Report of Activities
during Major Site Study for RLA
at Unit 3 of Dadri TPS, NTPC, Nov. 30 to Dec. 8, 2015
under the India-Japan Cooperation for Efficiency and Environmental Improvement of Coal Fired Power Stations

1. Background and justification
The Government of India has been making its strenuous efforts toward sustainable power supply through massive capacity addition. CEA and JCOAL embarked on their bilateral cooperation based on shared recognition that R&M as well as Life Extension (LE) of existing power plants are quite significant in this context, apart from new construction of large scale power plants under Ultra Mega Power Projects (UMPP).

In the light of the foregoing situation, a MOU of Pre-primary Study of Efficiency and Environmental Improvement of Coal-fired Power Stations was signed on April 30, 2010, in the presence of Deputy Chairman, Planning Commission of India, and Minister of Economy, Trade and Industry of Japan, under which and the following MOU diagnostic activities for eight (8) units out of three (3) state owned and four (4) NTPC owned TPS was performed. The proposed improvement has been under discussion at some of the partner utilities, though they have to take time for administrative reasons, etc.

Right now another MOU is at the last stage of government approval process; i.e. the fresh framework of cooperation is substantially in place, under which CEA, JCOAL and NTPC have agreed to conduct two important studies; that is, an RLA study at Dadri TPS and a replacement study at Badarpur TPS, both of which will immensely contribute to the efficiency and environmental improvement of coal power as well as power capacity enhancement in India.

2. Objective and scope of the RLA Study at Dadri TPS
The objective of the RLA Study is to identify the remaining life and the current condition of the target unit; Unit 3, to constitute the base for formulation of the plan of R&M implementation that is tentatively scheduled in 2018. The scope of the Study is BTG (Boiler, Turbine and Generator).
3. Purpose of the Major Site Study at Dadri TPS
   a. To conduct the required testing and inspection following the standard method
      and procedures in India while incorporating the applicable points of method and
      procedures in Japan.
   b. To conduct visual inspection according to the standard method and approach
      employed in Japan.
   c. To collect the required data and information for the RLA Study
   d. To observe O&M practices at the plant for advice and proposal later in the Final
      Report.

4. Period of implementation of the Major Site Study
   From November 30 to December 4, 2015

5. Composition of the Japanese Expert Team
   One leader/coordinator
   Three boiler experts
   Two electrical experts
   Two turbine experts

6. Summary of Activities
   ◈ Day 1
      Morning
      Kick-off Meeting (all together)
      Afternoon
      Site tour (all together)
      ● Boiler
         -Meeting for the final confirmation of the schedule and work items and
         procedures
      ● Electrical
         -Data collection
      ● Turbine
         -Instructed test positions and witnessed Replica & HT of LP rotor
         -Replica & Hardness on the rotor shaft and MPI of the Turbine Blade

   ◈ Day 2
      ● Boiler
- Instruction of test positions and procedures for replica collection of boiler hot parts
- Visual Inspection for Condition Assessment of Boiler Tubes (1st Pss)

- **Electrical**
  - Interview with Electrical Dep. and data collection
  - Visit main electricity equipment
  - Joint inspection of generator (tan delta and RSO test)

- **Turbine**
  - Instruction of test positions and witnessed Replica & HT of HP & IP valves
  - Instruction of test positions and witnessed UT of LP rotor
  - Performance data collection

✿ **Day 3**

- **Boiler**
  - Instruction of test positions and procedures for replica collection of boiler hot parts (All Day)
  - Visual inspection for conditional assessment of boiler auxiliaries

- **Electrical**
  - Interview with C&I Dep. and visit to C&I Dep. laboratory
  - Joint inspection of generator (PD test) and data collection

- **Turbine**
  - Collection of ST & Aux. drawings
  - Interviews on O&M of #3 ST (Troubles, S/P, etc.)
  - Observation of MPT of LP rotor blade groove
  - Collection of #3 ST history of Start/Stop

✿ **Day 4**

- **Boiler**
  - Interview with Boiler Maintenance Dep.
  - Interview with Operation Dep.

- **Electrical**
  - Data collection
  - Interview with Operation Dep.

- **Turbine**
  - Hearing of efficiency calculation
  - Review of the obtained survey of ST auxiliaries
Day 5

- Boiler, Electrical, Turbine
  - Compilation of the Activity Report
  - Interim Wrap-up and Tentative Reporting to GGM, Dadri TPS

<< Followings are testing and inspections done by Indian Expert Team >>

- Boiler
  - Replica on CRH, HRH & M.S. Line. VI, DIM, PT & UT test on SHH. UT test on Water Wall Panel.
  - Replica on LTSH, SHH & Eco Inlet. VI, DIM, PT & UT test on LTSH & ECO. Thick. Measurement on Water wall.

- Turbine
  - Eddy Current Test in Condenser (completed only approx. 7% of tubes due to scaling)

Day 6

- Boiler
  - Replica on Feed Water Line. Hardness test on ECO, Boiler drum, LTSH & PLSH. VI, PT & DIM on Feed water piping, Water wall Panel and SHH-4, 5 & 6.t
  - Replica on PRDS Line. VI, PT & DIM of Feed water piping and attemperator link pipe.

