality the Power Station Maintenance/operation staff should keep strict watch on the vibration readings of all the 3 units Portable vibration meters may be used for frequent checking of the vibration specially during starting of the unit and proper record of all these readings be kept	CE (O&M) Jamshoro to issue necessary instruction to his staff

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S No.	Problem/Deficiency	Proposal/Recommendation	Present Status	Action by
5	Overheating/burning of coil of the electrohydraulic governor	M/S CMEC will study the problem of the over heating of coil of electro-hydraulic governor change over value to Mechanical governing system and vice versa and will submit their proposals/recommendations regarding remedies by 15th of June, 1992	This problem still exists. In fact the coil of Electro hydraulic governor of Unit-2 was also damaged during shut down on 7.7.92. So far CMEC have taken no action on recommendation/ proposals of the Committee except reassembling & normal checking of EHG for solving this problem. CMEC informed that the condition of Unit 3&4 is quite satisfactory. However the overheating/ burning of coil of Unit-2 is still under their investigation and study. They have promised that they would submit a detailed report by 31st July 1992	CMEC must solve this problem by end of September 1992
6	Thermocouples directly installed without protecting tubes and some places flexible thermocouples have been used instead of fixed thermocouples	M/S CMEC agreed the proposal of the Committee that the thermocouples of boiler and turbine side should be installed with thermocouple wells. M/S CMEC will check each point on unit-4 with WAPDA Engineers and where discrepancies exist it will be removed. Similar steps will be taken on Unit-2 & 3	CMEC have replaced the electric thermocouples installed for high temperature and high pressure on Unit 3&4 (4 Nos. on Unit-4, and 2 each on Unit 3 & 2). Some modification have also been made on Unit 4 regarding reduction of length of thermocouple wells. CMEC have now ensured that the problem of thermocouples will not reoccur again	Job attended by CMEC. CE (O&M) Jamshoro to issue instructions to his staff to keep strict watch.
7	Reliability and correctness of gas and furnace oil flow meters	The gas and R.O. flow have no fault. The gas flow meters require correction factor due to variation in the gas density from the design density. Oil flow meters require frequent maintenance and CMEC will demonstrate the correct procedure of its servicing and repair to WAPDA Engineers.	CMEC informed that correction factor for the oil and gas flow meters have already been provided to WAPDA. Procedures of servicing of oil and gas flow meters have also been demonstrated by CMEC specialists to WAPDA maintenance staff and now WAPDA maintenance staff is attending the job satisfactorily	Job attended by CMEC
8	Providing reliable level indicators for R.O. Service tanks	The Committee recommended that the level indicators be replaced with those of better make. However M/S CMEC have informed that they will give comments/recommendations by 15th June 1992	CMEC informed that there is no problem in the level gauge. They only require continuous and proper maintenance. CMEC will provide guidance and training to WAPDA maintenance staff in Aug. 1992, when their specialist will arrive at site. CE (O&M) Jamshoro may kindly be advised to coordinate this work with CMEC	CE (O&M) Jamshoro to coordinate this job with CMEC & inform progress.

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S.No.	Problem/Deficiency	Proposal/Recommendation	Present Status	Action by
9	Providing thermo wells for temperature indicators/gauges and thermocouples is also not good	M/S CMEC agreed to provide better quality thermocouples with wells where ever necessary WAPDA instrument Engineers are required to show all actual locations where such thermowells are required	CMEC have changed their stand and now they do not agree to provide thermocouples/temperature gauges with wells on low pressure steam/water/oil pipe lines However the Committee still feels that such wells must be provided as it is international practice and similar arrangements exist in other power plants under operation in WAPDA System The committee emphasized that it is not entirely for liability but the above modification is also necessary for the safety of the operating staff on duty On pursuant of the committee CMEC desired that WAPDA should inform the locations where thermocouple/gauge wells are necessary on low temperature steam water/oil pipe lines CE (O&M) may therefore please be advised to provide such information to CMEC within one week so that necessary action regarding provision of thermocouple gauge wells may be taken by CMEC on Unit-4 before the end of 1st inspection	CE (O&M) Jamshoro should provide the requisite information to CMEC so that they amy attend the job CMEC must ensure completion of this job specially on Unit-4 during its first inspection
10	Problem in digital temperature scanners for generator, F D fan and feed pumps	M/S CMEC agreed to ask their specialists to check and rectify the fault However the committee recommends that these scanners are not reliable and should be replaced with better quality Similar type of scanner installed on Guddu Unit-4 are also not reliable and most of the points are out of order	CMEC have informed that they have already carried out necessary adjustment and repair of digital scanners during 1st inspection of unit-4. However the committee still recommends that WAPDA should arrange replacement of these scanners with the better quality from its own resources. CE (O&M) Jamshoro may therefore please be advised to study this modification in association with CMEC and furnish specifications and other technical details for arrangement of procurement The problem is in electronic components such as I C's and transistors CMEC were however requested to provide necessary guidance to WAPDA Engineers and also furnish a list of important spares till the replacement of better quality scanners is made by WAPDA.	CE (O&M) Jamshoro must provide tech specifications of the required scanners by end of Oct 1992
11	Problem in the level indicators for Demi water tank, service water tanks. Modifications are required	CMEC will give their comments/ recommendations by 15th June, 1992	CMEC are still studying this problem They will require more time for providing reliable solution of this problem	CMEC must solve the problem by end of Sept 1992

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S.No	Problem/Deficiency	Proposal/Recommendation	Present Status	Action by
12	Most of temperature monitoring points of HP & LP metal temperature are out of order	M/S CMEC agreed that these points are very important but at present it could not be attended on Unit 2 & 3 as it requires lifting of casing. However on Unit 4 M/S CMEC are considering this problem seriously and will find out the reasons for its occurrence. The committee recommends that quality of the thermocouples be improved. In the existing thermocouples the wires inside protective steel tubing breaks. The replacement of thermocouples with improved type must be considered. M/S CMEC stated that the problem is already under study by them and reply can only be given if reasons for their failure is determined by their specialist during 1st inspection of Unit-4	CMEC informed that they have replaced damaged thermocouples with the similar type of new thermocouples on Unit-4. However the committee thinks that these replaced thermocouples will not last long and will start giving trouble again within one year of the operation of the plant. The Committee therefore did not agree with the replacement of similar thermocouples and recommend that CMEC Beijing may kindly be requested to arrange for the replacement of better quality thermocouples as change of better quality thermocouples is beyond the powers of CMEC Site offices. CE (O&M) may therefore be advised to take necessary action immediately	CE (O&M) in association with CMEC should collect tech specifications of all thermocouples by end of Oct 1992 so that arrangement of better quality thermocouples could be made
13	Additional temperature recorders for recording temperature before and after non-return check valves on HP exhaust pipe line and for curtis stage temperature	CMEC agreed but there are no spare points on the existing recorders. Therefore committee recommended to install additional recorders by WAPDA	CE (O&M) may kindly be advised to coordinate work with CMEC and expedite installation of the temp recorders as proposed by the Committee first on Unit-4 and then on Unit whenever is possible	CE (O&M) Jamshoro to please ensure that the proposed temp recorders be installed by CMEC specially on Unit 4 before end of 1st inspection
14	Most of the impulse lines are not properly looped for compensation of expansion and contraction	M/S CMEC were shown such lines on Unit-4. They have agreed to study the problem in detail and rectify necessary defects	The modification work is in progress and will be completed before the end of 1st inspection of Unit-4. However the work of similar modifications on Unit-2 and 3 will be carried out by CMEC in association with WAPDA staff as and when shut down on these units is available. CE (O&M) may please be advised to coordinate this work	Job is almost completed by CMEC
15	Difference in the readings of boiler drum level indicator/ specially on unit-2	M/S CMEC told that on Unit-3 & 4 there is no such problem. However o Unit-2, M/S CMEC experts are actively looking into the problem and they will submit a report to WAPDA regarding the problem and their remedial measures.	CMEC have informed that the condition have improved considerably and they hope that it will improve further with the passage of time	Job is attended

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S.No.	Problem/Deficiency	Proposal/Recommendation	Present Status	Action by
16	No proper identification on control wire terminals and difference in drawing terminal numbers and actual existing terminal numbers	M/S CMEC requested that WAPDA should point out the drawing in which such discrepancy exists However they are already carrying out identification markings on Unit-4 CMEC were requested to contact the design institute in China to provide the list of as built modified drawings supplied to WAPDA	a) The work on unit 4 is in progress b) Regarding as built drawings CMEC informed that they could not contact the agency responsible for supply of as built drawings in Beijing China They are again advised to take immediate action in this regard PES has also been advised to expedite CMEC in this regard	CMEC must complete this job by end of Oct 1992
17	Paging system/ communicating system is to be made operative	M/S CMEC agreed to carry out repair of main equipments of paging/ communication system	The work in progress	CMEC must complete this job by end of Oct 1992
18	Level indicator of C W pumps intake pit and raw water receiving ponds	M/S CMEC will study and give the solution by 15th of June, 1992	The problem is still under investigation CMEC will submit their report by the end of July 1992	CMEC must solve this problem by end of Oct 1992
19	C W pumps motor bearing/winding temperature indicator problem	M/S CMEC will study and given proper reply by 15th of June 1992	Same as above	do
20	Temperature/vibration indicators/protection for cooling tower fans	M/S CMEC will study and give proper reply by 15th of June, 1992	Same as above	do

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Thermal Power Station, Jamshoro
Mechanical Problems on Unit-2, 3 and 4

S.No	Problem/deficiency	Proposal/Recommendations	Present Status	Action by
1	Rapid change in upper and lower casing temperature on LP turbine is observed on every shut down	M/S CMEC agreed that the fault exists but reason of the rapid increase in temperature differential of LP casing is not confirmed They however agreed to study the problem at their design institute Meanwhile M/S CMEC will carry out thorough checking of the insulation of Unit-4 If required improvement will be made and behavior will be observed	In this regard a letter No CSO/1279/GM dated 1 6 92 from CMEC head office has been received in which it is informed that the problem of difference of temperature between MP and HP turbine is due to operational fault The committee do not agree as this problem persists from very beginning and could not be controlled even by Chinese specialists themselves Moreover similar problem is being experienced on Unit-4 at TPS Guddu which is also a Chinese u CMEC site office therefore informed that they require more time for further study of the problem They however confirmed that they have checked the insulation of the turbine casing location of thermocouples and found them OK. The difference of temperature between upper and lower flange of HP and IP turbine is not due to either improper insulation or defective thermocouples To investigate further CMEC informed that the Turbine Specialists form the manufacturer will be visiting Jamshoro site to study this problem The committee therefore suggested that till final solution of the problem is achieved, CE (O&M) Jamshoro may be advised to take special precautionary measures during starting and stopping of the unit to avoid any problem	CMEC must solve this problem and they must submit a detailed report on this problem and its solution in the light of the finding of their factory specialists

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S.No.	Problem/deficiency	Proposal/Recommendations	Present Status	Action by
2	Drain pipes of main steam pipings leading to HP turbine have frequently busted	M/S CMEC agreed that such bursting of drain pipes should not occur. They agreed with the view of committee and ensured following actions i Suitability of pipe material will be investigated ii Proper clampings will be provided iii Sufficient expansion arrangement to compensate for expansion due to elongation will be provided iv Sufficient provision will be made in the insulation to give room for the expansion of drain line freely	The Metallurgical test reports of various pipes arranged by WAPDA form outside agencies was provided to CMEC for checking/comparison. CMEC informed that pipe material is OK. Proper clamps of the pipes have also been checked and necessary action/repair work was carried out where ever required on Unit-4. However for Unit 2 and 3 similar work can be carried out by WAPDA under the supervision of CMEC during annual inspection/overhauling of this unit. CE (O&M) may kindly be advised to take action accordingly	CE (O&M) Jamshoro in association with CMEC must solve this problem by end of Sept 1992
3	Proper arrangement of Main steam drains to atmosphere	M/S CMEC will check the existing system and will contact the design department for suitable advice. They will submit their scheme by 15th June, 1992	The committee proposed that the drain of Unit-2 should also be diverted to outside turbine hall towards transformer as is done on Unit No. 3 and 4. CMEC will require more time to study this problem. They will submit their report before end of July 1992	CMEC must submit this report by end of Aug. 1992
4	Bearing cooling water alternate arrangement for River Intake water pumps	An alternate arrangement is necessary to continue operation of the pumps eve in case cooling/sealing water line is damaged. M/S CMEC showed their inability to help WAPDA in providing scheme for an alternate arrangement. However the committee proposes that a storage tank of sufficient capacity of water alongwith a tube well be provided to supply cooling/sealing water source in emergency for the design features. PES should submit proper scheme latest by 15th June, 1992	C.E. Projects may kindly be advised to request PES for providing proper scheme for alternate arrangement for Bearing Cooling water for river intake water pumps	CE Project may expedite PES to furnish their proposal and Tech details by end of Aug. 1992
5	Lube oil contamination problem and moisture entrance problem.	The Committee recommends to procure new oil centrifuge for Units 2, 3 and 4	C.E. (O&M) may kindly be advised to procure oil centrifuge one each for Unit 2, 3 and 4 on priority basis.	CE (O&M) Jamshoro ensure installation of centrifuge on Unit 2 and 3 by end of Aug. 1992 and on Unit 4 by end of Nov 1992

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S.No.	Problem/deficiency	Proposal/Recommendations	Present Status	Action by
6	Leakage problem in seal oil cooler	The two seal oil coolers removed form Unit-2 are under testing by M/S CMEC. Final report will be submitted by them by 15th June, 1992	CMEC informed that seal oil cooler was dismantled and checks were carried out by them, but they could not find any problem which may cause frequent leakage of the coolers. They are now carrying out further tests and will submit their report by end of July	CMEC must submit this report by end of August 1992
7	Speed control problem of emergency diesel generator set of Unit-2	M/S CMEC are waiting for their specialist to attend the fault. The specialist is expected to reach the site by 20th June, 1992	CMEC specialists are at site and are attending the job	CMEC must confirm that the job is attended by them satisfactorily
8	Bearing cooling water pumps have not been taken in service since commissioning	M/S CMEC stated that bearing cooling water pumps will initially be commissioned on Unit-4 and to be followed on other units later on	The modification/repair work has been done on emergency bearing cooler water pumps installed on Unit-4. They will be taken in service at the time of restarting of Unit-4	CMEC must ensure taking in service the emergency bearing cooling water pump by end of Oct. 1992
9	Problem of accumulation of huge quantity of sand on the coagulator Arrangement for their disposal	Removal of sand and its disposal from the coagulators require detailed in depth study. At present it is being removed through manual labour which is costly and time consuming. M/S CMEC have been requested to furnish their comments and recommendations	For the solution of problem of accumulation of huge quantity of sand in the water pretreatment area, the committee recommends that CMEC proposal given by them vide their letter No. CSO/1303/GM dated 15.6.92 may be accepted.	CE (O&M) Jamshoro to take necessary action
10	Frequent leakages in the intake raw water pipes	The committee recommends that these lines be interconnected before receiving ponds. M/S CMEC have already submitted their proposal which should be followed up. Moreover sufficient spare M.S. pipe pieces with seals is kept in stock for repairing of the lines	The case of issue of variation order to M/S CMEC for interconnection of intake water pipe lines may kindly be expedited case is in the office of GM (D&D). CE Projects Jamshoro may kindly be advised to follow up	Approval of the variation order has been granted by GM (D&D) Thermal Please ensure completion of work by end of October 1992
11	Flexibility in the supply of clarified water	The committee recommends that Unit-1, 2, 3 and 4 be connected to ensure additional reliability. The work can be carried out departmentally	CE (O&M) may kindly be advised to attend this job departmentally	CE (O&M) Jamshoro must ensure completion of the job by end of Dec. 1992
12	Interconnection of Demi water tanks	The committee recommends that all the Demi water tanks be interconnected. The work can be carried out departmentally	Same as above	- do -

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S.No.	Problem/deficiency	Proposal/Recommendations	Present Status	Action by
13	Interconnection of caustic soda and Hydrocholic storage tanks	They may be interconnected departmentally	Same as above	do
14	Interconnection of instrument air supply of unit 2 and 4	M/S CMEC agreed that for better reliability the instrument air supply of unit 2, 3 and 4 may be interconnected M/S CMEC have agreed to submit the scheme with cost estimate	M/S CMEC informed that they have requested their design institute in China for Technical details which are still awaited. A reminder is being sent against. The committee recommends instead of interconnection of the existing instrument air supply station to Unit 2, 3 and 4 an independent source of supply of instrument air be provided for each unit so that it can be connected in emergency. CE (O&M) may kindly be advised to study this problem in association with CMEC and PES and take appropriate action immediately	CMEC must submit their report by end of aug. 1992 CE (O&M) should work out the details of the 2nd alternative in association with PES and CMEC and submit to the o/o GM THE(O) for approval by end of Sept 1992
15	Interconnection of Hydrogen gas tanks of Unit 2, 3 and 4	M/S CMEC did not agree for interconnection of Hydrogen tanks of Unit-2, 3 and 4 because it may affect the safety of the other units if problem of purity or leakage occurred in any of the units. However they agreed that in case of emergency requirement, they can be temporarily interconnected.	Same as above	do

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Thermal Power Station, Jamshoro
Electrical Problems on Unit-2, 3 and 4

S No	Problem/Deficiency	Proposal/Recommendations	Present Status	Action by
1	Alternate Power supply for River Intake Pumps	In the opinion of the committee instead of making separate 6.6 KV overhead lines as an alternate power supply source to river intake pumps, the existing 11 KV supply being presently used for street lighting can be utilized by installing 11 KV/0.4 KV transformers at river intake pump house. However to ensure safety of the line against floods and water logging in the area, alternate structures of the line be reinforced with piping. There are four intake pumps for each unit. Each pump is of about 100 KW capacity. Normally one or two pumps are in service.	Chief Engineer (O&M) Jamshoro may kindly be advised to study the proposal and take action accordingly.	CE (O&M) must submit the details to the o/o GM THE(O) for approval by end of Sept 1992
2	400 V breakers have frequent problems with the result that all spare breakers have been utilized during the guarantee period	M/S CMEC suggested that they would study the problem in detail alongwith WAPDA Electrical Engineers and will submit their report by 15th June 1992. In the opinion of the committee some modifications can be made to avoid overheating/melting of plastic covers. Moreover sufficient spare breakers be kept in stock. M/S CMEC have also agreed to supply the spare breakers which they have utilized during guarantee period as replacement in place of damaged ones.	M/S CMEC informed that the replacement of used breakers will be arranged by them shortly. However the problem of burning/overheating of plastic covers of the breaker coils required further investigation by CMEC. CMEC will submit their report by the end of July 1992.	CMEC must submit their report by end of August, 1992.
3	No proper numbering on control wire terminals. There is also difference in drawing terminal numbers and actually existing terminal number	M/S CMEC are already carrying out proper numbering on # 4. Similar numbering will be done by them on Unit-2 and 3 as and when these units are shutdown. M/S CMEC requested that WAPDA Electrical Engineer may pointout the drawings in which such discrepancies exist	Work is in progress	The job must be completed by end of Oct 1992
4	Name plate of equipment relays etc. is in Chinese language only	M/S CMEC informed that the work has already been started and is in progress. The committee recommended that WAPDA Electrical staff should remain associated with M/S CMEC persons	M/S CMEC informed that they have assigned special staff for providing name plates of equipments, relays, etc in English. The work is in progress and will be completed shortly.	The job must be completed by end of October 1992

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S.No.	Problem/Deficiency	Proposal/Recommendations	Present Status	Action by
5	Sparking in slipring carbon brakes	M/S CMEC informed that it was mainly due to improper adjustment of carbon brushes spring tension. They have also adjusted brushes properly and after that the sparking has decreased considerably. They instructed that the frequency of changing carbon brushes be increased. Moreover M/S CMEC agreed to carry out modifications for the generator sliprings cooling air filtration system. WAPDA will provide the material and M/S CMEC will prepare modification scheme and help WAPDA in installation	After detail study of the problem, CMEC informed that the modification proposed earlier by the committee for providing additional filtration arrangements for cooling air cannot be provided as there is no space available for the same. Solution of the problem is beyond their competency, as such it may be referred to CMEC design institute Beijing China for some suitable arrangement. CE (O&M) may please be advised to take up the matter with CMEC Design Institute accordingly	E.E. Jamshoro was personally advised by GM TH(O) on 27.7.92 to slightly modify the existing fitting arrangement. CE (O&M) Jamshoro must ensure that the job is completed accordingly by end of Oct 1992 on Units 2, 3 and 4
6	Problem of scaling on the positive plate of the station D.C. battery cells on Units 2, 3 and 4	M/S CMEC informed that their experts form the battery manufacturer works visited the site. He delivered two lectures on the problem and maintenance of batteries and has already submitted a letter to WAPDA on this issue	Needful done	-
7	6.6 KV breakers have Mechanical problem such as rackin and rackout problem and limit switch problem	There is no such problem but only lack of Technical know how on the part of WAPDA staff. However M/S CMEC agreed to impart more practical training and demonstration to WAPDA Operation and Maintenance staff	Necessary training was provided and now there is no problem	-
8	Frequent damages to cooling tower motors of Unit 2, 3 and 4	Proper adjustment of blade angles has been carried out by CMEC and since then there is no such problem	The condition has improved considerably and the operation of cooling tower motor is satisfactory. The repair of cooling tower fan blade is now in progress by CMEC in association with WAPDA staff.	-
9	No proper tags on control and power cables	The work is in progress in Unit-4. The same on Units-2 and 3 will be carried out accordingly to availability of shut down	Needful done	-

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S No	Problem/Deficiency	Proposal/Recommendations	Present Status	Action by
10	Sealing of Electrical Panels	The Committee recommended to seal all the Electrical panels properly to protect entry of animals/insects etc M/S CMEC agreed to carryout checking and sealing of all electrical panels together with WAPDA staff	Sealing of Electrical Panels is in progress	CE (O&M) Jamshoro must pay special attention to this job in association with CMEC It must be completed by end of Oct 92 on all the units
11	Protection of 0.4 KV panels at 10 meter floor from water steam [illegible]	Committee recommended that adequate permanent arrangements be made on the panels to protect them from entrance of steam/water in case of leakage, so as to avoid any short circuiting WAPDA will carryout the work. For technical guidance CMEC will help WAPDA	No progress has so far been made in this regard CMEC were again requested to arrange sealing of all instruments and electrical panels on all the 3 units from dust water and steam CE (O&M) may please be advised to follow up the progress	- do -

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Thermal Power Station, Jamshoro
General Problems on Unit-2, 3 and 4

S No.	Problem/Deficiency	Proposal/Recommendations	Present Status	Action by
1	Shortage of spare parts	M/S CMEC agreed to prepare list of spar parts which are required by WAPDA and submit quotations at the earliest, however the committee emphasized M/S CMEC to give priority on the urgently required spares	CMEC informed that the work is in progress and complete list of spare parts for Units 2, 3 and 4 will be submitted to WAPDA very shortly	CMEC must furnish the complete list by end of Sept 1992
2	Doors and gates opening of machine hall compressor room etc to be sealed for protecting from dogs and cats	The committee proposes that opening of machine hall and other areas should be provided with the additional wire gauze doors to prevent the entrance of dogs and cats	CE (O&M) may kindly be advised to take up the matter departmentally This is very important as presently the condition is quite hazardous	CE (O&M) Jamshoro must ensure completion of this job by end of Nov 1992
3	Fire fighting arrangement to be provided to newly constructed ware house	The committee proposes that Chief Engineer (O&M) should make fire fighting arrangement for newly constructed ware house	CE (O&M) may kindly be advised to take action accordingly	CE (Project) must ensure completion of the job by end of Oct 1992
4	Alternate arrangement for return/waste water at pre treatment area	The committee recommends that in order to avoid this frequent interruption it is proposed that a separate return water pit alongwith pump arrangement be constructed at pretreatment are so that the return of water to river Indus may be continuous	Work is in hand with C E Projects Jamshoro. He may kindly be advised to expedite completion of the job	CE Project must expedite progress of work
5	Frequent cleaning of oil decanting area	The committee recommends that the area should be kept clean from oil and other fire hazard material such as oil socked cotton rags, rubber hoses etc	Action from C E (O&M) is requested	CE (O&M) Jamshoro must ensure regular cleaning the condition is extremely hazardous
6	Arrangement of simulator and special emphasis on improvement of training facilities	Considering the experience and technical capability of the existing operation staff posted at Jamshoro, the committee recommends that arrangement for installation of a simulator at Jamshoro should be made on top priority basis This could not only help in training of the operation staff of TPS, Muzaffargarh where similar power generating units are being installed	The case of procurement and installation of simulator at Jamshoro may kindly be expedited	Case is with CE (MMS). needful is being done

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	Replacement of flange gaskets and glands of pumps and valves Grinding and checking of all regulating and control valves	Unit No 4 is under Inspection in order to improve its reliability it is proposed that CMEC in association with WAPDA staff must ensure replacing flange gakets valve and pump glands installed on all steam water and oil circuits	C E (O&M) Jamshoro may kindly be advised to ensure attendance of these jobs	CE (O&M) Jamshoro must ensure that these jobs must be attended on Unit-4 during its 1st inspection

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U. S. AGENCY FOR INTERNATIONAL DEVELOPMENT
PRIVATE SECTOR POWER PROJECT

CONTRACT NUMBER
391-0494-C-00-0540-00

DRAFT REPORT

JAMSHORO POWER STATION
UNITS 1,.2, 3, & 4
EQUIPMENT CONDITION ASSESSMENT REPORT

CONTROL WORK PLAN 1.23.0
EBASCO SERVICES INC.

ONE VOLUME ONLY

Submitted by:

International Resources Group, Ltd.
ATS Center, 1st Floor
30 West, Blue Area
Islamabad, Pakistan

In Association With:

John T. Boyd Company
Ebasco Overseas Corporation
Hunton & Williams
International Training and Education Company
ESI/Florida Power and Light Company

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November 1991

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JAMSHORO POWER STATION

UNITS 1, 2, 3 & 4

EQUIPMENT CONDITION ASSESSMENT REPORT

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JAMSHORO POWER STATION

UNITS 1, 2, 3 & 4

EQUIPMENT CONDITION ASSESSMENT REPORT

SECTION 1.0 - SUMMARY

This report documents our equipment condition assessment review of the Jamshoro Power Station. The purpose of this review is to provide an overall condition assessment of the major systems, components and structures necessary for the safe and reliable generation of electricity. Also identified are repairs or replacements of major components normally designed to last 20 plus years but due to the current condition or operation are anticipated to fail within the next 20 years.

Section 2.0 "Introduction" outlines the purpose and scope of work presented in the report together with background information on the generating station. The sources of data used in our analysis are also identified. Section 3.0 "Overall Assessment and General Concerns" provides performance data and lists concerns in the areas of operation, maintenance, quality of installation and housekeeping that should be addressed to provide safe and reliable operation of the units. Following this section, details of our assessment for the power plant major system and components are provided. Separate sections are provided for the Unit 1 Boiler, Turbine-Generator and Balance of Plant Systems and Components. A similar breakdown is provided for Units 2, 3 & 4, (treated as one) since the units are duplicates. An additional section for the Common Facilities, is also provided.

1.1 Overall Assessment

The systems and components reviewed at the four units of the Jamshoro Power Station should be suitable for continued operation for the next 20 years. Projected repairs and replacement of major components and sub-components of equipment that can reasonably be expected to provide relatively trouble free service, by American standards, for 20 plus years service are provided in Section 1.2. The assessments are based upon the newness of the units, the effects of the operation to date (September, 1991), projected operating regimen, adherence to manufacturer's recommended operating and maintenance procedures and resolution of current deficiencies. The assessment assume all equipment currently in place was designed, manufactured and installed in accordance with applicable code and standards and are of power house quality. Verification that the above criteria have been met was not part of the scope of this equipment condition assessment report.

In general, Unit 1 facility appears to be of superior quality and exhibits better overall

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workmanship with fewer current problems than Unit 2, 3 & 4 Unit 1 is expected to operate with fewer difficulties and less maintenance than anticipated for Units 2, 3 & 4.The current deficiencies, especially in the instrumentation and control systems, will cause more frequent unit trips and require higher maintenance levels that Unit 1

1.2 Projected Repairs and Replacements

The following repairs and replacements of major components are anticipated

- Replacement of the cold end baskets due to corrosion on the two Unit 1 air heaters at 10 years intervals. Estimated cost is $275,000 per replacement.

- Replacement of the cold end baskets due to corrosion of the two Units 2, 3, & 4 air heaters at 5 year intervals. Estimated cost is $275,000 per replacement per unit.

- Major repairs, due to corrosion, of the Unit 1 outlet flue between the years 2001-2011. Estimated cost of the repair is $250,000.

- Major repairs, due to corrosion, of the Units 2, 3 & 4 outlet flues between the years 1996-2011. Estimated cost of the repair is $250,000 per unit.

- Replacement of the DC batteries for Units 2, 3 & 4 within 5 years. Estimated cost for new batteries is $100,000 per unit not including installation.

Note: All costs are given in current (1991) US dollars and are based on costs for similar repairs or replacements at plants operating in the United States of America.

In addition to the above anticipated repair and replacements, there are a number of outstanding deficiencies and areas requiring further study identified in the report. Most of these problems are currently being addressed by plant personnel or are items covered under the warranties for Units 3 and 4. It is anticipated these items will be corrected prior to privatization.

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JAMSHORO POWER STATION

UNITS 1, 2, 3 & 4

EQUIPMENT CONDITION ASSESSMENT REPORT

SECTION 2.0 - INTRODUCTION

2.1 Purpose

The purpose of this equipment condition assessment report for Jamshoro Units 1, 2, 3 & 4 is to provide the following:

- A general overview of the power plant systems and equipment.
- Identification of anticipated future repairs and replacements of major components based on the current condition of the equipment, review of the current plant operating and maintenance records and practices and projected operating duty.
- Estimated costs for repairs or replacements identified above.
- Identification of general concerns noted during the review process.

2.2 Scope

The equipment condition assessment applies to the bulk of the power plant systems and components necessary for safe and reliable operation of the units. The current condition of the equipment is based on the information provided by our review of plant records, interviews with plant operating and maintenance personnel and observations made during the site visit.

It is assumed all equipment currently in place was designed, manufactured and installed in accordance with applicable codes and standards and are of power house quality. Verification that the above criteria have been met were not part of the scope of this report.

The projections for future repairs or replacements is limited to major components and sub-components of equipment that can reasonably be expected to provide relatively trouble free service, by American standards, for 20 plus years service. Components and component parts subject to normal wearing mechanisms are usually handled as part of

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JAMSHORO POWER STATION

UNITS 1, 2, 3 & 4

EQUIPMENT CONDITION ASSESSMENT REPORT

SECTION 2.0 - INTRODUCTION

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maintenance and are excluded. Future operation of the units, according to the Water and Power Development Authority (WAPDA) personnel, will be base loading for the next 20 years with a minimum capacity factor of 60% and approximately 10 starts per year. The projected repairs and replacements are based on this operating regimen and assumes the manufacturer's operating and maintenance procedures are followed and the systems and equipment are kept in good operational condition. It is anticipated the current problems identified will be resolved in the near future.

2.3 Plant Background

The site is located at the Jamshoro area on the bank of the Indus River. The nearest city is Hyderabad City which is approximately 18 km from the site. Currently there are four units installed and in operation at the Jamshoro Power Station. Unit 1 was designed and built by Tokyo Electric Power Service Co., Ltd.. Units 2, 3, 4 were designed and built by North East Electric Power Design Institute, Ministry of Water Resources and Electric Power Changchun - Peoples Republic of China (CMEC). All the units are built on the solid limestone formation at the plant site.

The units were commissioned as follows:

Unit No. 1	January 27, 1990
Unit No. 2	December 3, 1989
Unit No. 3	June 27, 1990
Unit No. 4	January 21, 1991

Units 1 and 2 have been turned over to WAPDA and are currently being operated and maintained by WAPDA personnel; Units 3 and 4 are under warranty and are currently being operated and maintained by CMEC and WAPDA personnel.

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2.4 Data Sources

The data required to perform the current condition assessment was obtained by a team of five Ebasco engineers during a ten (10) day visit to the Jamshoro Station in September 1991. The following sources of information were utilized

- Plant records including contract conformance documents, manufacturer's operating instructions and maintenance manuals, design drawings, first inspection reports for Units 1 & 2, unit trip reports, daily operating log sheets, and maintenance records. It is noted the maintenance records were minimal as the units are new and maintenance for Units 3 & 4, and until recently, Units 1 & 2 were responsibility of the supplier

- Visual inspection of the power facility. As the units were in operation, internal inspection of components was not feasible. It is noted that visual external inspection of mechanical, electrical and instrumentation and control equipment provide limited data to perform condition assessment. In the case of the civil structures, a visual inspection is essential in assessing the current condition.

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JAMSHORO POWER STATION

UNITS 1, 2, 3 & 4

EQUIPMENT CONDITION ASSESSMENT REPORT

SECTION 3.0 - OVERALL ASSESSMENT AND GENERAL CONCERNS

3.1 Unit Performance - Capacity

Based upon review of selected Unit Daily Log Sheets and review of Summary Data from Commissioning to August 31, 1991, the units are capable of the following output:

	Continuous Operation	Demonstrated Maximum
Unit # 1	250 MW	262 MW
Unit #. 2	200 MW	210 MW
Unit # 3	200 MW	210 MW
Unit # 4	200 MW	210 MW

3.2 Unit Performance - Heat Rates

Unit #	Heat Rate (K. Cal/KWH)	
	Design	Average
1	2284	2441
2	2584	2547
3	2584	2594
4	2584	2725

The average heat rates above are plant operating personnel estimates based on fuel consumed and power generated from Date of Commissioning to August 31, 1991. These encompass all operating loads and start-ups and thus are expected to be above the Design (guaranteed) Heat Rate at the best operating point - Economic Continuous Rating.

Performance acceptance tests for Units 1 & 2 have been completed and the units accepted by WAPDA. As recorded in the Unit 1 Report on Performance Test, the actual performance met the guarantee. The Unit 2 performance Test Report was unavailable at the time of our site visit.

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JAMSHORO POWER STATION

UNITS 1, 2, 3 & 4

... CONDITION ASSESSMENT

3.3 Unit Performance ...ty

The information provi... operating personnel on Summary Data Sheets "As of 31.08.1991 Since Commissioning" indicates the following Unit Availabilities:

Unit 1	-	85.02% Available
Unit 2		61.06% Available
Unit 3	-	...% Available
Unit 4	-	38% Available

Unit 1 & 2 availability percentages include the 45 day and 57 day shutdowns respectively for First Inspections. In addition, the Unit 2 availability suffered due to a bowed high pressure turbine rotor keeping the plant off line for 55 days. It is noted however, these availability factors should not be considered indicative of future plant availability. The start-ups of the units are recent and low availabilities during the first year of operation are normal until all equipment has been completely checked out.

3.4 Unit Operation

Per the plant personnel provided Summary Data, the hours of operation, capacity factor, and total KWH for each unit from commissioning through August 31, 1991 are as follows:

Unit Number	Hours of Operation	Capacity Factor	Total MWH Generated
1	...587	.63	1,837,126
2	9,329	.73	1,355,655
3	7,376	.76	1,115,441
4	4,505	.78	707,604

Operation of Unit 1 is satisfactory. The unit is capable of and normally operates in the automatic mode on unit master load control. The operating instructions prepared by Mitsui, the constructor, are comprehensive. In addition, plant personnel indicated an extensive operator training program was conducted by Mitsui.

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All of the above have contributed to the relatively good operation of Unit 1 and a unit availability of 83% o[illegible]ths of [illegible]ration.

Operation of Units 2, 3 & 4 have been more troublesome than Unit 1. The units are incapable of operating in a co[illegible]ely automated mode at this time due to the unreliability of instrumentation. The units require a high degree of operator attention to adjust the process variables manually. In addition, calibration of the instrumentation has not been completed resulting in inconsistent measurements relayed back to the control room. It was noted that the thermocouples on Units 2, 3 & 4, unlike Unit 1, are not installed in thermowells. This necessitates a shutdown of the unit to repair or replace a faulty thermocouple and thus will tend to lower overall unit availability. The Operating Manuals provided by CMEC are not as comprehensive as those furnished for Unit 1 by Mitsui. Additionally, operator training suffered more from the difficulties in communicating between plant operating personnel and Chinese engineers, resulting in less skilled operators.

3.5 Maintenance

A long term maintenance program for all four units has not yet been established. Due to the current shortage of power throughout Pakistan, plant maintenance personnel stated these units will not be shut down for overhaul outages for at least 5 years. Maintenance activities for all four units were directed by the suppliers for the first year of operation. Maintenance for Units 1 and 2 was only recently turned over to WAPDA, while Units 3 and 4 maintenance is currently being coordinated by CMEC. Routine maintenance checks are performed daily by WAPDA personnel and repairs made as required. This maintenance mode is acceptable based on the newness of the units; however, a long term maintenance program should be established.

The Maintenance Manuals provided with Unit 1 are comprehensive and supply the necessary information for proper care. The manuals for Units 2, 3 & 4 however, are sketchy at best. More complete manuals should be prepared for these units to aid the maintenance staff in performance of their duties. In addition, maintenance and trouble shooting activities will be hindered on Units 2, 3 & 4 due to lack of "as built" drawings. These "as-built" drawings have been provided for Unit 1.

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3.6 Quality of Installation

The walk-through inspections of major components and systems that comprise the power generating equipment for Jamshoro Unit 1 through 4 revealed that there is a major contrast in the workmanship on Unit 1 (Mitsui) as compared with Unit 2, 3 & 4 (CMEC) Although, certain of these differences may be strictly appearance related, such as the quality of boiler lagging installation, there are areas where the workmanship of installation will result in increased maintenance during the operating life of the units Several examples of conditions observed on Units 2, 3, & 4 that will probably affect future operation and maintenance are cited below:

1 Cable trays that have no covers and are exposed to the environment Several areas have accumulated considerable debris on and around the cables

2 Incomplete lagging at each backstay elevation at the corners of the boiler. The blanket insulation is exposed to the weather, and in several areas the boiler tubes are visible where the insulation is missing.

3 Much of the lagging around the burner deck on unit #2 was assembled using pop rivets. In many areas the pop rivets have failed, probably because of inadequate expansion provision. In these areas the lagging is hanging loose

4 The welding on many supports is very poor. The fillet welds have excess crown, are irregular, and appear to have poor penetration.

5. The local control boxes located throughout the plant have no gaskets on the access door assembly to prevent moisture and dust from accumulating inside the control boxes.

6. The wiring of various instruments is poorly terminated and exposed to the elements.

7. Control board wiring is not marked with permanent identification tags.

Aside from the external appearance, a major concern is these conditions may or may not reflect the quality of workmanship that was used in the fabrication of equipment and components not visually accessible during the walk-through inspection.

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3.7 General Housekeeping

The General Housekeeping of the station was relatively poor. Construction debris was observed throughout the facility even though all units are operational. The residual oil unloading area was especially lacking in good housekeeping practice. Oil spillage was commonplace with oil and water mixtures noted in trenches and on grade level. This creates a serious fire hazard and should be attended to immediately. Good housekeeping practices promote ease of operation and maintenance and will be reflected in the units availability and reliability.

3.8 Detailed Condition Assessments

The general concerns discussed above were based upon the observations made during the site visit and discussions with plant operating and maintenance personnel. These concerns, as well as the items identified in the condition assessments for the individual system and components, may not reflect all current deficiencies or problems, but only the more apparent and serious ones uncovered during our review. Many of these deficiencies have an adverse impact on operation and maintenance, but may not necessarily result in repairs or replacements of the major components. However, if false instrumentation readings lead to maloperation of the equipment or result in exceeding the design margins of the equipment, premature failures may occur. It is recognized that the units have only recently started and a number of the outstanding problems are commonly encountered during the start-up phase of all units. Plant personnel are currently addressing most of the problems on Units 1 & 2. Since Units 3 and 4 are still under warranty, it is expected that problems for these units will be addressed by the supplier.

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JAMSHORO POWER STATION

UNITS 1, 2, 3 & 4

EQUIPMENT CONDITION ASSESSMENT REPORT

The Condition Assessments, listed below, follow this section:

Unit 1 Steam Generator Components & Systems

Unit 1 Turbine-Generator Components & Systems

Unit 1 Balance of Plant Components & Systems

Units 2, 3 & 4 Steam Generator Components & Systems

Units 2, 3 & 4 Turbine-Generator Components & Systems

Units 2, 3 & 4 Balance of Plant Components & Systems

Units 1, 2, 3 & 4 Common Facilities

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JAMSHORO UNIT 1

STEAM GENERATOR COMPONENTS & SYSTEMS

The unit 1 steam generator is a Mitsui-Riley type ISR boiler. The unit is equipped for firing residual oil only. The steam generator components and systems evaluated consist of the following:

Steam Generator
- Superheater/Reheater - Tubing
- Superheater/Reheater - Headers
- Superheater/Reheater - Piping
- Economizer Inlet Header
- Economizer Inlet Tubing
- Steam Drum
- Boiler Enclosure

Boiler Air and Flue Gas Systems
- Forced Draft Fans
- Steam Coil Air Heaters
- Air Preheaters
- Gas Recirculation Fans
- Ducts, Dampers & Expansion Joints

Boiler Combustion System

Automatic Burner System

Automatic Boiler Control System, High Pressure/Low Pressure Turbine Bypass System

Auxiliary Steam Systems - Boiler Side
- House Boiler
- Soot Blower System

Boiler Structure

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JAMSHORO UNIT 1

STEAM GENERATOR

Description

The Unit #1 steam generator is a Mitsui-Riley type ISR boiler equipped with a three-stage superheater and split reheater. The boiler is pressure fired with gas recirculation for reheater steam temperature control. Maximum rated steam output is 795.633 tons per hour (1,750,000 lb per hour) at 169 kg/cm² (2400 psi) and 538° C (1000°F) at the superheater outlet. Steam conditions leaving the reheater are 538°C (1000°F) and 40.91 kg/cm² (581 psi)

All superheater, reheater and economizer elements are designed to be completely drainable. The boiler is fired by eighteen (18) circular burners located on the front and rear furnace walls at three (3) elevations. The unit is equipped for firing residual oil exclusively. There are no natural gas firing provisions currently installed on this boiler.

The primary furnace is 13.38 meters (44 ft.) wide by 9.003 meters (29'-6") deep. The front, upflow convection pass, which is approximately 14.75 feet deep, contains the final superheater, final reheater, and secondary superheater elements. The rear, downflow convection pass is approximately 14.75 feet deep and encloses the primary superheater, primary reheater, and the economizer elements.

Comments and Current Condition

The first year inspection of the boiler was conducted between April 15 and June 1, 1991. No major abnormalities were found on either the gas side or water side of the boiler. Minor repairs were made to the refractory throats on several burners during the outage.

Based on the walkdown of the unit, the review of the first year inspection report, and interviews with plant personnel, it was determined that the boiler is in good condition after accumulating approximately 12,000 operating hours since commissioning on January 27, 1990.

Assessment

Prior to the first year inspection, a complete performance test of Unit #1 was conducted by Mitsui, Fuji Electric and the Riley-Mitsui Consortium during April, 1990. The results of the testing determined that boiler performance and efficiency meet or exceed contract requirements.

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JAMSHORO UNIT 1

STEAM GENERATOR

This boiler can be expected to provide reliable service over an extended period of time by operating the unit within the parameters established by the manufacturer and by performing routine maintenance and periodic inspections.

The pressure firing feature of this boiler requires special consideration to avoid hot spots and gas leaks Very conservative rates of temperature change during start-ups and shutdowns are recommended to prevent long range problems associated with a pressure fired boiler

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JAMSHORO UNIT 1

BOILER AIR AND FLUE GAS SYSTEMS

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Description

The air and gas systems supply heated combustion air to the boiler windbox and provide a conduit for conveying flue gas from the boiler outlet to the stack. The major components of the air and gas systems consist of the forced draft fans, air heaters, air ducts, windbox, boiler outlet flue, and the flue from the air heater gas outlet to the stack. In addition, the boiler is equipped with a gas recirculation system that extracts a portion of the flue gas from the economizer outlet and reintroduces it into the boiler furnace as a means of extending the temperature control range of both the superheater and reheater.

The major components of the air and gas systems include:

(2) Forced draft fans by Nakashima Mfg. Co. Air foil rotor design, double inlet

(2) Steam coil air heaters by Seo Koatin Kogyo Co., Ltd

(2) Ljungstrom 26-VIX-2550 Air Preheaters by Gadelius K.K

(2) Turbo Vane, double inlet gas recirculation fans by Nakashima Manufacturing Co., Limited.

Comments and Current Condition

All components of the air and flue gas systems were inspected during the first year inspection. Per the Inspection Report, fan bearings were disassembled and inspected, and the fan rotors were examined. The air heater was water washed, and all components, including the cold end baskets, were found to be highly satisfactory. Operation has been normal since returning the unit to service June 1, 1991 following completion of the first year inspection.

Assessment

With the exception of the air heater baskets and the flue connecting the boiler to the stack, the air and gas systems were judged to be suitable for extended operation. The heating surface of the air heater and the flue connecting the air heater to the stack are subject to corrosion resulting from the exclusive firing of residual oil containing approximately 3 percent sulfur. It is anticipated that air heater cold end baskets will require replacement at 10 year intervals at an estimated cost of $275,000 per replacement. The outlet flue is projected to require major repairs at a point between 10 and 20 years

JAMSHORO UNIT 1

BOILER COMBUSTION SYSTEM

Description

The boiler is equipped with eighteen (18) circular Venturi-type steam atomized oil burners manufactured by Volcano Co., Limited. The burners are located at three elevations on the front and rear walls of the furnace in an opposed-firing configuration. Eighteen electric spark, light oil ignitors by the Volcano Co. have been provided for ignition of the main burners.

The burners are designed for residual oil firing only. This boiler is not equipped for burning natural gas.

Comments and Current Condition

Burner operation was observed to be fully automatic with burners placed in service or removed from operation, depending on load, without operator intervention. No significant operating problems have been experienced with the combustion systems equipment on this unit.

The burners and lighters were inspected during the first year inspection in early 1991 and were found to be completely satisfactory.

Assessment

The oil burners and ignitors are projected to operate satisfactorily for an extended period of time. Normal maintenance is expected involving routine cleaning and adjustment. Periodic sprayer plate replacement can be expected due to erosion of the exit orifice. Replacement of the sprayer plates is normal, and is required to maintain proper operation of the burners.

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JAMSHORO UNIT 1

AUTOMATIC BURNER SYSTEM (ABS)

Description

The automatic burner system is an electronic digital control system manufactured by Forney International Incorporated of United States of America. The system is Model AFS 100 and controls nine (9) burner pairs. The system is microprocessor based except the Master Fuel Trip (MFT) circuit which consists of DC electromagnetic relays.

All top and middle level burners can be manually started and stopped in pairs from the BTG board in the central control room and corresponding local control panels near the front burners. However, six (6) burners at the lowest level, which also serve as warm-up burners, can be manually started and stopped either in pairs or individually from the BTG board and individually only at local control panels

The six (6) burners, at the lowest level are automatically started and stopped in pairs depending on burner header pressure

The twelve (12) burners except those at the lowest level, are automatically stopped in pairs in case of emergency condition, such as, Fast Cut Back (FCB).

A master fuel trip pushbutton is available on BTG board to quickly shutdown the boiler in case of emergency.

This system provides of the following control functions:

- Furnace purge sequence
  Master fuel trip
- Ignition fuel trip
- Warm-up fuel trip
- Oil fuel trip
- Ignition burner start/stop
- Oil burner start/stop
- Gun purge
- Fast cut back
- Air resister open/close
- Oil selection
- Ignition burner header leak check

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JAMSHORO UNIT 1

AUTOMATIC BURNER SYSTEM (ABS)

- Warm-up burner header leak check
- Oil burner header leak check

Comments and Current Condition

Interviews with plant O&M personnel and review of unit trip record indicated that the unit tripped two times, on June 30, 1990 and March 7, 1991, due to the automatic burner system. Both trips were due to human error while working on the system.

The automatic burner system appears to be in satisfactorily condition based upon the data reviewed and unit walk-through inspection No unusual conditions were noted.

Assessment

Assuming proper selection of component, availability of spare parts and adherence to the manufacturer's O&M procedures, the automatic burner system should be suitable for 20 years.

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JAMSHORO UNIT 1

AUTOMATIC BOILER CONTROL SYSTEM (ABC)
HIGH PRESSURE/LOW PRESSURE TURBINE BYPASS SYSTEM

Description

The automatic boiler control system is microprocessor based and manufactured by Yokogawa Microprocessor Electric Corporation (System CENTUM-DE)

The system hardware consists of (2) field control stations, (1) terminal board cubicle, (2) marshalling cabinet, (4) I/P converters, (7) I/O positioners, (39) hand/auto stations, (1) unit master supervisor panel, flow/level/pressure/differential pressure transmitters, flow elements, T/Cs, O_2 analyzers, regulators, and HP turbine bypass control valves

The Automatic Boiler Control System (ABC) is designed to control the boiler with coordination between turbine, generator, and boiler. The ABC provides the following functions

- o Unit master control (including turbine master and boiler master)
- o Automatic Combustion Control provides fuel oil flow control, flue gas O_2 control, air flow control, and residual oil pump discharge pressure control.
- o Feedwater Control is designed to maintain the drum level at normal level within limits Single element (drum level) is used at low load, and three elements (level, feedwater flow, and steam flow) are used at normal loads. Feedwater regulators and BFP speed control are utilized to maintain drum level within the various modes of operation. A startup feedwater control valve and main feedwater control valve are provided
- o The Superheat (SH) steam temperature is controlled by regulation of spray water flow of the secondary SH inlet to maintain a final SH outlet temperature of 541°C.
- o Reheat steam temperature control. It is designed to maintain reheat steam temperature at 541°C for loads greater than 50% by positioning the dampers of the gas recirculation fans A&B.
- o Air Preheater (AH) Cold-End Temperature Control is designed to maintain average temperature of air inlet and flue gas outlet at 115°C based upon residual oil sulfur content of 3 to 5%. This is accomplished by regulating the heating steam flow to the steam coil air preheater.

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JAMSHORO UNIT 1

AUTOMATIC BOILER CONTROL SYSTEM (ABC)
HIGH PRESSURE/LOW PRESSURE TURBINE BYPASS SYSTEM

- High Pressure Turbine Bypass Control is designed to operate during startup to increase the boiler load quickly and shortcut the unit startup time to reduce mismatching between main steam and turbine metal temperature. It also operates when a large load rejection occurs in the power system. The excess steam is dumped into the condenser by LP and HP turbine bypass valves.

The automatic boiler control (ABC) system also has the following necessary and effective interlocks:

- Protection interlocks in case of ABC failure.
- Interlock for unit operation mode selection (coordinate mode, turbine follow mode, boiler follow mode, unit manual mode).
- Master fuel trip interlock.
- Cross limit interlock which restricts unbalance between fuel flow and air flow to avoid unstable firing and steam temperature excursion.
- Fast Cut Back (FCB) interlock, which reduces the load quickly to 20% of rated MW.

Comments and Current Condition

Interviews with plant personnel, walk-downs, and review of Unit 1 records, indicated high reliability and excellent performance.

Assessment

Based upon newness of the plant, assuming proper design and selection of components, adherence to the manufacturer recommended O&M procedures and availability of spare parts, the system should be suitable for 20 years continued operation without major repairs or replacements.

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JAMSHORO UNIT 1

AUXILIARY STEAM SYSTEMS - BOILER SIDE

Description

The major components of the boiler-side auxiliary steam systems consist of the house boiler and the soot blowers serving the main boiler and the air preheaters.

The house boiler is a pressurized furnace, shop-assembled, membrane wall construction, oil fired unit manufactured by Hyundai Heavy Industries Co., Ltd. The boiler is rated at 20,000 kg (44,100 lbs.) per hour of saturated steam at 7 kg per cm² (100 psi). The boiler is equipped with one burner.

The soot blower system consists of twenty-eight (28) STR-8E long retractable and eight (8) STR-8E half retractable soot blowers by Mitsubishi Heavy Industries Ltd.; and two (2) swing type cleaning devices for the air preheaters supplied by Gadelius K.K.

Comments and Current Condition

Complete inspection of the auxiliary boiler and the soot blowers system were incorporated in the first year inspection. All equipment checked out to be satisfactory.

Assessment

The auxiliary house boiler and the soot system are expected to operate satisfactorily for an extended period of time. Normal maintenance is anticipated to maintain the equipment in good running order and to prevent the need for major repairs or replacement.

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JAMSHORO UNIT 1

BOILER STRUCTURE

Description

The boiler structure is 23.2 meters wide in the North/South direction, 50.0 meters long in East/West direction and 47.2 meters high at its highest roof points. There are twelve floor levels most of which are spaced 3 meters from each other. The weight of the entire boiler is suspended by hangers from the girders at the roof elevation. The boiler wall is laterally supported at platform elevations for wind and earthquake loads but is allowed to expand and contract due to temperature changes without being restrained. The girder loads are transferred to columns and carried down to the reinforced concrete mat foundation at El - 1.00 meters. The columns and beams at several platform elevations are braced by a vertical and horizontal bracing system to resist the horizontal loads due to wind and earthquakes. The boiler building is not enclosed by walls.