Day 7

- Boiler
  - Hardness test on LTSH Coil, Final SH coil. VI, PT & DIM in SCW and PRDS Line
  - Hardness test on Re-heater Inlet outlet, PLSH, LTSH, FSH & RH coils. UT test on Hopper bottom bend, hopper bottom slop, Rear arch nose panel, Water wall tubes and water wall ring header.

Day 8

- Boiler
  - DPT, DIM on PRDS Main Line. DIM in Bottom ring header and Radiand roof tube.
7. Comments by Japanese Experts
   a. Residual Life Assessment for boiler tubes
      While the basic philosophy of Boiler RLA is common between NTPC and JCOAL Team, we've found some differences in method and procedure of replica collection. This time replica collection was done following the standard method and procedure of Kyushu Electric Power.
   b. Conditional assessment for boiler and its auxiliaries
      We have observed that Dadri has achieved high standards of maintenance management and keeps a set of best practices based on their own experiences.
   c. Conditional assessment for generator and electrical equipments
      According to our observation, the plant sustains its value thanks to timely and appropriate updates and maintenance of equipment, all of which are realized through excellent management by NTPC.
   d. Turbine replica collection
      Some replica inspection points of HP & IP Valves were changed, due to difficulty of polishing.
   e. Additionality about turbine inspection
      UT inspection on the LP rotor was applied additionally.
   f. L-0 blades condition
      Erosion by drain attack on L-0 blades surface is not so severe considering that it has been operating more than 20 years
   g. Low cycle fatigue analysis on turbine
      Repeated number of Start & Stop of #3 ST is about 250 times. Low cycle fatigue analysis will be carried out basing on this number
   h. Turbine assessment method and procedure
      Microstructure of replica will be observed by microscope in laboratory. Final assessment of the residual life will be made using these microstructural data, operating temperature, stress and period, by employing the latest Japanese technology and approach.

8. Forthcoming schedule of the study
   Data Analysis: December 2015 to February 2016
   Reporting: Mid to late February 2016
   Provision of the final report: March 2016
9. Appendix
   Appendix - I Table Outline of the work
   Appendix - II Presentation at Kick-off Meeting
   Appendix - III Presentation at Interim Wrap-up Meeting
<table>
<thead>
<tr>
<th>Day</th>
<th>AM</th>
<th>PM</th>
<th>Japanese experts</th>
<th>Boiler</th>
<th>Indian experts</th>
<th>Japanese experts</th>
<th>Electrical</th>
<th>Indian experts</th>
<th>Japanese experts</th>
<th>Turbine</th>
<th>Indian experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kick-off Meeting</td>
<td>Site tour</td>
<td></td>
<td>Data collection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>PM</td>
<td></td>
<td>The meeting for the final confirmation of the examination schedule and contents between the Japanese experts</td>
<td>Videoprobe in headers in Pent House</td>
<td>Interview to Electricity Dep. and data collection</td>
<td>Joint inspection of Generator (tan delta and RSO test)</td>
<td>Electrical Test in Generator- Stator &amp; Rotor</td>
<td>Interview to Operation Dep. Laboratory</td>
<td>Joint inspection of Generator (PD test) and data collection</td>
<td>Observed MPT of LP rotor blade groove</td>
<td>DPT test &amp; Visual inspection on the turbine auxiliaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Videoprobe in headers in Pent House</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>AM</td>
<td></td>
<td>Instruction of test positions &amp; procedure for Replica of Boiler Hot parts (All Day)</td>
<td>Replica On the Superheater Outlet Header &amp; Reheater Outlet Header Left side</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Visual Inspection for Condition Assessment of Boiler Tubes (1st Pos)</td>
<td>UT test on Generator Retaining Ring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>AM</td>
<td></td>
<td>Interview to Boiler Maintenance Dep.</td>
<td>Replica On the Main steam pipe line (Repeat) &amp; HRH Line Visual, DPT and DIM: PLSH, RH / VI of FSH/ VJ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Visual Inspection for Condition Assessment of Boiler Aux.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AM</td>
<td></td>
<td>Compilation &amp; Data collection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Interview to Maintenance Dep.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>PM</td>
<td></td>
<td>Completion of work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Eddy Current Test in Condenser</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wrap-up Meeting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
- 1st Pss: Videoprobe
- MP: Mechanical Parts
- RP: Replacement Parts
- S/P: Structural Parts
- Aux.: Auxiliary Parts
- C&I: Control and Instrumentation
- HRH: High Rank Headers
- PRDS: Pre-Run-Down Service
- DPT: Diminish and Point Test
- AM: AM Hardness
- VI: Visual Inspection
- DPT: Diminish and Point Test
- RH: Rotor Hub
- VI: Visual Inspection

**Table:** Outline of the work: Residual Life Assessment for Unit3, Dadri Thermal Power Station, NTPC conducted by JCOAL
Japan Coal Energy Center (JCOAL) and its engagements under the CEA-JCOAL Cooperation