The stairwells provide access to the platforms. There is also an elevator shaft, separate from the boiler building structure, with horizontal ties at the platform levels. The elevator operates between ground level El. 0.0 meters and boiler drum level at El. 39.00 meters. The platforms are covered by galvanized steel gratings and protected by hand rails and toe plates.

Air heaters and gas ducts, fans, burners and steam pipes to and from the turbine building are supported by the boiler building structure. The ground floor in the boiler area has a 1/200 slope and a trench for floor drains with a checker plate cover.

Comments and Current Condition

The Unit 1 boiler structure appears adequately designed and detailed. It is in good condition. There are no pockets to accumulate water and other loose debris which could initiate corrosion and deterioration.

Because the boiler building is a tall structure, there was a high wind constantly blowing dust and fine sand at the higher platform elevations. This may accelerate weathering of the paint on the steel surfaces.

No deterioration, cracks or settlement were observed at the ground floor level. The top of the mat foundation is 1 meter below the ground elevation and was not accessible for inspection. The mat foundation is supported by a solid limestone formation.

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JAMSHORO UNIT 1

BOILER STRUCTURE

Assessment

Assuming proper design and erection, the boiler building structure should be suitable for the next 20 years of operation. The structural steel should be protected against corrosion by proper maintenance at the required intervals.

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JAMSHORO UNIT 1

TURBINE - GENERATOR COMPONENTS & SYSTEMS

The Unit 1 turbine-generator is a FUJI Electric (Japan) 250 mw FTHR1 562/68-2 type indoor unit. The turbine is a tandem compound, 3 casing, double-flow exhaust, reaction, reheat, condensing type. The generator is a synchronous, 2 pole unit type which is hydrogen cooled. The unit has a static excitation system.

The turbine-generator components and systems that were evaluated consist of the following:

High Pressure Stationary Components:
- High Pressure (HP) Outer Casing
- HP Inner Casing
- Intermediate Pressure (IP) Outer Casing
- IP Inner Casing
- HP Stationary Blades
- IP Stationary Blades
- Combined Main Stop and Main Steam Control Valves
- Combined Reheat Stop and Intercept Valves
- HP Turbine Lead Piping and IP Turbine Lead Piping

Turbine Rotating Components:
- HP Rotor
- IP Rotor
- Low Pressure (LP) Rotor
- HP Rotating Blades
- IP Rotating Blades
- LP Rotating Blades

Low Pressure Stationary Components:
- LP Outer Casing
- LP Inner Casing 1
- LP Inner Casing 2
- LP Stationary Blades
- Crossaround Piping

Generator and Excitation - Electrical & Isolated Phase Bus Duct

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JAMSHORO UNIT 1

TURBINE - GENERATOR COMPONENTS & SYSTEMS

Generator Rotating Components Mechanical
- Generator Rotor Forging
- Generator Retaining Rings

Turbine Supervisory Instrumentation & Monitoring

Stream Turbine Controls, Electrohydraulic Governor Control System

Turbine-Generator Auxiliary Components/Systems
- Lubricating and Hydraulic Oil System
- Turning Equipment
- Gland Steam Seal System
- Turbine Bearings
- Turbine Pedestals
- Generator Seal Oil System
- Generator Hydrogen System

Performance

The Jamshoro Unit 1 performance test was conducted in April 1990 The pertinent turbine-generator results of that testing were:

The corrected gross turbine-generator heat rate (ECR) was measured to be 1912.1 Kcal/Kwh which is 0.10% better than the guaranteed turbine-generator heat rate (ERC) of 1914.0 Kcal/Kwh with an allowable tolerance of + 1.5%

The corrected turbine-generator maximum output (MRC) was measured to be 254.0 Mw which is 1.6% better than guaranteed turbine-generator maximum output (MCR) of 250 Mw with an allowable tolerance of - 0.2%.

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JAMSHORO UNIT 1

HIGH PRESSURE STATIONARY COMPONENTS

Description

The high pressure stationary components on this FUJI Electric FTHRI 562/68-2 turbine are composed of the following: HP outer casing of the barrel type with a vertical circumferential flange at the exhaust and with four main steam connections, HP inner casing with a split bolted vertical-longitudinal joint, IP outer casing with a conventional bolted horizontal joint and with two hot reheat steam connections, IP inner casing with a conventional bolted horizontal joint, HP stationary blades including the inlet impulse nozzle and 20 stages of reaction nozzles, IP stationary blades of 17 rows of reaction stages, 4 combined main stop and main steam control valves, and 2 combined reheat stop and intercept valves, HP turbine lead piping and IP turbine lead piping.

The HP outer casing, HP inner casing and IP inner casing are Chromium-Molybdenum-Vanadium alloy steel. HP and IP stationary blades are 12% Chromium-Molybdenum-Vanadium stainless steel. The combined main stop and main steam control valves and the combined reheat stop and intercept valves are made from Chromium-Molybdenum-Vanadium alloy steel. The HP and IP turbine lead piping is from the steam valves to the casings.

Comments and Current Condition

No problems were uncovered based on interviews with Jamshoro plant maintenance and operating personnel and the review of the first year inspection report on this unit. During that first inspection the HP and IP sections of the turbine were not opened; only the LP section was dismantled. The HP and IP sections will be inspected at the next scheduled outage in about 5 years. Currently there are no known problems with these high pressure stationary components.

The high pressure stationary components (described above) all appear to be in good condition based on the plant personnel interviews and the absence of maintenance problem records.

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JAMSHORO UNIT 1

HIGH PRESSURE STATIONARY COMPONENTS

Assessment

Based on the evaluation performed using design data, information obtained from the interviews, industry experience with similar design units, and the early age of this unit, no major problems are anticipated in the near future.

The turbine metal life consumptions for the HP casing and the main stop valve are 1.31 % and 0.4% respectively from the commission date to June 25, 1991. Extrapolating this data and assuming the same severity of start-ups for the next 20 years and assuming base load operation with a minimum capacity factor of 60% and 10 start-ups per year (2 cold, 4 warms, 4 hot), it is estimated that the HP casing turbine metal life consumption will be less than 25 % and the main stop valve turbine metal life consumption will be less than 10%. The high pressure stationary components of Unit 1 are expected to be suitable for 20 years of continued operation without major repairs or replacement. Maintenance should be routinely performed at regularly scheduled maintenance outages.

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JAMSHORO UNIT 1

TURBINE ROTATING COMPONENTS

Description

The turbine rotating components on this 250 MW tandem compound double flow turbine are comprised of the HP rotor, IP rotor and LP rotor and the assembled rotating blades. The HP rotor is a single flow type with one impulse stage followed by 20 reaction stages. The IP rotor is also a single flow type with 17 rows of reaction stages. The LP rotor is a double flow type with 7 rows of reaction stages on each end.

The HP rotor and the IP rotor are Chromium-Molybdenum-Vanadium alloy steel and the HP and IP rotating blades are 12 Chromium-Molybdenum-Vanadium stainless steel. The double flow LP rotor is a Nickel-Chromium-Molybdenum-Vanadium alloy steel forging and the LP rotating blades are 13% Cr stainless steel.

Comments and Current Condition

Interviews with plant maintenance and operating personnel and review of the first year inspection report did not reveal any problems with these components. During the first year inspection in 1991 only the LP turbine section was opened and disassembled for inspection of the LP rotor. The HP rotor and the IP rotor are planned for inspection at the next scheduled outage in about 5 years. At the present there are no known problems with these components.

The turbine rotating components, HP rotor, IP rotor, LP rotor and all rotating blades all appear to be in satisfactory condition based on the records reviewed and the plant interviews.

Assessment

The turbine metal life consumption for the IP rotor is 0.07% from the commission date to June 25, 1991. It is assumed that the turbine metal life consumption for the HP rotor is no greater than that of the HP casing which had a value of 1.3% from the commission date to June 25, 1991. Extrapolating this data and assuming similar seventy of future start-ups in the next 20 years and assuming base load operation with a 60% capacity factor and

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JAMSHORO UNIT 1

TURBINE ROTATING COMPONENTS

10 start-ups per year (2 cold, 4 warm, 4 hot), it is estimated that the HP rotor and IP rotor turbine metal life consumptions will be less than 25% and 5% respectively. Based on that evaluation, the information obtained from record reviews, personnel interviews and the newness of the unit, the turbine rotating components, HP rotor, IP rotor, LP rotor and the assembled rotating blades should be suitable for 20 years of continued operation without major repairs and replacements. Routine maintenance should be performed during scheduled maintenance outages.

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JAMSHORO UNIT 1

LOW PRESSURE STATIONARY COMPONENTS

Description

The low pressure stationary components on this FUJI Electric tandem compound double flow turbine are made up of the LP outer casing, LP inner casing 1, LP inner casing 2, LP stationary blades and the crossaround piping. The low pressure section is a double flow section with crossaround admission and downward exhaust to the condenser. The stationary blades are symmetrical and opposite hand on each side. There are 2 crossaround pipes; one on each side of the turbine.

Comments and Current Condition

There were no problems found with the low pressure stationary components based on the interviews conducted with Jamshoro plant maintenance and operations personnel and the review of the first year inspection report of this unit. During that first year inspection the LP section was completely disassembled and inspected. No problems were reported.

The low pressure stationary components noted above all appear to be in satisfactory condition based on the plant personnel interviews and the review of maintenance records.

Assessment

No major problems on the low pressure stationary components were found nor are they anticipated in the future. This assessment is based on the information obtained from the plant personnel interviews, maintenance records review and industry experience with other similar low pressure stationary components. The low pressure stationary components of Unit 1 are expected to be suitable for 20 years of continued operation without major repairs or replacements. Normal maintenance and inspections should be regularly performed at scheduled major maintenance outages.

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JAMSHORO UNIT 1

GENERATOR AND EXCITATION - ELECTRICAL

Description

The generator is a synchronous type manufactured by Fuji Electric. The generator is hydrogen cooled, 294.2 MVA at 3.0 Kg/cm² H_2, 0.85 p.f. lag, 16.5 kV, 10.294 kA, 50 Hz, 3-phase, 3000 rpm, 370V field voltage, insulation class F

The static excitation and main exciter field breaker are provided by Fuji Electric

The isolated phase bus duct is manufactured by the Furukawa Co., Ltd., with an aluminum conductor and rated 16.5 kV, 150 kV BIL., enclosure temperature rise 40 C, conductor temperature rise 65 C, aluminum enclosure. The main bus circuit is rated at 12,000 Amp with symmetrical current of 80 kA. The sub bus circuits are rated 100 Amp with symmetrical current of 160 kA.

Comments and Current Condition

Interview with plant personnel, walk-downs, and review of plant records, indicated that all the above systems are functioning satisfactorily.

Assessment

Assuming proper selection of components and adherence to the manufacturer O&M procedures the generator excitation system and isolated phase bus duct should be suitable for 20 years of continued operation without major repairs or replacement.

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JAMSHORO UNIT #1

GENERATOR ROTATING COMPONENTS - MECHANICAL

Description

The generator rotating components-mechanical on this FUJI Electric horizontal cylindrical rotating field hydrogen cooled generator are composed of the following; the generator rotor forging and the generator retaining rings The generator rotor forging is a single piece forging with integral turbine-generator coupling and fan hubs. The generator retaining rings are high strength high alloy non-magnetic steel shrunk on to the rotor body to contain the rotor coil ends at operating speed.

Comments and Current Condition

No problems were discovered based on the interviews with Jamshoro plant maintenance and operating personnel. Currently there are no known problems with the generator rotating components- mechanical

The generator rotating components- mechanical, the generator forging and the generator retaining rings, appear to be in good condition based on the plant personnel interviews and the absence of maintenance problem records.

Assessment

Based on the information obtained from personnel interviews, the generator rotating components-mechanical: the generator rotor forging and the retaining rings, should be suitable for 20 years of continued operation without major repairs or replacements. The condition of the generator retaining rings should be carefully monitored by nondestructive examinations during regularly scheduled maintenance outages. Routine maintenance and inspections should be performed on the generator rotor forging during scheduled maintenance outages.

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JAMSHORO UNIT 1

TURBINE SUPERVISORY INSTRUMENTATION & MONITORING

Description

The Turbine Supervisory Instrumentation (TSI) consists of cabinets, sensors, indicators, records and alarms. The TSI provides monitoring of the following parameters:

- Eccentricity
- Control valves position
- Speed
- Shaft vibration and position
- Expansion
- Differential expansion for HP, IP, and LP turbines
- Bearing (metal, drain) temperature
- Shell metal temperature

Comments and Current Condition

Interviews with plant personnel, review of records, and walk-through inspections, indicated that the system is operating trouble -free.

Assessment

Assuming proper selection of component, spare parts availability and adherence to manufacturer's O&M procedures, the turbine supervisory system should be suitable for 20 years of service.

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JAMSHORO UNIT 1

STEAM TURBINE CONTROLS
ELECTROHYDRAULIC GOVERNOR CONTROL SYSTEM

Description

The steam turbine by Fuji Electric, type reheat condensing tandem compound double flow, is equipped with solid-state and analog electrohydraulic control system (EHC). The EHC takes charge of speed, load control and protection interlocks. The EHC is manufactured by Fuji Electric.

Comments and Current Condition

Interviews with plant personnel, review of records, and walk-through inspections, indicated that the system is operating trouble-free.

Assessment

Assuming proper selection of components, spare parts availability and adherence to manufacturer's O&M-manufacturer procedures, the steam turbine control system should be suitable for 20 years of service.

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JAMSHORO UNIT 1

BALANCE OF PLANT COMPONENTS & SYSTEMS

220 KV Underground Cables

6 6 KV Cables

DC Station Batteries

Local Control Boxes, BTG Boardwiring Control Cables, Cable Trays and Ducts

Plant Computer System

Turbine and Central Control Buildings

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JAMSHORO UNIT #1

TURBINE-GENERATOR AUXILIARY COMPONENTS/SYSTEMS

Description

The turbine generator auxiliary components/systems on this FUJI Electric FTHRI 562/68-2 unit consist of the following: lubricating and hydraulic oil system, turning equipment, gland steam seal system, turbine bearings, turbine pedestals, generator seal oil system and generator hydrogen system.

The lubricating and hydraulic oil system includes

- Main oil tanks
- Main oil pump
- Relay dump valve
- Oil cooler
- Auxiliary oil pump
- Turning gear oil pump
- Emergency oil pump
- Jacking oil pump
- Oil conditioner
- Oil filter pump
- Vapor extractor for main oil tank
- Vapor extractor for oil conditioner
- Turbine oil storage tank
- Oil transfer pump.

The turning equipment is an oil hydraulic type turning gear which has a turning speed range of 80-120 rpm.

The gland steam seal system includes:

- Gland seal regulator
- Gland steam exhaust blower
- Gland steam condenser

This tandem component three (3) casing turbine has four (4) journal turbine bearings. The number two bearing is a combined thrust and journal bearing. The thrust bearing is of the Kingsbury type with straddle construction. The generator has two journal bearings located in the end shields. There are sliding turbine pedestals at the governor end of the HP section and between the HP and IP sections. The turbine bearing pedestal between the IP and LP section is of the fixed type.

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TURBINE-GENERATOR AUXILIARY COMPONENTS/SYSTEMS

The generator seal oil system includes.

- Seal oil cooler
- Main seal oil pump
- Emergency seal oil pump
- Radial shaft seals
- Seal oil unit

The generator hydrogen system consists of the:

- Hydrogen coolers
- Hydrogen gas control cubicle
- Hydrogen gas dryer
- Hydrogen cylinders
- Pressure gages
- Purity measuring devices
- Valves
- Carbon dioxide cylinders

Comments and Current Condition

There were no reported problems with the turbine-generator auxiliary components/systems noted above based on the interviews with Jamshoro plant maintenance and operating personnel and the review of the first year inspection report for the unit

The turbine-generator auxiliary components/systems all appear to be in good operating condition.

Assessment

No major problems were found nor are they anticipated on the turbine-generator auxiliary components/systems. This assessment is based on the plant personnel interviews, the results of the first year inspection and industry experience with other similar turbine-generator auxiliary components/systems. The turbine-generator auxiliary components/systems for Unit 1 are expected to be suitable for 20 years of continued operation without major repairs or replacements. Normal maintenance and inspections should be regularly performed at scheduled maintenance outages.

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BALANCE OF PLANT COMPONENTS & SYSTEMS

The balance of plant mechanical, electrical, instrumentation and controls and civil structures evaluated consists of the following:

Feedwater System
- Condensate pumps
- Feedwater heaters
- Dearator
- Boiler feedwater pumps

Cooling Water System
- Cooling tower
- Circulating water pump
- Condenser

Cooling Tower Structure

Instrument Air System

Fire Protection

Chemical Feed System and Sampling Rack

Water Pretreatment System

Coagulation Sedimentation Tanks

Water and Wastewater Treatment Systems

Water Treatment Building

Emergency Diesel-Generator

Power Transformers

6.6 KV Metalclad Switchgear, 400V Power Centers, 400V Motor Control Centers (MCC)

Uninterruptible Power Supply (UPS)

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JAMSHORO UNIT 1

FEEDWATER SYSTEM

Description

The feedwater system conveys water from the condenser outlet to the boiler economizer inlet. It preheats the boiler inlet water temperature through seven stages of heating as well as condensing the steam in the steam jet air ejector coolers and turbine gland steam condenser. The major components addressed in this report are the condensate pumps, feedwater heaters, dearator and boiler feedwater pumps.

Three 50% capacity motor driven condensate pumps are provided. Under normal operating conditions at full load, two pumps would be operating with the third pump in stand-by mode. The pumps are vertical centrifugal multi stage with bronze impellers and stainless steel shafts.

There are four low pressure and two high pressure closed feedwater heaters. All heaters are horizontal "U"-tube type. Low pressure heater #1 has aluminum brass tubes and the remaining low pressure heaters and both high pressure heater have carbon steel tubes.

The dearator is a cylindrical tray type with a horizontal storage tank. The dearator and storage tank shell are carbon steel and the dearator trays are stainless steel.

Three nominal 60% capacity four stage barrel type motor driven boiler feedwater pumps are provided. Each pump includes a variable speed hydraulic coupling and a feedwater booster pump. Under full load conditions, two pumps would normally be operating with the third pump in stand-by.

Comments and Current Conditions

A review of the Unit #1 trip records indicate there were no unit trips attributed to the feedwater systems. The condition of the major feedwater system components, as documentated in the First Inspection Report, are summarized as follows:

Visual inspection of Heaters #1 & 7 waterboxes was performed and conditions were noted as satisfactory.

Condensate pumps were not inspected due to absence of abnormalities during operation.

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JAMSHORO UNIT 1

FEEDWATER SYSTEM

Inspection of the dearator revealed a dent on the surface of the storage tank manhole flange. The dent was repaired by welding. No other defects were found.

Boiler Feedwater Pump A had damaged thrust pads and collars. These parts were replaced with new ones. Boiler feedwater pumps A&C had erosion of the reheat spray port. This problem was addressed and resolved in FUJI Electric Co. Ltd report dated July 25, 1991. New parts for all three pumps will be supplied by the manufactures.

Boiler feedwater pump hydraulic couplings were inspected. A wire ring and sand were found in pump A coupling casing, and removed. No damage was found. Couplings for pumps B&C were satisfactory.

Discussions with plant operating and maintenance personnel indicated a current problem with the boiler feed pump mechanical seals. It was stated this item would be corrected later this year by the supplier. Plant personnel indicated no other major problems with this system.

The feedwater system appears in satisfactory condition based on the data reviewed and unit walk-through inspection. No unusual conditions were noted.

Assessment

Based upon the age of the unit, assuming proper design and selection of equipment and adherence to the manufacturer's recommended maintenance and operating procedures, the major components of the feedwater system should be suitable for 20 years continued operation without major repairs or replacement.

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JAMSHORO UNIT 1

COOLING WATER SYSTEM

Description

The cooling water system provides the cooling water for the condenser and the bearing coolers. The major components addressed in the report are the cooling tower, circulating water pumps and condenser. The cooling tower structure is covered in detail in a separate section

The cooling tower is a mechanical induced draft multi-cell cross flow type. The structure is reinforced concrete and the fill material is polypropylene (splash type)

Three 50% capacity circulating water pumps are provided. Under normal conditions, two pumps are operating and one pump is in stand-by. The circulating water pumps are vertical, single suction mixed flow type. The pumps have stainless steel impellers and cast iron casings.

The condenser is a two pass, divided water box horizontal surface type. The tube material is aluminum brass in the condensing section and titanium in the air removal and exhaust impingement zone.

Comments and Current Condition

Interviews with plant maintenance and operating personnel and a review of the Unit No. 1 trip record indicated a scale build-up on the condenser tubes. The unit was tripped in October 1990 for condenser inspection. The unit was acid cleaned in 1991 to remove the scale. Subsequent testing of the tubes, as documented in the Minutes of Meeting dated August 12, 1991, revealed no damage to the tubes as a result of this cleaning. The cause of the scale build up was attributed to the poor quality of the make-up water to the cooling tower. Recommendations for make-up water treatment modifications to prevent future scaling are contained in the Mitsui Study on Condenser Scale dated 12/25/90.

The condition of the major cooling water system components, as documented in the First Inspection Report, are summarized as follows:

> Visual inspection results of the condenser and condenser cathodic protection system were satisfactory.

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JAMSHORO UNIT 1

COOLING WATER SYSTEM

Circulating Water Pump No. B was dismantled. All parts were checked and found in good condition. The pump was reassembled and tested by placing back into operation. Performance was satisfactory. Circulating water pumps A and C were visually inspected and an operating test performed. Results were satisfactory.

Plant personnel indicated no other major problems with this system. No other unit trips were associated with this system.

The system appears in satisfactory condition based on the data reviewed and unit walk-through inspection. No unusual conditions were noted.

Assessment

Based upon the newness of the plant, assuming proper design and selection of components, and adherence to the manufacturer's recommended maintenance and operating procedures, the system should be suitable for 20 years continued operation without major repairs or replacement. The make up water treatment system should be modified to prevent future scale build-up in the condenser.

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JAMSHORO UNIT 1

COOLING TOWER STRUCTURE

Description

The cooling tower is a multi-cell basically cast in place concrete structure. There are some prefabricated sections, such as concrete draft baffles visible along the outside of the cooling towers and the cover slabs at the top. Each cell has a fan inside a short fiberglass hyperbolic shaped stack. The fan is supported on a column at the center of the cell. The column is framed with beams at the top and at an intermediate level in four directions against the external columns or cell separating walls.

Comments and Current Conditions

The cooling tower of Unit 1 was in operation when the site was visited. The structural parts of cooling tower appear to be in good condition. Most components are concrete, therefore no near-term deterioration is expected. The water splashing plastic boards and their hangers will deteriorate as aging and corrosion is unavoidable.

The stairs and handrails in the cooling tower structure are welded steel and painted. Steel parts will corrode in a wet environment if not maintained properly.

The cooling tower structure is supported on a solid limestone formation which was recognizable even at the ground surface. There was no settlement, cracks, or deterioration observed in the cooling tower structure nor in the adjacent pumphouse.

Assessment

Assuming proper design and erection, the cooling tower structure is suitable for the next 20 years of continued operation without major repair and replacement. Miscellaneous components, such as stairs, handrails, hangers and other attachments will require normal maintenance and repairs as necessary.

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JAMSHORO UNIT 1

INSTRUMENT AIR SYSTEM

Description

Two instrument air compressors are provided, one normally operating and one in standby. Each compressor is reciprocating type, water-cooled, oil free, nominal capacity 7 m^3/min, @ 33°C free air with one air receiver of 2.5 m^3 volume and one air dryer unit of nominal capacity 14 m^3/min @ 33°C free air

The discharge pipes of each instrument air compressor are connected together to the instrument air receiver. An instrument air back-up line from the service air system is connected to common header.

The system includes a self-operated pressure regulator and air filter set and vertical self-standing control panel.

Comments and Current Condition

Interviews with plant O&M, review of plant records, and walk-downs, indicated that the instrument air system operates in satisfactory condition.

Assessment

Assuming proper selection of components and adherence to the manufacturer's O&M procedures, the system should have 20 years life without major repairs or replacement.

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JAMSHORO UNIT 1

FIRE PROTECTION

Description

The fire protection system consists of the following components with accessories:

- Freshwater Extinguishing Equipment

  a) Motor driven and diesel driven emergency freshwater fire pumps. Each has a capacity of 760 m^3/hr @ 9 Kg/cm^2g discharge pressure.

  b) Two (2) fire water pumps manufactured by EBARA, each with a capacity of 30 m^3/hr discharge pressure.

  c) Sixty-six (66) fire hydrants and 145 hose connections.

- Air foam extinguishing equipment, which includes air foam concentrate tank, injection pump, hydrants, and fire fighting truck.

- Dry chemical extinguishing equipment.

- Fire alarm system which includes a fire protection panel, fire detectors and manual pushbuttons.

- Portable fire extinguishing equipment, which includes fifty-four (54) hand carried and two (2) wheel carried dry chemical extinguishers.

Comments and Current Condition

Walk-down of the system, visual inspection, and review of plant records indicate that the system is in satisfactory condition. However, the fuel oil unloading and receiving area is considered hazardous due to the oil spillage throughout the areas. It was also noted that fire hoses for use throughout the plant were stored in a warehouse due to security reasons.

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JAMSHORO UNIT 1

FIRE PROTECTION

Assessment

Assuming proper selection of components, periodic functional tests, and adherence to manufacturers recommendation, the system should be suitable for 20 years continued operation. However, immediate clean-up of the fuel oil unloading facility is needed to avoid potential fire. In addition, fire hoses should be reinstalled in the hose racks provided in order to minimize response time and extensive fire damage

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JAMSHORO UNIT 1

CHEMICAL FEED SYSTEM AND SAMPLING RACK

Description

Condensate and feedwater are chemically adjusted to prevent scale formation, corrosion, caustic embrittlement, and contamination of steam, such as silica carryover which would deposit on the turbine blades. This chemical feed system, combined with boiler blowdown, demineralized make-up water quality, and boiler manufacturer's recommendations provides the basis for each unit water cycle quality.

The system feeds chemicals to the boiler feedwater to control the ph and to inhibit release of oxygen in the boiler tubes, drum, superheater, and economizer

Diluted hydrazine is added to remove dissolved oxygen contained in the feedwater and to control the ph value. However, during plant startup and shutdown, ammonium solution is added to control the ph of the feedwater, and is injected in the condensate pump discharge. During long term shutdown, concentrated hydrazine is used to protect the boiler from rust.

The sodium phosphate solution is used for inhibiting caustic embrittlement, and to remove hardness of the boiler water.

The sampling rack supervises the quality of make-up water, condensate, feedwater, boiler water and steam.

The chemical feed system consists of the following equipment manufactured by Nikkiso Company Ltd.:

(2) Hydrazine solution plunger pumps (0.286 liter/min)
(1) Diluted hydrazine solution tank (1000 liter)
(1) Concentrated hydrazine solution tank (400 liter)
(2) Phosphate solution positive displacement type pumps (0.58 liter/min)
(1) Phosphate solution tank (780 liter)
(1) Ammonium solution tank (400 liter)
(1) Ammonium agitator
(2) Ammonium solution positive displacement pumps (0.286 liter/min)
(1) Stand-alone control panel
(1) Stand-alone sampling rack, open type, single side mounted with pH analyzers, conductivity meters, dissolved oxygen meters, hydrazine meters, pH indicators, and conductivity indicators by L&N/Yokagawa

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JAMSHORO UNIT 1

CHEMICAL FEED SYSTEM AND SAMPLING RACK

Comments and Current Condition

Interviews with O&M personnel, walk-downs, and review of plant records indicated that the chemical feed and sampling rack are functioning on automatic/manual operation as designed. No major troubles were reported by the O&M personnel

Assessment

Assuming proper selection of components and adherence to manufacturer's O&M procedures, the chemical feed and sampling rack should provide 20 years service.

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JAMSHORO UNIT 1

WATER PRETREATMENT SYSTEM

Description

The river water is pumped to the intake water receiving pond for removing large size particles. Before the water flows into the coagulation-sedimentation tank, coagulants and other required chemicals for coagulation-sedimentation are injected into the river water feeding pipeline. When good coagulation is not obtained, the suitable agent is injected to make the floc stabler and heavier. The pH of the river water is adjusted by caustic soda injection to maintain the optimum pH value which fluctuates often by the addition of the coagulant. In normal operation, two units operate and one unit is in standby.

The clarified water flowing out of the coagulation-sedimentation tank is collected in the clarified water storage tank. Some of the water is pumped into the cooling tower and the rest is pumped to filter equipment for final treatment.

The sludge concentrated from the intake water receiving pond and sedimentation tank is discharged to the evaporation pond. The filter equipment is installed to thoroughly remove fine suspended solids and organic matter carried from the coagulation-sedimentation tank.

Normally, two sets are in service operating semi-automatically and one set is in rinse or standby. The filtered water is collected in the treated water storage tank and the water is used for plant water and domestic water for the colony.

Comments and Current Condition

Interview with plant personnel, walk-downs, and review of plant records indicated the system, with the exception of the coagulation sedimentation tank, is functioning satisfactorily and on auto and semi-automatic as designed. Refer to the assessment of the Coagulation Sedimentation Tanks for details.

The system components were included in the First Inspection Report. All components were in good condition with exception of the coagulation sedimentation tank B agitator gear box and filter scrubber air blower A. The gear box was replaced and blower surface finish was repaired.

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JAMSHORO UNIT 1

WATER PRETREATMENT SYSTEM

The system appears to be in satisfactory condition based upon the data reviewed and unit walk-through inspection. However, we have observed that when the coagulation tanks are cleaned-up, the mud is dumped on top of the discharge pumps and pipes which will cause increased maintenance for these components.

Assessment

Assuming proper selection of components and adherence to the manufacturer's O&M procedures, the system should be suitable for 20 years of continued operation without major repairs or replacement. Care should be exercised when cleaning the tanks to preclude dumping mud on equipment.

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JAMSHORO UNIT 1

COAGULATION SEDIMENTATION TANKS

Description

There are three coagulation sedimentation tanks for the unit. Each is shaped like a truncated cone in the upside down position with the larger diameter at the top and the narrower diameter at the bottom.

Inside the tank there is another truncated cone made out of steel with the smaller diameter on the top and the larger diameter towards the tank bottom. The water from the receiving tank is mixed with coagulant chemicals and is distributed at the top center of the inside cone. An agitator motor rotates the fluid inside the cone letting the particles grow and settle at the bottom of the settling tank. The openings at the lower side of the metal cone let the incoming water pass towards the space between the inside and outside cones moving upwards. The water reaching the top surface then flows through small holes into radially placed steel troughs for transfer to the clarified water storage tanks. The sludge formed in the inside cone bottom is removed by the sludge drains provided at the bottom of sedimentation tank. To facilitate the emptying process, a pressurized air pipe is also installed at the inside bottom tank periphery.

Comments and Current Condition

The coagulation sedimentation tanks showed white calcified cracks at the lower 1/3 elevation of their sloped walls. No major leakage was seen. This does not assure that possible corrosion of reinforcing bars is not occurring. In the long run, deterioration of reinforcing bars may be expected. Soil conditions around the tanks did not indicate to any settlement. The coagulation settlement tanks did not have any reported damage to the internal steel cone structures, troughs or agitating system.

Plant personnel reported clean-up of the tanks are excessive compared to Units 2, 3 and 4. The sludge removed pipes are not performing their function. Clean-up is performed manually on a continuous basis by local contractors.

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JAMSHORO UNIT 1

COAGULATION SEDIMENTATION TANKS

Assessment

The internal metal cone is subjected to frequent changing wet and dry conditions. These conditions accelerate the corrosion process and normal repairs of the internal cone can be expected in approximately 10 years. Abnormally high O&M costs are also being incurred. It is recommended a study be performed to determine if modification to the tanks are feasible to reduce these costs.

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Description

o Water Treatment System

Some of the filtered water is treated by demineralizer and stored in the demineralizer water storage tank. The demineralizer consists of cation exchanger, degasifier, anion exchanger and polisher.

Normally, one train carries out service run, while the other train performs regeneration.

The cation exchanger is furnished to substitute hydrogen ions from essentially all cations using strong and weak cation exchange resin, and the anion exchanger is furnished to substitute hydroxyl ions for essentially all anions in the degasified water, using strong and weak anion exchange resin.

The degasifier, which is vacuum tower filled with packing to accelerate air-liquid contact, is furnished to release oxygen and carbon dioxide in decationized water.

For the regeneration of resin, hydrochloric acid is used for cation resin, and caustic soda is used for the anion resin. In each exchanger, diluted chemical is downflowed for weak resin and upflowed for the strong resin.

The mixed bed polisher is furnished to remove completely trace ions in the demineralized water and designed to provide service time of approximately seven (7) days between successive regeneration.

In regeneration of cation and anion exchange resin, the diluted caustic flows downward simultaneously with the diluted acid from bottom upward. The regeneration wastes are discharged to wastewater pit and the final rinse water much purified than demineralized water is recovered to the service water storage tank.

Wastewater of acid and alkali discharged from demineralizer system is received in the wastewater pit mixed automatically by agitating air blower. The mixed wastewater is pumped to wastewater system.

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JAMSHORO UNIT 1

WATER AND WASTEWATER TREATMENT SYSTEMS

o Wastewater Treatment System

The chemical wastewater from plant is collected in the wastewater storage pond through each sump and pit. In this pond, the waste is stored and agitated temporarily and pumped up to the neutralization equipment which is processed in two steps by diluted acid or alkali injection. This pH adjustment is carried out automatically and, if not suitable, treated water is returned to storage pond.

Comments and Current Condition

The water treatment components were included in the First Inspection Report and were in satisfactory condition. Interview with plant personnel, walk-downs, and review of plant records, indicated that all the above systems are functioning satisfactorily on auto and semi-automatic modes as designed.

Assessment

Assuming proper selection of components and adherence to the manufacturer's O&M procedures, the systems should be suitable for 20 years of continued operation without major repairs or replacement.

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JAMSHORO UNIT 1

WATER TREATMENT BUILDING

Description

The water treatment building of Unit 1 is located inside the main power plant grounds on the left side just passed the main entry guard post. In this building there are metal tanks with acids, anions, and cations, which are used to demineralized the pretreated water. The water treatment building is constructed as a concrete frame structure. The concrete surfaces are finished with mortar and paint. The floor where the tanks are placed are covered with acid resistant tiles and their surroundings are raised in case of spills. Outside of the protected tank areas the floor has a terrazzo finish. There are covered trenches below the walkable floor level.

Comments and Current Condition

No defects or deterioration were visible externally or internally. The structural frame elements have mortar finish on them. Around the outside perimeter there were no signs of settlement observed.

Assessment

Assuming proper design and erection, the water treatment building should provide satisfactory service for the next 20 years.

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JAMSHORO UNIT 1

EMERGENCY DIESEL-GENERATOR

Description

The generator is rated 750 kVA, 0.85 p.f., 400V, 1083A, 50 Hz, 3-phase, 1500 rpm, insulation class "B", and with a brushless excitation system. The generator was manufactured by Fuji Electric.

The diesel engine is type S12 NPTA, 650 kW, 150 rpm, 12 cylinders, 13.5 compression ratio with direct injection combustion systems. The diesel engines was manufactured by Mitsubishi.

The diesel-generator is equipped with control panel, air circuit breaker, and air compressor equipment which include:

(1) Vertical 2-stage air compressor of 70 mm stroke/700 rpm
(1) 3.7 kW 380V electric motor, and
(2) air receivers of 300x2 m^3 capacity

The diesel generator is capable of automatic start to reach full speed within 40 seconds. It automatically starts when power is lost to the 400V critical bus and automatically stopped when normal power is restored.

Comments and Current Condition

Interviews with plant personnel, review of records and walk-through inspection, indicated that the system is operating trouble-free.

Assessment

Assuming proper selection of components and adherence to manufacturer's O&M procedures, this system should be suitable for 20 years service.

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JAMSHORO UNIT 1

POWER TRANSFORMERS

Description

- The main power transformer is manufactured by Fuji Electric Company, outdoor, oil immersed, OFAF rating is 294.2 MVA, 50 Hz, 220 kV/15.7 kV, Z = 14.91% at 294.2 MVA base, mineral insulating oil by Idemtsui Kosan Ltd

- The auxiliary transformer is manufactured by Fuji Electric Company, outdoor, oil immersed, 25 MVA, 16.5 kV/6.9 kV, 50 Hz, Delta/Star, with transformer ground, Z = 10% at rated MVA, mineral insulating oil by Idemtsui Kosan Ltd.

- The startup transformer is manufactured by Fuji Electric Company Ltd., oil immersed, outdoor, 15 MVA (ONAN)/25 MVA (ONAF), 220 kV/6.9 kV, Z = 10% at 25 MVA base.

Current Condition

Interviews with plant personnel, walk-downs, visual inspection of the transformers and review of the plant records, indicated that the operation of the transformers is satisfactory.

Assessment

Assuming proper selection of the transformers and adherence to manufacturer's recommended O&M procedures, the transformers should be suitable for 20 years continued operation. However, oil sampling and insulation integrity tests are recommended on a periodic basis to detect transformer deterioration.

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JAMSHORO UNIT 1

6.6 KV METALCLAD SWITCHGEAR
400V POWER CENTERS
400V MOTOR CONTROL CENTERS (MCC)

Description

- Two (2) 6.6 kV metalclad switchgear assemblies are provided. Both have copper buses with 2200A current carrying capacity and draw-out vacuum circuit breakers.

  The incoming and bus tie breakers are rated at 7.2 kV, 2000A, and 31.5 kA interrupting capability. The feeder breakers are rated at 7.2 kV, 600A, and 31.5 kA interrupting capability.

- Five (5) 400V metal enclosed power centers are provided: (1) unit power center, (1) cooling tower power center, (1) common power center, and (2) pre wastewater treatment centers. The transformers are Fuji Electric dry type, rated 1300 kVA or 700 kVA.

  The air circuit breakers are draw-out type with the main breakers rated 2000A or 1600A frame, and 50 kA interrupting capability. The feeder breakers are 1000A frame, with 50 kA interrupting capability.

- Fourteen (14) 400V, 3-phase 3 wire motor control centers are provided with main copper buses rated 600A and branch buses rated 400A.

Comments and Current Condition

Interviews with O&M personnel, visual observation and review of plant records indicated that all the switchgear, power centers, and motor control centers are in satisfactory condition. No unusual conditions were noted.

Assessment

Assuming proper selection of the components and adherence to manufacturer's recommended O&M procedures, the switchgear, power centers, and motor control centers should be suitable for 20 years continued operation.

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JAMSHORO UNIT 1

UNINTERRUPTIBLE POWER SUPPLY (UPS)

Description

Unit 1 has two sets of 30 kVA static type UPS. The input voltages are 220 VDC and 400 VAC, and the output voltage is 110 VAC. One set is used for all the computer equipment, and the second set is used to supply 120 VAC for the following control applications:

- Turbine bypass system cabinet
- Auto burner control system cabinet
- Auto boiler control system cabinet
- BTG board
- BTG auxiliary board
- Auto volt regulator cabinet
- Electrohydraulic system cabinet
- Turbine Supervisory System Cabinet

Comments and Current Condition

Interviews with plant personnel and review of maintenance records indicated the UPS is operating satisfactorily.

Assessment

Assuming proper selection of components and adherence to the manufacturer's O&M procedures, the UPS should be suitable for 20 years service.

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JAMSHORO UNIT 1

220KV UNDERGROUND CABLES

Description

Two (2) circuits of forced oil cooled 220 kV underground cables run in the underground concrete tunnel:

- From Unit #1 main transformer to the 220 kV switchyard
- From Unit #1 startup transformer to the 220 kV switchyard

Comments and Current Condition

No problems were reported on the Unit 1 220 kV cables. The electrical maintenance personnel run daily checks of the cable system and log the following:

- Oil tank pressure
- Oil leakage
- Sheath grounding
- Lighting systems
- Drain pump motors
- Tunnel fans
- Other abnormal conditions

Interview with plant personnel, visual inspection of the cables and review of maintenance records, indicated that the cables are operating satisfactorily.

Assessment

Assuming proper selection of components and adherence to the manufacturer's O&M procedures, the 220 kV cables should be suitable for 20 years service.

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JAMSHORO UNIT 1

6.6 KV CABLES

Description

The 6.6 KV cables are used on the low voltage side of the auxiliary transformer, start-up transformer, subfeeders to the 6.6 KV/400 power centers, and as feeders to the 6.6 KV motors. The cables are non-combustible type.

Comments and Current Condition

Interviews with electrical maintenance and operation personnel and visual inspection, indicated that the cables are in good condition.

Assessment

Assuming proper selection of cables sizes to the application, the cables should be suitable for 20 years of life.

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JAMSHORO UNIT 1

DC STATION BATTERIES

Description

Unit 1 has a 220 VDC battery system manufactured by Furukawa (TFP 2375) The batteries are lead acid type, 110 cells; nominal voltage of each cell is 2 VDC, rated capacity at 10 hr. is 2000 amp-hr.

The unit has one three phase rectifier, thyristor type, self air cooled. 800 amp, 200-230 VDC

Comments and Current Condition

Interview with plant O&M personnel and review of plant records indicated that the DC batteries and chargers are in good working condition.

Assessment

Assuming proper selection of components and adhere to manufacturer's recommended O&M procedures, the system should be suitable for 20 years service.

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JAMSHORO UNIT 1

LOCAL CONTROL BOXES, BTG BOARDWIRING CONTROL CABLES, CABLE TRAYS, AND DUCTS

Description

The Boiler-Turbine-Generator (BTG) board contains the instruments, and control switches from the Boiler, Turbine, and Generator Systems. The local control boxes are wall mounted or rack mounted near the applications. Cable trays run throughout the unit without interfering with the equipment layout. The underground cables are routed in ductbanks with concrete manholes.

Comments and Current Condition

Interview with O&M personnel, walk-downs, and review the of documentation indicated the following:

- The cable trays are not congested and are covered as needed to meet the application. The workmanship of the cable trays appears satisfactory.
- Local controls boxes were properly selected for indoor or outdoor application as appropriate. Insulated conduit bushings were provided at the cable entries into the boxes.
- The power and control cables run in ductbank separate from the medium voltage cables. However, in some areas the manhole covers are left open exposing cables to the elements.
- It appears that the low voltage signal cables (4-20 ma, 0-1 ma, 0-5V, 0-10V) are shielded.
- Cables and wiring of the BTG board in the control room are marked with permanent identification tags in English.

Assessment

Assuming proper selection of components, covering the exposed manholes, and adherence to the manufacturer O&M procedures, the local control boxes, BTG boardwiring, control cables, cable trays, and ducts should provide 20 years service.

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JAMSHORO UNIT 1

PLANT COMPUTER SYSTEM

Description

The computer system is microprocessor based, and utilizes centralized database. CRT screens are installed at the operator's desk to display data and request printout, at the BTG board to display alarms, and at the engineer's desk to change settings and provide software maintenance. Graphic displays of plant equipment conditions, temperatures and pressures at major points in the unit, facilitates the operator interface

The plant performance calculations are carried out every 5 minutes for plant efficiency factors. The results are logged each hour based upon calculations performed five minutes before the hour. The turbine life consumption program calculates the amount of thermal stress occurring in main turbine parts due to start-up, shutdown, and operation of the plant. It also calculates the life consumption from low cycle fatigue caused by thermal stress of material. This information is useful for the operation and maintenance of the turbine.

Comments and Current Condition

Interviews with plant O&M personnel, visual observations and review of plant records indicated that the system operates satisfactorily.

Assessment

Assuming proper selection of components, adherence to the manufacturer's O&M procedures, and availability of spare parts, the system should be suitable for 20 years of continued operation without major repairs or replacement.

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JAMSHORO UNIT 1

TURBINE & CENTRAL CONTROL BUILDINGS

Description

The turbine building is a steel frame structure which houses the turbine, generator, condenser, bearing cooling water heat exchangers, air compressors, chillers, various pumps, HP and LP heaters and other equipment to run and control the turbine and generator The turbine building is oriented in the North/South direction, (parallel to the turbine generator rotation axis).

It is 74.0 meter long, 33.0 meters wide and 27.1 meter high. Ground floor elevation is at EL +0.0 meters Other floors are mezzanine floor at El. 5.50 meters, operating floor at El 11.00 meters, heater floor at El. 16.00 meters and deaerator floor at El. 21.00 meters There is a bridge crane inside the turbine building with 60 ton capacity The top of the rail is at El. 21.50 meters. The crane span is 21.4 meters. The width between columns A and G, where the crane is operating, is 23.00 meters

There are north and south side gable wall construction as closures of the turbine building. The north side gable wall is covered on its outside surface by a cast-in-place concrete wall up to El. 11.00 meters and above that level by prefabricated reinforced concrete elements The south side gable wall was considered as temporary in the Unit 1 technical specification on the extension side but remained in place separating the Unit 1 turbine building from Units 2, 3 and 4. It is covered with painted corrugated sheet metal panels. The corrugated sheet metal starts above El. 1.0 meter, below which there was a poorly constructed brick wall. At the ground elevation there is a passage-way with a wooden frame through the south gable wall from Unit 1 to Unit 2. There is also leftover forming wood from construction under the mezzanine floor slab along axis P107 and P108.

The east and west side walls are covered by prefabricated reinforced concrete wall elements which are bolt connected to the outside columns of the turbine building structure. There are window bands between the prefabricated wall units which provide sufficient daylight to the operating floor level. At lower elevations there are louvers which serve as the fresh air intake for the turbine building. Air is vented through covered air outlets at the roof. The roof is covered with prefabricated reinforced concrete roof elements supported on roof purlines. There is bituminous insulation over the roof elements. The insulation is protected by brick tiles on the outside which are mortared at their joints.

The mezzanine and operating floors have 12 meters high reinforced concrete slabs which are rigidly connected to the floor framing by the studs welded on the upper flange of the beams. The horizontal bracing, which is visible under the floor beams, was used only for

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temporary duty during erection. Floor beams are framed to the floor girders by double angles bolted to the beam and welded to the girders. The pedestal foundations for heavy equipment onthe ground floor level are raised from the mat concrete.

The turbine and the generator are supported on a reinforced concrete turbine pedestal. The turbine pedestal is housed within the turbine building except for the common mat foundation.

The mat foundation is built on a solid limestone formation. The top of the mat foundation is at El. -1.00 meter. The bottom of the mat foundation is at El. -2.00 meters. Turbine pedestal and condenser area at the mat foundation top is at El. -3.2 meters and mat foundation bottom is at El -6.05 meters. This thick portion of mat was poured in three layers.

Part of the main powerhouse, which looks like an "L" shaped extension of the turbine building the in plan view, is located on its own mat foundation. It is referred to as the Central Control Building of Units 1 and 2. In the North/South direction it is 26.0 meters wide between the column axes 107, 108, 201 and 207. In East/West direction it is 41.5 meters long from column J through column P. It houses the chilling and condensing pumps and the air compressors at the ground level. At the mezzanine floor level there are battery rooms, control equipment rooms, water analysis laboratory, lockers and showers and auxiliary relay panels. At the operating floor elevation, the control room, computer room, meeting and shift room with amenities are located. There is 1.5 meters distance between the H axis of turbine building and the J axis of central control building. The two buildings are separated with an extension joint from the foundation level to the roof. The building is designed as a steel structure. The external walls are similar to the turbine building (prefabricated concrete elements). The floor slabs are cast in place concrete over steel beams compositely connected with the welded studs on steel. The roof covering is also similar to the roof of the turbine building. Top of the roof is accessible from the staircase located at the southeast corner of the building. There is a stair passageway between the roof of the turbine building and the roof of its "L" shaped extension.

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JAMSHORO UNIT 1

TURBINE & CENTRAL CONTROL BUILDINGS

Comments and Current Condition

Ground level inspection of accessible areas indicated no cracks or displacement both from inside of the turbine building as well as at its outside periphery. There were also no cracks, displacements, or deterioration at the equipment foundations at ground level or on slabs at higher level elevations. However, there were hairline cracks on the cast in place concrete wall at the west side of the gable wall which was probably caused due to shrinkage of concrete during construction. A portion of cracking extended along the lower side of the mezzanine floor steel beam flange showing some indication of deterioration of the external paint on the wall.

A similar crack was observed on the wall parallel to the H axis between Columns 101 and 102. This crack starts under the mezzanine floor beam and turns at 1/3 span slightly diagonal downward to the top left corner of the trench at the ground level.

The steel structure appears to be adequately designed and erected. The main framing beam connections are bolted. Secondary floor beams were welded during erection.

All steel structural elements were painted. There were no signs of chipping or peeling of the paint and no observable corrosion of the structure.

At the turbine building roof level there was loose debris. Roof drain inlets seem to have rather small holes which may easily clog if proper inspection, maintenance and housekeeping is not provided. Parapet walls approximately 1.00 meter high are provided around the roof perimeter so that any clogging of drains will form a pool effect on the roof in the rare instances of heavy rainfall. The parapet walls are built by prefabricated wall elements on the outside, and other prefab elements butted tightly with vertical joints inside. Vertical joints seemed to have no elastic caulking. Any water seepage through these joints may start hidden corrosion of the steel structure underneath.

The turbine pedestal concrete structure is well proportioned. The vibration felt by touching the surface of the pedestal column was slight. The concrete surfaces indicated good forming during construction. No cracks or deterioration were observed. The space between the turbine pedestal structure and the turbine floor is covered with grating. The grating used seems to easily deflect under the weight of one man. The grating over the condenser piping area did not have proper support towards the outside column foundation creating an unsafe condition. At this location the grating was deflecting excessively. Proper corrective measures are required.

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JAMSHORO UNIT I

TURBINE & CENTRAL CONTROL BUILDINGS

Assessment

The reinforced concrete portion of the turbine building, including foundations, should not deteriorate for the next 20 years of operation. The steel structure should serve equally long without any anticipated repair or maintenance except to follow good housekeeping rules and repaint surfaces when required. Roof insulation may require partial repair work after 10 to 15 years

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JAMSHORO UNITS 2, 3 & 4

STEAM GENERATOR COMPONENTS & SYSTEMS

The Units 2, 3, & 4 steam generators were manufactured by the Harbin Boiler Works. The units are equipped for firing residual oil and natural gas. The steam generator components and systems evaluated consist of the following:

Steam Generator
- Superheater/Reheater Tubing
- Superheater/Reheater Headers
- Superheater/Reheater Piping
- Economizer Inlet Header
- Economizer Tubing
- Steam Drum
- Boiler Enclosure

Boiler Air and Flue Gas Systems
- Forced Draft Fans
- Induced Draft Fans
- Steam Coil Air Heaters
- Air Preheaters
- Gas Recirculation Fans
- Ducts, Dampers & Expansion Joints

Combustion System

Furnace Safeguard Supervisory System (FSSS)

Boiler Instrumentation and Control System and Auto Regulation

Auxiliary Steam Systems - Boiler Side
- House Boiler
- Soot Blower System

Boiler Structure

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JAMSHORO UNITS 2, 3 & 4

STEAM GENERATORS

Description

Units 2, 3, and 4 steam generators are essentially duplicate boilers designed and manufactured by the Harbin Boiler Works, PRC. Each boiler is designed to produce 680 tons per hour (1,500,000 lb. pr hr.) main steam at 140 kg per cm² (2000 psi) and 541°C (1005F). Reheat steam flow is 579.3 tons per hour (1,274,500 lb. per hr.) at 23.9 kg per cm² (340 psi) and 541°C (1005F). Design feedwater temperature is 250.7°C (483F).

The boilers are designated as type HG-680/240-Y1 designed for natural circulation. The furnace and front upflow convection pass have the same plan cross-sectional dimensions - 9.82 meters wide and 9.66 meters deep. The rear, downflow convection pass is 9.82 meters wide and 6.14 meters deep, and forms a back-to-back arrangement with the front convection pass. All superheater, reheater, boiler, and economizer circuits are fully drainable.

The boilers are tangentially fired and are currently equipped to fire either residual oil or natural gas.

Comments and Current Conditions

The overall design of the steam generators and the method of firing indicate that the Harbin Boiler Works is either a licensee of Combustion Engineering Corporation or they have a technical interchange with a company affiliated with Combustion Engineering. This is a proven design of boiler used by Combustion Engineering for at least twenty-five years for a significant number of units.

The boilers have been operated for a relatively short period of time. Unit #2 boiler has had the one-year inspection. Units 3 and 4 are currently operating in the time period prior to the first year inspection.

There have been only two tube leaks in the boilers since initial operation. One leak occurred in an economizer tube on Unit 2 on June 9, 1990. The failure was attributed to external abrasion of the tube at a support. Since there have been no similar failures, the economizer tube leak is considered to be an isolated incident which is not indicative of a generic design problem.

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JAMSHORO UNITS 2, 3 & 4

STEAM GENERATORS

The second leak occurred March 10, 1991 in a superheater tube in Unit 3. No details are available concerning this failure, however, it is not considered to be indicative of a recurring tube failure problem.