Japan Coal Energy Center (JCOAL)
At Kick-off Meeting for RLA Study at Dadri TPS
November 30, 2015

Overview

1. JCOAL and its activities in India Coal Sector
2. Outline of the India-Japan cooperation for improvement of coal fired power stations
3. On-going activities
4. Summary
1. Profile of Japan Coal Energy Center (JCOAL)

Japan Coal Energy Center (JCOAL)

- Established as a foundation in 1990, with its origin back to 1948
- Covers all coal related issues from upstream to downstream of the coal chain
- Members: 119 incl. major public-listed companies and main players in energy and relevant sectors
- Supervision by METI (Ministry of Economy, Trade and Industry of Japan)
1. JCOAL activities in India Coal Sector
High Efficiency Coal Washery Plant (NEDO)

High efficiency coal preparation plant in Odisha
✓ High efficiency coal preparation plant with the latest vari-wave jig technology with a capacity of 350t/h. has been commissioned on July 25th, 2014 in Angul, Odisha.

Source: NEDO (New Energy and Industrial Technology Development Organization)

CCT Transfer/Knowledge and Technology Exchange Program on coal preparation technology

CCT transfer project on coal preparation technology
✓ Coal preparation technology is deemed to be a key technology to address the requirement of high ash coal processing and a course on the technology under the scheme of CCT Transfer Program has been arranged and conducted.
✓ 150 Indian experts out of the grand total of 1,305 participants visited Japan on the Program as of the end of JFY2011.
✓ Exchanges under the Program have been conducted in both ways; through having the relevant sector stakeholders visiting Japan and also by dispatching Japanese experts to India.
2. Outline of the India-Japan cooperation for improvement of coal fired power stations

Short history of CEA-JCOAL Cooperation

A MOU of Pre-primary Study of Efficiency and Environmental Improvement of Coal-fired Power Stations was signed on April 30, 2010, in the presence of Deputy Chairman, Planning Commission of India, and Minister of Economy, Trade and Industry of Japan.

Diagnostic activities for two (2) state owned and one (1) NTPC owned TPS
Diagnostic activities for two (2) state owned, one (1) NTPC owned TPS
R&M Workshop in Delhi

A MOU for the Project on Efficiency and Environmental Improvement of Coal fired Power Station was signed on June 11, 2012.
Diagnostic activities for Durgapur of DVC, Unchahar & Badarpur of NTPC were conducted; all of which were referred to in the Joint Statement on the occasion of the 6th Japan-India Energy Dialogue between the Ministry of Economy, Trade and Industry of Japan and the Planning Commission of India on October 10, 2012. CCT workshop in Delhi

Follow up activities in close cooperation with partner utilities as well as CEA have been ongoing.
CCT Transfer program for the relevant stakeholders of India power sector has been carried out.
CEA-JCOAL workshop in Delhi

Next MOU with CEA is expected to be signed very soon.
CCT Transfer Program in its 3rd year is to be conducted in Jan-Feb 2016; RLA Study for Dadri and FS for Badarpur is on-going.

Appendix - II

Presentation @ Kick-off Meeting
Scope of diagnostic activities

<table>
<thead>
<tr>
<th>Target power station</th>
<th>Conducted in FY</th>
<th>O&amp;M</th>
<th>Boiler</th>
<th>Turbine</th>
<th>ESP</th>
<th>BOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramagundam, NTPC</td>
<td>2010</td>
<td></td>
<td></td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Kahalgaon, NTPC</td>
<td>2011</td>
<td></td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unchahar, NTPC</td>
<td>2012</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badarpur, NTPC</td>
<td>2012</td>
<td></td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wanakbori, GSECL</td>
<td>2010 &amp; 2011</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Dr. NTTPS, APGENCO</td>
<td>2010-2012</td>
<td></td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durgapur, DVC</td>
<td>2012</td>
<td></td>
<td>○</td>
<td></td>
<td></td>
<td>○</td>
</tr>
</tbody>
</table>

Risk Based Maintenance is recommended

Discussion is on-going in preparation for R&M tender and implementation including LMZ turbine rehabilitation based on diagnosis with measurements and cost-benefit analysis.

HPT has been awarded as contractor for ESP rehabilitation at NTPC’s Rihand Power Station.

Some others are also under consideration.

CCT Transfer/Knowledge and Technology Exchange Program for the power sector

First group of Clean Coal Technology (CCT) Transfer Program was implemented in October, 2013 reflecting the newly incorporated item of activities under the CEA-JCOAL Cooperation for the Project on Efficiency and Environmental Improvement of Coal fired Power Stations. They visited relevant equipments or facilities actually working and effective and see the high technology of O&M in subcritical coal-fired thermal power station, the latest USC technology, etc. and exchange views with Japanese experts.

2013 : 9 delegates in 1 Group
2014 : 42 delegates in 3 Groups
2015 : 20 delegates in 2 Groups
CEA-JCOAL Workshop

Project on Efficiency and Environmental Improvement for Sustainable, Stable and Low-carbon Supply of Electricity

CEA –JCOAL annual Workshop is held in Delhi so that all relevant organization can participate to hear latest topics and discuss the pressing issues to be addressed in India power sector.

Focus of each workshop
2010 : Debriefing of Diagnosis at 3 TPS
2011 : R&M technologies Diagnostic plan in 2011
2012 : Technologies in coal utilization, blending and R&M for existing unit
2013 : Technologies of USC and its O&M, Outcomes of Diagnosis
2014 : USC, O&M, Emission control, coal quality evaluation, Finance,
2015 : USC, Environmental measures, Finance,

3. On-going activities
The forthcoming MOU is further focused

### 1st and 2nd MOU (2010 - 2015)

<table>
<thead>
<tr>
<th>4 mainstays to meet surging power demand</th>
<th>Diagnostic Activities</th>
<th>CCT Transfer programme</th>
<th>Workshop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity addition</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>R&amp;M</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>demand side management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewable energy</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Thrusts to meet surging power demand

<table>
<thead>
<tr>
<th>Fresh capacity addition</th>
<th>High efficiency SC/USC</th>
<th>Diagnostic Activities</th>
<th>Replace ment FS</th>
<th>CCT Transfer programme</th>
<th>Workshop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

| Environmental measures  | ✓                      | ✓                     | ✓               | ✓                      | ✓        |

| R&M                     | R&M or replacement of Existing plant | ✓                      | ✓               | ✓                      | ✓        |

| demand side management  |                           |                        |                  |                        |          |
| Renewa ble energy       |                           |                        |                  |                        |          |

Gov. institutions and utilities
All designated power sector stakeholders
Feasibility Study of Replacement of Badarpur TPS
HELE: High Efficiency Low Emissions

Sub-Critical, Efficiency = 40%

Old Isogo COD in 1967
Current Badarpur TPS

Efficiency Improvement

Cleaner Environment
Increasing Power supply

Capacity 530MW (265MW × 2)

Ultra Super Critical, Efficiency = 45%

New Isogo COD: Unit 1 in 2002, Unit 2 in 2009

Capacity 1,200MW (600MW × 2)

Outline of Combustion Test of Indian Coal

Objectives
• Acquisition of data about performances of the emission control system
• Feasibility study

Expected Results
• Low emission by the combined system of SCR low-temperature EP and FGD system
• Basic design for the next stage; demonstration

Background
• Regulatory enhancement on emissions from power station is under discussion by the Government of India. That may be introduced as a new regulation.
• Japan may provide a set of knowledge, experience and technology that has been obtained through coping with the emission issues and achieving low emissions of dust, Sox and Nox.

Source: MHPS
R&M (1): Follow-up activities

Follow-up by sharing of the diagnosis experiences with potential partner utilities

<table>
<thead>
<tr>
<th>Plan</th>
<th>Policy / Effort</th>
<th>Specification</th>
<th>Type of Capacity/OMG</th>
<th>Energy / Heat and/or MED</th>
<th>Design</th>
<th>Actual</th>
<th>after R&amp;M</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(GE only)</td>
<td></td>
<td>Replacement of more parts only</td>
<td>--</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>HT-UR 0000</td>
</tr>
<tr>
<td>D</td>
<td>D: Expected capacity to 2016P with heat management ex. improved by 5% and 20 year LE</td>
<td>Basic features, replacement of PHE, EHP and ESP rehabilitation</td>
<td>210 220</td>
<td>210 220</td>
<td>210 220</td>
<td>210 220</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>C: Expected capacity to 2016P with heat management ex. improved by 5% and 20 year LE</td>
<td>Basic features, replacement of PHE, EHP, and ESP rehabilitation</td>
<td>210 220</td>
<td>210 220</td>
<td>210 220</td>
<td>210 220</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>B: Expected capacity to 2016P with heat management ex. improved by 5% and 20 year LE</td>
<td>Basic features, replacement of PHE, EHP, and ESP rehabilitation</td>
<td>210 220</td>
<td>210 220</td>
<td>210 220</td>
<td>210 220</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R&M proposal of Plans B, C and D are found to be effective for efficiency and environmental improvement as well as economic/beneficial.

Two from State Utilities will be selected to introduce our main proposal for R&M.
March, 2016

R&M (2): RLA Study at Unit 3 of Dadri TPS: Background

The initial idea came from NTPC in July 2014, when JCOAL discussed with NTPC how to make the relevant knowledge, technology and experience Japan has nurtured may be utilized in R&M in India, in relation to which the planned R&M of Dadri in 2018 and possibility of involvement of Japanese expert team came up. Based on it, CEA, NTPC and JCOAL have been together deliberating and discussing to conduct an RLA study for Dadri under the framework of the CEA-JCOAL Cooperation.
R&M (2): RLA Study at Unit 3 of Dadri TPS:
Schedule

- Preliminary data collection: Sept. 10, 2015
- Hot/cold walk-down survey: November 2, 2015
- Visual inspection of the inner part of LP turbine: November 23, 2015
- Major site study: November 30 to December 10, 2015
- Data Analysis: December 2015 to February 2016
- Reporting: Mid to late February 2016
- Provision of the final report: March 2016

Basic framework

- JCOAL will be responsible in interacting with NTPC on behalf of the Team, so the Leader/Coordinator from JCOAL will participate in the site study until it is over on December 10.