There were no reported major operating problems on boiler 2 prior to the first year inspection. The load limitation prior to the inspection was attributed to pluggage of the air preheater cold-end baskets.

During the first year inspection started 20 February 1991, both the water and gas sides of the boiler were inspected. No major problems were found and no significant repairs were required.

Assessment

Based on information currently available concerning the Units 2, 3, and 4 boilers, there are no planned modifications or major repairs required to achieve satisfactory operation.

There was no report covering a formal acceptance test on unit #2 boiler to verify efficiency or guaranteed performance. The results of efficiency or performance testing is essential to evaluate the operating characteristics of the boilers, and to determine whether or not boiler performance complies with contract requirements.

Assuming future operation of the boilers is consistent with the recommendations provided by the equipment supplier and within the general guidelines for effective plant practices, the boilers can be expected to operate satisfactorily for twenty years. Routine inspections and normal maintenance are essential for maintaining boiler reliability and availability.

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JAMSHORO UNITS 2, 3 & 4

BOILER AIR AND FLUE GAS SYSTEMS

Description

The air and flue gas systems provide heated combustion air to the boiler; direct flue gas from the outlet of the economizer, through the air heater, and to the stack; and recirculate a portion of the flue gas from the economizer outlet and inject it into the lower furnace of the boiler. The purpose of the gas recirculation system is to extend the control range of the superheater and reheater outlet steam temperatures.

Major components include two (2) forced draft fans, two (2) induced draft fans, two (2) steam coil air heaters, two 26-VI-1370 vertical shaft regenerative air heaters, air ducts, windboxes, two (2) gas recirculation fans and ducts, dampers, expansion joints, and the outlet flue connected into the stack.

The boiler outlet flue connecting the boiler outlet to the stack is approximately 130 meters (425 feet) in overall length.

Comments and Current Conditions

Prior to the first year inspection outage on unit #2 that began 20 February 1991, unit load was limited to between 80 and 100 MW because of an induced draft fan capacity limitation wherein the fan dampers were 100 percent open and the fans were unable to maintain a negative furnace pressure. In addition, a noise was heard in the auxiliary drive gear box of the B preheater.

During the first-year inspection of unit #2, extensive damage was found in the cold end section of the air heaters. One hundred eighty-three enamel-coated, cold end baskets were found damaged in the two (2) air heaters. Inspection determined that the enamel coating on the plates was pitted and that individual plates were falling out of the baskets. Eighty-three baskets were replaced, and one hundred (100) baskets were repaired during the outage. The repaired and replaced elements represent approximately 75 percent of the total cold-end baskets in the two (2) air heaters.

The gear drive on B heater was replaced and is now operating satisfactorily.

The air and flue gas systems are operating satisfactorily at the present time. The units are capable of achieving rated capacity.

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JAMSHORO UNITS 2, 3 & 4

BOILER AIR AND FLUE GAS SYSTEMS

Assessment

The deterioration of the cold end baskets on unit #2 prior to the first year inspection has been partially attributed to the method used for water washing. Jamshoro Maintenance personnel advised that cold-water was used by the boiler manufacturer to wash the air heaters. Reportedly this caused damage to the enameled surfaces, resulting in accelerated corrosion. Plant maintenance intends to follow the washing procedure developed for the unit #1 air heaters which includes the use of warm water for washing the heating surfaces.

Based on experience at Jamshoro, plus overall experience with Ljungstrom air heaters, it is anticipated that cold end baskets will require replacement at an estimated interval of every five (5) years on units #2, #3 and #4. Estimated cost is $275,000 per replacement for the two (2) air heaters on each unit.

Units #3 and #4 have not had the first year inspection as of September 1991. The experience of these units will provide the basis for a more accurate projection of the interval between basket replacement. The future operating regimen of the units, and whether natural gas or residual oil is the primary fuel, will be factors in establishing the service-life of the air heater baskets.

The flue connecting the air heater outlet to the stack is an unusually long run of ductwork. As a result of firing residual oil containing 3% sulfur, this flue is subject to corrosion whenever the temperature drops below the acid dew point.

It is projected that areas of the flue will require partial replacement at a point in time beyond 5 years if residual oil remains the primary fuel. Assuming 25% replacement, the estimated cost is $250,000 per unit covering new platework, internal struts, insulation, lagging, and installation.

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JAMSHORO UNITS 2, 3 & 4

BOILER COMBUSTION SYSTEM

Description

Boilers 2, 3, and 4 are equipped for firing both residual oil and natural gas. The tilting tangential firing system is used for maintaining main and reheat steam temperatures over the control range. Sixteen (16) steam-atomized oil guns are installed at four elevations in the four corners of the furnace. Ignition of the main oil and gas burners is established through high-energy spark ignitors.

Comments and Current Conditions

Boiler #2 has been fired on residual oil exclusively since being placed in service. Gas firing provisions have been completed and the unit is now capable of operation on natural gas. Boilers #3 and #4 have been operated on both gas and residual oil.

Observations of burner operation from both the burner deck and via the control room television monitors found no problems associated with either gas or oil operation. From a fire hazard and maintenance standpoint, oil leakage has occurred at the four corners of #2 boiler to the extent that oil has run down the windbox and coated components located underneath the burners.

The oil guns have been provided with actuators for remote insertion and withdrawal from the firing position. Operations has experienced difficulty with some actuators, and it is then necessary to manually assist the actuators to insert or retract the oil guns.

All indications are that the natural gas elements are in satisfactory condition. The burner tilts operate through the design range of plus or minus 30° from the horizontal position.

Assessment

The oil guns, gas elements, and ignitors should provide satisfactory service for the life of the unit. Normal maintenance and parts replacement can be anticipated, especially the atomizing plates and the nozzle bodies which are subject to erosion by the fuel oil.

Steps should be taken to clean up the oil spills on unit #2 and prevent future spills on any of the boilers. Oil leaks and spills are a fire hazard that can cause extensive damage if ignited.

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JAMSHORO UNITS 2, 3, & 4

FURNACE SAFEGUARD SUPERVISORY SYSTEM (FSSS)

Description

The FSSS (MS-III) is supplied by Achang Relay Works (ARW) of China.

The FSSS provides boiler purge, ignition and furnace control functions for (4) elevations of burners (total 16 burners). Each corner is equipped with oil guns, gas elements, spark ignitors, flame detectors and cooling air. The system cabinets, located at the electronics room, consist of power distribution panels, flame detector panels, unit logic panels, elevation oil burner logic panels, and gas burner logic panels. Burner local control boxes are located near every burner with local/remote selector switch, pushbuttons start/stop switches, and indicator lamps for ignitor, oil gun, oil valve, and gas valve. The system utilizes various pressure, differential pressure and temperature switches for oil/gas/air process measurement. The system includes high speed diesel (HSD) oil for igniting and warming the boiler, compressed air system for the cylinder of oil gun and igniting actuator. Steam atomization spray nozzles are provided for all burners. Elevation 2 and 4 burners utilize residual oil. Elevation 1 and 3 burners utilize residual oil and HSD.

Comments and Current Condition

Interview with plant maintenance and operating personnel, review of forced outage records, and walk through inspections indicated that operation and maintenance problem frequently occur in the burner management system in the areas of ignitors, oil guns, and valves.

Visual inspection indicated leaks from the oil guns during operation of Units 2, 3, and 4. The residual oil flow switch leaks in most of the oil guns.

Automatic burners retractors are out of service for Units 2, 3, and 4. The retractors is accomplished by local manual.

Unit 2 pneumatic tilt drive for Corners B, C, and D are out of service, which affects the steam temperature control.

The tilt drives for Units 3 and 4 work satisfactorily.

Frequent problems are encountered with three-way valve (ON/OFF/Purge) which is driven by electric hydraulic actuators (manufactured by Skotch Inc. Portland, CT). The valve controls the fuel oil and the steam atomization. When the valve is fully open, it allows the fuel oil and atomizing medium to reach the burner. The motor which

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drives the hydraulic fluid pump frequently burns up, taking the burner out of service and reducing the MW capability of the unit. This problem could be caused by component selection or maintenance since the adjustment of pressure limit switches is essential for reliable operation of the three-way valve driven by the electrohydraulic actuator.

Assessment

The above mentioned problems will cause increased O&M costs. Assuming repair of existing problems, proper design selection of component, and adherence to the manufacturer recommended maintenance and operating procedures, the system should be suitable for 20 years continued operation.

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JAMSHORO UNITS 2, 3, & 4

BOILER INSTRUMENTATION AND CONTROL SYSTEM AND AUTO REGULATION

Description

Each unit has a boiler control system manufactured by Xian Instrument Factory, Type YS-80. Automatic control range is from 25% to 100% of full load. The system is designed to maintain steam pressure setpoint within ±2 Kg/cm²g, steam temperature setpoint within ±5°C, and drum level setpoint within ±75 mm

The boiler control system is designed to provide the following regulation functions:

- Feedwater regulation, which controls water drum level, utilizes single element (water level) and three element control. The single element is used for low loads. Above 30% load, three elements (water level, steam flow, feedwater flow), boiler feed pump speed, and feedwater regulator are utilized to control the drum level.

- Boiler combustion control, in which the draft air, induced air, and fuel oil systems are regulated to keep the furnace pressure at rated range.

- Boiler steam temperature regulation controls the superheat steam and reheat steam temperature at 541°C. The main steam should be maintained at rated temperature at 100-40% load, and the reheated steam should be maintained at rated temperature at 100-50% load. The main steam is regulated by tilting burners and by superheat spray water of the secondary and final superheat. The reheated steam is regulated by flow control of flue gas recirculation along with tilting burners at low load. Reheat spray water side A&B is also utilized under emergency condition when the reheated steam temperature rises abruptly

  When the burner moves upward one degree (1°), the superheat steam temperature rises 1.38°C, and the reheat steam temperature rises 1.88°C. When the burner moves downward one degree (1°), the superheat steam temperature decreases 0.8°C, and reheat steam temperature decreases 0.95°C.

- Pressure regulation for HP auxiliary steam. The auxiliary steam is supplied redundantly from two sources, the turbine and boiler. The HP auxiliary steam supplies steam to the oil supply system, oil unloading facility, water treatment plant, and evaporator.

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- o Atomizing steam pressure regulation for fuel oil.

The boiler control system also provides the following control functions

- o Control burner angles, each burner (4x4) total 16 burners can tilt up and down 30° maximum with reference to the horizontal position. The burners in each elevation are synchronously controlled in the control room. Steam temperature is changed by changing the flame center "Fireball".

- o Secondary air dampers (cooling air) of the boiler furnace chamber. The selection operation for furnace secondary air baffles consists of four sets, in which each set controls five dampers of secondary air at one corner of the furnace chamber.

Comments and Current Condition

Interviews with plant operation personnel indicated that the majority of the following regulators are on manual, which require constant operator attention to control the process:

1) H.S.D. Oil Flow
2) R.O. Flow
3) Atomizing Steam Pressure
4) Inlet Damper of Forced Draft Fan Side A
5) Inlet Damper of Forced Draft Fan Side B
6) Damper of Induced Draft Fan Side A
7) Damper of Induced Draft Fan Side B
8) H. P. Aux. Steam Press
9) R. H. Temp - Damper Side A
10) R. H. Temp - Damper Side B
11) R. H. Spray Water-A
12) R. H. Spray Water-B
13) Superheater Sec: Spray-A
14) Superheater Sec: Spray-B
15) S. H. Spray Water on Side-A
16) S. H. Spray Water on Side-B
17) Low Load Feedwater Valve
18) Steam Coil Air Heater Outlet Temp

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19) O2 Station
20) Deaerator Level Control 1
21) Deaerator Level Control 2
22) Gland Sealing Steam Pressure Control
23) Condenser Level Control
24) B.F.P. No. 1 Flow Control
25) B.F.P. No. 2 Flow Control
26) B.F.P. No. 3 Flow Control

Review of Units 2, 3, and 4 trip recorders indicated a history of control and regulator malfunctioning.

The disagreement of instrumentation readings at the panel indicators, recorders, computer monitor, and local indicators for Units 2, 3 and 4, makes safe and economical operation of the boiler and other regulation loops very difficult.

The plant operating staff documented these problems on correspondence to the contractor, CMEC.

Assessment

Assuming proper selection of components and adherence to manufacture's recommended O&M procedures, the system could be suitable for 20 years life with higher than normal O&M costs. Repairs of the instrumentation readings inconsistency and auto regulation are needed for safe and reliable operation.

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JAMSHORO UNITS 2, 3 & 4

AUXILIARY STEAM SYSTEMS - BOILER SIDE

Description

The boiler-related auxiliary steam systems consist of a single house boiler serving Units 2, 3 & 4 and the soot blower system for the main steam generators

The house boiler is a Harbin Boiler Works 2-drum, natural circulation type SZYZO-10 boiler rated at 20 tons per hour. Per CMEC Operating Manual, the boiler produces saturated stream at 169°C, and is fired with light oil through two (2) burners located in the front wall. The unit is equipped with forced draft and induced draft fans, and operates with balanced draft maintained in the furnace. Trip/trouble alarm is available at the annunciator window on the BTG Board in the control room.

The steam soot blower system for each of the steam generators consists of sixteen (16) type RC-111 furnace waterwall short retract blowers and twenty (20) type CC-1 long retractable blowers located in the superheater, reheater, and economizer cavities, plus two blowers serving the air preheaters. The source of soot blowing steam is the crossover pipe between the primary superheater outlet and the secondary superheater inlet downstream of the desuperheater.

Comments and Current Conditions

The physical condition of the house boiler is good. The boiler was not operating at the time of the plant visit. Interviews with plant O&M personnel indicates the house boiler operates on manual and not on automatic as designed.

Mechanical problems were reported with the soot blowers. During the walkdown inspection, a general condition noted was oil leakage from the soot blower drive mechanisms. The soot blowers require minor maintenance to correct the oil leakage and mechanical problems.

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JAMSHORO UNITS 2, 3 & 4

AUXILIARY STEAM SYSTEMS - BOILER SIDE

Assessment

The house boiler and soot blower systems are suitable for extended operation. Normal maintenance is anticipated to keep the systems in good working order. Restoring automatic operation of the house boiler is recommended for safety and reliability considerations.

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JAMSHORO UNITS 2, 3 & 4

BOILER STRUCTURE

Description

The boiler structures of Units 2, 3 and 4 are identical. Each boiler building is 30.0 meters wide in the North/South direction, 40.5 meters long in the East/West direction, 56.00 meters high. The boiler structure has a symmetrical axis in the East/West direction. The boiler structure is supported on an independent mat foundation separate from the adjacent turbine building mat foundation. The top of the mat is at El -1.0 meters. The mat is one meter thick reinforced concrete and supported on a solid limestone formation. The structural steel is framed around the boiler and the weight of the boiler is suspended from the highest level beam allowing the boiler to expand and contract with the temperature changes it will experience in operation.

There are nine platform levels at varying elevations. There are vertical and horizontal bracing systems which tie columns and beams together and carry the horizontal loads, including wind and earthquake, down to the foundation.

The boiler building is covered by a metal roof but is open on all sides. The stairwell provides access to the platforms. There is also a free standing elevator shaft supported horizontally by the boiler structure through the horizontal beam connections.

The platform floors and stairs are covered with galvanized steel grating and are furnished with hand railings and toe plates. The boiler structure also supports the air heaters, air and flue gas ducts, steam pipes, burners and fans.

Comments and Current Condition

The design of the Units 2, 3 and 4 structures are much different than that of Unit 1. Since the boiler structure is tall and carries considerable weight, structural steel design is very important. Normally, rolled sections specifically developed for heavy, high structures are used. In order to provide sufficient material to the cross section in heavily loaded columns, built-up closed box-type cross sections were used. Welded boxed girders for beams and for diagonal bracing members followed the same selection route. A boxed section saves steel since it provides a larger moment of inertia, increased torsional rigidity and improved local and overall stability. However, it complicates the connection details and the erection. The gussets became double walled, the member end remained open in some

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cases, leaving the interior of the boxed member unprotected against corrosion. Not only the shop connections but the total erection · ·tion joints became welded. Welded erection joints are difficult to control to produce quality work since the environmental effects, such as, high wind, blowing sand, and extreme heat are difficult to control. These effects were very visible on the erection joints of the boiler structures The boxed column pieces were butt-fitted without welds, and the cover plates were welded on four faces of the boxed section to provide the continuity required. The cover plates appeared to have been trimmed on site due to their rough notched edges. The welds were equally rough, and did not indicate good quality workmanship. The main floor beams approaching the face of the column did not appear to be well framed to transfer any moment. Most of the beams were seated on brackets off the face of the column creating an eccentricity to the column. In many cases the beam web was 1 1/2 to 2 inches short of the column outside face. The ends of the boxed beams were open to the weather conditions and painting of the inside surface could not be confirmed. Similarly, diagonal members of the vertical braces had open end boxed cross sections which were unprotected from the weather. With such practices even the root of the shop welds, which make up the boxed sections, may be in jeopardy since moisture intrusion may reduce the strength of the weld. This will result in the strength of the member being reduced. The bottom end of diagonal boxed members at the ground level were closed with the concrete placed over the column anchors. However, where the top of the diagonal member is open, any rain water or moisture that gets into the opening has no other place to go except to fill the member with water. Fine dust will also get inside. Moist mud can form creating undetectable rusting of the member. As a minimum precaution, these hidden areas should be provided with drain holes.

Some column flange plates were misaligned in thickness as they were butted together. Horizontal bracing members under the platform level were made up of two channels to form a boxed member. Since a single gusset plate was used to connect the two channels, the plate thickness kept the channel flange edges apart, again creating a dirt and moisture trap to form inside the lower channel with no access to maintain or clean. The gusset plate was welded horizontally to the outside of one web of the boxed beam. Relative stiffness of the web with no backing inside the boxed member would have reduced the effectiveness of the bracing member. Therefore, what may have been calculated and designed on the drawings was not fully developed in practice because of the poor detailing.

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JAMSHORO UNITS 2, 3 & 4

BOILER STRUCTURE

At the boiler air intake supporting structure back-to-back double angles with spacer plates were used as a diagonal member. The gusset plate at the end connection was much thicker than the spacer plate thickness. This forced the spacer plates to be welded to one angle, and not to the other angle. Therefore, the spacers became ineffective. The two angles are not forming a combined crossed section as was calculated. The member, therefore, is not capable of resisting the forces for which it was designed. The spacers should be replaced with spacers of the proper thickness.

Pipe snubbers and pipe supports seem to have been connected arbitrarily to the structural members. This impression is supported by the choice of pipe support elements. They are long, and the ends of some of the elements are not properly tied to each other. Cantilevered supports are formed using the weak axis of channel section, and some of the pipe supports deliver their reactions directly to the web flanges of the unreinforced boxed members.

The unit 2 electrical conduits were almost all externally corroded. In order to continue the routing of conduits, horizontal handrails were abruptly cut and stopped. Below grating, electric boxes had no box covers thereby exposing the wire connections to the weather. Fluorescent light fixtures were attached to slender 1" poles. They vibrated greatly under the effects of wind at the higher elevations. Several of the fixtures were disconnected and broken. Although these items are not part of the structure, they are supported by them. These problems will affect the safe working environment around platforms and stairs.

Gloss paint of the handrailing was chipped off and cracked in many places. These areas require repainting. At higher elevations of the Unit 2 structure, the galvanized support channels for the grating were already corroding indicating poor quality of the galvanizing process used.

In Units 3 and 4 structures, the site welding workmanship was as poor as in the Unit 2. None of the erection cover plate edges were smooth. Evidence of grinding was not seen at any location. The vertical gusset plate welds were of especially poor quality.

On Unit 3 boiler structures, a beam located at approximate 20.0 meters elevation spanning in the North/South direction along axis 3 had an especially poor quality appearance. A space of one inch between the box beam and a bracket plate underneath from the column edge almost to the midspan of the beam had been attempted to be filled with perhaps 4 or 5 passes of bad weld. The beam was boxed by welding two channels in the upright position. The function of the long bracket was not obvious. Tying a long bracket to weld along the existing weld seam is not good practice. It is even a poorer practice to try to fill

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JAMSHORO UNITS 2, 3 & 4

TURBINE-GENERATOR COMPONENTS & SYSTEMS

Each of the turbine-generators of Units 2, 3, & 4 is a Harbin Turbine Works (The People's Republic of China) 200MW N210-132/538/538 type indoor unit The turbine is a tandem compound, three casing, double flow exhaust, impulse, reheat, condensing type. The generator is a synchronous, two pole unit type which is hydrogen cooled and has a water cooled stator. The unit has a rotating AC exciter

The turbine-generator components and systems evaluated in the study consist of the following:

High Pressure Stationary Components
- High Pressure (HP) Outer Cylinder
- HP Inner Cylinder
- No. 1 Diaphragm Carrier
- No. 2 Diaphragm Carrier
- No. 3 Diaphragm Carrier
- No. 4 Diaphragm Carrier
- No. 5 Diaphragm Carrier
- Nozzle Blocks
- HP Diaphragms
- Intermediate Pressure (IP) Outer Cylinder
- IP Diaphragms
- Main Steam Stop Valves
- Control Valve Steam Chests
- Reheat Stop Valves
- Interceptor Valves (Shell Mounted)
- HP Turbine Lead Piping and IP Turbine Lead Piping

Turbine Rotating Components
- HP Rotor
- IP Rotor
- Low Pressure (LP) Rotor
- IP Shrunk on Wheels
- IP Shrunk on Coupling
- LP Shrunk on Wheels and Couplings
- HP Blades
- IP Blades
- LP Blades

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JAMSHORO UNITS 2, 3 & 4

TURBINE-GENERATOR

Low Pressure Stationary Components
- LP Exhaust Hoods
- LP Mid Cylinder
- No. 6 Diaphragm Carriers
- LP Diaphragms
- LP Crossover Pipes

Generator and Excitation - Electrical & Isolated Phase Bus Duct

Generator Rotating Components - Mechanical
- Generator Rotor Forging
- Generator Retaining Rings

Turbine Supervisory Instrumentation & Monitoring

Steam Turbine Controls and Coordinated Controls
- Speed up
- Mechanical Hydraulic (MHC)
- Electrohydraulic (EHC)
- Coordinated Control (CCS)

High Pressure & Low Pressure Turbine Bypass System

Turbine-Generator Auxiliary Components/Systems
- Hydraulic and Lubricating Oil System
- Turning Equipment
- Gland Steam Seal System
- Turbine Bearings
- Turbine Pedestals
- Generator Seal Oil System
- Generator Hydrogen System
- Generator Cooling Water System

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a big gap with weld instead of removing the bracket and fitting it properly to the connecting member. Approximately 75% of the erection welds observed in Units 3 and 4 did not have smooth surfaces. They appeared to be the work of unqualified welders.

Assessment

The reinforced concrete mat foundations of Boiler Units 2, 3 and 4 should not deteriorate within the next 20 year period.

The erection practice and detailing used may have reduced the design strength value of the boiler structure. The diagonal member at the boiler air intake supporting structure should be modified by installing the correct size spacers. All boxed members where moisture may accumulate should be provided with drain holes. The structure must be kept under systematic maintenance inspection in order to recognize any corrosion damage that may occur, especially on the boxed members. Assuming proper design, correction of deficiencies, systematic inspections and preventive maintenance practices, the boiler steel structures should not deteriorate to the point of unsuitability within the next 20 year period.

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JAMSHORO UNITS 2, 3 & 4

HIGH PRESSURE STATIONARY COMPONENTS

Description

The high pressure stationary components for each of these three Harbin Turbine Works N210-132/538/538 turbines are composed of the following: HP outer cylinder with a conventional bolted horizontal joint and with four (4) main steam inlet connections, HP inner cylinder with assembled nozzle blocks and the locating bores for diaphragms-stages 2 through 9, No. 1 diaphragm carrier for diaphragms-stages 10-12, IP outer cylinder with conventional bolted horizontal joint, with interceptor valve bodies fabricated integral to the cylinder and with four (4) reheat steam connections, No. 2, 3, 4 and 5 diaphragm carriers for diaphragms-stages 13-15, stages 16-18, stages 19 and 20 and, stages 21 and 22 respectively, nozzle blocks and HP diaphragms for impulse stages 1-12. IP diaphragms for impulse stages 13-22, two main stop valves, two control valve steam chests with two control valves each, two reheat stop valves-one on each side, two interceptor valve chests fabricated integral with the IP outer cylinder - each with two interceptor valves each, HP turbine lead piping and IP turbine lead piping

Comments and Current Condition

No problems were reported during the interviews with Jamshoro plant maintenance and operating personnel on Units 2, 3 & 4 which are still in the warranty period. On Unit 2 no significant problems were uncovered from the interviews and from the review of the first year inspection report. Some deformation was reported on the Unit 2 HP inner and outer casings after the thermal incident of June 6 & 7, 1991 (See Jamshoro Units #2, 3 & 4 Turbine Rotating Components). The amounts of distortion reported were small and not unusual. This should not affect proper assembly and alignment of these components in the future if the amount of distortion does not significantly increase.

The high pressure stationary components noted above all appear to be in good condition based on the plant personnel interviews and the maintenance reviews. The deformation of the HP outer and inner casings of Unit No. 2 (reported to be as much as 4mm joint opening on the HP inner casing) does not appear to be excessive based on experience with similar components in service.

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JAMSHORO UNITS 2, 3 & 4

HIGH PRESSURE STATIONARY COMPONENTS

Assessment

Based on the evaluation performed using design data, information obtained from the interviews, reports on the thermal incident on Unit No. 2, industry experience with similar design units and the young age of these units no major problems are anticipated in the near future. Assuming similar operating practices as for Unit No. 1 being applied to Units No. 2, No. 3 and No. 4, similar turbine metal life consumptions for the HP casing and the main stop valve may be expected. Assuming the same severity of start-ups for the next twenty-years and assuming base load operation with a minimum capacity factor of 60% and 10 start-ups per year (2 cold, 4 warm, 4 hot), it is expected that the turbine metal life consumptions for the HP casing and main stop valves will be very low, similar to unit No.1 The distortion of the Unit No. 2 HP inner and outer casings should be monitored at future maintenance outages.

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JAMSHORO UNITS 2, 3 & 4

TURBINE ROTATING COMPONENTS

Description

The turbine rotating components for each of the three duplicate Jamshoro Units No. 2, 3 & 4 consist of the HP rotor, IP rotor, LP rotor and the assembled rotating blades. The HP rotor is a single piece alloy steel forging with 12 integral wheels and a integral coupling at the IP end. The IP rotor is a single flow rotor made from an alloy steel forging with seven integral wheels (stages 13-19), an integral coupling at the HP end, three shrunk-on wheels (stages 20-22) and a shrunk on coupling at the LP end. The LP rotor is a double flow rotor made from an alloy steel forging with shrink fitted wheels (stages 23 through 27 on the generator end and stages 28 through 32 on the IP end).

Comments and Current Condition

The only significant problem was that of the Unit No. 2 bowed HP rotor that was discovered after the thermal incident of June 6 & 7, 1991. Interviews with Jamshoro plant maintenance and operating personnel and a review of the first year inspection report on the Unit No. 2 did not reveal any other problems on the turbine rotating components of Unit No. 2. There were no problems found on the turbine rotating components of Units 3 and 4 based on the interviews of Jamshoro plant maintenance and operating personnel and the maintenance records. The Unit No. 2 HP bowed rotor was replaced with a new rotor in August 1991. The old Unit No. 2 HP turbine rotor is being returned to the Harbin Turbine Works for repair. It will be used as a spare HP rotor for the Jamshoro Units No. 2, 3 & 4. WAPDA has initiated a Committee of Inquiry to investigate the cause of the Unit No. 2 HP bowed rotor and to make recommendations.

The turbine rotating components, HP rotor, IP rotor, LP rotor and all rotating blades currently all appear to be in good condition. This includes the new HP rotor in operation in Unit No. 2. No unusual conditions or problems are known.

Assessment

The turbine metal life consumption of the HP rotors and the IP rotors may be roughly approximated by assuming similar operating practices for Units No. 2, 3 & 4 as was experienced on Unit No. 1. The one exception is the Unit No. 2 HP bowed rotor which experienced plastic deformation but it has since been replaced with a new HP rotor with virgin material.

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JAMSHORO UNITS 2, 3 & 4

TURBINE ROTATING COMPONENTS

Also assuming similar basic rotor geometry for Units No. 2, 3 & 4 compared to Unit No. 1, the turbine metal life consumptions for the HP rotors (not including the new Unit No. 2 HP rotor) and the IP rotors can be estimated by the number of start-ups experienced to date. Assuming the same severity of start-ups for the next twenty (20) years and assuming base load operation with a minimum capacity factor of 60% and 10 Start-ups per year (2 cold, 4 warm, 4 hot) it is expected that the turbine metal life consumptions for the Units No. 3 and 4 HP rotors and the Units No. 2, 3 and 4 IP rotors will be very low, similar to Unit No. 1. The turbine metal life consumption for the Unit No. 2 HP rotor will be less than that of the Unit No. 1 HP rotor because it is a new rotor just installed in August 1991.

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JAMSHORO UNITS 2, 3 & 4

LOW PRESSURE STATIONARY COMPONENTS

Description

The low pressure stationary components on the Units No. 2, 3 & 4 Harbin Turbine Works 200MW tandem compound double flow turbines are each made up of LP exhaust hoods, LP mid cylinder, No. 6 diaphragm carriers, LP diaphragms and LP crossover pipes

The low pressure section is a double flow section with two crossover pipe admissions on the upper half LP mid cylinder. There is a LP exhaust hood on each end with downward exhaust to the condenser. There are two No. 6 diaphragm carriers, one on each end, containing two diaphragms (stages 29 and 30 on the IP end and stages 24 and 25 on the generator end). The LP mid cylinder contains the LP admission diaphragms, one on each end (stage 23 on the generator end and stage 28 on the IP end). There are two latter stage diaphragms on each end of the LP section (stages 26 and 27 on the generator end and stages 31 and 32 on the IP end).

Comments and Current Condition

No problems were discovered with any of the low pressure stationary components of the Jamshoro Units No. 2, 3 & 4 based on the interviews conducted with plant maintenance and operating personnel and the review of the first year inspection report of the Jamshoro Unit No. 2.

The low pressure stationary components described above on Jamshoro Units No. 2, 3 & 4 all appear to be in satisfactory condition.

Assessment

No major problems were found on the low pressure stationary components of Jamshoro Units No. 2, 3 & 4 nor are any anticipated in the future. This assessment is based on the information obtained at the plant during personnel interviews, review of maintenance records, and industry experience similar with other low pressure stationary components. The low pressure stationary components of Jamshoro Units No. 2, 3 & 4 are expected to be suitable for the next twenty (20) years of continued operation without major repairs or replacements. Normal maintenance and inspections should regularly be performed at scheduled major maintenance outages.

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JAMSHORO UNITS 2, 3, & 4

GENERATOR AND EXCITATION - ELECTRICAL & ISOLATED PHASE BUS DUCT

Description

Three (3) Generators:	247 MVA, Type GFSN-210-2, manufactured by HEMW, 50 Hz, 15.75 ±5% kV, 9.056 kA rated current, 3000 rpm, 0.85 power factor, 470V field voltage, 1830A field current, class of insulation "F" for the stator and rotor. 3-phase, 2 poles, hydrogen and water cooled.
Three (3) Main Exciters:	Type JL-1165-4, manufactured by HEMW. AC exciter, 1165 kW, 431V, 1562A. 0.91 pf. 160 Hz
Three (3) Pilot Exciter:	Type TFY-46-5a, manufactured by HEMW, AC exciter, 46 kW, 161/93V, 165-285.8 amp. 0.875 pf. 500 Hz.
Isolated Phase Bus Duct:	The isolated phase bus duct is manufactured by Fuxin enclosed bus factory, type GFM-20-1, aluminum conductor, rated 20 kV, 150 kV BIL, conductor temperature rise less than 60° C with aluminum enclosure. The main bus circuit is rated at 10,000 Amp with 400 kA symmetrical current. The sub bus circuits are rated at 2000 Amp with 560 kA symmetrical current.

Comments and Current Condition

Interviews with plant O&M personnel, walk through inspections, and review of plant records revealed that there is a persistent overheating problem with the generator exciter carbon brushes in Units 2, 3, and 4. The O&M personnel reported that in some cases, they had to operate the units on reduced load as a result of this problem. This problem was addressed on Unit 2 during the First Inspection. According to the Report of First Inspection of Unit 2, the carbon brush and slide ring were precision ground and the overheating phenomenon was eliminated. Plant personnel however stated the overheating still exists. During our visit, Unit 2 exciter enclosure was removed to reduce the temperature.

Interviews with electrical maintenance personnel, walkdown visual inspections, and review of plant trip report, indicates no problem history with the isolated phase bus duct.

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JAMSHORO UNITS 2, 3, & 4

GENERATOR AND EXCITATION - ELECTRICAL & ISOLATED PHASE BUS DUCT

Assessment

Normal repair such as precise grinding of carbon brushes and slide ring is needed to overcome the overheating.. Assuming repairs are made, proper design and selection of components and adherence to the manufacturer recommended maintenance and operating procedures, the generator, excitation system and isolated phase bus duct are expected to be suitable for 20 years continued operation.

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JAMSHORO UNITS 2, 3 & 4

GENERATOR ROTATING COMPONENTS - MECHANICAL

Description

The generator rotating components-mechanical on the Harbin Works QFSN-210-2 generator consist of the generator rotor forging and the generator retaining rings. The generator rotor forging is alloy steel and the generator retaining rings are high strength alloy steel rings shrunk on to the rotor body to contain the rotor coil ends at operating speeds. Jamshoro Units No. 2, 3 & 4 are duplicate units and have duplicate generator rotating components-mechanical

Comments and Current Condition

There is no history of problems on the generator rotating components-mechanical noted above for the Jamshoro Units No. 2, 3 & 4 based on interviews with plant operating and maintenance personnel and the review of the maintenance records.

The generator rotating components-mechanical which consist of the generator rotor forging and the generator retaining rings at each end for the Jamshoro Units No. 2, 3 & 4 all appear to be in satisfactory condition.

Assessment

Based on the information obtained for personnel interviews and the review of records, the generator rotating components-mechanical of the generator rotor forging and the generator retaining rings for the duplicate Jamshoro Units No. 2, 3 & 4 should be suitable for 20 years of continued operation without major repairs and replacements. The condition of the generator retaining rings should be carefully monitored by non-destructive examinations during regularly scheduled maintenance outages. Routine maintenance and inspections should be performed on the generator rotor shaft forging during scheduled maintenance outages.

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JAMSHORO UNITS 2, 3, & 4

TURBINE SUPERVISORY INSTRUMENTATION & MONITORING

Description

The steam turbine safety monitoring system consists of cabinets, sensors, indicators, recorders and alarms. The system provides monitoring of the following parameters:

- Eccentricity of rotor
- Left/right travel of control valves servo motors
- Travels of reheat intercept valve servo motors
- Oil level in oil reservoir
- Absolute expansion HP & IP cylinders
- Mechanical synchronizer travel
- Differential expansion (HP/IP/LP)
- Vibration of (9) bearings
- Load limiting indication
- Overspeed emergency governor action

The system provides protection function of the following parameters:

Speed:	Alarms when over than 110%, and trips turbine when over 116% of rated speed.
Axial Displacement:	Alarms at +0.8mm and -1.0mm, trips the turbine at +1.0mm & -1.2mm.
Low Lube Oil Pressure:	When the lube oil pressure is lower than 0.6 Kgf/Cm², the AC motor driven oil pump automatically starts.. When lower than 0.5 Kgf/Cm² the DC motor driven oil pump automatically starts and the turbine is tripped. When the lube oil pressure is lower than 0.3 Kgf/Cm² the rotor turning gear of the turbine is stopped. Pressure regulator with range 0.2 Kgf/Cm² is utilized.
Vacuum Drop in Condenser:	Alarm at 0.25 ata, and when lower than 0.35 ata the turbine is tripped. Pressure regulator with rang 0-760mm Hg is utilized.

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JAMSHORO UNITS 2, 3, & 4

TURBINE SUPERVISORY INSTRUMENTATION & MONITORING

Comments and Current Condition

Interviews with plant O&M personnel, review of correspondence and status reports of instrumentation, and walk through inspections indicated that the data acquisition system computer, recorders, and indicators reading do not agree. This is a common problem on all 3 units. This causes confusion as to appropriate actions to be taken by operating personnel.

Specific problems on the units are as follows:

Unit 2:	Vibration recorder out of order, the turbine bearing high vibration prevailing, and the generator temperature scanner is out of service.
Unit 3:	The eccentricity indicator and recorder, bearing metal temp recorder, IP cylinder metal temperature and turbine digital speed meter are out of service. The most serious is the condenser vacuum protection which has been disabled by CMEC since commissioning of Unit 3 (per plant records).
Unit 4:	Inconsistent readings between indicators, records and monitors for condenser vacuum, lube oil pressure and turbine speed.

Assessment

Calibration, repairs or replacement are needed to put the above mentioned instruments back into service. Based upon the newness of the plant, correction of deficiencies, assuming proper selection of instrumentation and compliance with the manufacturer recommended O&M procedures, the turbine supervisory system should be suitable for 20 years continued operation.

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JAMSHORO UNITS 2, 3, & 4

STEAM TURBINE CONTROLS AND COORDINATED CONTROLS

Description

The steam turbine type N210-122/538/538 is equipped with both electrohydraulic (EHC) and mechanical-hydraulic control systems (MHC). A common actuator is used for both the EHC and MHC with a switching valve to transfer between the two systems. The speed-up system performs closed loop control over the full speed range from turning gear to synchronous speed to automatically control the warming speed, warming time, percentage speed variation, and acceleration rate for passing through the critical speed zones. When the steam turbine reaches 3000 rpm, the speed-up system control is automatically switched over to EHC system control.

When the unit is synchronized, the EHC system automatically loads the turbine with initial load. The unit could be operated with or without system frequency bias

The unit picks up load with sliding pressure by setting the MW while the MW rate ratio is controlled by the boiler. The unit could be loaded with fixed MW rate ratio controlled by the EHC. The MHC tracks the EHC such that bumpless transfer is achieved.

The system also has a coordinated control system (CCS) feature to operate the unit with coordination between boiler-turbine-generator.

Comments and Current Condition

Interview with plant maintenance and operating personnel, review of records, and walk through inspections indicated the following:

- Operation and performance of the above systems are not satisfactory for Units 2, 3, and 4. It was reported in a letter from WAPDA to CMEC dated 9/9/91 that Unit 2 MW varies sharply in response to small frequency changes

- The CCS cannot be activated since several loops, such as fuel oil and steam temperature control loops, are on manual at all times. Even if the loops are on auto, the CCS has not been tested for reliable operation to the satisfaction of the operating personnel.

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JAMSHORO UNITS 2, 3, & 4

STEAM TURBINE CONTROLS AND COORDINATED CONTROLS

- The O&M personnel reported that the tracking system of the MHC does not work, which means that in case of failure of the EHC and automatic switchover to MHC, MW upset takes place. The O&M personnel reported two incidents where a 15 MW bump was experienced while the unit was producing 150 MW. To activate the MHC, the operator had to manually lift the changeover pilot valve at the turbine front.

The O&M manual calls for switching over between MHC & EHC once every two days to prevent the convertor from jamming. Due to lack of records which support the unreliability of the EHC & MHC system, we requested the plant operations to demonstrate the switchover from EHC to MHC while Unit 2 was on line. The plant operators declined our request on basis that they felt confident the bump would take place and did not want to risk upsetting the system.

Assessment

Repairs are needed to resolve the EHC frequency response problem and the MHC tracking problems. These problems could be attributed to either original design or not following O&M procedures. We cannot make an assessment of the coordinated control system (CCS) since the system was very seldom operational according to the plant records and operators experience. However, the fact that the CCS is not in service increases the operating cost and the risk of human error in manual control of the Units 2, 3, and 4. Assuming the above problems are resolved, manufacturer's O&M procedures are adhered to and based on the newness of the equipment, these systems should be suitable for 20 years continued operation.

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JAMSHORO UNITS 2, 3, & 4

HIGH PRESSURE & LOW PRESSURE TURBINE
BYPASS SYSTEM

Description

The turbine bypass system is manufactured by Sulzer of Switzerland and consists of the following:

- Electronics cabinets in the equipment room which includes high pressure (HP) and low pressure (LP) bypass pressure and temperature controllers
- HP & LP bypass electrohydraulic servo valves.
- Desuperheating stations.

The HP bypass system is mainly used during startup of the boiler and in case of turbine trip or load rejection. The steam is bypassed directly to the reheater and controlled to match the prevailing conditions in the reheater. The HP bypass system enables the boiler and turbine to be started independently.

Comments & Current Condition

Interviews with plant O&M personnel and review of plant records indicated that the bypass system is in satisfactory condition.

Assessment

Assuming proper design and selection of components, and adherence to the manufacturer's recommended maintenance and operating procedures, the system should be suitable for 20 years continued operation without major repairs or replacement.

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JAMSHORO UNITS 2, 3 & 4

TURBINE-GENERATOR AUXILIARY COMPONENTS/SYSTEMS

Description

The turbine-generator components/systems on this Harbin Works N210-132/538/538 type indoor unit consist of the following:

Hydraulic and Lubricating Oil System
Turning Equipment
Gland Steam Seal System
Turbine Bearings
Turbine Pedestals
Generator Seal Oil System
Generator Hydrogen System
Generator Cooling Water System

The hydraulic and lubricating oil system includes:

Main Oil Tank
Main Oil Pump
Oil Coolers
Auxiliary Oil Pump
Turning Gear Oil Pump
Emergency Oil Pump
Turbine Oil Storage Pump
Oil Transfer Pump
Oil Conditioning Equipment
Relay Dump Valve

The turning equipment is a motor operated gear driven turning gear which has a turning speed of approximately 3 rpm.

The gland steam seal system includes:

Gland Steam Seal Regulator
Gland Steam Exhaust Blower
Gland Steam Condenser

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This tandem compound three (3) casing turbine has five (5) journal bearings. The number two bearing is a combined thrust and journal bearing. The number two journal bearing is the self aligning type and the other four (4) turbine bearings are fixed type.

JAMSHORO UNITS 2, 3 & 4

TURBINE-GENERATOR AUXILIARY COMPONENTS/SYSTEMS

There are sliding turbine pedestals at the governor end of the HP section and between the HP and the IP sections. The turbine pedestal between the IP and the LP sections is of the fixed type.

The generator seal oil system includes:

Bearing Drain Enlargement Equipment
Seal Drain Enlargement Equipment
Seal Oil Control

The generator hydrogen system includes:

Hydrogen Supplying Unit
Hydrogen Gas Control Cubicle
Hydrogen Gas Dryer
Hydrogen Gas Storage Tank
Gas Analyzer
Control Panel

The generator cooling water system is a separate system that cools the generator stator.

Comments and Current Condition

In Units 2, 3 and 4, the hydrogen valves, which should open automatically on low hydrogen pressure, currently operate only on manual. The control room operator is required to observe the hydrogen pressure indication and dispatch an operator to manually open the valve as the unit MW increases.

There were no other reported problems with the turbine-generator auxiliary components/systems noted above on the Jamshoro Units No. 2, 3 & 4 based on the interviews with plant maintenance and operating personnel and the review of the Jamshoro Unit No. 2 first year inspection report.

With the exception of the hydrogen valves, the turbine-generator components/systems for the Jamshoro Units No. 2, 3 & 4 all appear to be in satisfactory operating condition. No unusual conditions or problems were uncovered.

JAMSHORO UNITS 2, 3 & 4

TURBINE-GENERATOR AUXILIARY COMPONENTS/SYSTEMS

Assessment

Automatic operation of the hydrogen valves should be restored. The remaining turbine-generator auxiliary components/systems for the three (3) duplicate Jamshoro Units 2, 3 & 4 are expected to be suitable for twenty (20) years of continued operation without any major repairs or replacements. Normal maintenance and inspections should be regularly performed at scheduled maintenance outages.

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JAMSHORO UNITS 2, 3 & 4

BALANCE OF PLANT COMPONENTS & SYSTEMS

The balance of plant mechanical, electrical, instrumentation and controls, and civil structures evaluated consists of the following:

Feedwater System
- Condensate pumps
- Feedwater heaters
- Dearator
- Boiler feedwater pumps

Cooling Water System
- Cooling tower
- Circulating water pump
- Condenser

Cooling Tower Structure

Instrument Air System

Fire Protection

Chemical Feed System and Sampling Rack

Water Pretreatment System

Coagulation Sedimentation Tanks

Water and Wastewater Treatment Systems

Water Treatment Building

Emergency Diesel-Generator

Power Transformers

6.6 KV Metalclad Switchgear

400V Power Centers, 400V Motor Control Centers (MCC)

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JAMSHORO UNIT I

BALANCE OF PLANT COMPONENTS & SYSTEMS

Uninterruptible Power Supply (UPS)

220 KV Underground Cable

66 KV Cable

DC Station Batteries

Local Control Boxes, BTG Boardwiring, Control Cables, Cable Trays and Ducts

Plant Computer System

Turbine and Central Control Buildings

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JAMSHORO UNITS 2, 3 & 4

FEEDWATER SYSTEM

Description

The feedwater system conveys water from the condenser outlet to the boiler economizer inlet through eight stages of heating as well as condensing the steam in the steam jet air ejector coolers and the turbine gland steam condenser. The major components addressed in the report are the condensate pumps, feedwater heaters, dearator and boiler feedwater pumps

These 50% capacity motor driven condensate pumps are provided for each unit Under normal operating conditions at full load, two pumps would be operating with the third pump in stand-by mode. The pumps are vertical centrifugal multi-stage with stainless steel impellers and shafts.

There are four low pressure and three high pressure closed feedwater heaters per unit. All heaters are vertical "U" tube type. The two lowest pressure heaters (#1 & #2) have tin brass tubes. Heater 3 & 4 have copper nickel alloy tubes; the three high pressure heaters have 15 Mo3 alloy tubes.

The dearator is a cylindrical tray type mounted on a separate horizontal storage tank. The dearator is designed to maintain oxygen content in the effluent not greater than 0.005 cc/l.

Three horizontal barrel type multi-stage boiler feedwater pumps are provided for each unit. Each pump includes a variable speed hydraulic coupling and feedwater booster pump. Under full load conditions, two pumps would normally be operating with the third pump in stand-by.

Comments and Current Condition

A review of the rather sketchy Report of First Inspection of Unit 2 did not indicate any problems with the feedwater system. A review of the unit trip records noted three trips of Unit 2 were caused by the boiler feedwater pumps. Discussions with operating and maintenance personnel indicated the trips were due to a leaky feedwater control valve. Maintenance personnel stated the feedwater control valve was replaced and this solved the problem.

Plant personnel indicates no other major problems with this system for all three units.

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JAMSHORO UNITS 2, 3 & 4

FEEDWATER SYSTEM

The feedwater system appears in satisfactory condition based on the data reviewed and unit walk-through inspection. No unusual conditions were noted.

Assessment

Based upon the age of the unit, assuming proper design and selection of equipment and adherence to the manufacturer's recommended maintenance and operating procedure, the major components of the feedwater systems for all three units should be suitable for 20 years continued operation without major repairs or replacement

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JAMSHORO UNITS 2, 3 & 4

COOLING WATER SYSTEM

Description

The cooling water system provides the cooling water for the condenser and the bearing coolers. The major components addressed in the report are the cooling tower, circulating water pumps and condenser. The cooling tower structure is covered in detail in a separate section

The cooling tower is mechanical induced draft multi-cell cross flow type The structure is reinforced concrete and the fill material is PVC.

Three 50% capacity circulating water pumps are provided. Under normal conditions, two pumps are operating and one pump is in stand-by. The circulating water pumps are vertical, single suction mixed flow type.

The condenser is a two pass, divided water box horizontal surface type. The tube material is tinbrass in the condensing section and copper nickel in the air cooling section.

Comments and Current Conditions

A review of the rather sketchy Report of First Inspection of Unit 2 indicated low vacuum in the condenser. During the inspection a leaking flange connection between the 7th extraction valve and gland steam header was found. The connection was repaired and subsequent operation indicated condenser vacuum returned to normal.

A review of the unit trip records indicated Unit 4 tripped twice due to tripping of the circulating water pumps. Maintenance personnel indicated this was not a pump related problem. No other trips of the three units were attributed to the cooling water system.

Unit 3 cooling tower experienced a failure of one fan motor shaft which caused some damage to the tower. It is expected this will be fixed prior to acceptance of the unit.

The condenser for Units 2, 3 & 4 did not experience scaling problem as did the Unit 1 condenser. Interviews with plant operating and maintenance personnel indicated no major problems with the cooling water system.

The system appears in satisfactory condition based on the data reviewed and unit walk-through inspection. No unusual conditions were noted.

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JAMSHORO UNITS 2, 3 & 4

COOLING WATER SYSTEM

Assessment

Based upon the newness of the plant, correction of existing deficiencies, assuming proper design and selection of components, and adherence to the manufacturer's recommended maintenance and operating procedure, the major components of the cooling water systems should be suitable for 20 years continued operation without major repairs or replacement

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JAMSHORO UNITS 2, 3 & 4

COOLING TOWER STRUCTURE

Description

The cooling towers of all units are in general the same except for minor differences between the Unit 1 and Units 2, 3 & 4. Refer to the Description given for Unit 1 for details.

Comments and Current Condition

Except in one cell in the Unit 3 cooling tower, there was no observable damage. In this unit, a shaft between the fan motor and gear broke damaging the sloped fiberglass baffle wall, fan stack and fan blade.

The workmanship of the welding for the staircases leading from the inside to the top of cooling towers was of inferior quality.

The water splash boards are hung by rods or supported from channel sections. Some of these channels appeared to be corroding. Although the units are only a couple years old, corrosion was also obvious on other steel parts such as entry door frame, incoming cooling water pipes and hand railings at the roof level of the cooling towers.

Similar to Unit 1, these cooling towers are also supported on a solid limestone formation. There were no sign of settlement in either the cooling towers or the adjacent pump house structures. The concrete parts of the structures appear adequately built and did not indicate any major chipping, cracking or deterioration.

Assessment

Assuming proper design and erection, the cooling tower structures are expected to be suitable for 20 year continued operation. Miscellaneous components such as stairs, handrails, hangers and other attachments will require normal maintenance and repairs as necessary.

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JAMSHORO UNITS 2, 3, & 4

INSTRUMENT AIR SYSTEM

Description

Each unit has two sets of instrument air compressors. The compressors are vertical, belt driven, and manufactured by Shenyang Gas Compressor Factory. One set is normally in operation, the other is on standby, ready to start on low air pressure The discharge pressure of each compressor is 7 Kgf/Cm^2. The instrument air is dehumidified by an air dryer

The air compressors provide instrument air to the boiler control system, burner control system, and reverse current valves of turbine extraction steam line

Comments and Current Condition

Interviews with plant O&M personnel and review of Unit 2 trip report indicated that Unit 2 was tripped on May 19, 1991 due to low instrument air pressure. The maintenance personnel indicated that the transfer pump at the pretreatment facility was out of service at that time which provided cooling water for the instrument air compressor through the clarifier. The low level of clarifier water tripped the compressors which in turn tripped the unit.

The compressors in all units are in operating condition, however, there is no program in place to periodically change the air filters and conduct maintenance on the compressors.

Currently, every unit is being served by two compressors, without cross-ties to other units. The plant personnel indicated that the cross-ties are being planned for installation to avoid trips similar to that of Unit #2 on May 19, 1991.

Frequent tripping of instrument air compressors for Units 2, 3, and 4 has been reported in Pakistan Engineering Services Letter JS/18/91-92 to CMEC, dated July 7, 1991.

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JAMSHORO UNITS 2, 3, & 4

INSTRUMENT AIR SYSTEM

Assessment

The overall system appears to be in satisfactory condition with the exception of poor workmanship of cable terminations which is a general condition existing in Units 2, 3, and 4. The conformance document for Units 2, 3, and 4 require the instrument air systems to be provided with interconnection lines of neighboring units. This evidently was not provided.

Assuming proper design and selection of components, normal repairs to alleviate frequent tripping, and adherence to the manufacturer recommended maintenance and operating procedures, the system should be suitable for 20 years continued operation without major repairs or replacement. However, cross-tieing the instrument air system will increase the reliability factor of the units and should be installed.

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JAMSHORO UNITS 2, 3, & 4

FIRE PROTECTION

Description

The system consists of the following:

(6) Emergency Fire Water Pumps
(3) Motor Driven Emergency Fresh Water Fire Pump
(3) Diesel Driven Emergency Fresh Water Fire Pump
(3) Sets of Air Foam Extinguishing Equipment
(38) Sets of Air Foam Hydrants with (65) Hose Connections
(3) Fire Lighting Trucks
(6) Sets of Dry Chemical Extinguishing Equipment with Local/Remote capability (2000 Kg each)
(3) Fire Protection Panels
(6) Wheel Carry Power Chemical (50 Kg each)
(162) Hand Carry Power Chemical (8 Kg each)

Current Condition

Interviews with plant personnel, review of records, and walk-downs indicated that the plant stores the fire hoses in a warehouse because they were subject to theft.