- Testing and inspection work is undertaken by our sub-team of Indian experts in close consultation with the sub-team of Japanese experts. The report of testing and inspection will be first submitted to our Japanese experts for deliberation and examination, followed by analytical work.

- Japanese experts mainly engage in analysis & judgment of replication and hardness data, making judgment and providing advice during the site study.

- Reporting and provision of the report will be conducted by JCOAL Team.
We look forward to working with you

Website:  
http://www.jcoal.or.jp/index-en.html

Contacts:  
Mr. K. Murakami (kzmurakami@jcoal.or.jp)  
Ms. Yamada, F. (fyamada@jcoal.or.jp)
Overview
Of
Kyushu Electric Power (KEPCO)’s Team
November 2015

Kyushu Electric Power Co., Inc.

Purpose of Diagnosis Work on RLA, O&M Dadri TPS

Taking advantage of the knowledge of Japan, comprehensively carried out the testing and inspection for each unit, and the confirmation of the state of equipment

(1) Remaining Life Assessment for Boiler Tubes
   • Super Heater Outlet Header / Re-Heater Outlet Header
   • Main Steam Pipe / Hot Re-Heater Pipe etc.
(2) Condition Assessment for Boiler and its auxiliaries
(3) Condition Assessment for Generator and Electric Equipments
(4) O&M improvement
   • Maintenance and/or Improvement of Thermal Efficiency
   • Power Saving and/or Cost Saving based on Our Experience
   • Occupational Health, Safety and Environment

Schedule
Site survey: 2015. 11. 30 – 12. 4 (at Dadri TPS)
## Draft Schedule of the Work at Dadri TPS

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Time</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 Nov.</td>
<td>Mon.</td>
<td>AM</td>
<td>Kick-off Meeting / Site Tour (Taking Photos)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PM</td>
<td>Site Tour (Taking Photos)</td>
</tr>
<tr>
<td>1 Dec.</td>
<td>Tue.</td>
<td>AM</td>
<td>Witness to Generator Electrical Tests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PM</td>
<td>Witness to Boiler NDT Inspection</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replication Sampling (Super Heater Outlet Header)</td>
</tr>
<tr>
<td>2 Dec.</td>
<td>Wed.</td>
<td>AM</td>
<td>Witness to Electric Equipments Inspection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PM</td>
<td>Witness to Boiler auxiliaries Inspection</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replication Sampling (Re-Heater Outlet Header)</td>
</tr>
<tr>
<td>3 Dec.</td>
<td>Thu.</td>
<td>AM</td>
<td>Interview on I&amp;C and Electrical Equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Interview on Mechanical Maintenance &amp;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Operation of Balance of Plant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replication Sampling (Main Steam Pipe/Hot Re-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heater Pipe)</td>
</tr>
<tr>
<td>4 Dec.</td>
<td>Fri.</td>
<td>AM</td>
<td>Site Tour (Taking Photos)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PM</td>
<td>Wrap-Up Meeting</td>
</tr>
</tbody>
</table>

These schedule is tentative and will depend on actual site condition and availability of front.

### The Team Members

**Kazutoshi HIWAKI**  
(Mechanical)

**Masatoshi YAMAMOTO**  
(Metallurgical)

**Satoshi NAKASHIMA**  
(Metallurgical)

**Ryousuke TANIGUCHI**  
(I&C, Electrical)

**Shinya KONDO**
Integrity Inspection for Life Assessment of ST

JCOAL / Turbine Team

- November 2015 -

Aged Deterioration Mode and Damage

(DETERIORATION MODE)  ( DAMAGE )  ( LOCATION )

- CREEP - CRACKING - BLADE TENON
- LOW CYCLE FATIGUE - CRACKING - BLADE GROOVE
- EMBRITTLEMENT - DEFORMATION - BLADE TENON
- CORROSION - CRACKING - STATIONARY BLADE
- WEAR - CRACKING - HEAT GROOVE
- EROSION - PERFORMANCE DEGRADATION - BLADE GROOVE
- CORROSION - CRACKING - CORROSION FATIGUE
- PERFORMAN  CE DEGRADATION - LOW PRESS. STATIONARY VANE
- WEAR - PERFORMANCE DEGRADATION LEAKAGE - DISC GROOVE
- EROSION - PERFORMANCE DEGRADATION LEAKAGE - BLADE
- CORROSION - CRACKING - LABYRINTH SEAL
- WEAR - PERFORMANCE DEGRADATION LEAKAGE - BEARING
- EROSION - PERFORMANCE DEGRADATION LEAKAGE - VALVE STEM
Factors of SCC generation
(Stress corrosion Crack)

- Stress
- Fatigue
- Corrosion
- Environment

Material

- Operation Start
- Integrity Inspection & Life Time Assessment at 100,000 Running Hours (12 years)
- Life Time Assessment at 160,000 Running Hours (20 years)