The fuel oil unloading receiving area is considered hazardous due to the oil spillage throughout the area.

Assessment

Fire hoses should be reinstalled in the hose racks provided. Immediate clean-up of the fuel oil unloading facility is needed to avoid potential fire. Assuming proper selection of components, adherence to the manufacturer recommended O&M instructions and periodical functional tests, the system should continue to operate for 20 years.

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JAMSHORO UNITS 2, 3, & 4

CHEMICAL FEED SYSTEM & SAMPLING RACK

Description

Condensate and feedwater are chemically adjusted to prevent scale formation, corrosion, caustic embrittlement, and contamination of steam, such as silica carryover which would deposit on the turbine blades. This chemical feed system combined with boiler blowdown, demineralized make-up water quality, and boiler manufacturer recommendation provides the basis for each unit water cycle quality.

The system feeds chemicals to the boiler feedwater to control the ph and to inhibit release of oxygen in the boiler tubes, drum, superheater, and economizer.

Diluted hydrazine is applied to remove dissolved oxygen contained in the feedwater and to control the ph value. However, during plant startup and shutdown, an ammonium solution is injected in the condensate pump discharge to control the pH of the feedwater. During long term shutdown, concentrated hydrazine is used to protect the boiler from rust.

The sodium phosphate solution is used for inhibiting caustic embrittlement, and to remove hardness of the boiler water.

The sampling rack supervises the quality of make-up water, condensate, feedwater, boiler water and steam.

The chemical feed system consists of the following equipment:

(1) Hydrazine Solution Positive Displacement Pump (0.33 liter/minute)
(3) Diluted Hydrazine Solution Tank
(6) Phosphate Solution Positive Displacement Pumps (0.66 liter/minute)
(3) Phosphate Solution Tank (1 m^3)
(3) Ammonium Solution Tank (1 m^3)
(6) Ammonium Solution Pump (0.33 liter/minute)
(3) Stand-alone Control Panels
(3) Stand-Alone Sampling Racks manufactured by Changzhou Power Machine Works, with ph analyzers, conductivity meters, dissolved oxygen meters, hydrazine meters, ph indicators, conductivity indicator. In the control room, there are oxygen and hydrazine recorders.

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JAMSHORO UNITS 2, 3, & 4

CHEMICAL FEED SYSTEM & SAMPLING RACK

Comments and Current Condition

Interviews with O&M personnel, walk-downs, and review of plant records indicated that the chemical feed and sampling rack are on manual control. The conductivity meters are out of service. The sampling rack is located inside an enclosed room where temperature could reach 41°C.

Assessment

Proper ventilation is needed in the sampling rack room. Repair of conductivity meters and restoration of automatic functioning is essential. The current condition will cause increased O&M cost. Assuming proper selection of components, adherence to manufacturer's O&M procedures, the system is expected to last 20 years.

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JAMSHORO UNITS 2, 3, & 4

WATER PRETREATMENT SYSTEM

Description

The water is pumped form the intake structure at the Indus River to water receiving tanks to eliminate flocculation, then treated by coagulant. The clarified water is pumped to clarified water tanks then to the service water tanks.

The quality of treated water at the outlet of coagulation sedimentation tank is 6 to 8.5 ph, suspended solid is less than 10 ppm, and treated capacity is 2427.2 m^3/hr for two units, quality of treated water at outlet of filter equipment is 6 to 8.5 ppm, and suspended solid is 1.0 ppm.

The pretreatment facilities consist of the following equipment:

(6) Intake Water Receiving Tank (788.8 m^3)
(18) Coagulation Sedimentation Tank Transfer Pumps (HP LaserJet Series IIHPLASEII.PRSnk (3000 m^3)
(6) Cooling Tower Make-up Pumps (950 m^3/hr)
(6) Filter Equipment Transfer Pum, s (288-548 m^3/hr)
(9) Vertical Pressure Filters (45 m^3/hr)
(6) Air Scrubbing Blower, Rotary Type (28 Nm^3/min)
(3) Semi-underground Treated (Clarified) Water Storage Tank (1000 m^3)
(6) Filter Backwashing Pumps (360 to 576 m^3/hr)
(6) Drinking Water Feed Pumps (180 m^3/hr)
(6) Treated (Clarified) Water Transfer Pumps (110 to 200 m^3/hr)
(3) NaOH Chemical Storage Tank (10 m^3
(3) NaOH Horizontal Unloading Pump (13.1 m^3/hr)
(9) Dilute NaOH Tank (3 m^3)
(6) Dilute NaOH Dosing Pump (0.126 m^3/hr)
(9) Dilute NaOH Tank Agitator, Puddle Type
(6) Coagulant Tank (150 m^3)
(6) Coagulant Dosing Pump (1 m^3/hr)
(6) Coagulant Acid Tank (30 m^3)
(6) Coagulant Acid Dosing Pump (2.5 m^3/hr)
(6) Coagulant Aid Tank Agitator
(3) Concentrated NaOH Transfer Pump (13.1 m^3/hr)
(6) Chemical Storage Yard Pit Pumps (15 to 25 m^3/hr)

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JAMSHORO UNITS 2, 3, & 4

CHEMICAL FEED SYSTEM & SAMPLING RACK

ption

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Phosphate Solution Positive Displacement Pumps (0.66 liter/minute)
Phosphate Solution Tank (1 m^3)
Ammonium Solution Tank (1 m^3)
Ammonium Solution Pump (0.33 liter/minute)
Stand-alone Control Panels
Stand-Alone Sampling Racks manufactured by Changzhou Power Machine Works, with ph analyzers, conductivity meters, dissolved oxygen meters, hydrazine meters ph indicators, conductivity indicator. In the control room, there are oxygen and hydrazine recorders.

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(3) Local Control Panels (as needed) ph Meters and Flow Integrating Meters
(6) Service Water Tanks (1500 m^3)
(6) Service Water Pumps (54 m^3/hr)

Comments and Current Condition

Normally two out of three coagulation sedimentation tanks are in service, and the third is on standby. The cleaning of the tank is done manually once every year and requires approximately 3000 person hours. Unit 3 pneumatic control system of the mechanical filters is out of service as well as other miscellaneous pressure, flow, and local indicators. On Unit 2, in July one (1) out of six (6) coagulation tank raw water transfer pumps were in service. The equipment runs on manual control and requires a high degree of periodic maintenance and parts replacement due to the service operating conditions.

Assessment

All out-of-service equipment should be repaired and returned to service. Assuming proper design and selection of water pretreatment system equipment, the system should be suitable for 20 years continued operation O&M costs will be high due to the severe service encountered.

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JAMSHORO UNITS 2, 3 & 4

COAGULATION SEDIMENTATION TANKS

Description

For each unit there are three coagulation sedimentation tanks. The coagulation sedimentation tanks externally look similar to the tanks of Unit 1, but there are some structural differences. The tanks are constructed of reinforced concrete. At the center portion of the tank there is a cylindrical space with 7.8 meters inside diameter. The water to be coagulated is pumped into this cylindrical space. There is an agitator mounted on the slab acting as the top platform, over the cylindrical part. The platform is covered with an elaborate concrete roof on columns. Unit 1 tank does not have any slab or roof to cover the agitator motor. The top of platform is at EL 5.85 meters and the top of roof is at EL 9.72 meters.

The cylindrical wall is supported on radially oriented wall like columns. Between the radial walls, the cylindrical wall flares up into the shape of a cone. The bottom of the sedimentation tank with an inside diameter of 15.60 meters is formed like a flat spherical bowl in order to collect the sludge and pump it out from the centrally located pit. The clean water is collected on the radially positioned troughs at the upper elevation of the coagulation sedimentation tank. All the radial troughs are connected to a circular trough which feeds the outlet pipe. The external tank diameter at the top is 25.00 meters and 19.40 meters at the bottom. Between El. 0.0 and El +3.50, the tank wall is 0.35 m thick and conical in shape.

Comments and Current Condition

The concrete forming of the coagulation tanks was fair. There were no critical leaks or seepage observable from the walls. The surrounding of the tanks reflected natural ground conditions with no pavement These tanks collect fine clay sediments and need to be routinely emptied similar to the tanks of Unit 1, but not as frequently. The automatic sludge removal system is not functioning so that a long duration of down time is required in order manually to remove the sludge. During this process the walls and surrounding areas get dirty. The central cylindrical space below the agitator is more difficult to access.

Assessment

Structurally the coagulation sedimentation tanks should all provide 20 years service. They are superior to the coagulation sedimentation tanks of Unit 1 since they have less structural steel parts to corrode and lesser downtime due to sludging.

JAMSHORO UNITS 2, 3, & 4

WATER & WASTEWATER TREATMENT SYSTEMS

Description

The water treatment system is designed to produce treated water with conductivity of less than 0.5 us/cm at 25°C, with Si02 (silicon) of less than 0.015 ppm, and dissolved oxygen of less than 0.3 ppm.

The design capacity is 25 t/hr, two (2) sets of demineralizing system are installed per unit. The system is manufactured by WuXi Boiler Works.

The system is designed to regenerate automatically, the chemical consumption for regeneration is HCl 600 Kg and NaOH 250 Kg.

The system consist of:

(6) Water treatment Supply Pumps (70 to 120 m³/hr)
(6) Regeneration Water PumpS (30.6 TO 64.1 m³/hr)
(6) Booster Pumps (30.6 to 64.1 m³/hr)
(6) Anion Tower
(6) Cation Tower
(6) Mix-bed Tower
(6) Vacuum Degassing Towers
(6) Vacuum Generating Equipment, Steam Injection Type
(6) NaOH Tank, Pumps and Accessories
(3) Control Panels and as needed Instrumentation (silica meters, ph meters, etc)
(1) Wastewater pit with (6) Wastewater Discharge Pumps (50.5 to 110 m³/hr)
(3) Mix Air Blowers (360 m³/hr)
(6) Demineralized Water Tanks (1000 m³)
(6) Demineralized Water Transfer Pumps (35 to 60 m³/hr)

Comments and Current Conditions

Interview with plant O&M personnel, walk-downs, and review of the plant records indicated that O&M problems exist in the system.

Even though the systems are designed for manual and automatic operation, the systems only function in the manual mode. This requires the constant attention of operating personnel to keep it running. For example, in Units 2 and 3, all the alkaline concentration

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and silicon analyzer meters were out of order. Service water tank level indication is out of service. Outlet caustic soda concentration indicators for the NaOH injectors are out of service Additionally, outlet hydrochloric acid concentration indicators for the HCL injectors are out of service. In Unit 4, the meters and indicator are in service but the system is operated manually by the operators and can not continuously function automatically

Assessment

The out of service instruments should be repaired or replaced and the supplier be required to make necessary modifications to meet specification requirements for automatic operation to reduce operating costs. Assuming repairs are made, proper design and selection of components and adherence to the manufacturer recommended maintenance and operation personnel, the water and wastewater treatment system should be suitable of 20 years life

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JAMSHORO UNITS 2, 3 & 4

WATER TREATMENT BUILDINGS

Description

An individual water treatment building is provided for each unit. These buildings are duplicates and are similar in construction and shape to the Unit 1 water treatment building. They are located south of Unit 1 water treatment building.

Comments and Current Condition

No defects or deterioration on the structures were observed externally or internally. It was observed that pipe hangers were attached from the underside of the concrete beams. One pipe hanger was connected to an angle halfway buried inside the mortar covering the beam. If the angle was directly welded to the beam reinforcement and then covered with mortar, the strength of the frame may be critically jeopardized and in the long run the weakened beam may fail and not perform as designed.

Assessment

The mortar of the suspected pipe hanger location on the underside of concrete beams should be removed and attachment locations investigated to determine if the hangers were properly installed. The water treatment buildings are suitable for the next 20 years of plant operation, if it is proven that hanger attachment was properly executed and the strength of the beam is not reduced.

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JAMSHORO UNITS 2, 3, & 4

EMERGENCY DIESEL-GENERATOR

Description

Each of Units 2, 3, and 4 has an emergency diesel-generator manufactured by Guizhou Diesel Factory. The Unit 2 diesel generator is also connected to the Unit 1 400V critical bus.

The generator is rated 500 kW, 50HZ, 400V, 903 Amp, 0.8 power factor. The diesel is 750 HP 6 cylinders, water cooled and with a compressed air starting system.

The diesel-generators were specified for automatic start and automatic stop when normal power is restored for the 400V critical bus section.

There are two air compressors for each diesel.

Comments and Current Conditions

In Unit 2 one of the two air compressors has been damaged per WAPDA correspondence PD/re(0)/OPER:-2/15419-20 dated June 16, 1991. This has rendered the diesel generator inoperable since one air compressor does not provide enough pressure to roll the diesel engine. This has complicated the events during the shutdown of June 6, 1991 in which the turbine rotor bow occurred. The operator opened the generator breaker while the automatic transfer from auxiliary transformer bus to startup transformer bus was not accomplished. The emergency diesel generator was out of service and therefore Unit 2 was in blackout until the operator took corrective measures to restore power. It is currently out of service. Currently the diesel-generator for Units 3 & 4 are incapable of automatic start and therefore must be started manually. When the power is lost all the 400V AC critical loads will be out of service until operators start the diesels. At the time of the site visit, the root cause of this inability to start automatically was not yet identified.

Assessment

It is essential for any power plant to have a reliable diesel generator to automatically feed the AC critical bus in case of emergency, such as the incident at Unit 2 that occurred on June 6, 1991. Therefore, repairs or replacement of Unit 2 starting air compressors and restoring Units 3 and 4 to automatic mode capability are essential for the safe reliable operation of Units 2, 3, and 4.

JAMSHORO UNITS 2, 3, & 4

POWER TRANSFORMERS

Description

Units 2, 3, and 4 (3 sets) - Main Transformers:

Manufactured by Shenyang Transformer Works, OFAF, 250 MVA, 50 Hz; 220 ±10% kV/15.75 ±10% kV, wye/delta, high voltage neutral by direct grounding, insulation class "A", 12% impedance, BIL insulation level on high side 1050 kV and on low side 150 kV, insulating oil type is DB-25 GB 2536-81 by Dalian Seventh Oil Refinery, winding temperature rise limit 60°C, oil temperature rise limit 50°C, each transformer has three current transformers rated 600/5 A.

Units 2, 3, and 4 (3 sets) - Auxiliary Transformers:

Manufactured by Shenyang Transformer Works, ONAF, 25 MVA, 50 Hz, 15.75 ±10% kV/6.91 ±10% kV, delta/wye, low voltage neutral by transformer grounding, 10% impedance, insulation class "A", 150/60kV BIL, 10 cooling radiators, insulating oil type is DB-25 2536-81 by Dalian Seventh Oil Refinery, each transformer has (3) 12000/5 CTs and (6) 15000/5 CTs, winding temperature rise limit 50°C.

Units 3 and 4 (1 set) - Starting Transformer:

Manufactured by Shenyang Transformer Works, OFAF, 25 MVA, 50 Hz, 132 ±10% kV/6.9 ±10% kV, wye/wye, high voltage neutral is by direct grounding, 11% impedance, insulation class "A", insulation level 650/60 kV BIL, four cooling radiators, insulation oil type DB-25 GB2536-81 by Dalian Seventh Oil Refinery, 2 CTs 600/5, winding temperature rise limit 60°C, oil temperature rise limit 50°C.

Unit 2 (1 set) - Starting Transformer:

Manufactured by Shenyang Transformer Works, OFAF, 25 MVA, 220 ±10% kV/6.9 ±10% kV, wye/wye, high voltage neutral by direct grounding, 11% impedance, 1050/60 kV BIL, 5 cooling radiators, insulating oil type DB-25 GB2536-81 by Dalian Seventh Oil Refinery, 2 CTs 600/5 by SYTW, winding temperature rise 60°C, oil temperature rise 50°C.

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JAMSHORO UNITS 2, 3, & 4

POWER TRANSFORMERS

Comments and Current Conditions

Interviews with electrical maintenance and operating personnel and review of Units 2, 3, and 4 outage record indicated that Unit 3 tripped on July 11, 1991 due to operation of the main transformer protection relays. Plant personnel stated that the trip was due to operation of the transformer pressure relay. The cause of the transformer trip was not determined nor was damage, if any, assessed. Subsequently, the transformer was returned to service

By visual inspection, the power transformers appear to be in satisfactory condition with exception of Unit 3 main transformer oil tank. The tank appears to have leakage at the piping joints

Assessment

The unit 3 main transformer should be tested to determine if any change occurred due to the trip. Repairs of existing leakage on Unit 3 main transformer is required, and periodic oil sampling and insulation integrity tests are needed to implement corrective measures and avoid forced outages. Based upon the newness of the plant, corrective active identified are performed, assuming proper design and selection of components, and adherence to the manufacturer's recommended maintenance and operating procedures, the power transformers should be suitable for 20 years continued operation without major repairs or replacements.

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JAMSHORO UNITS 2, 3, & 4

6.6 KV METALCLAD SWITCHGEAR

Description

There are five (5) sets of indoor, drip proof metalclad switchgear assemblies manufactured by Bejing Switchgear Factory and rated 6.6 kV, 2500 amp, 50 Hz, 31.5 kA interrupting capacity, 60 kV BIL. Sixty-four (64) vacuum circuit breakers rated at 7.2 kV, 2500 amp, and 40 kA interrupting capacity, interrupting time 0.075 sec, opening time 0.06 sec, no load closing time 0.075 sec, 220 VDC control voltage are provided for the five switchgear assemblies.

Comments and Current Conditions

Interviews with plant electrical maintenance and operating personnel and review of the outage records indicated that Unit 3 trip on March 21, 1990 was due a to fault on the 6.6 kV tie breaker. The plant personnel stated that this was a fatal accident and was caused by a Chinese technician working on the tie breaker in which one side was hot

No unusual conditions were observed during walkdown and visual inspection of the 6.6 kV switchgear. However, it appears that the plant electrical maintenance personnel are not familiar and haven't received training in relay settings and vacuum breaker maintenance. Also, generally the cables are tagged in Chinese and the English tags are not permanent.

Assessment

Based upon the newness of the plant and assuming proper design and selection of components, the 6.6 kV switchgear should be suitable for 20 years continued operation without major repairs or replacement. However, the electrical maintenance personnel should receive training on protection relay settings and breaker maintenance.

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JAMSHORO UNITS 2, 3, & 4

400V POWER CENTERS & 400V
MOTOR CONTROL CENTERS (MCC)

Description

- Nineteen (19) 600V, indoor/drip proof power centers, manufactured by Shenyang L.V. Switchgear Factory, are provided. The power centers include nineteen (19) 6.6 kV/400V transformers and 200 air circuit breakers rated 600V, 40 kA interrupting capacity, with continuous current ratings ranging from 630A to 3000A. Control voltage for the circuit breakers are derived from the 220 VDC system.

- Twenty-nine (29) 400V motor control centers, manufactured by Shenyang L.V. Switchgear Factory, are provided. The MCC main copper buses are rated for 600V and 1500A and the branch copper buses are rated for 400A.

Comments and Current Conditions

Interviews with O&M personnel review of plant records, and visual inspection of the power centers and motor control centers in the various location throughout plant, indicated that physical condition of the centers are satisfactory with the exception of the residual oil unloading facility. At this location, the building is left open and the 400V control center is exposed to the elements and contaminated with dirt and dust. Moreover, the cable ducts are filled with oil which creates a hazardous condition.

In discussion with plant electrical maintenance personnel, they felt that the cooling tower fans and the intake water pumps are not provided with adequate overload protection causing premature failures of the motors in both locations. The problem was addressed to CMES on Pakistan Engineering Consulting Services Letter JS/252/90-90 dated August 5, 1991, which called upon CMES to replace all the overload protection for cooling tower fans and intake water pumps motors. The electrical maintenance personnel also reported that the breaker remote controls for the intake pump motors do not function.

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JAMSHORO UNITS 2, 3, & 4

400V POWER CENTERS & 400V
MOTOR CONTROL CENTERS (MCC)

Assessment

An engineering study is needed to determine the root cause of the frequent failure of the intake water pump and the cooling tower fan motors. The study should include:

- Evaluating the load required to meet the application and verifying the proper selection of motors.

- Evaluating the overload and short circuit protection provided for the motors and cables.

Cleanup of the residual oil unloading area is required to assure proper service life of the motor control center in that location. Based upon the newness of the plant, correction of current deficiencies and assuming proper selection of the power center and MCC components, they should provide 20 years service.

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JAMSHORO UNITS 2, 3, & 4

UNINTERRUPTIBLE POWER SUPPLY (UPS)

Description

The UPS system equipment, Model B311 is manufactured by Siemens. Each unit has redundant 30 kVA UPS consisting of 10 kVA modules. The main components consist of rectifiers, inverters, static bypass switches and batteries.

Comments and Current Conditions

Interviews with plant maintenance and operation personnel and review of the forced outages history for Units 2, 3, and 4 indicated low reliability of the UPS even though the UPS has redundant inverters. Several forced outages have occurred due to failure of the UPS which tripped the Furnace Safeguard and Safety System (FSSS).

The electrical maintenance personnel indicated a lack of adequate documentation to repair and troubleshoot the UPS, and that frequent failure of UPS components which require above normal stocking of spare parts.

The frequent tripping of the UPS for Units 2, 3, and 4 has been addressed in a letter JS/18/91-92 from Pakistan Engineering Services to CMES dated July 20, 1991.

Assessment

Adequate drawings and component cut sheets should be obtained from CMES/manufacturer. Further investigation is needed to establish the cause of the UPS low reliability. This could be a result of components failure, installation problems, or O&M procedures not being followed. In any case, the current condition is causing increased O&M costs and is reducing Units 2, 3, and 4 availability. Based upon resolving current problems, the newness of the plant, assuming proper design and selection of components, and adherence to the manufacturer recommended maintenance and operating procedures, the system should be suitable for 20 years continued operation.

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JAMSHORO UNITS 2, 3, & 4

132 KV & 220 KV UNDERGROUND CABLES

Description

Four (4) circuits of forced oil cooled 220 kV underground cables are routed:

- o From main transformers of Units 2, 3, and 4 to the switchyard
- o From Unit #2 starting transformer to the switchyard.

One (1) circuit of oil cooled 132 kV underground cable is running from Units 3 and 4 common starting transformer to the switchyard

The cables run in an underground concrete tunnel, manufactured by Shenyang Cable Works. The maximum oil pressure is 6×10^5 Pa, and the minimum is 0.2×10^5 Pa. Current carrying capacity at 55°C is 690 amp for the 220 kV cables and 435A for the 132 kV cables.

Comments and Current Condition

Interviews with plant maintenance and operation personnel, and review of the forced outage records, indicated the forced shutdown of Unit 3 on March 31, 1991 was due to oil leakage from the 220 kV cable. The leakage was repaired and Unit 3 went back on line.

The electrical maintenance personnel run daily checks including the following for the 220 kV cable tunnel system:

- Oil tank pressure
- Oil leakage
- Sheath grounding
- Lighting system
- Drain pump motors
- Tunnel fans
- Other abnormal conditions

Visual inspection of the underground tunnel indicated oil seepage in the 220 kV cables to the Units 3 and 4 main transformers

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JAMSHORO UNITS 2, 3, & 4

132 KV & 220 KV UNDERGROUND CABLES

Assessment

Normal repairs of the current seepage is needed. Assuming, repairs are made proper design and selection of components and adherence to the manufacturer recommended maintenance and operating procedures, the 220 kV and 132 kV cables should be suitable for 20 years service.

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JAMSHORO UNITS 2, 3, & 4

6.6 KV CABLES

Description

The 6.6 kV cables are used as subfeeders connecting the 6.6 kV/400V transformers in the 400V power centers, cabling from the low voltage side of the auxiliary transformers and for the feeders to the 6.0 kV motors. The 6.6 kV cables are XLPE insulated, manufactured by Shenyang Cable Works.

Comments and Current Condition

Interviews with electrical maintenance and operation personnel revealed single phase grounding problems with the Unit 2 6.6 kV feeder running underground from the 6.6 kV switchgear to the intake water 400V power and control center

Assessment

Assuming proper design of cables and selection of cables type and rating to meet the application, the cables should be suitable for 20 years continued operation. Appropriate instrumentation should be purchased for locating cable faults. At the present time repairs are needed for Unit 2 6.6 kV feeder to the intake water pump station The root cause of this failure in the underground cable should be determined to preclude similar failure in other underground cables.

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JAMSHORO UNITS 2, 3, & 4

DC STATION BATTERIES

Description

Each unit has a set of 220 VDC batteries manufactured by Shenyang Batteries Factory, located at the unit's battery room. The batteries are lead acid, 130 cells nominal voltage of each cell is 2V DC, rated capacity at 10 hr discharge rate of 1600 amp-hr and maximum discharge current of 2250 amp.

Each unit has a full wave rectifier manufactured by "Xian Power Rectifier Works", rated 3-phase 380V, 45-52.5 Hz, 200 amp, 200-260 VDC.

Comments and Current Conditions

Interviews with plant maintenance personnel indicated that 122 cells are filled with acid, of which 112 cells are in operation and 10 cells standby. The maintenance personnel check the voltage daily.

Visual inspection and walk through with electrical maintenance personnel, revealed that deterioration of cell poles are obvious throughout the batteries in Unit 2 and the same deterioration could be expected in Units 3 and 4.

Assessment

The deterioration could be a result of many factors which require further investigation. However, based upon the current condition, replacement of cells is expected in 5 years for each unit.

Estimated cost of replacement for each unit is estimated at $100,000 F.O.B. U.S. excluding installation.

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JAMSHORO UNITS 2, 3, & 4

LOCAL CONTROL BOXES, BTG BOARD WIRING, CONTROL CABLES, CABLE TRAYS AND DUCTS

Description

Power and Control Cables

The conformance document Volume II Section V Item 12, called for power and lighting cables to be rated at 1000V and 50°C, aluminum or copper, PVC insulated, and the multiconductor cables to be copper, PVC jacketed cable for direct buried or duct installation, and maximum voltage drop not to exceed 2.5% of the rated voltage.

The conformance document Volume III data sheets didn't include specifications for the 220 VAC and 220 VDC control cables or specifications for low voltage shielded cables for instrumentation applications, computer, and communication cables. Due to the lack of markings on the cables, ratings could not be determined by visual inspection.

Comments and Current Condition

Interview with O&M personnel, walk-downs, and review of documentation indicated the following:

- The cable trays are congested and in some areas are loaded above the top of the tray.
- Some cable trays welded parts and surfaces have sharp edges which could damage the cables.
- Some areas of the cable trays are exposed to the elements and accumulated considerable debris.
- Local control boxes located throughout the plant have no gaskets on the access door assembly to prevent moisture and dust from accumulating inside control boxes.
- The control cables entering the boxes are installed without conduit or conduit insulating bushings and thus the cables are in direct contact with sharp edges of the box.

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JAMSHORO UNITS 2, 3, & 4

LOCAL CONTROL BOXES, BTG BOARD-WIRING, CONTROL CABLES, CABLE TRAYS AND DUCTS

- The medium voltage cables, power cables and control cables run in the same ductbank, and in some areas the manholes and duct covers are left open and exposed to the elements.

- It appears that the cable trays are not classified into high voltage tray, low voltage, power and control cables tray, and low level signals tray. All the cables run together indiscriminately.

- There is no evidence that the instrumentation cables (4-20 ma, 0-1 ma, 0-5V, 0-10V) are shielded.

- Cables and wiring of the BTG board in the control room are not marked with permanent identification tags and some of the temporary marked tags are already faded away.

- Cables in some cases are marked in Chinese numbers only.

Assessment

During the 20 years life span, the above conditions will cause higher O&M cost as some of the cables will be subject to failure. This will also cause unreliable control and measurement of processes which has a direct affect on the availability and reliability of the units. It is recommended that a maintenance program be established to test the cable insulation integrity on a periodic basis in order that corrective action may be taken before failure occurs. Without a detailed analysis of the ampacity of consideration for each circuit it is not feasible time to predict the number cable of failures over a 20 year time frame.

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JAMSHORO UNITS 2, 3, & 4

PLANT COMPUTER SYSTEM

Description

Each unit has a computer system which provides data logging, graphic displays, sequence of events, turbine startup sequence monitor, alarming and performance calculation. The system consists of the following:

(6) CPU is manufactured by "Intel" Type ISBC 86/35
(6) Fixed hard disk unit is manufactured by "Japan FUJITSU" Type Winchester M2242A
(3) Input/output cabinets are manufactured by "New China Company"
(9) CRTs are manufactured by Hitachi, Type HM-3719A
(9) Dot Matrix printers manufactured by "Star Micronics Company"
(3) Dot Matrix I/O printers manufactured by "Texas Instruments"
(6) Trend Recorder manufactured by Japan, Type YEW-3061
(6) Floppy disk drives manufactured by Japan, Type Shugart 45
(3) Color copier by Japan, Type Multicolor
(3) Operators console by "New China Company"
(3) Operators desk, (3) printer desk, (3) engineers desk

The process input/output unit has the following capabilities:

Analog Input Points:	128 (1 to 5V or 4-20 ma)
RTD Points:	48
Thermocouple Points:	272
Digital Inputs:	192 wetted by 24 VDC (48 per module)
Pulse Inputs:	24 (8 per module)
Analog Outputs:	16
Digital Outputs:	48

Comments and Current Condition

Interviews with O&M personnel, review of plant records, and walk-downs indicated that the plant computer systems for Units 2, 3, & 4 operate satisfactorily.

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JAMSHORO UNITS 2, 3, & 4

PLANT COMPUTER SYSTEM

Assessment

Assuming proper selection of components, adherence to manufacturers recommended O&M procedures, and continuing supply of spare parts, the system will be suitable for 20 years of continuing operation.

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JAMSHORO UNITS 2, 3 & 4

TURBINE & CENTRAL CONTROL BUILDINGS

Description

The width of turbine building is 36.0 meters between axes A and G1. The height is 28.5 meters which is 1.4 meters higher than Unit 1. The length of Unit 2 and Unit 4 is 63 meters and that of Unit 3 is 72 meters Between the ending and beginning axis of two consecutive Units there are 2 meters spaces. The mezzanine floor level is at EL +5.00 meters The operating floor level is at EL +10.00 meters The dearator unit is at floor elevation EL +18.00 meters There is only one gable wall at the south end of Unit 4. There are two bridge cranes, each with 75/20 ton hook capacity. The top of the rail is EL is +21.00 meters The bridge crane span is 26.00 meters

The walls along axes A and G1, as well as the gable wall one meter south of the last column axis 408 is covered by prefabricated reinforced concrete wall elements. The roof is covered with cast-in-place concrete. The roof and floor slabs are finished using a metal deck. There is bituminous insulation over the roof which is further protected by brick tiles.

The turbines and generators are supported on reinforced concrete pedestals. Each turbine pedestal is housed inside the turbine building below the operating floor level. The pedestals are not connected with the steel structure of the turbine building except at their common mat foundation. Each unit is separated with expansion joints from the foundation up to the roof.

A common control building serves Units 3 and 4. This building is 40.0 meters long between axes H to N in the North/East direction and 26.00 meters wide in the North/South direction. From axes G1 to H1 there is 1.50 meter distance.

Comments and Current Condition

There were no cracks or displacement observable at the ground level. There were also no cracks, displacements or deterioration noted at the equipment foundation. Higher floor slabs, walls and the roof had good appearances without any apparent defects.

The turbine building steel structure appeared adequate, but the erection showed signs of problems. The presence of empty bolt holes at vertical brace connections above EL +10.00 meters between column axes F1 and G1 also occurred in Units 3 and 4. At some joints, gaps between the two connected parts were very large. Erection accuracy appeared to be very questionable. Since the joint holes could not be matched properly or, as it appeared

in some cases, there were not enough available bolts, welding was used instead. Normal steel joint practice never combines the capacities of bolting and welding together since the load transfer to the bolts can only occur after weld receives its ultimate load and starts failing.

Another poor detailing practice was observed at EL +10.0 meters column row F1 Here the column splice location was selected too low, such that the flange splice plates on column face looking towards G1, was cutting deep into the oncoming gusset plate, making the erection difficult and that section of gusset plate not functional.

Furthermore, the steepness of the vertical bracing between column A and B1, near Unit 4 condenser entry, resulted in a gusset plate with a long narrow appearance Plate buckling consideration alone would probably not allow such a practice. At a nearby location the diagonal member of vertical bracing was connected with a kinked gusset plate, which creates torsion in columns.

Most of the welded erection joints had very rough and poor quality appearances. It is not known if the welders of these joints were qualified welders or not. It is also questionable if the erection practices followed resulted in safe and acceptable connections in the turbine building vertical bracing system. The vertical bracing system transfers the horizontal loads such as wind and earthquakes to the columns and foundation.

Assessment

Assuming proper design and construction, the reinforced concrete parts of the turbine building of Units 2, 3 and 4 as well as the attached control room and amenities building for Units 3 & 4 should be suitable for the next 20 years.

The erection practices observed cast some doubts about the actual strength of some bracing joints. In the event of severe horizontal loads on the structure the ability of these joints to perform their intended function is questionable. This is not to say that the overall safety of the turbine building is in jeopardy since there should built-in redundancies in the total frame work so that loads will redistribute along a stronger path if a one local joint failure occurs.

A detailed evaluation of the bracing joints and implementation of corrective actions is required to assure a continued 20 years of suitability. Without this, major repairs may be required.

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JAMSHORO UNITS 1, 2, 3 & 4

COMMON FACILITIES

The common components and structures evaluated consist of the following:

Stacks

River Intake Structure and Piping

Intake Water Receiving Tanks

Water Pretreatment Buildings

Clarified Water Storage Tanks

Demineralized Water and Service Water Storage Tanks

Residual Oil Unloading System

Residual Oil Unloading Area Structures

Residual Oil Storage Tanks

Pipe Rack Bridge

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JAMSHORO UNITS 1, 2, 3 & 4

STACKS

Description

There are two concrete stacks. Stack 1 supports the flues of Units 1 and 2. Similarly Stack 2 support the flues of Units 3 and 4. Each flue is independent from each other inside each stack.

Both stacks are similar in shape, size and height. The geometric data below were obtained from the drawings prepared for Units 2, 3, 4. The height shown in the technical specification for the stack of Unit 1 is the same as the height shown in the drawings from Units 2, 3, 4. With the absence of geometric information for Unit 1 stack the following evaluations are generically made for both stacks.

There are three major distinct parts for each stack. These are:

a) Reinforced concrete chimney and foundation
b) Inner flue with lining and insulation
c) Platfo[illegible] and ladder

a) The reinforced concrete chimney is 147.00 m high from the top of the foundation to the top of chimney. At the base the external diameter is 15.20 meters with a wall thickness of 0.70 meters. The top external diameter is 11.40 meters. and wall thickness reduces to 0.25 meters. The foundation is 5.50 m thick and has the octagonal shape with 30.00 m external diameter. The thickness of foundation tapers down to 2.00 m at the outside periphery of the foundation. The stack foundation is built on the solid limestone foundation. There is one opening for a steel door at the ground elevation and two openings for the flue duct entry opposite to each other in the North/South direction with the bottom at EL 8.38 meters. The height of these openings is 6.40 meters. The width is estimated to be 3.0 meters.

b) There are two flues with an outside diameter of 4100 mm. supported on the foundation with anchor bolts at El +0.00 meters. Each flue is horizontally supported by a steel guide frame against the concrete stack at elevations 36.00 meters, 73.00 meters 100.00 meters and 147.00 meters. The top of the flues reach EL 150.00 meters with an slightly conical ending which has a 3600 mm. outside diameter. Each flue is free to expand or contract vertically.

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c) A ladder attached to each flue provides access to platforms at every 6.00 meters or less throughout the stack.

The flues are built out of 14 mm. thick corrosion resistant steel. The upper portion, closer to the weather exposure, was built using nickel chromium steel. Internally, including the bottom hoppers, the flues have a 50 mm. gunite type lining which is heat resistant up to 1000 degrees C. Externally there is 50 mm. thick fiberglass insulation, firmly attached on the flue by 3.5 mm. diameter welded Nelson studs. The insulation is covered by 20 mm x 25 mm wire mesh. On areas within 3.00 meters height above each platform level, the external insulation is covered by 0.5 mm thick aluminum plates instead of the wire mesh. There is an inspection manhole at EL 1.60 meters for each flue.

Comments and Current Condition

a) The reinforced concrete chimneys were built using the slip form technique where the inside and outside forming was supported from the reinforcement of the stack portion, already cast in place. Only a few feet height of the chimney is formed as a ring at one time. As this portion is built and the concrete is sufficiently cured, the forming is raised as a unit up to a new height. This technique saves construction time, expense and provides a uniformly smooth and even surface. In the case of the Jamshoro stacks both radial and vertical surface evenness was maintained to an acceptable limit. The foundations support the weight of the structure as well as the dynamic effects of wind and earthquake forces on the solid limestone foundation.

b) The flues are supported and protected to some degree from external effects by the reinforced concrete chimney. The materials used for the flues were selected to be resistant to the corrosive environment of the sulfurous gas exiting the boiler. The internal surface of the flues is further coated with a special lining to reduce the effect of the hot gases. To provide good draft and to minimize the heat loss along the path of flue, the flue is insulated externally. The flues are in good functional condition.

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JAMSHORO UNITS 1, 2, 3 & 4

STACKS

c) Platforms and ladders, provided for inspection and repair of the chimney and its integral parts, appeared in good condition.

Assessment

a) The reinforced concrete chimney and foundation should last more than 20 years.

b) The flues should last for the 20 year period of operation

c) Platforms and ladders should last more than 20 years.

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JAMSHORO UNITS 1, 2, 3 & 4

CLARIFIED WATER STORAGE TANKS

Description

There are two rectangular prismatic concrete tanks with a common middle wall. They store clarified water after it passes the receiving tanks, sedimentation tanks, chemical treatment and filter equipment. Each of the tanks is 21 meters wide, 40 meters long and 6.9 meters high. The walls and bottom slab is 50 cm. and the roof slab is 20 cm thick.

Comments and Current Condition

There was water seepage at one of the pipe locations at the storage tank. An attempt was made to repair the seepage by externally pouring concrete around pipe exit and against tank wall. Evidently, the tank was full when the repair was attempted and the leak did not stop.

No external settlement, cracks or deterioration were observed. No internal observation was made.

Assessment

The clarified water storage tanks are suitable to last for the next 20 years of operation. The leak problem should be solved by proper repair.

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JAMSHORO UNITS 1, 2, 3 & 4

RIVER INTAKE STRUCTURE AND PIPING

Description

The water needed by the power plant is pumped from the Indus River. The river is flowing in a North/South direction. It is approximately 3 km. east of the plant site. A road connects the plant site with the river intake location. Along the side of the road there is the boiler blowdown water pipe over ground going to the river. Parallel to the road but underground there are buried conduits, power cable ducts and intake water pipes for each plant unit.

At a few places along the road, there were below grade valve pits formed as concrete shafts roughly 2 meters inside diameter and depth. In these pits the intake pipe and cables were visible. The shaft contained water almost 0.3 meters high. This area is flooded almost to the edge of the road during the high water levels in the Indus River which is regulated by the Kotri Barrage dam gates 3 km. down the river.

Some statistics about water level are as follows:

Flood Level 23.2 meters
High Water Level 20.8 meters
Low Water level 18.9 meters
Lowest low water Level 14.8 meters

Close to the river shore the intake pipes and control cables rise above ground and approach the intake pipe bridges. There are two parallel river intake structures. The down river side intake structure was designed and built by Tokyo Electric Power Services Co. Ltd. Japan and carries the intake pipes for Units 1 and 2. The up river intake structure was designed and built by North East Electric Power Design Institute Ministry of Water Resources and Electric Power Changchun Peoples Republic of China to supply water for Units 3 and 4.

The river intake structure, which is also called intake tower, is located 200 meters from the shore in the Indus River. There are 8 pumps on one intake tower. Half of these pumps are deep water pumps used during low water levels and the others, are used during high water levels. Four pumps are connected with one header to a 22" intake pipe of one powerhouse unit. The intake structure is supported by ten concrete piles each 1200 mm. O.D. The steel jacket frame over the concrete piles served as a template to drive the piles at the correct position in the river and as form work for the intake platform at El 25.20 meters. The top of the intake tower measures 9 meters

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in width perpendicular to the river flow and 19.2 meters in length parallel to the river. The river bottom elevation at intake location is El. 10.00 meters. The tip of the concrete pile is at El. -6.70 meters. Intake pipes, power and conduit cables and a footway are carried from intake tower to the shore on the "down river" bridge by four simple span truss type steel bridges and on the "up river" bridge by three simple span truss type steel bridges. The bridges are supported on piers at every 50 meters. Each pier has a pile cap measuring 4.5 m width and 6 meters length and 1.2 meters thickness. The pile cap is supported by four concrete piles. The river bottom elevations at bridge support locations are El 10.7 meters, 12.8 meters, 17.6 meters and 21.00 meters. Corresponding pile tip elevations are -4.5 meters, 0.0 meters 1.9 meters and 3.0 meters. Concrete pile lengths inside rock surface vary between 5 and 7 meters. The span of each steel truss bridges is 48.5 meters. The truss height is 4.0 m and bridge width between supports or truss plane is 4.00 meters. The bottom of truss lower chord is at El +25.6 meters.

Comments and Current Condition

The total intake facility is in good condition and is operational. The plant personnel stated there is corrosion protection for the buried intake pipe; but how the corrosion protection is provided was not visible.

The pipe bridge structures, the bridge piers and the intake tower were all in good condition. The design and workmanship appear good. There was no apparent damage or deterioration of any kind.

Assessment

The river intake water bridge and tower facilities appear structurally sound. The structural elements of intake facilities should be suitable for service during the next 20 year period of operation.

The life span of the intake pipes, especially the underground portion is difficult to estimate since they are buried and not visible. Additionally, there is a high amount of sand sucked in from the river and transported through the pipe. Externally the pipes will be under corrosion influence; internally the amount of sand flowing through will wear the pipe over time.

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JAMSHORO UNITS 1, 2, 3 & 4

INTAKE WATER RECEIVING TANKS

Description

There are two open top rectangular concrete tanks for each unit built above ground with a common wall in between. The intake pipe is supplying water to each tank header. It is approximately 20 meters wide, 4.0 meters long and 5.5. meters high. Half of the depth of the tank is below ground level and the other half is above ground level.

Comments and Current Condition

The receiving tanks of all units appear adequately constructed. There was no leakage observed through the walls. The tanks are rapidly filled with the incoming sand from the Indus River, sometimes in as little as 15 days. Emptying the tanks is done manually.

Assessment

Structurally, the receiving tanks are in good condition and should last for the next 20 years Operating costs will be high due to the large quantities of sand entering the tank.

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JAMSHORO UNITS 1, 2, 3 & 4

WATER PRETREATMENT BUILDINGS

Description

The water pretreatment buildings for each unit are single story reinforced concrete frame structures. The buildings house the necessary control equipment for pretreatment operations. In part of the facility, chloride is produced from sodium chloride.

Comments and Current Condition

Currently the buildings are in fairly good shape. The concrete framing and the walls appear to be sound. Externally or internally there are no signs of deterioration. Since chloride is manufactured from industrial quality salt, the environment is very corrosive. There are checkered plate covered trenches at the floor level. Since exposed steel surfaces will corrode, these components must be maintained and replaced as required. The ceiling concrete of the building displayed uneven, rough and in some parts a porous surface look, which indicates poor workmanship. Although no reinforcing bars were detectable from the underside of the ceiling, the porous and rough concrete surface is susceptible to the affects of corrosive fumes. Therefore the ceiling may require maintenance and repair.

Assessment

The water pretreatment buildings should provide satisfactory service for the next 20 years provided maintenance and good housekeeping practices are performed.

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JAMSHORO UNITS 1, 2, 3 & 4

CLARIFIED WATER STORAGE TANKS

Description

There are two rectangular prismatic concrete tanks with a common middle wall. They store clarified water after it passes the receiving tanks, sedimentation tanks, chemical treatment and filter equipment. Each of the tanks is 21 meters wide, 40 meters long and 6.9 meters high. The walls and bottom slab is 50 cm. and the roof slab is 20 cm thick

Comments and Current Condition

There was water seepage at one of the pipe locations at the storage tank An attempt was made to repair the seepage by externally pouring concrete around pipe exit and against tank wall. Evidently, the tank was full when the repair was attempted and the leak did not stop.

No external settlement, cracks or deterioration were observed. No internal observation was made.

Assessment

The clarified water storage tanks are suitable to last for the next 20 years of operation. The leak problem should be solved by proper repair.

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JAMSHORO UNITS 1, 2, 3 & 4

DEMINERALIZED WATER AND SERVICE WATER STORAGE TANKS

Description

For each unit there are two demineralized water storage tanks each with 1000 cubic meter capacity. These tanks are located east of the water treatment building of each unit. There is an external stair welded on the tank wall, leading to the tank entry at the semispherical tank dome. Each tank is supported on a base contained inside a concrete cylindrical wall which elevates the tank above ground level.

The service water storage tanks are located east of the demineralized tanks. There are two tanks for each unit. These tanks are similar in size and shape to those of the demineralized tanks for the corresponding units

Comments and Current Condition

The tanks were welded on location. The appearance of the exterior painting on the tanks indicated quality work. The paint on the tanks of Units 2, 3 and 4 are not as impressive as the Unit 1 tanks. The welded seams are not ground flush. The plate thickness changes are externally visible which gives an uneven stepped surface. This, however, should not affect service life. There are no external defects or settlements in any of the tanks.

Assessment

Assuming proper design and normal maintenance, the demineralized water and service storage tanks should provide satisfactory service for the next twenty years.

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JAMSHORO UNITS 1, 2, 3, & 4

RESIDUAL OIL UNLOADING SYSTEM

Description

The system consists of the following:

- o Residual Oil Unloading Facilities
- o Residual Oil Receiving Facilities
- o High Speed Diesel Oil Receiving Facilities
- o Oil Drain and Oil Separation System
- o Residual Oil Transfer System to Transfer the RO to Service Oil Tanks

Pressure gauges are installed in strainer inlets/outlets, discharge and pump outlets of pressure control valves. Low pressure switches are installed on the pump discharges for alarm purposes. Temperature sensors are installed to indicate temperature of residual oil inlet/outlet, heating steam and drain. Outdoor local control panels at the residual oil transfer pump area and oil separator transfer pump area have the follow components:

- o Operating Switches
- o Indicating Lamps
- o Ammeters
- o Strainer Differential Pressure Alarms
- o Motor Overload Alarms

Comments and Current Condition

The residual oil unloading area had considerable oil in trenches and on the ground. (Reference Residual Oil Unloading Area Structures). This will lead to higher maintenance costs and present a fire hazard. The area should be cleaned up. Interviews with plant personnel, walk downs and review of plant records, indicated that the systems are in working condition. However, plant personnel indicated difficulties are encountered in unloading the rail cars especially in cold weather. Currently, oil is being delivered by truck to a truck unloading facility.

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JAMSHORO UNITS 1, 2, 3 & 4

RESIDUAL OIL UNLOADING AREA STRUCTURES

Assessment

Assuming the area is cleaned up, good housekeeping practices are established, proper design and selection of system components and adherence to manufacturer's recommended O&M procedures, the system should be suitable for 20 years life.

Description

The residual oil unloading area is located at the west end of the power plant. It covers the railroad unloading facilities and receiving and transfer pump stations. Residual oil unloading area facilities serve all four units of the power plant. There are railroad tracks running parallel to the North/South direction. Tracks are numbered #1 to #4 from east to west. The railroad unloading area is approximately 800 meters long

Between rail tracks #3 and #4, there is a pipe trench below grade which is almost 512 meters long capable of unloading a total of 60 railroad tanker cars (30 cars per track) at a time. The pipe trench is similar to a rectangular concrete underground tunnel with clear inside dimensions of 3.20 meters width and 2.25 meters height. The trench bottom is sloped from both ends towards the trench mid length. There are residual oil (R.O.) receiving pipe, heating steam pipe, heating drain pipe, trace drain pipe, fire water pipe, air foam pipe, an electrical conduit, a walk path and a small rain water trench inside the pipe trench. At each railroad car park position, the top of pipe trench is 1.92 meters long and has a full width access opening.

At the approximate midpoint, the pipe trench tunnel branches out westward and passes under track #4. The pipes and conduits go through the tunnel then pass under the plant road through a concrete culvert and reach the residual oil receiving pump station area. The oil pipe goes through the air separator units before entering the road culvert.

The residual oil pump station is a concrete structure built like a pit below road grade. There are reinforced columns which support the reinforced concrete roof. There are no walls above street level. A smaller trench along the side of the road and the receiving pump station provide a catch basin for possible oil spill at street level and for rain. The pumps in the receiving pump station transfer the arriving oil into four storage tanks each designated for one power station unit. Next to the receiving pump station there is a residual oil transfer pump station. The oil from the storage tanks is pumped through the transfer pump station to the residual oil pump and heater area near the boiler units.

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JAMSHORO UNITS 1, 2, 3 & 4

RESIDUAL OIL UNLOADING AREA STRUCTURES

Comments and Current Condition

The residual oil unloading area is functional and intact. The reinforced pipe trench, the connection tunnel under track #4, the culvert under plant road, the receiving and transfer pump stations and, their walls, columns and roof appear in good condition. There were no observable cracks, settlement or damage to any of the structures. During the site visit there was no train unloading operation. Between and around the rail tracks there was compacted soil with evidence of heavy oil spillage at most unloading locations. The spilled oil, mixed with water, was several inches high throughout the pipe trench. The oil spill continued through the tunnel under the roadway around the receiving pump station area but not inside the pump station itself

A truck unloading station is also provided. The tank trucks unload the residual oil to a pump pit close to the receiving pump station. The pump pit is below the level of plant road and protected on the road side by a concrete trench. There was oil and water standing inside this trench as well. The trench is covered by grating made out of reinforced bars.

Assessment

The structures appear to be in satisfactory condition and should provide 20 years continued operation. However, with the current condition there is a potential danger due to a major fire. The area should be cleaned up immediately to remove this hazard.

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JAMSHORO UNITS 1, 2, 3 & 4

RESIDUAL OIL STORAGE

Description

There are four residual oil storage tanks, each used for one of the units of the power plant. They are located west of the residual oil unloading area. The storage tanks were built on-site by welding steel plates. They are cylindrical in shape with slight spherical dome roofs. Each tank has 27,000 cubic meter oil storage capacity. Each tank is almost one meter above ground and supported on compacted soil placed inside a cylindrical concrete wall which forms the height above ground. It is not known what kind of corrosion protection of the steel base plate is provided as it is in direct contact with the base fill. A levee like stone wall is between two neighboring tanks. Concrete walls protect the surrounding areas from oil spills. Tanks for Unit 1 and 2 are further separated from the tanks for units 3 and 4 by a plant road on three sides. All tanks are painted.

Comments and Current Condition

The tanks appear to be in good condition. The welding, the geometrical shape and the paint application indicate good workmanship. The concrete foundation also appears to be in good condition. There are no signs of settlement or cracks. There were no external holes or reinforcing bars visible on the concrete surfaces which indicated good form work and bar placing.

The levee like wall separating Tank 1 from Tank 2 contained a construction opening which has not been closed. This opening should be closed in order to maintain the function of the wall.

Assessment

The residual storage tanks appear to be in good condition and should provide satisfactory service for 20 years assuming proper design and normal maintenance. Painted surfaces should also be maintained at proper intervals. During the lifetime of the tanks, internal cleaning may also be required. Inspection of the base plate for any corrosion damage will be difficult. Therefore the tanks should be kept under surveillance to detect any leakage at an early stage to minimize environmental damage.

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JAMSHORO UNITS 1, 2, 3 & 4

PIPE RACK BRIDGES

Description

The main pipe rack bridge is almost 600 meters long routed in an east/west direction between the residual oil transfer pump area and the water treatment building for Unit 3, and running over the neutral ground on the north side of the plant inside it. [illegible] rack is four meters wide and simple span truss type steel bridge system elevated on heavy steel columns with varying spans from 10 meters to 17 meters. The bridge structure supports the residual oil pipe from the transfer pump station to the heater and oil pump area near the plant site. It further supports the heating steam pipe, air, foam and fire water pipes, and electrical conduits from the plant site to the residual oil unloading area. The east half of the bridge carries the pipes and conduits to and from the water treatment building towards the main powerhouse. A secondary pipe rack bridge, perpendicular to the main pipe rack in North/South direction, starts from the main pipe rack and continues southward on the east side of the plant street passing behind the boiler building of each unit. This pipe rack mainly carries the fuel supply lines to the boiler units from the residual oil pump and heater area. It also carries pipes used for the boiler make up water and the cable conduits.

Comments and Current Condition

The steel truss bridges and the supporting steel columns of the pipe rack appear adequately designed and constructed. The columns are supported on individual reinforced concrete footing pedestals and foundations below grade. There were no signs of settlement or cracking. The pipe rack structure was painted and there was no evidence of peeling, blistering or corrosion.

Assessment

Assuming proper design and normal maintenance, the pipe rack bridge system should be suitable for the next 20 years of operation

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