Maintenance Intervals

- Expected Plant Life: 35-45 years
- Operation Start
- Major Outage Every 4 years
- Expected Plant Life: 35-45 years

Inspection Grade
- Category “C” (every year)
- Category “B” (every 2 years)
- Category “A” (every 4 years)
- Category “S” (Life Assessment Inspection)
Example of Creep Damage (IP Blade Tenon)

- IP blade
- Sectional Macrostructure
- Tip of crack

Example of SCC of LP Rotor (T-shaped Groove)

- Blade inserting disc groove
- Branched cracking
- Intergranular cracking

Appendix - II

Presentation @ Kick-off Meeting
## Life Assessment Inspection Menu (Typical)

<table>
<thead>
<tr>
<th>Components</th>
<th>Inspection</th>
<th>Point/Area/Zone</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rotor</strong></td>
<td>VI, PT, MT</td>
<td>All Surface</td>
<td>Crack, Erosion Corrosion</td>
</tr>
<tr>
<td></td>
<td>DI</td>
<td>Shroud Clearance</td>
<td>Creep</td>
</tr>
<tr>
<td></td>
<td>UT</td>
<td>Blade Groove</td>
<td>Crack, SCC</td>
</tr>
<tr>
<td></td>
<td>HT</td>
<td>High Temp. Surface</td>
<td>Softening</td>
</tr>
<tr>
<td>Replica</td>
<td></td>
<td>Blade Groove</td>
<td>SCC, Fatigue</td>
</tr>
<tr>
<td><strong>Casing</strong></td>
<td>VI, PT, MT</td>
<td>All Surface</td>
<td>Crack</td>
</tr>
<tr>
<td></td>
<td>HT</td>
<td>High Temp. Surface</td>
<td>Softening</td>
</tr>
<tr>
<td></td>
<td>HT, MT</td>
<td>Casing Bolt of HP Part</td>
<td>Creep, Softening</td>
</tr>
<tr>
<td><strong>M.S.V G.V</strong></td>
<td>VI, PT, MT</td>
<td>All Surface</td>
<td>Crack</td>
</tr>
<tr>
<td></td>
<td>HT</td>
<td>High Temp. Surface</td>
<td>Softening</td>
</tr>
<tr>
<td>Replica</td>
<td></td>
<td>High Temp. Surface</td>
<td>Creep</td>
</tr>
<tr>
<td></td>
<td>HT, MT</td>
<td>Casing Bolt of HP Part</td>
<td>Creep, Softening</td>
</tr>
</tbody>
</table>

## Procedure of Replica Test for Microstructure

1. **Step 1. Polishing & Etching for Replica**
   - Oxidation Scale: Surface of metal
   - Remove Scale
   - Polishing Surface
   - Rough Polishing
   - Mirror Surface
   - Finish Polishing
   - Etching Surface
   - Collect Replica

2. **Step 2. Replica**
   - Precipitant

3. **Step 3. Evaluation of Deterioration**
   - Scanning Electron Microscope for Physical Damage
   - Optical Microscope for Microstructure
MT for Side-face of Side-Entry Profile Groove

MT or Replica Test for Inner Surface of Blade Grooves (After Removing Blades)

Microstructure by Replica Test
Typical Flow on Residual Life Assessment of Hot Components

- Heat Transfer Rate (Material Data)
- Target Hot Parts (Configuration, Dimension)
- Operation Data
- NDT* Data

**Calculation of Temperature and Stress**

- Fatigue Component
- Creep Component

**Fracture Mechanics**

- Fatigue Crack Growth Law
- Creep Crack Growth Law

**Crack Growth Calculation due to Fatigue and Creep**

- $\Delta K$
- $\Delta a$

**Damage Calculation due to Fatigue and Creep**

- $\Delta S$
- $\sigma$

- Cycles to Failure
- Rupture Time

**Neubauer's Creep Damage Classification by Observation of Replicas**

<table>
<thead>
<tr>
<th>Damage Parameter</th>
<th>Micro-structure</th>
<th>Corresponding Action in Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Presence of isolated micro-cavities</td>
<td>Observe</td>
</tr>
<tr>
<td>B</td>
<td>Presence of directional micro-cavities</td>
<td>Observe, Fix Inspection intervals</td>
</tr>
<tr>
<td>C</td>
<td>Presence of micro-cracks</td>
<td>Limited service until repair</td>
</tr>
<tr>
<td>D</td>
<td>Presence of macro-cracks</td>
<td>Immediate repair</td>
</tr>
</tbody>
</table>

**Figure 1.** Neubauer’s classification of creep damage from observation of replicas and consequent action to be taken.
Inspection Points for Replication & Hardness

LP Rotor

Rep/Hard-LPR-1: Steam inlet
Rep/Hard-LPR-2: Area of alternate dry
Rep/Hard-LPR-3: L-0 Root
Rep/Hard-LPR-4: Flange

UT-LPR-1
UT-LPR-2
UT-LPR-3

Inspection Points for Replication & Hardness

HP Stop & Control Valve

Rep/Hard-MV-1: Hottest inner surface
Rep/Hard-MV-2: Hottest outer surface
Rep/Hard-MV-3: Hottest inner surface
Rep/Hard-MV-4: Hottest outer surface
Inspection Points for Replication & Hardness

- Rep/Hard-RV-2: Hottest outer
- Rep/Hard-RV-1: Hottest inner surface
- Rep/Hard-RV-3: Hottest inner surface
- Rep/Hard-RV-4: Hottest outer

IP Intercept & Control Valve
Major Site Study for RLA at Unit 3 of Dadri TPS, NTPC under the CEA-JCOAL Cooperation

Japan Coal Energy Center (JCOAL)
At Wrap-up & Interim Activity Report Meeting for RLA Study at Dadri TPS
December 4, 2015

Overview

1. Summary of activity by study area
2. Comments by Generator/Electrical/Turbine Team
3. Timeline toward Final Report
1. Summary of activities by study area

<table>
<thead>
<tr>
<th>AM</th>
<th>Japanese experts</th>
<th>Indian experts</th>
<th>Japanese experts</th>
<th>Indian experts</th>
<th>Japanese experts</th>
<th>Indian experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>The meeting for the final confirmation of the examination schedule and contents</td>
<td>Data collection</td>
<td>Instructed test positions and witnessed Replica &amp; HT of LP rotor</td>
<td>Replica &amp; Hardness on the rotor shaft and MPI of the Turbine Blade</td>
<td>Replica &amp; Hardness: Three Locations MPI</td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>Instructed test positions and procedure for Replica of Boiler Hot parts</td>
<td>Videoprobe in headers in Pent House</td>
<td>Interview to Electricity Dep. and data collection</td>
<td>Instructed test positions and witnessed Replica &amp; HT of HP &amp; IP valves</td>
<td>Replica &amp; Hardness on the rotor shaft &amp; Blade Grooves, MPI of the Turbine Blade</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Visual Inspection for Condition Assessment of Boiler Tubes (1st Pss)</td>
<td>Videoprobe in headers in Pent House</td>
<td>Visit main electricity equipment &amp; Joint inspection of Generator (tan delta and RSO test)</td>
<td>Electrical Test in Generator- Stator &amp; Rotor</td>
<td>Instruction of test positions and witnessed UT of LP rotor &amp; Performance data collection</td>
<td>Replica &amp; Hardness on the HP &amp; IP Valve &amp; UT test on the Rotor Shaft and MPI test of the Turbine Blade</td>
</tr>
<tr>
<td>3</td>
<td>Completed</td>
<td>Completed</td>
<td>Completed</td>
<td>Completed</td>
<td>Completed</td>
<td>Completed</td>
</tr>
</tbody>
</table>

Note: Some positions of Replica & HT of HP & IP valves are limited due to space.
## Activities on Day 3, Day 4, and Day 5

<table>
<thead>
<tr>
<th>Day</th>
<th>AM</th>
<th>Japanese experts</th>
<th>Indian experts</th>
<th>Japanese experts</th>
<th>Indian experts</th>
<th>Japanese experts</th>
<th>Indian experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td>Replica On the Superheater Outlet Header &amp; Reheater Outlet Header Left side</td>
<td>Interview to C&amp;I Dep. and visit C&amp;I Dep. Laboratory</td>
<td>UT test on Generator Retaining Ring</td>
<td>Obtained ST &amp; Aux. drawings</td>
<td>Hearing of O&amp;M of #3 ST (Troubles, S/P etc)</td>
<td>MPI test of the Turbine Blade</td>
</tr>
<tr>
<td></td>
<td>- Instruction of test positions &amp; procedure for Replica of Boiler hot parts (All Day)</td>
<td>- Visual Inspection for Condition Assessment of Boiler Tubes (2nd Pass)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td></td>
<td>- Visual Inspection for Condition Assessment of Boiler Aux.</td>
<td>Joint inspection of Generator (PD test) and data collection</td>
<td>- Obtained MPT of LP rotor blade groove</td>
<td>- Obtained #3 ST history of Start/Stop</td>
<td>DPT test &amp; Visual inspection on the turbine auxiliaries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replica on the Main steam pipe line</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Completed</td>
<td>Completed</td>
<td></td>
<td></td>
<td>In progress</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AM</td>
<td>Interview to Boiler Maintenance Dep.</td>
<td>Replica On the Main steam pipe line (Repeat) &amp; HRH Line Visual, DPT and DIM: PLSH, RH / VI of FSH / VI,DPT,UT of LTSH and Economiser</td>
<td>- Data collection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PM</td>
<td>Interview to Operation Dep.</td>
<td>Replica On the Final SH, Re-heater &amp; Platen SH Header, (Inlet &amp; Outlet) VI: Eco to Boiler Drum Link pipe, Boiler Drum and Downcomer Pipe/ VI and DPT of link pipe FSH</td>
<td>- Interview to Operation Dep.</td>
<td>- Survey of ST Aux.</td>
<td>DPT test &amp; Visual inspection on the turbine auxiliaries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Completed</td>
<td>Completed</td>
<td>ST at rated load after this O/H is to be printed out and sent to JCOAL</td>
<td>Completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>AM</td>
<td></td>
<td>Compilation &amp; Data collection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PM</td>
<td>+ Compilation &amp; Data collection</td>
<td>Interview to Maintenance Dep.</td>
<td>Compilation &amp; Data collection</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Completed**

**Note**

In progress

Interim wrap-up & tentative reporting

## 2. Comments by Boiler/Electrical/Turbine Team

Presentation @ Interim Wrap-up Meeting
## JCOAL Work on Dadri TPS in India

### Diagnosis Work on RLA, CA, O&M Dadri TPS

**(30th Nov. – 4th Dec. 2015)**

<table>
<thead>
<tr>
<th>Point of View</th>
<th>Our Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Remaining Life Assessment for Boiler Tubes</td>
<td>Guidance and advice of work for the collection of the replica sample of boiler hot section tube</td>
</tr>
<tr>
<td>(2) Condition Assessment for Boiler and its auxiliaries</td>
<td>Visual Inspection for Boiler Tubes and Coal Burner Part</td>
</tr>
<tr>
<td>(3) Condition Assessment for Generator and Electric Equipments</td>
<td>Check the status of the witness facilities to test and inspection</td>
</tr>
<tr>
<td>(4) O&amp;M improvement</td>
<td>Interviewing about O &amp; M for improvement of O &amp; M Procedure to reduce the workload and to continue to effectively maintenance</td>
</tr>
</tbody>
</table>
(1) Remaining Life Assessment for Boiler Tubes

While the basic philosophy of Boiler RLA is common between NTPC and JCOAL Team, we’ve found some differences in method and procedure of replica collection. This time replica collection was done following the standard method and procedure of Kyushu Electric Power.

(2) Condition Assessment for Boiler and its auxiliaries

We have observed that Dadri has achieved high standards of maintenance management and keeps a set of best practices based on their own experiences.
(3) Condition Assessment for Generator and Electric Equipments

According to our observation, the plant keeps its value thanks to timely and appropriate updates and maintenance of equipment, all of which are realized through excellent management by NTPC.

Kyushu Electric Power Co., Inc.
Replication & Hardness Test on LP Rotor

Rep/Hard-LPR-3: L-0 Root
Rep/Hard-LPR-2: Area of alternate dry and wet part
Rep/Hard-LPR-3: L-0 Steam outlet
Rep/Hard-LPR-4: Flange
Rep/Hard-LPR-1: Steam inlet part
Turbine side
Generator side

UT-LPR-3
UT-LPR-1
UT-LPR-2

: additionally inspected

Replication & Hardness Test on LP Rotor

Replica Test

Hardness Test

Ultrasonic Test

Magnetic Particle Test
Replication & Hardness Test on HP Valve

Rep/Hard-MV-1: Hottest inner surface
Rep/Hard-MV-2: Hottest outer surface
Rep/Hard-MV-3: Hottest inner surface

Rep/Hard-RV-2: Hottest outer surface
Rep/Hard-RV-1: Hottest inner surface
Rep/Hard-RV-3: Hottest inner surface

•: inspected
○: planned only
→: converted to possible location

Replication & Hardness Test on IP Valve

Rep/Hard-RV-2: Hottest outer surface
Rep/Hard-RV-1: Hottest inner surface
Rep/Hard-RV-3: Hottest inner surface

•: inspected
○: planned only
→: converted to possible location

Appendix - III
Presentation @ Interim Wrap-up Meeting
Preliminary comments

● Some replica inspection points of HP & IP Valves were changed, due to difficulty of polishing.

● UT inspection on the LP rotor was applied additionally.

● Erosion by drain attack on L-0 blades surface is not so severe, considering operation period more than 20 years.

● Repeated number of Start & Stop of #3 ST is about 250 times. Low cycle fatigue analysis will be carried out basing on this number.

● Microstructure of replica will be observed by microscope in laboratory. RLA will be done using these microstructural data, operating temperature, stress and period, basing on the latest Japanese technology.
3. Timeline toward Final Report

- Testing and inspection of the Major Site Study: December 5 to December 9, 2015*
  *To be completed one day earlier than planned
- Data Analysis: December 2015 to February 2016
- Reporting: Mid to late February 2016
- Provision of the final report: March 2016
For the optimal outcome of the RLA Study

- Testing and inspection work will go on until December 9 and will be supervised by JCOAL. One JCOAL person will be based at the VIP Guest House throughout the period.

- While most of the required data and information have been provided thanks to enthusiastic involvement and firm cooperation by Dadri officers and engineers devoted to the RLA Study, some of them are to be provided later due to the circumstances. In this connection, prompt provision of such data and information will be most appreciated.

- We will do our best in producing the optimal outcome of the RLA Study under the India-Japan Cooperation.

Thousands of thanks for your kind cooperation

Website: http://www.jcoal.or.jp/index-en.html

Contacts:
Mr. K. Murakami (kzmurakami@jcoal.or.jp)
Ms. Yamada, F. (fyamada@jcoal.or.jp)